REXYGEN www.rexygen.com

Function Blocks of REXYGEN
Reference manual

REX Controls s.r.o.

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Contents

Note: Only a partial documentation is available in blocks marked by * .

Chapter 1

Introduction

The manual "REXYGEN system function blocks" is a reference manual for the REXYGEN system function block library RexLib. It includes description and detailed information about all function blocks RexLib consists of.

1.1 How to use this manual

The extensive function block library RexLib, which is a standard part of the REXYGEN system, is divided into smaller sets of logically related blocks, the so-called *categories* (sub-libraries). A separate chapter is devoted to each category, introducing the general properties of the whole category and its blocks, followed by a detailed description of individual function blocks.

The content of individual chapters of this manual is as follows:

1 **Introduction**
This introductory chapter familiarizes readers with the content and ordering of the manual. A convention used for individual function block descriptions is presented.

2 **EXEC – Real-time executive configuration**
The EXEC library is essential for setting up the real-time executive in the REXYGEN system and includes key blocks like `EXEC`, `TASK`, `QTASK`, and `HMI`. These blocks are fundamental for managing task execution, determining process priorities, and interacting with user interfaces, significantly contributing to the efficiency and controllability of applications within the REXYGEN ecosystem.

3 **INOUT – Input and output blocks**
The INOUT library serves as a crucial interface in the REXYGEN system, enabling smooth interaction with input/output drivers. It is designed for efficient simultaneous signal processing, essential for fast control tasks. This library simplifies the connection between control algorithms and hardware, ensuring minimal latency. Additionally, it provides advanced features, such as virtual linking (flags) of signals for increased clarity of diagrams and flexibility of subsystems.

4 **MATH – Math blocks**
The MATH library offers a comprehensive collection of mathematical operations and functions. It includes basic arithmetic blocks like ADD, SUB, MUL, and DIV for standard calculations, and more specialized blocks such as ABS for absolute values, SQRT for square roots, and SQR for squaring. Advanced functionalities are provided by blocks like LIN for linear transformations, POL for polynomial evaluations, and FNX, FNXY for customizable mathematical functions. The library also features integer-specific operations through blocks like IADD, IMUL, IDIV, and IMOD.

5 **ANALOG – Analog signal processing**
Library presents a versatile range of functional blocks, designed for control and signal processing applications. It includes blocks like ASW, AVG, BPF, and DEL, which provide functionalities from signal manipulation and averaging to filtering and complex conditional operations, catering to a broad spectrum of system requirements and scenarios.

6 **GEN – Signal generators**
The GEN library is specialized in signal generation. It includes blocks like ANLS for generating a piecewise linear function of time or binary sequence generators BINS, BIS, BISR. The library also features MP for manual pulse signal generation, PRBS for pseudo-random binary sequence generation, and SG for periodic signals generation. This library provides essential tools for creating and manipulating various signal types.

7 **REG – Function blocks for control**
The control function blocks form the most extensive sub-library of the RexLib library. Blocks ranging from simple dynamic compensators to several modifications of PID (P, I, PI, PD a PID) controller and some advanced controllers are included. The blocks for control schemes switching and conversion of output signals for various types of actuators can be found in this sub-library. The involved controllers include the PIDGS block, enabling online switching of parameter sets (the so-called *gain scheduling*), the PIDMA block with built-in moment autotuner, the PIDAT block with built in relay autotuner, the FLCU fuzzy controller or the PSMPC predictive controller, etc.

8 **LOGIC – Logic control**
The LOGIC library encompasses a range of blocks for executing logical and sequential operations. It includes basic Boolean blocks like AND, OR, NOT for fundamental logical operations, and advanced blocks like ATMT for finite state machines. Blocks like COUNT and TIMER extend functionality to bidirectional pulse counting and time-based operations. Additional elements like BITOP, BMOCT, and BDOCT offer bitwise operations and multiplexing/demultiplexing capabilities, enhancing the library's versatility in handling combinational and sequential logic control.

9 **TIME – Blocks for handling time**
The TIME library is specialized for time-based operations and scheduling in REXY-

GEN system. It includes blocks like DATE, TIME and DATETIME for handling date and datetime, providing essential tools for working with temporal data. The library features TC for itnernal timer control. Additionally, WSCH is used for scheduling, enabling efficient management of time-dependent tasks. This library is particularly valuable for systems requiring precise time management and scheduling capabilities.

10 **ARC – Data archiving**
The library is integral to the archiving subsystem of the REXYGEN system, focusing on recording the history of the control algorithm. It encompasses blocks for generating alarms and events, recording trends, and handling archives. This library is essential for maintaining a comprehensive history of events, alarms, and trends, with support for various types of archives like RAM, backed-up memory, and disk archives, ensuring versatility in data storage and access.

11 **STRING – Blocks for string operations**
The STRING library is dedicated to string manipulation and analysis in REXYGEN system. It includes blocks like CONCAT for concatenating strings, FIND for searching within strings, and REPLACE for replacing string segments. The library offers LEN and MID for determining string length and extracting substrings, respectively. Advanced pattern matching is provided by REGEXP. Conversion blocks such as ITOS, STOR and RTOS convert integers and real numbers to strings, while a simple CNS block defines a string constant. Additionally, the library features blocks like PJROCT for JSON parsing. This collection of blocks is essential for handling and processing string data in various applications.

12 **PARAM – Blocks for parameter handling**
The PARAM library is designed for parameter management and signal processing in the REXYGEN system. It includes blocks like PARR and its variants for defining and modifying various types of parameters. Search blocks like GETPA and GETPS enable the extraction of these parameters for further processing. Conversely, SETPA, SETPR, and SETPS are used for dynamically setting parameter values. Additionally, the library contains SILO and SILOS for exporting and importing values from a file. This library is crucial for systems requiring dynamic parameter manipulation and the ability to read/save values to a file.

13 **MODEL – Dynamic systems simulation**
The MODEL library is centered around system modeling and simulation. It includes blocks like CSSM and DSSM for continuous and discrete state-space models, and DFIR for digital finite impulse response filters. The library offers EKF for Extended Kalman Filter implementations, and FOPDT, SOPDT for first and second order process time delay models. Additionally, it provides FMUCS and FMUINFO for interfacing with Functional Mock-up Units, and MDL, MDLI for generic model interfaces. Advanced functionalities are covered by blocks like CDELSSM, DDELSSM for continuous and discrete state space models of a linear system with time delay, and MVD

for model variable delays, catering to a wide range of modeling requirements in REXYGEN system.

14 MATRIX – Blocks for matrix and vector operations

The MATRIX library is designed for advanced matrix computations and manipulations. It encompasses a wide range of blocks such as MB_DGEMM, MB_DTRMM, and MB_DGER for matrix-matrix and matrix-vector operations. The library includes functions for matrix decomposition (ML_DGEBRD, ML_DGEQRF), eigenvalue problems (ML_DGEEV, ML_DGEES), and singular value decomposition (ML_DGESDD). Additionally, it offers utility blocks like MX_MAT, MX_VEC, and MX_FILL for matrix creation and manipulation, as well as specialized blocks such as MX_DTRNSP for matrix transposition and MX_RAND for generating random matrices. This library is essential for complex mathematical operations involving matrices in various applications.

15 OPTIM – Optimization blocks

The OPTIM library is tailored for optimization algorithms and processes. It includes QCEDPOPT for Quadratic Cost Economic Dispatch Problem optimization, providing advanced tools for handling complex optimization problems. The library also features blocks like QP_MPC2QP and QP_OASES for Quadratic Programming, essential in Model Predictive Control (MPC) scenarios. Additionally, QP_UPDATE is available for updating quadratic program parameters. This library is particularly useful in systems requiring high-level optimization solutions, such as in advanced control and decision-making algorithms.

16 SPEC – Special blocks

The SPEC library encompasses a diverse set of functional blocks designed to integrate a wide range of functionalities into automation, control systems, and communication protocols. From facilitating precise thermodynamic calculations with the STEAM block to enabling seamless data communication through UART and SMTP, the library serves as a comprehensive toolkit for engineers and developers. It includes specialized blocks for executing external programs (EPC), handling web-based requests (HTTP2). Additionally, it offers unique input-output solutions (RDC) and a versatile programming environment with REXLANG.

17 LANG – Special blocks

18 DSP – Digital Signal Processing blocks

The DSP library is tailored for advanced digital signal processing. It includes blocks like FFT for Fast Fourier Transform operations and PSD for Power Spectral Density analysis. The library also features BSFIFO, BSGET, BSGETV, BSSET, and BSSETV for buffer storage and retrieval, enabling efficient data handling in signal processing tasks. Additionally, MOSS provides multi-objective signal selection capabilities. This collection of blocks is essential for sophisticated signal analysis and manipulation in digital systems.

19 **MQTTDrv – Communication via MQTT protocol**
The MQTTDrv library is designed for IoT (Internet of Things) communication using the MQTT (Message Queuing Telemetry Transport) protocol. It consists of two primary blocks: `MqttPublish` and `MqttSubscribe`. The `MqttPublish` block is used for sending messages to an MQTT broker, enabling the publication of data to MQTT topics. Conversely, the `MqttSubscribe` block is designed for subscribing to topics and receiving messages from a broker. This library facilitates efficient and effective data communication in IoT applications, leveraging the lightweight and widely-used MQTT protocol for message exchange.

20 **MC_SINGLE – Motion control - single axis blocks**
The MC_SINGLE library is designed for motion control in single-axis systems. It features blocks like `MC_MoveAbsolute`, `MC_MoveRelative`, and `MC_MoveVelocity` for precise positioning and speed control. The library includes `MC_Home` for homing operations, and `MC_Power` for controlling the power state of the axis. Advanced functionalities are provided by `MC_AccelerationProfile`, `MC_PositionProfile`, and `MC_VelocityProfile` for customizing motion profiles. It also offers monitoring and parameter adjustment capabilities through `MC_ReadActualPosition`, `MC_ReadAxisError`, `MC_ReadParameter`, and `MC_WriteParameter`. Additionally, the library contains blocks like `MC_Halt`, `MC_Reset`, and `MC_Stop` for emergency and control operations. This library is essential for applications requiring precise and controlled motion in single-axis configurations.

21 **MC_MULTI – Motion control - multi axis blocks**
The MC_MULTI library is specialized for multi-axis motion control. It includes blocks like `MC_CombineAxes` for synchronizing multiple axes, `MC_GearIn` and `MC_GearOut` for gearing operations, and `MC_PhasingAbsolute`, `MC_PhasingRelative` for precise axis phasing. The library offers `MC_CamIn` and `MC_CamOut` for camming functionalities, allowing complex motion profiles to be followed. Additionally, `MCP_CamTableSelect` provides flexibility in selecting cam tables, and `MC_GearInPos` enables position-based gearing. This library is essential for advanced applications requiring coordinated motion control across multiple axes.

22 **MC_COORD – Motion control - coordinated movement blocks**
The MC_COORD library is specifically designed for the coordination of multi-axis motion control within complex systems. It encompasses a variety of blocks, including `MC_MoveLinearAbsolute` for executing precise linear movements, complemented by `MC_MoveLinearRelative` for relative linear motion. For the execution of circular motion, the library incorporates `MC_MoveCircularAbsolute` alongside `MC_MoveCircularRelative`, ensuring detailed circular trajectories. In the context of managing group axis control, this library introduces `MC_AddAxisToGroup`, which is further supported by functionalities such as `MC_GroupEnable` for activation, `MC_GroupDisable` for deactivation, and `MC_GroupHalt` for immediate stopping of grouped axes. Furthermore, the library provides `MC_MoveDirectAbsolute` and `MC_MoveDirectRelative`, enabling direct control over axis movements. For navi-

gating through complex paths, MC_MovePath is made available. Essential monitoring and control features are facilitated by MC_GroupReadActualPosition for positional data, MC_GroupReadActualVelocity for velocity insights, MC_GroupReadError for error detection, and MC_GroupReadStatus for status updates. Additionally, the library integrates MC_ReadCartesianTransform and MC_SetCartesianTransform, which are vital for Cartesian transformation processes. This collection of functionalities underscores the library's significance in applications that demand the synchronized control of multiple axes, particularly in the realms of robotics and automation systems.

23 **CanDrv – Communication via CAN bus**
The CanDrv library is dedicated to handling CAN (Controller Area Network) bus communication in REXYGEN system. It features CanItem for managing CAN data items, CanRecv for receiving messages from the bus, and CanSend for sending messages. This library provides essential tools for efficient and reliable communication over CAN networks, facilitating data exchange and control commands between various system components.

24 **OpcUaDrv – Communication using OPC UA**
The OpcUaDrv library is specialized in interfacing with OPC UA (Open Platform Communications Unified Architecture) servers for industrial automation. It comprises three key blocks: OpcUaReadValue, OpcUaServerValue, and OpcUaWriteValue. The OpcUaReadValue block is designed for reading data from servers, making it pivotal for data acquisition in automated systems. The OpcUaWriteValue block enables writing data to servers, allowing for control and command execution. Additionally, the OpcUaServerValue block facilitates the monitoring and management of server values. This library serves as a critical tool for seamless communication and interaction with OPC UA servers, enhancing the capabilities of automation systems.

The individual chapters of this reference guide are not much interconnected, which means they can be read in almost any order or even only the necessary information for specific block can be read for understanding the function of that block. The electronic version of this manual (in the `.pdf` format) is well-suited for such case as it is equipped with hypertext bookmarks and contents, which makes the look-up of individual blocks very easy.

Despite of that it is recommended to read the following subchapter, which describes the conventions used for description of individual blocks in the rest of this manual.

1.2 The function block description format

The description of each function block consists of several sections (in the following order):

Block Symbol – displays the graphical symbol of the block

Function Description – brief description of the block function, omitting too detailed information.

Inputs – detailed description of all inputs of the block

Outputs – detailed description of all outputs of the block

Parameters – detailed description of all parameters of the block

Examples – a simple example of the use of the block in the context of other blocks and optional graph with input and output signals for better understanding of the block function.

If the block function is obvious, the section Examples is omitted. In case of block with no input or no output the corresponding section is omitted as well.

The inputs, outputs and parameters description has a tabular form:

`<name>`	[*nam*] Detailed description of the input (output, parameter) `<name>`. Mathematical symbol *nam* on the right side of the first column is used in the equations in the Function Description section. It is listed only if it differs from the name more than typographically. If the variable value is limited to only enumerated values, the meaning of these values is explained in this column. [⊙`<def>`] [↓`<min>`] [↑`<max>`]	`<type>`

The meaning of the three columns is quite obvious. The third column contains the item `<type>`. The REXYGEN control system supports the types listed in table 1.1. But the most frequently used types are `Bool` for Boolean variables, `Long (I32)` for integer variables and `Double (F64)` for real variables (in floating point arithmetics).

Each described variable (input, output or parameter) has a default value `<def>` in the REXYGEN system, which is preceded by the ⊙ symbol. Also it has upper and lower limits, preceded by the symbols ↓ and ↑ respectively. All these three values are optional (marked by [ ]). If the value ⊙`<def>` is not listed in the second column, it is equal to zero. If the values of ↓`<min>` and/or ↑`<max>` are missing, the limits are given by the the minimum and/or maximum of the corresponding type, see table 1.1[1].

1.3 Conventions for variables, blocks and subsystems naming

Several conventions are used to simplify the use of the REXYGEN control system. All used variable types were defined in the preceding chapter. The term variable refers to function block inputs, outputs and parameters in this chapter. The majority of the blocks uses only the following three types:

[1]Precise range of the `Large` data type is -9223372036854775808 to 9223372036854775807.

Type	Meaning	Minimum	Maximum
Bool	Boolean value 0 or 1	0	1
Byte (U8)	8-bit integer number without the sign	0	255
Short (I16)	16-bit integer number with the sign	-32768	32767
Long (I32)	32-bit integer number with the sign	-2147483648	2147483647
Large (I64)	64-bit integer number with the sign	$-9.2234 \cdot 10^{18}$	$9.2234 \cdot 10^{18}$
Word (U16)	16-bit integer number without the sign	0	65535
DWord (U32)	32-bit integer number without the sign	0	4294967295
Float (F32)	32-bit real number in floating point arithmetics	$-3.4 \cdot 10^{38}$	$3.4 \cdot 10^{38}$
Double (F64)	64-bit real number in floating point arithmetics	$-1.7 \cdot 10^{308}$	$1.7 \cdot 10^{308}$
String	character string		

Table 1.1: Types of variables in the REXYGEN system.

`Bool` – for two-state logic variables, e.g. on/off, yes/no or true/false. The logic one (yes, true, on, 1) is referred to as `on` in this manual. Similarly the logic zero (no, false, off, 0) is represented by `off`. This holds also for REXYGEN Studio. Other tools and 3rd party software may display these values as `1` for `on` and `0` for `off`. The names of logic variables consist of uppercase letters, e.g. `RUN`, `YCN`, `R1`, `UP`, etc.

`Long (I32)` – for integer values, e.g. set of parameters ID, length of trend buffer, type of generated signal, error code, counter output, etc. The names of integer variables use usually lowercase letters and the initial character (always lowercase) is in most cases {`i`, `k`, `l`, `m`, `n`, or `o`}, e.g. `ips`, `l`, `isig`, `iE`, etc. But several exceptions to this rule exist, e.g. `cnt` in the `COUNT` block, `btype`, `ptype1`, `pfac` and `afac` in the `TRND` block, etc.

`Double (F64)` – for floating point values (real numbers), e.g. gain, saturation limits, results of the majority of math functions, PID controller parameters, time interval lengths in seconds, etc. The names of floating point variables use only lowercase letters, e.g. `hilim`, `y`, `ti`, `tt`.

The function block names in the REXYGEN system use uppercase letters, numbers and the `'_'` (underscore) character. It is recommended to append a lowercase user-defined string to the standard block name when creating user instances of function blocks.

It is explicitly not recommended to use diacritic and special characters like spaces, CR (end of line), punctuation, operators, etc. in the user-defined names. The use of such characters limits the transferability to various platforms and it can lead to incomprehension. The names are checked by the REXYGEN Compiler compiler which generates warnings if inappropriate characters are found.

1.4 Signal Quality Corresponding with OPC

Every signal (input, output, parameter) in the REXYGEN system has the so-called *quality flags* in addition to its own value of corresponding type (table 1.1). The quality flags in the REXYGEN system correspond with the OPC (Open Platform Communications) specification [1]. They can be represented by one byte, whose structure is explained in the table 1.2.

Bit number	7	6	5	4	3	2	1	0
Bit weight	128	64	32	16	8	4	2	1
Bit field	**Quality**		**Substatus**				**Limits**	
	Q	Q	S	S	S	S	L	L
BAD	0	0	S	S	S	S	L	L
UNCERTAIN	0	1	S	S	S	S	L	L
not used in OPC	1	0	S	S	S	S	L	L
GOOD	1	1	S	S	S	S	L	L

Table 1.2: The quality flags structure

The basic quality type is determined by the QQ flags in the two most important bits. Based on these the quality is distinguished between GOOD, UNCERTAIN and BAD. The four SSSS bits provide more detailed information about the signal. They have different meaning for each basic quality. The two least significant bits LL inform whether the value exceeded its limits or if it is constant. Additional details and the meaning of all bits can be found in [1], chapter 6.8. The list of blocks propagating signal quality is given in table 1.3.

ABSROT	ABS	ADDHEXD	ADD	ANDHEXD	AND	ASW	ATMT
AVG	AVSI	AVS	BDHEXD	BITOP	BMHEXD	BPF	CMP
CNB	CNDR	CNI	CNR	COUNT	DELM	DEL	DER
DIF	DIV	EAS	EATMT	EDGE	EMD	EQ	EVAR
FNXY	FNX	GAIN	IADD	IDIV	IMOD	IMUL	INTE
INTSM	ISSW	ISUB	ITOI	KDER	LIN	LPF	MINMAX
MUL	NOT	NSCL	ORHEXD	OR	OSD	POL	RDFT
REC	REL	RLIM	RS	RTOI	SELHEXD	SHIFTOCT	SHLD
SINT	SPIKE	SQRT	SQR	SR	SSW	SUB	SWR
TIMER	UTOI	VDEL	ZV4IS				

Table 1.3: The list of blocks prapagating signal quality

The principle of quality propagation between blocks operates as follows: The lowest quality among all *data* inputs to a block is determined and applied to all *data* outputs. Any unconnected input is considered as good quality (GOOD). Quality on *control* inputs is not tracked; however, *control* inputs can influence the propagation of quality from *data* inputs. On *status* outputs, the quality is invariably set to good (GOOD).

For instance, in a DEL block, the input u is considered *data* because it carries operational data. The input R1 is classified as *control* since it controls the block's operation. The output y is *data* because it conveys the block's output information. The RDY output is *status* as it indicates the operational state of the block.

Except for certain cases (SAI, VIN, S1OF2), the quality does not influence the block's algorithm (i.e., the actual values at the outputs). Some blocks may assign a lower quality (UNCERTAIN, BAD) as a result of their algorithm (e.g., DEL prior to buffer filling or DIV when dividing by zero).

Chapter 2

EXEC – Real-time executive configuration

Contents

The EXEC library is essential for setting up the real-time executive in the REXYGEN system and includes key blocks like EXEC, TASK, QTASK, and HMI. These blocks are fundamental for managing task execution, determining process priorities, and interacting with user interfaces, significantly contributing to the efficiency and controllability of applications within the REXYGEN ecosystem.

ALARMS – Alarms Definition Configuration

Block Symbol

Licence: STANDARD

Function Description

The ALARMS is placed in the *main project file* and allows the user to configure list of alarms. Alarms are activated by the ALM or ALMI blocks. Alarms are defined in a .csv (Comma separated variable) file. The **afile** parameter contains the file name of the .csv file. An alarm could be activated also by the ALB, ALBI, ALN, ALNI blocks, but these blocks not use definitions in the ALARMS block.

The configuration file has the following columns:

- **id** . . . Unique alarm reference number. The number is used in the ALM block, in archive records, etc.
- **level** . . . The value stored into an archive record (in the **level** field).
- **archives** . . . Bit field – identifies archives for recording events associated with the alarm (alarm starts, ends, acknowledges). E.g. 0 = not stored in the archive, 1 = stored in the 1st archive, 2 = stored in the 2nd archive, 4 = stored in the 3rd archive, 3 = stored in the 1st and 2nd archives, etc.
- **group** . . . Reserved for future use, now some number (or bitfield up to 64 bits) to filter alarm's list in HMI.
- **name** . . . Name of the alarm; can be used as the alarm identifier, so it should be unique.
- **description** . . . Text description of the alarm. It is possible to insert formatting characters for multilingual texts and to insert values associated with the alarm associated values) in the text, see below.

Multilingual support

REXYGEN supports multilingual alarm description. The description field must be in the form:

```
<lang1_ID>:<lang1 text>|<lang2_ID>:<lang2 text>|<lang3_ID>:<lang3 text>
```

Number of languages is not limited, but total size of the field is limited to 32765 bytes (english characters). The lang1 (language 1) is used if the user sets unsupported language. Example: let's expect the description field in the form: `cz:Přepětí|en:High voltage alarm`. The user will see `High voltage alarm` if the language is set to `en`. The user will see `Přepětí` if the language is set to `cz`. The user will see `Přepětí` in all other cases (for example if the language is set to `de`, `cze`, `EN`, `en-us`, etc.).

Associated values

The desription field can contain special marks that is replaced by values from control algorithm – so-called associated values. The mark has the form:

%<value number>[<format>][:<number of characters>[:<precision>]]

where the format is one of the following characters:

b, B ... binary value (string on or off is shown)
d, D ... integer number shown as decimal string, the default value for integer types
x, X ... integer number shown as hexadecimal string
f, F ... real number in fix point form, the precision of it is a number of digits behind decimal point (if precision is specified)
e, E ... real number in exponential (scientific) form
g, G ... the same as F or E (depends on actual value), the default format for real number types
s, S ... text string

The default type is used if the format is not specified or if the type of the value is not compatible with the specified format. More characters than it is specified is used if it is necessary to show the correct value.

Format Examples:

%2 ... value of 2nd variable (e.g. av2 in the ALM block)
%1:8:2 ... value of 1st variable (e.g. av1 in the ALM block), 2 characters behind decimal point, total 8 characters (leading spaces are used if necessary)
%1e ... value of 1st variable (e.g. av1 in the ALM block) in exponential form

The ALB, ALBI blocks not use associated values. The ALN and ALNI maps it this way:

1 ... value of the u input
2 ... value of the h parameter (input)
3 ... value of the hh parameter (input)
4 ... value of the l parameter (input)
5 ... value of the ll parameter (input)
6 ... value of the tout parameter (input)

Remarks:

- It is possible to use comma or semicolon as a separator in the .csv file. The first row with column names is optional.
- Alarms (lines) in the file must be in the ascending order respect to the id.
- The id must be unique including other alarming/archiving blocks (TRND, ALB, ALN, ...).
- It is possible to use the internal editor (the Configure button in parametric dialog) or external tool. Internal editor generates a correct example if the .csv file does not exist.

- The blocks ALB, ALBI, ALN and ALNI regard lvl $>$ 127 as an event, where only its begin (nor end nor acknoledge) is stored into archives. The blocks ALM, ALMI do not implement this event function.
- Alarm's associated values are stored into alarm's value when alarm is triggered (begin). Later changes of the associated values are not updated in an alarm window in HMI.
- Alarm window in HMI can show also alarm name. It is the name of the block (without block type if it prefixes the block name) that is connected to the alarm.
- The whole description string is displayed, if client sets the empty language (e.g. "").

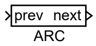
Parameters

afile	file name of an alarm's definition .csv file	String

ARC – The REXYGEN system archive

Block Symbol

Licence: STANDARD



Function Description

The ARC block is intended for archives configuration in the REXYGEN control system. The archives can be used for continuous recording of alarms, events and history trends directly on the target platform. The output `Archives` of the EXEC block must be connected to the `prev` input of the first archive. The following archives can be added by connecting the input `prev` with the preceding archive's output `next`. Only one archive block can be connected to each `next` output, the output of the last archive remains unconnected. The resulting archives sequence determines the order of allocation and initialization of individual archives in the REXYGEN system and also the index of the archive, which is used in the `arc` parameter of the archiving blocks (see chapter 10). The archives are numbered from 1 and the maximum number of archives is limited to 15 (archive no. 0 is the internal system log).

The `atype` parameter determines the type of archive from the data-available-after-restarting point of view. The admissible types depend on the target platform properties, which can be inspected in the `Diagnostics` section of the REXYGEN Studio program after successful connecting to the target device.

Archive consists of sequenced variable-length items (memory and disk space optimization) with a timestamp. Therefore the other parameters are the total archive size in bytes `asize` and maximum number of timestamps `nmarks` for speeding-up the sequential seeking in the archive.

The frequency of writing values to disk can be influenced by the `period` parameter. For devices using flash memory or SD cards as a disk, it is not suitable to write values too often, therefore it is appropriate to set this parameter to a value in the order of minutes. Furthermore, it is possible to select a suitable source of time stamps with the `timesrc` parameter.

Input

`prev`	Input for connecting with the `next` output of the preceding archive or with the `Archives` output of the EXEC block in the case of the first archive	Long (I32)

Output

`next`	Output for creating sequences of archives by connecting to the `prev` input of the following archive	Long (I32)

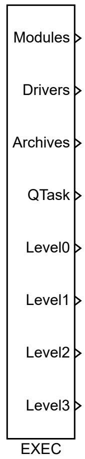
Parameters

`atype`	Archive type	⊙1	`Long (I32)`
	1 ..... archive is allocated in the RAM memory (data is irreversibly lost after restarting the target device) 2 ..... archive is allocated in backed-up memory, e.g. CMOS (data remains available after restarting the target device) 3 ..... archive is allocated on a drive (data remains available in the file after restarting)		
`asize`	Size of the archive in bytes	↓256 ⊙102400	`Long (I32)`
`nmarks`	Number of time stamps for speeding-up sequential seeking in the archive	↓2 ⊙720	`Long (I32)`
`ldaymax`	Maximum size of archive per day [bytes]	↓1000 ↑2147480000 ⊙1048576	`Large (I64)`
`period`	Period of writing data to disk [s]	⊙60.0	`Double (F64)`
`timesrc`	Source of timestamps	⊙1	`Long (I32)`
	1 ..... `CORETIMER` – technological time – at current tick 2 ..... `CORETIMER-PRECISE` – technological time – at block execution 3 ..... `RTC` – real time clock (wallclock) from operating system – at current tick 4 ..... `RTC-PRECISE` – real time clock (wallclock) from operating system – at block execution 4 ..... `PFC` – raw high precision time (PerFormanceCounter)		

EXEC – Real-time executive

Block Symbol

Licence: STANDARD



Function Description

The EXEC block is a cornerstone of the so-called *project main file* in the .mdl format, which configures individual subsystems of the REXYGEN system. No similar block can be found in the Matlab-Simulink system. The EXEC block and all connected configuration blocks do not implement any mathematic algorithm. Such configuration structure is used by the REXYGEN Compiler compiler during building of the overall REXYGEN control system application.

The REXYGEN system configuration consists of modules (Modules), input/output drivers (Drivers), archive subsystem (Archives) and real-time subsystem, which includes quick computation tasks (see the QTASK function block description for details) and four priority levels (Level0 to Level3) for inserting computation tasks (see the TASK function block description for details).

The base (shortest) period of the application is determined by the tick parameter. This value is checked by the REXYGEN Compiler compiler as its limits vary by selected target platform. Generally speaking, the lower period is used, the higher computational requirements of the REXYGEN system runtime core (RexCore) are.

The periods of individual computation levels (Level0 to Level3) are determined by multiplying the base period tick by the parameters ntick0 to ntick3. Parameters pri0 to pri3 are the logical priorities of corresponding computation levels in the REXYGEN system. The REXYGEN system uses 32 logical priorities, which are internally mapped to the target platform operating system dependent priorities. The highest logical priority of the REXYGEN system is 0, the value 31 means the lowest. Should two tasks with different priorities run at the same time, the lower priority (higher value) task would be interrupted by the higher priority (lower value) task.

The default priorities `pri0` to `pri3` reflect the commonly accepted idea that the "fast" tasks (short sampling period) should have higher priority than the "slow" ones (the so-called *Rate monotonic scheduling*). This means that the default priorities need not to be changed in most cases. Impetuous changes can lead to unpredictable effects!

In devices with multiple CPUs, it is possible to assign different levels to various CPUs. The assignment of CPUs is managed using the parameters `cpu0` to `cpu3`. The CPUs are numbered starting from 0, where -1 denotes the default setting.

Outputs

`Modules`	Output for connecting the REXYGEN system expansion modules, see the MODULE function block description for details	`Long (I32)`
`Drivers`	Output for connecting the REXYGEN system input/output drivers, see the IODRV and TIODRV function block descriptions for details	`Long (I32)`
`Archives`	Output for archives configuration, see the ARC block	`Long (I32)`
`QTask`	Output for connecting quick tasks with the highest priority and the shortest period, see the QTASK block	`Long (I32)`
`Level0`	Computation level for inserting tasks (see the TASK block) with high priority `pri0` and short period determined by the `ntick0` parameter	`Long (I32)`
`Level1`	Computation level for inserting tasks with medium priority `pri1` and medium-length period determined by the `ntick1` parameter	`Long (I32)`
`Level2`	Computation level for inserting tasks with low priority `pri2` and long period determined by the `ntick2` parameter	`Long (I32)`
`Level3`	Computation level for inserting tasks with the lowest priority `pri3` and the longest period determined by the `ntick3` parameter	`Long (I32)`

Parameters

`target`	Target device `Generic target device` ⊙`Generic target device`	`String`
`tick`	The base period (tick) of the REXYGEN system core and also the quick task (QTASK) period (in seconds) ⊙`0.05`	`Double (F64)`
`ntick0`	The multiplication `tick*ntick0` determines the period of tasks connected to `Level0` ↓`1` ⊙`10`	`Long (I32)`
`ntick1`	The multiplication `tick*ntick1` determines the period of tasks connected to `Level1` ↓`ntick0+1` ⊙`50`	`Long (I32)`
`ntick2`	The multiplication `tick*ntick2` determines the period of tasks connected to `Level2` ↓`ntick1+1` ⊙`100`	`Long (I32)`
`ntick3`	The multiplication `tick*ntick3` determines the period of tasks connected to `Level3` ↓`ntick2+1` ⊙`1200`	`Long (I32)`
`pri0`	Priority of all `Level0` tasks ↓`3` ↑`31` ⊙`5`	`Long (I32)`
`pri1`	Priority of all `Level1` tasks ↓`pri0+1` ↑`31` ⊙`9`	`Long (I32)`

`pri2`	Priority of all `Level2` tasks	↓`pri1+1` ↑`31` ⊙`13`	`Long (I32)`
`pri3`	Priority of all `Level3` tasks	↓`pri2+1` ↑`31` ⊙`18`	`Long (I32)`
`cpu0`	Level0 tasks CPU core (-1=default, 0=core 0, 1=core 1, ...)	↓`-1` ↑`127` ⊙`-1`	`Long (I32)`
`cpu1`	Level1 tasks CPU core (-1=default, 0=core 0, 1=core 1, ...)	↓`-1` ↑`127` ⊙`-1`	`Long (I32)`
`cpu2`	Level2 tasks CPU core (-1=default, 0=core 0, 1=core 1, ...)	↓`-1` ↑`127` ⊙`-1`	`Long (I32)`
`cpu3`	Level3 tasks CPU core (-1=default, 0=core 0, 1=core 1, ...)	↓`-1` ↑`127` ⊙`-1`	`Long (I32)`

HMI – Human-Machine Interface Configuration

Block Symbol

Licence: STANDARD

Function Description

The HMI block is a so-called "pseudo-block" which stores additional settings and parameters related to the Human-Machine Interface (HMI) and the contents of the internal web server. The only file where the block can be placed is the main project file with a single EXEC block.

The REXYGEN system currently provides three straightforward methods of how to create Human-Machine Interface:

- **WebWatch** is an auto-generated HMI from the REXYGEN Studio development tool during project compilation. It has similar look, attributes and functions as the online mode of the REXYGEN Studio development tool. The main difference is that **WebWatch** is stored on the target device, is available from the integrated web server and may be viewed with any modern web browser or any application that is compatible with HTML, SVG and JavaScript. The **WebWatch** is a perfect tool for instant creation of HMI that is suitable for system developers or integrators. It provides a graphical interaction with almost all signals in the control algorithm.

- **WebBuDi**, which is an acronym for Web Buttons and Displays, is a simple JavaScript file with several declarative blocks that describe data points which the HMI is connected to and assemble a table in which all the data is presented. It provides a textual interaction with selected signals and is suitable for system developers and integrators or may serve as a fall-back mode HMI for non-standard situations.

- **RexHMI** is a standard SVG file that is edited using REXYGEN HMI Designer. The REXYGEN HMI Designer is a great tool for creating graphical HMI that is suitable for operators and other end users.

The IncludeHMI parameter includes or excludes the HMI files from the final binary form of the project. The HmiDir specifies a path to a directory where the final HMI is located and from where it is inserted into the binary file during project compilation. The path may be absolute or relative to the project. The GenerateWebWatch specifies whether a **WebWatch** HMI should be generated into HmiDir during compilation. The GenerateRexHMI specifies whether a **RexHMI** and **WebBuDi** should be generated into HmiDir during compilation.

The logic of generating and including HMI during project compilation is as follows:

1. Delete all contents from `HmiDir` when `GenerateWebWatch` or `GenerateRexHMI` is specified.

2. Generate RexHMI and WebBuDi from `SourceDir` into `HmiDir` if `GenerateRexHMI` is enabled. All **WebBuDi** source files should be named in a `*.hmi.js` format and all **RexHMI** source files should be named in a `*.hmi.svg` format. The generated files are then named `*.html`.

3. Copy all contents from `SourceDir` except **WebBuDi** or **RexHMI** source files into `HmiDir` if `IncludeHMI` is enabled.

4. Insert HMI from `HmiDir` into binary configuration if `IncludeHMI` is enabled.

The block does not have any inputs or outputs. The `HMI` block itself does not become a part of the final binary configuration, only the files it points to do. Be careful when inserting big files or directories as the integrated web server is not designed for massive data transfers. It is possible to shrink the data by enabling gzip compression. The compression also reduces amount of data transferred to the client, but decompression must be performed by the server when a client does not support gzip compression, which brings additional load on the target device.

For a proper operation of the `HMI` block the compilation must be launched from the REXYGEN Studio development tool and the REXYGEN HMI Designer must be installed.

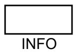
Parameters

`IncludeHMI`	Include HMI files in the project	⊙on	`Bool`
`HmiDir`	Output folder for HMI files	⊙hmi	`String`
`SourceDir`	Source directory	⊙hmisrc	`String`
`GenerateWebWatch`	Generate WebWatch HMI files	⊙on	`Bool`
`GenerateRexHMI`	Generate HMI from SVG and JS files	⊙on	`Bool`
`RedirectToHMI`	Web server will automatically redirect to HMI webpage if enabled otherwise it will serve a standard home page as a starting page.	⊙on	`Bool`
`Compression`	Enables data compression in gzip format.		`Bool`

INFO – Description of Algorithm

Block Symbol

Licence: STANDARD



Function Description

The INFO block is a so-called "pseudo-block" which stores textual information about a real-time executive. The only file where the block can be placed is a main project file with a single EXEC block an so it belongs to the EXEC category. The block does not have any inputs or outputs. The information specified with this block becomes a part of the final configuration, is stored on the target device and may be seen on different diagnostics screens but does not have any impact on execution of the control algorithm or target's behavior.

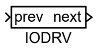
Parameters

`Title`	Project title	`String`
`Author`	Project author	`String`
`Description`	Brief description of the project	`String`
`Customer`	Information about a customer	`String`

IODRV – The REXYGEN system input/output driver

Block Symbol

Licence: STANDARD



Function Description

The input/output drivers of the REXYGEN system are implemented as extension modules (see the MODULE block). A module can contain several drivers, which are added to the REXYGEN system configuration by using the IODRV blocks. The prev input of the block must be connected with the Drivers output of the EXEC block or with the next output of a IODRV block which is already included in the configuration. There can be only one driver connected to the next output of the IODRV block. The next output of the last driver in the configuration remains unconnected. This means that the drivers create a unidirectional chain which defines the order of initialization and execution of the individual drivers.

Each driver of the REXYGEN system is identified by its name, which is defined by the classname parameter (beware, the name is case-sensitive!). If the name of the driver differs from the name of the module containing the given driver, the module name must be specified by the module parameter, it is left blank otherwise. Details about these two parameters can be found in the documentation of the corresponding REXYGEN system driver.

The majority of drivers stores its own configuration data in files with .rio extension (REXYGEN Input/Output), whose name is specified by the cfgname parameter. The .rio files are created in the same directory where the project main file is located (.mdl file with the EXEC block). Driver is configured (e.g. names of the input/output signals, connection to physical inputs/outputs, parameters of communication with the input/output device, etc.) in an embedded editor provided by the driver itself. The editor is opened when the Configure button is pressed in the parameter dialog of the IODRV block in the REXYGEN Studio program of the REXYGEN control system. In Matlab/Simulink the editor is opened upon ticking the "Tick this checkbox to call IOdrv EDIT dialog" checkbox.

The remaining parameters are useful only when the driver implements its own computational task (see the corresponding driver documentation). The factor parameter defines the driver's task execution period by multiplying the EXEC block's tick parameter factor times (factor*tick). The stack parameter defines the stack size in bytes. It is recommended to keep the default setting unless stated otherwise in the driver documentation. The parameter pri defines the logical priority of the driver's task. Inappropriate priority can influence the overall performance of the control system critically so it is highly recommended to check the driver documentation and the load of the control system (drivers, levels and tasks) in the Diagnostics section of the REXYGEN Studio program. The cpu parameter can be used to specify where the driver thread should run on multi-CPU devices.

Input

`prev`	Input for connecting the driver with the `Drivers` output of the `EXEC` block or with the `next` output of the preceding driver	`Long (I32)`

Output

`next`	Output for connecting to the `prev` input of the succeeding driver	`Long (I32)`

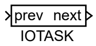
Parameters

`module`	Name of the module, which includes the input/output driver (mandatory only if module name differs from `classname`)		`String`
`classname`	I/O driver class name; case sensitive!	⊙`DrvClass`	`String`
`cfgname`	Name of the driver configuration file	⊙`iodrv.rio`	`String`
`factor`	Multiple of the `EXEC` block's `tick` parameter defining the driver's task execution period	↓1 ⊙10	`Long (I32)`
`stack`	Stack size of the driver's task in bytes	↓1024 ⊙10240	`Long (I32)`
`pri`	Logical priority of the driver's task	↓1 ↑31 ⊙3	`Long (I32)`
`cpu`	CPU core assigned to driver thread (-1=default, 0=core 0, 1=core 1, ...)	↓-1 ↑127 ⊙-1	`Long (I32)`

IOTASK – Driver-triggered task of the REXYGEN system

Block Symbol

Licence: STANDARD



Function Description

Standard tasks of the REXYGEN system are integrated into the configuration using the TASK or QTASK blocks. Such tasks are executed by the system timer, whose **tick** is configured by the EXEC block.

But the system timer can be unsuitable in some cases, e.g. when the shortest execution period is too long or when the task should be executed by an external event (input signal interrupt) etc. In such a case the IOTASK can be executed directly by the I/O driver configured by the TIODRV block. The user manual of the given driver provides more details about the possibility and conditions of using the above mentioned approach.

Input

prev	Input for connecting the first task to the **Tasks** output of the TIODRV block or for connecting to the previous task's **next** output	Long (I32)

Output

next	Output for sequencing the tasks by connecting to the **prev** input of the following task	Long (I32)

Parameters

factor	Execution factor which can be used to determine the task execution period, see the user guide of the corresponding I/O driver ⊙1	Long (I32)
stack	Stack size [bytes] ⊙10240	Long (I32)
filename	Name of the file with the .mdl extension which contains the task algorithm; in the case **filename** is not specified, the filename is given by the name of the IOTASK block in the project main file (the .mdl extension is attached automatically)	String

LPBRK – **Loop break**

Block Symbol

Licence: STANDARD

Function Description

The LPBRK block is an auxiliary block often used in the control schemes consisting of the REXYGEN system function blocks. The block is usually placed in all feedback loops in the scheme. Its behavior differs in the REXYGEN system and the Simulink system.

The LPBRK block creates a one-sample delay in the Simulink system. If there exists a feedback loop without the LPBRK block, the Simulink system detects an algebraic loop and issues a warning (Matlab version 6.1 and above). The simulation fails after some time.

The REXYGEN Compiler omits the LPBRK block, the only effect of this block is the breaking of the feedback loop at the block's position. If there exists a loop without the LPBRK block, the REXYGEN Compiler compiler issues a warning and breaks the loop at an automatically determined position. It is recommended to use the LPBRK block in all loops to achieve the maximum compatibility between the REXYGEN system and the Simulink system.

Note: Behavior of the LPBRK block has been changed since the version 3.0. The block is not removed by the REXYGEN Compiler but is present in the algorithm and clears the quality flag of the y output. This change is useful and necessary due to the quality propagation in function blocks. Original behaviour (e.g. the block is removed from the algorithm) can be forced by the RB = on parameter. The main function of the block (indication of the feedback signal) remains unchanged in all cases.

Input

u	Input signal	Double (F64)

Output

y	Output signal	Double (F64)

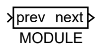
Parameters

RB	Removing block flag	Bool

MODULE – Extension module of the REXYGEN system

Block Symbol

Licence: STANDARD



Function Description

The REXYGEN system has an open architecture thus its functionality can be extended. Such extension is provided by modules. Each module is identified by its name placed below the block symbol. The individual modules are added to the project main file by connecting the **prev** input with the **Modules** output of the EXEC block or with the **next** output of a **MODULE** which is already included in the project. There can be only one module connected to the **next** output of the **MODULE** block. The **next** output of the last module in the project remains unconnected. This means that the modules create a unidirectional chain which defines the order of initialization of individual modules.

Input

prev	Input for connecting the module with the Modules output of the EXEC block or with the next output of the preceding module	Long (I32)

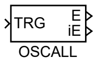
Output

next	Output for connecting to the prev input of the succeeding module	Long (I32)

OSCALL – Operating system calls

Block Symbol

Licence: STANDARD



Function Description

The OSCALL block is intended for executing operating system functions from within the REXYGEN system. The chosen action is performed upon a rising edge (off→on) at the TRG input. However, not all actions are supported on individual platforms. The result of the operation and the possible error code are displayed by the E and iE outputs.

Note that there is also the EPC block available, which allows execution of external programs.

Input

TRG	Trigger of the selected action	Bool

Outputs

E	Error flag	Bool
iE	Error code i ..... REXYGEN general error	Long (I32)

Parameter

action	System function to perform 1 ..... Reboot system 2 ..... System shutdown 3 ..... System halt 4 ..... Flush disc caches 5 ..... Lock system partition 6 ..... Unlock system partition 7 ..... Disable internal webserver 8 ..... Enable internal webserver	⊙1	Long (I32)

PROJECT – Additional Project Settings

Block Symbol

Licence: STANDARD

Function Description

The PROJECT block is a so-called "pseudo-block" which stores additional settings and parameters related to a project and a real-time executive. The only file where the block can be placed is a main project file with a single EXEC block an so it belongs to the EXEC category.

The block does not have any inputs or outputs. The block does not become a part of the final binary configuration.

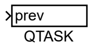
Parameters

CompileParams	Command-line options that are passed to REXYGEN Compiler during project compilation. To display the documentation for the available parameters, run REXYGEN Compiler from the command line with the parameter -?: RexComp -?.	String
SourcesOnTarget	Store source files on target device ⊙on	Bool
TargetURL	URL address of a target on which the configuration should be run. The address is inserted into all connection dialogs automatically.	String
LibraryPath	Path to libraries referenced in the project. Can be absolute or relative to project folder.	String

QTASK – Quick task of the REXYGEN system

Block Symbol

Licence: STANDARD



Function Description

The QTASK block is used for including the so-called quick task with high priority into the executive of the REXYGEN system. This task is used where the fastest processing of the input signals is necessary, e.g. digital filtering of input signals corrupted with noise or immediate processing of switches connected via digital inputs. The quick task is added into the configuration by connecting the prev input with the EXEC block's QTask output. The quick task is initialized before the initialization of the Level0 computation level (see the TASK block).

There can be only one QTASK block in the REXYGEN control system. It runs with the logical priority no. 2. The algorithm of the quick task is configured the same way as the standard TASK, it is a separate .mdl file.

The execution period of the task is given by a multiple of the factor parameter and the tick of the EXEC block. The task is executed with the shortest period of tick seconds for factor=1. In that case the system load is the highest. Under all circumstances the QTASK must be executed within tick seconds, otherwise a real-time executive fatal error occurs and no other tasks are executed. Therefore the QTASK block must be used with consideration. The block's execution time is shown in the Diagnostics section of the REXYGEN Studio program.

Input

prev	Input for connecting the task with the QTask output of the EXEC block	Long (I32)

Parameters

factor	Multiple of the EXEC block's tick parameter defining the quick task execution period ⊙1	Long (I32)
stack	Stack size [bytes] ⊙10240	Long (I32)
filename	Name of the file with the .mdl extension which contains the quick task algorithm; in the case filename is not specified, the filename is given by the name of the QTASK block in the project main file (the .mdl extension is attached automatically)	String

SLEEP – Timing in Simulink

Block Symbol

Licence: STANDARD

Function Description

The Matlab/Simulink system works natively in simulation time, which can run faster or slower than real time, depending on the complexity of the algorithm and the computing power available. Therefore the `SLEEP` block must be used when accurate timing and execution of the algorithm in the Matlab/Simulink system is required. In the REXYGEN system, timing and execution is provided by system resources (see the `EXEC` block) and the `SLEEP` block is ignored.

In order to perform real-time simulation of the algorithm, the `SLEEP` block must be included. It guarantees that the algorithm is executed with the period given by the `ts` parameter unless the execution time is longer than the requested period.

The `SLEEP` block is implemented for Matlab/Simulink running in Microsoft Windows operating system. It is recommended to use periods of 100 ms and above. For the proper functionality the 'Solver type' must be set to `fixed-step` and `discrete (no continuous states)` in the 'Solver' tab of the 'Simulation parameters' dialog. Further the `Fixed step size` parameter must be equal to the `ts` parameter of the `SLEEP` block. There should be at most one `SLEEP` block in the whole simulation scheme (including all subsystems).

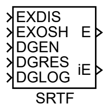
Parameter

`ts`	Simulation scheme execution period (in seconds)	⊙0.1	`Double (F64)`

SRTF – Set run-time flags

Block Symbol

Licence: ADVANCED



Function Description

The SRTF block (Set Run-Time Flags) can be used to influence the execution of tasks , subsystems (sequences) and blocks of the REXYGEN system. This block is not meant for use in Matlab-Simulink. When describing this block, the term object refers to a REXYGEN system object running in real-time, i.e. input/output driver, one of the tasks, subsystem or a simple function block of the REXYGEN system.

All the operations described below affect the object, whose full path is given by the bname parameter. Should the parameter be left blank (empty string), the operation applies to the nearest owner of the SRTF object, i.e. the subsystem in which the block is directly included or the task containing the block.

The run-time flags allow the following operations:

- **Disable execution** of the object by setting the EXDIS input to on. The execution can be enabled again by using the input signal EXDIS = off. The EXDIS input sets the same run-time flag as the Halt/Run button in the upper right corner of the Workspace tab in the Diagnostics of the REXYGEN Studio program.

- **One-shot execution** of the object. If the object execution is disabled by the EXDIS = on input or by the Diagnostics section of the REXYGEN Studio program, it is possible to trigger one-shot execution by EXOSH = on.

- **Enable diagnostics** for the given object by DGEN = on. The result is equivalent to ticking the Enable checkbox in the Diagnostics section of the corresponding tab (I/O Driver, Level, Quick Task, Task, I/O Task, Sequence) of the REXYGEN Studio program.

- **Reset diagnostic data** of the given object by DGRES = on. The same flag can be set by the Reset button in the Diagnostics section of the corresponding tab in the REXYGEN Studio program. The flag is automatically set back to 0 when the data reset is performed.

The following table shows the flags available for various objects in the REXYGEN system.

Object type	EXDIS	EXOSH	DGEN	DGRES
I/O Driver	√	√	√	√
Level	√	×	√	√
Task	√	√	√	√
Quick Task	√	√	√	√
I/O Task	√	√	√	√
Sequence, subsystem	√	×	√	√
Block	√	×	×	×

Inputs

EXDIS	Disable execution	Bool
EXOSH	One-shot execution	Bool
DGEN	Enable diagnostics	Bool
DGRES	Reset diagnostic data	Bool
DLOG	Enable more verbose logging	Bool

Outputs

E — Error flag — Bool
- off . . . No error
- on . . . . An error occurred

iE — Error code (for E = on) — Long (I32)
- 0 . . . . . No error
- 1 . . . . . The object specified by the bname parameter was not found
- 2 . . . . . REXYGEN system internal error (invalid pointers)
- 3 . . . . . Flag could not be set (timeout)

Parameter

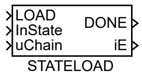
bname — Full path to the block/object. Case sensitive. Individual layers are separated by dots, the object names excluding tasks (TASK, QTASK) start with the following special characters: — String
- ^ . . . . . Computational level, e.g. ^0 for Level0
- & . . . . . Input/Output Driver, e.g. &WcnDrv

Name of the task triggered by input/output driver (IOTASK) has the form &<driver_name>.<task_name>.

STATELOAD – Load multiple block states and parameters

Block Symbol

Licence: ADVANCED



Function Description

The STATELOAD block reloads values of state and parameters from a file or string. The file is specified by the filename parameter and must be in JSON format, usually stored by the STATESAVE block. It is also possible to read data from the InState input, which is a JSON string in the same format as the input file. The InState input is used if the filename parameter is empty.

All values configured by the parameters blocks, depth, and mask that are stored in the file are loaded. If the parameter Strict is set to on, the block checks if the configured blocks and values match those stored in the file, and the file is refused if there is a mismatch.

Inputs

LOAD	Trigger to load the state	Bool
InState	JSON string to load if the filename parameter is empty	String
uChain	This input is not used by the block but is useful for placing the block in the correct execution order	Long (I32)

Parameters

filename	Filename from which to load	String
blocks	List of blocks to load. The block name must be a relative connection string (e.g. beginning with a dot) and they are separated by semicolons. All blocks (in the current subsystem) are loaded if this parameter is empty	String
depth	If the loading block is a subsystem, this parameter specifies how many levels are also loaded. 0 = current level only, 1 = current level and blocks directly in the current level subsystems, etc. ↓0 ↑65535	Long (I32)

`mask`	Select which objects are loaded. Each bit of the number signifies: • 1 ... inputs • 2 ... outputs • 4 ... parameters • 8 ... internal states • 16 ... array parameters • 32 ... array states • 64 ... cyclic (trend) buffers • 256 ... metadata (STATESAVE only) ↓0 ↑65535 ⊙65535	`Long (I32)`
`LoadOnInit`	The file is loaded during the configuration initialization ⊙on	`Bool`
`STRICT`	If set, the file is checked against the current configuration and data are refused if there is a mismatch ⊙on	`Bool`

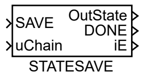
Outputs

`DONE`	State has been loaded	`Bool`
`iE`	Error code if block execution fails	`Error`

STATESAVE – Save multiple block states and parameters

Block Symbol

Licence: ADVANCED



Function Description

The STATESAVE block stores the values of states and parameters in a file. The file is specified by the filename parameter and is in JSON format, which can usually be reloaded by the STATELOAD block. It is also possible to store data in the OutState output, which is a JSON string in the same format as the file output. The OutState output is used if the filename parameter is empty.

All values configured by the parameters blocks, depth, and mask are stored.

Inputs

SAVE	Trigger to save the state	Bool
uChain	This input is not used by the block but is useful for placing the block in the correct execution order.	Long (I32)

Parameters

filename	Filename where to store	String
blocks	List of blocks to store. Block names must be relative connection strings (e.g., begin with a dot) and are separated by semicolons. All blocks (within the current subsystem) are stored if the parameter is empty.	String
depth	If the saved block is a subsystem, this parameter specifies the number of levels to save. 0 = current level only, 1 = current level and blocks directly in the current level subsystems, etc. ↓0 ↑65535	Long (I32)

`mask`	Select which objects are saved. Each bit of the number represents: • 1 ... inputs • 2 ... outputs • 4 ... parameters • 8 ... internal states • 16 ... array parameters • 32 ... array states • 64 ... cyclic (trend) buffers • 256 ... metadata (STATESAVE only) ↓0 ↑65535 ⊙65535	`Long (I32)`
`SaveOnExit`	If set, the file is stored when the entire configuration is terminated. ⊙on	`Bool`

Outputs

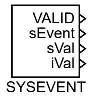
`OutState`	JSON string where values are stored (only if the `filename` parameter is empty)	`String`
`DONE`	Indicates whether the state has been saved	`Bool`
`iE`	Error code if block execution fails	`Error`

"

SYSEVENT – * Read system log

Block Symbol

Licence: STANDARD



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Parameters

arc	Archive to read (0=system log)	↓0 ↑16	Long (I32)
filter	String that item must contain		String
idfrom	Minimum item ID to show	↓0 ↑65535	Long (I32)
idto	Maximum item ID to show	↓0 ↑65535 ⊙65655	Long (I32)
lvlfrom	Minimum item level to show	↓0 ↑255	Long (I32)
lvlto	Maximum item level to show	↓0 ↑255 ⊙255	Long (I32)

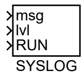
Outputs

VALID	Output data are valid (actual)	Bool
sEvent	Whole archive item in JSOM	String
sVal	Archive item value (string)	String
iVal	Archive item value (integer)	Long (I32)

SYSLOG – Write system log

Block Symbol

Licence: STANDARD



Function Description

The SYSLOG block is intended for writing any messages to the REXYGEN system log. It can be used for basic logging of user events. To write, it is necessary to have messages of the given level enabled in the System Logs Configuration (Target -> System Logs Configuration -> Function block messages).

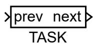
Inputs

msg	The message you want to save to the log (max. 512 znaků)	String
lvl	Level of logged message: 0 ..... Error 1 ..... Warning 2 ..... Info 3 ..... Verbose	Long (I32)
RUN	Writing enable. Writing to the log continues as long as the RUN input is ON	Bool

TASK – Standard task of the REXYGEN system

Block Symbol

Licence: STANDARD



Function Description

The overall control algorithm of the REXYGEN system consists of individual tasks. These are included by using the TASK block. There can be one or more tasks in the control algorithm. The REXYGEN system contains four main computational levels represented by the Level0 to Level3 outputs of the EXEC block. The individual tasks are added to the given computational level <i> by connecting the prev input with the corresponding Level<i> output or with the next output of a TASK, which is already included in the given level <i>. There can be only one task connected to the next output of the TASK block. The next output of the last task in the given level remains unconnected. This means that the tasks in one level create a unidirectional chain which defines the order of initialization and execution of the individual tasks of the given level in the REXYGEN system. The individual levels are ordered from Level0 to Level3 (the QTASK block precedes Level0).

All tasks at the given level <i> are executed with the same priority, which is determined by the pri<i> parameter of the EXEC block. The execution period of the task is calculated as a multiple of the factor parameter and the base tick of the ntick<i>*tick in the EXEC block.

The time allocated for task execution starts at the start tick and ends at the stop tick. The start and stop values can be fixed or left to be controlled by the RexCore. For RexCore control, the parameters can be filled in as follows:

- start = -1: The execution begins as soon as the previous Task ends.
- start = -2: The execution starts on the next tick after the completion of the previous task.
- stop = -1: The task execution must finish before the end of ntick<i>*tick.
- stop = -2: The task execution must finish in the next tick.

For fixed execution times, start and stop should be a non-negative integer.

The REXYGEN Compiler compiler additionally verifies that the stop parameter of the preceding task is less than or equal to the stop parameter of the succeeding task. This ensures that the allocated time intervals for individual tasks do not overlap. If the timing of individual levels is inappropriate, tasks may be interrupted by tasks and other events with higher priority. In such cases, execution is not aborted but delayed (in contrast to the QTASK block). The Diagnostics section of the REXYGEN Studio program assesses whether the execution delay is occasional or permanent (the Level and Task tabs).

Input

`prev`	Input for connecting the task with the corresponding `Level<i>` output of the `EXEC` block or with the `next` output of the preceding task of the given level	`Long (I32)`

Output

`next`	Output for connecting to the `prev` input of the succeeding task in the given level	`Long (I32)`

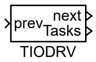
Parameters

`factor`	Execution factor; multiple of the execution period of the `i`-th level of the `EXEC` block defining the execution period of the task: `factor` ∗ `tick` ∗ `ntick<i>` ⊙1	`Long (I32)`
`start`	Number of tick of the given computational level which should trigger the task execution ↓0 ↑`ntick<i>` ⊙0	`Long (I32)`
`stop`	Number of tick of the given computational level by which the task execution should finish ↓`start+1` ↑`ntick<i>` ⊙1	`Long (I32)`
`stack`	Stack size [bytes] ⊙10240	`Long (I32)`
`filename`	Name of the file with the `.mdl` extension which contains the task algorithm. In the case `filename` is not specified, the filename is given by the name of the `TASK` block in the project main file (the `.mdl` extension is attached automatically)	`String`

TIODRV – The REXYGEN system input/output driver with tasks

Block Symbol

Licence: STANDARD



Function Description

The TIODRV block is used for configuration of special drivers of the REXYGEN system which are able to execute tasks defined by the IOTASK blocks. See the corresponding driver documentation.

The **prev** input of the IOTASK block must be connected with the **Tasks** output of the TIODRV block. If the driver allows so, the **next** output of a TIODRV block which is already included in the configuration can be used to add more tasks. The **next** output of the last task remains unconnected. On the contrary to standard tasks, the number and order of the driver's tasks are not checked by the REXYGEN Compiler compiler but by the input-output driver itself.

If the driver cannot guarantee periodic execution of some task (e.g. task is triggered by an external event), a corresponding flag is set for the given task. Such a task cannot contain blocks which require constant sampling period (e.g. the majority of controllers). If some of these restricted blocks are used, the executive issues a task execution error, which can be traced using the Diagnostics section of the REXYGEN Studio program. The **cpu** parameter can be used to specify where the driver thread should run on multi-CPU devices.

Input

prev	Input for connecting the driver with the **Drivers** output of the EXEC block or with the **next** output of the preceding driver	Long (I32)

Outputs

next	Output for connecting to the **prev** input of the succeeding driver	Long (I32)
Tasks	The IOTASK blocks executed by the driver are connected to this output using the **prev** input	Long (I32)

Parameters

module	Name of the module, which includes the input/output driver (mandatory only if module name differs from **classname**)		String
classname	Name of the driver class; case sensitive!	⊙DrvClass	String

`cfgname`	Name of the driver configuration file ⊙`iodrv.rio`	`String`
`factor`	Multiple of the `EXEC` block's `tick` parameter defining the driver's task execution period ↓`1` ⊙`10`	`Long (I32)`
`stack`	Stack size of the driver's task in bytes ↓`1024` ⊙`10240`	`Long (I32)`
`pri`	Logical priority of the driver's task ↓`1` ↑`31` ⊙`3`	`Long (I32)`
`cpu`	CPU core assigned to driver thread (-1=default, 0=core 0, 1=core 1, ...) ↓`-1` ↑`127` ⊙`-1`	`Long (I32)`

WWW – Internal Web Server Content

Block Symbol

Licence: STANDARD

Function Description

The WWW block is a so-called "pseudo-block" which stores additional information about a contents of an internal web server. The only file where the block can be placed is a main project file with a single EXEC block an so it belongs to the EXEC category.

The block does not have any inputs or outputs. The block itself does not become a part of a final binary configuration but the data it points to does. Be careful when inserting big files or directories as the integrated web server is not optimized for a large data. It is possible to shrink the data by enabling gzip compression. The compression also reduces amount of data transferred to the client, but decompression must be performed on the server side when a client does not support gzip compression which brings additional load on the target device.

Parameters

Source	Specifies a source directory or a file name that should be placed on the target and should be available via integrated web server using standard HTTP and/or HTTPS protocol. The path may be absolute or relative to path of a main project file.	String
Target	Specifies a target directory or a file name on the integrated web server.	String
Compression	Enables data compression in gzip format.	Bool

Chapter 3

INOUT – Input and output blocks

Contents

The INOUT library serves as a crucial interface in the REXYGEN system, enabling smooth interaction with input/output drivers. It is designed for efficient simultaneous signal processing, essential for fast control tasks. This library simplifies the connection between control algorithms and hardware, ensuring minimal latency. Additionally, it provides advanced features, such as virtual linking (flags) of signals for increased clarity of diagrams and flexibility of subsystems.

`Display` – **Numeric display of input values**

Block Symbol

Licence: STANDARD

Function Description

The `DISPLAY` block shows input value in a selected format. A suffix may be appended to the value. An actual value is shown immediately in REXYGEN Studio even without turning on *Watch* mode for the block, and the same in *WebWatch*. Actual conversion of input into its textual representation is performed on the target device in each `Decimation` period so the value displayed may be also read via the *REST* interface or used in visualization.

Input

`u`	Input signal	`Any`

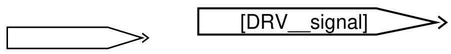
Parameters

`Format`	Format of displayed value	⊙1	`Long (I32)`
	`Best fit` same as long, but for extremely small or big numbers same as long_e; this is default format for real numbers `short` fixed point, no more than 3 places after the decimal point; default format is used for not-real numbers `long` .. fixed point, full precision (up to 16 digits); default format for is used not-real numbers `short_e` exponencial (scientific) format, no more than 3 places after the decimal point; default format is used for not-real numbers `long_e` , exponencial (scientific) format, full precision (up to 16 digits); default format is used for not-real numbers `bank` .. fixed point, 2 places after the decimal point; default format is used for not-real numbers `dec` ... integer number in decimal format (standard number); this is default format for integer numbers `hex` ... integer number in hexadecimal format (used by programmers); default format is used for not-integer numbers `bin` ... integer number in binary format (used by programmers); default format is used for not-integer numbers `oct` ... integer number in octal format (used by programmers); default format is used for not-integer numbers		
`Decimation`	Value is evaluated in each `Decimation` period	↓1 ↑100000 ⊙1	`Long (I32)`
`Suffix`	A string to be appended to the value		`String`

From, INSTD – Signal connection or input

Block Symbols

Licence: STANDARD



Function Description

The two blocks From (signal connection) and INSTD (standard input) share the same symbol. They are used for referring to another signal, either internal or external.

In the function block library, you can only find the From block. It is converted to the INSTD block at compile time if necessary. The following rules define how the REXYGEN Compiler compiler distinguishes between the two block types:

- If the parameter GotoTag contains the __ delimiter (two successive '_' characters), then the block is of the INSTD type. The part (substring) of the parameter before the delimiter (DRV in the block symbol above) is considered to be the name of an IODRV type block contained in the main file of the project. The REXYGEN Compiler compiler returns an error when such block does not exist. If the driver exists in the project, the other part of the GotoTag parameter (following the delimiter, signal in this case) is considered to be the name of a signal within the corresponding driver. This name is validated by the driver and in the case of success, an instance of the INSTD block is created. This instance collects real-time data from the driver and feeds the data into the control algorithm at each execution of the task it is included in.

- If there is no __ delimiter in the GotoTag parameter, the block is of type From. A matching Goto block with the same GotoTag parameter and required visibility given by the TagVisibility parameter (see the Goto block description) is searched. In case it is not found, the REXYGEN Compiler compiler issues a warning and deletes the From block. Otherwise an "invisible" connection is created between the corresponding blocks. The From block is removed also in this case and thus it is not contained in the resulting control system configuration.

In the case of INSTD block, the GotoTag parameter includes the symbol of the driver <DRV> and the name of the signal <signal> of the given driver:

```
<DRV>__<signal>
```

E.g. the first digital input of a Modbus I/O device might be referenced by MBM__DI1. Detailed information about signal naming can be found in the user manual of the corresponding I/O driver.

Since version 2.50.5 it is possible to use placeholders in names of I/O driver signals. This is useful inside subsystems where this placeholder is replaced by the value of subsystem parameter. E.g. the flag MBM__DI<id> will refer to digital input 1, 2, 3 etc. depending on the parameter id of the subsystem the block is contained in. See the SubSystem function block for information on defining subsystem parameters.

Output

value	Signal coming from I/O driver or Goto block. The type of output is determined by the type of the signal which is being referred by the GotoTag parameter.	Any

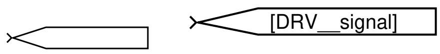
Parameter

GotoTag	Reference to a Goto block with the same GotoTag parameter, which should be connected with the From block or a reference to input signal of the REXYGEN I/O driver, which should provide data through the block's output.	String

Goto, OUTSTD – Signal source or output

Block Symbols

Licence: STANDARD



Function Description

The two blocks Goto (signal source) and OUTSTD (standard output) share the same symbol. They are used for providing signals, either internal or external.

In the function block library, you can only find the Goto block. It is converted to the OUTSTD block at compile time if necessary. The following rules define how the REXYGEN Compiler compiler distinguishes between the two block types:

- If the parameter GotoTag contains the __ delimiter (two successive '_' characters), then the block is of the OUTSTD type. The part (substring) of the parameter before the delimiter (DRV in the block symbol above) is considered to be the name of an IODRV type block contained in the main file of the project. The REXYGEN Compiler compiler returns an error when such block does not exist. If the driver exists in the project, the other part of the GotoTag parameter (following the delimiter, signal in this case) is considered to be the name of a signal within the appropriate driver. This name is validated by the driver and in the case of success, an instance of the OUTSTD block is created. This instance collects real-time data from the driver and feeds the data into the control algorithm at each execution of the task it is included in.

- If there is no __ delimiter in the GotoTag parameter, the block is of type Goto. A matching From block with the same GotoTag parameter for which the Goto block is visible is searched. In case it is not found, the REXYGEN Compiler compiler issues a warning and deletes the Goto block. Otherwise an "invisible" connection is created between the corresponding blocks. The Goto block is removed also in this case thus it is not contained in the resulting control system configuration.

The other parameter of the Goto block defines the visibility of the block within the given .mdl file. The TagVisibility parameter can be local, global or scoped, whose meaning is explained in the table below. This parameter is ignored if the block is compiled as the OUTSTD block.

In the case of OUTSTD block, the GotoTag parameter includes the symbol of the driver <DRV> and the name of the signal <signal> of the given driver:

```
<DRV>__<signal>
```

E.g. the first digital output of a Modbus I/O device might be referenced by MBM__DO1. Detailed information about signal naming can be found in the user manual of the corresponding I/O driver.

Since version 2.50.5 it is possible to use placeholders in names of I/O driver signals. This is useful inside subsystems where this placeholder is replaced by the value of subsystem parameter. E.g. the flag MBM__DO<id> will refer to digital output 1, 2, 3 etc. depending on the parameter id of the subsystem the block is contained in. See the SubSystem function block for information on defining subsystem parameters.

Input

value	Signal going to I/O driver or From block. In case of connection to an I/O driver, the type of input is determined by the I/O driver from the GotoTag parameter.	Any

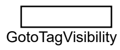
Parameters

GotoTag	Reference to a From block with the same GotoTag parameter, which should be connected with the Goto block or a reference to output signal of the REXYGEN control system driver, which should send the data from block input to the process.	String
TagVisibility	Visibility (availability) of the block within the .mdl file. Defines conditions under which the two corresponding Goto and From blocks are reciprocally available: ⊙local local — the two blocks must be in the same subsystem global — blocks can be anywhere in the given task (.mdl file) scoped — the From block must be placed in the same subsystem or in any lower hierarchical level below the GotoTagVisibility block with the same GotoTag parameter	String

GotoTagVisibility – Visibility of the signal source

Block Symbol

Licence: STANDARD



Function Description

The GotoTagVisibility blocks specify the visibility of the Goto blocks with scoped visibility. The symbol (tag) defined in the Goto block by the GotoTag parameter is available for all From blocks in the subsystem which contains the appropriate GotoTagVisibility block and also in all subsystems below in the hierarchy.

The GotoTagVisibility block is required only for Goto blocks whose TagVisibility parameter is set to scoped. There is no need for the GotoTagVisibility block for local or global visibility.

The GotoTagVisibility block is used only during project compilation by the REXYGEN Compiler compiler. It is not included in the binary configuration file for real-time execution.

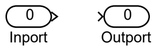
Parameter

GotoTag	Reference to a Goto block with the GotoTag parameter, whose visibility is defined by the position of this block (GotoTagVisibility)	String

`Inport`, `Outport` – Input and output port

Block Symbols

Licence: STANDARD



Function Description

The `Inport` and `Outport` blocks are used for connecting signals over individual hierarchical levels. There are two possible ways to use these blocks in the REXYGEN system:

1. To connect inputs and outputs of the subsystem. The blocks create an interface between the symbol of the subsystem and its inner algorithm (sequence of blocks contained in the subsystem). The `Inport` or `Outport` blocks are located inside the subsystem, the name of the given port is displayed in the subsystem symbol in the upper hierarchy level.

2. To provide connection between various tasks. The port blocks are located in the highest hierarchy level of the given task (`.mdl` file) in this case. The corresponding `Inport` and `Outport` blocks should have the same `Block name`. The connection between blocks in various tasks is checked and created by the REXYGEN Compiler compiler.

The ordering of the blocks to be connected is based on the `Port` parameter of the given block. The numberings of the input and output ports are independent on each other. The numbering is automatic in REXYGEN Studioand it starts at 1. The numbers of ports must be unique in the given hierarchy level, in case of manual modification of the port number the other ports are re-numbered automatically. Be aware that after re-numbering in an already connected subsystem the inputs (or outputs) in the upper hierarchy level are re-ordered, which results in probably unintended change in signal mapping!

In the blocks ‘Inport‘ and ‘Outport‘, it is also possible to explicitly specify the data type of the transmitted value using the ‘OutDataTypeStr‘ parameter. If no value is selected (the option ‘Inherit: auto‘ is chosen), the value type is determined automatically.

The ‘Description‘ parameter allows you to add a textual description of the block. This description is displayed in the properties of the subsystem and library block if the ‘Inport‘ or ‘Outport‘ is used to define the inputs and outputs of the subsystem.

Warning: The blocks `Inport` and `Outport` should not be use to connect arrays and other references between tasks (references often have **`ref`** in name and have a type **`intptr`** in the `Diagnostics` section of the REXYGEN Studio program). Consistence is not guaranteed in this case; incorrect value could be get and runtime code can crash in worst case scenario. Typical behaviour is that some array members are from one period of execution and other members of array from next period. The blocks SETPA and

GETPA ensure consistent read and write of the array between task. Some blocks guarantee consistence of references over task boundary (for example RM_AxisSpline). In this case, this is explicitly stated in the block manual.

Input

value	Value going to the output pin or Inport	Any

Output

value	Value coming from the input pin or Outport	Any

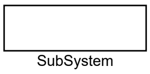
Parameters

Port	Ordering of the Inport or Outport pins	Long (I32)
OutDataTypeStr	Data type of item Inherit: auto double single uint8 int16 uint16 int32 uint32 boolean float int64 string array	String
Description	Description of the port	String

SubSystem – Subsystem block

Block Symbol

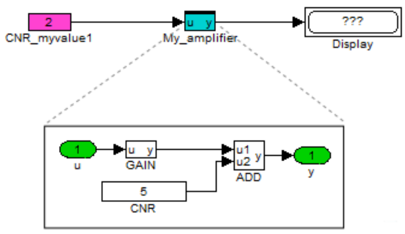
Licence: STANDARD



Function Description

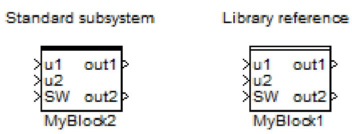
The SubSystem block is a cornerstone of hierarchical organization of block diagrams in REXYGEN. A subsystem is a container for a group of function blocks and their connections, which then appear as a single block. Nesting of subsystems is allowed, i.e. a subsystem can include additional subsystems.

The runtime core or REXYGEN executes the subsystem as an ordered sequence of blocks. Therefore the subsystem is sometimes referred to as sequence. All blocks from the surroundings of the subsystem are executed strictly before or strictly after the whole subsystem is executed.



Subsystems are also used for creating user-defined reusable components, which are then placed in user libraries.

A library reference can be distinguished from a standard subsystem by the style of the upper border.



Please refer to [2] for details on using subsystems and creating reusable components in REXYGEN.

Also see examples 0101-02 and 0101-03 demonstrating the use of subsystems. The examples are included in REXYGEN Studio.

Inputs

The ordering and names of the inputs are given by the numbers and names of the Inport blocks contained within the subsystem. See REXYGEN Studio manual [2] for details.

Outputs

The ordering and names of the outputs are given by the numbers and names of the Outport blocks contained within the subsystem. See REXYGEN Studio manual [2] for details.

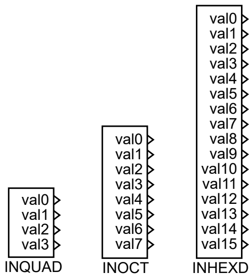
Parameters

The parameters of the subsystem are defined by the so-called subsystem mask. See REXYGEN Studio manual [2] for details.

`INQUAD`, `INOCT`, `INHEXD` – Multi-input blocks

Block Symbols

Licence: STANDARD



Function Description

The REXYGEN system allows not only reading of a single input signal but also simultaneous reading of multiple signals through just one block (for example all signals from one module or plug-in board). The blocks `INQUAD`, `INOCT` and `INHEXD` are designed for these purposes. They differ only in the maximum number of signals (4, 8 and 16, respectively).

The name of the block instance includes the symbol of the driver `<DRV>` and the name of the signal `<signal>` of the given driver:

```
<DRV>__<signal>
```

It is created the same way as the `GotoTag` parameter of the `INSTD` and `OUTSTD` blocks. E.g. the digital inputs of a Modbus I/O device might be referenced by `MBM__DI`. Detailed information about signal naming can be found in the user manual of the corresponding I/O driver.

The overhead necessary for data acquisition through input/output drivers is minimized when using these blocks, which is important mainly for very fast control algorithms with sampling period of 1 ms and lower. Moreover, all the inputs are read simultaneously or as successively as possible. Detailed information about using these blocks for particular driver can be found in the user manual for the given driver.

Since version 2.50.5 it is possible to use placeholders in names of I/O driver signals. This is useful inside subsystems where this placeholder is replaced by the value of subsystem parameter. E.g. the name `MBM__module<id>` will refer to module 1, 2, 3 etc. depending on the parameter `id` of the subsystem the block is contained in. See the `SubSystem` function block for information on defining subsystem parameters.

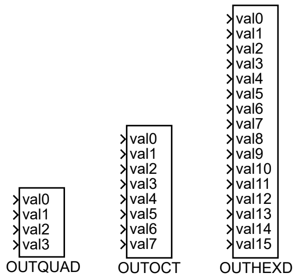
Outputs

`val`*i*	Input signals fed into the control algorithm through input/output drivers. The type and location of individual signals is described in the user manual for the given driver.	`Any`

OUTQUAD, OUTOCT, OUTHEXD – Multi-output blocks

Block Symbols

Licence: STANDARD



Function Description

The REXYGEN system allows not only writing of a single output signal but also simultaneous writing of multiple signals through just one block (for example all signals of one module or plug-in board). The blocks OUTQUAD, OUTOCT and OUTHEXD are designed for these purposes. They differ only in the maximum number of signals (4, 8 and 16, respectively). These blocks are not included in the RexLib function block library for Matlab-Simulink.

The name of the block instance includes the symbol of the driver <DRV> and the name of the signal <signal> of the given driver:

```
<DRV>__<signal>
```

It is created the same way as the GotoTag parameter of the INSTD and OUTSTD blocks. E.g. the digital outputs of a Modbus I/O device might be referenced by MBM__DO. Detailed information about signal naming can be found in the user manual of the corresponding I/O driver.

The overhead necessary for setting the outputs through input/output drivers is minimized when using these blocks, which is important mainly for very fast control algorithms with sampling period of 1 ms and lower. Moreover, all the inputs are written simultaneously or as successively as possible. Detailed information about using these blocks for particular driver can be found in the user manual for the given driver.

Since version 2.50.5 it is possible to use placeholders in names of I/O driver signals. This is useful inside subsystems where this placeholder is replaced by the value of subsystem parameter. E.g. the name MBM__module<id> will refer to signals of module 1, 2, 3 etc. depending on the parameter id of the subsystem the block is contained in. See the SubSystem function block for information on defining subsystem parameters.

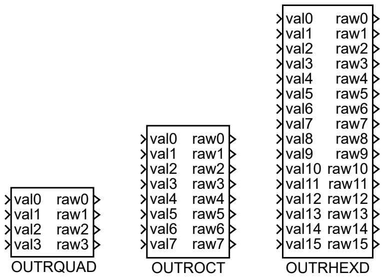
Inputs

`val`i	Signals to be sent to the process via the input/output driver. The type and location of individual signals is described in the user manual for the given driver.	`Any`

OUTRQUAD, OUTROCT, OUTRHEXD – Multi-output blocks with verification

Block Symbols

Licence: ADVANCED



Function Description

The **OUTRQUAD**, **OUTROCT** and **OUTRHEXD** blocks allow simultaneous writing of multiple signals, they are similar to the OUTQUAD, OUTOCT and OUTHEXD blocks. Additionally they provide feedback information about the result of write operation for the given output.

There are two ways to inform the control algorithm about the result of write operation through the raw*i* output:

- Through the value of the output, which can e.g. contain the real bit value in case of exceeding the limits of D/A converter (thus the raw notation).
- Through reading the quality flags of the signal. This information can be separated from the signal by the VIN and QFD blocks.

The raw*i* outputs are not always refreshed right at the moment of block execution, there is some delay given by the properties of the driver, communication line and/or target platform.

Inputs

val*i*	Output signals defined by the control algorithm through the input/output driver. The type and location of individual signals is described in the user manual for the given driver.	Any

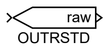
Outputs

raw*i*	Feedback information about the write operation result. The type and meaning of individual signals is described in the user manual for the given driver.	Any

OUTRSTD – Output block with verification

Block Symbol

Licence: ADVANCED



Function Description

The OUTRSTD block is similar to the OUTSTD block. Additionally it provides feedback information about the result of write operation for the output signal.

There are two ways to inform the control algorithm about the result of write operation through the raw output:

- Through the value of the output, which can e.g. contain the real bit value in case of exceeding the limits of D/A converter (thus the raw notation).
- Through reading the quality flags of the signal. This information can be separated from the signal by the VIN and QFD blocks.

The raw outputs is not refreshed right at the moment of block execution, there is some delay given by the properties of the driver, communication line and/or target platform.

Input

value	Output signal defined by the control algorithm through the input/output driver. The type and naming of the signal is described in the user manual for the given driver.	Any

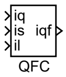
Output

raw	Feedback information about the write operation result. The type and meaning of the signal is described in the user manual for the given driver.	Any

QFC – Quality flags coding

Block Symbol

Licence: STANDARD



Function Description

The QFC block creates the resulting signal iqf representing the quality flags by combining three components iq, is and il. The quality flags are part of each input or output signal in the REXYGEN system. Further details about quality flags can be found in chapter 1.4 of this manual. The RexLib function block library for Matlab-Simulink does not use any quality flags.

It is possible to use the QFC block together with the VOUT block to force arbitrary quality flags for a given signal. Reversed function to the QFC block is performed by the QFD block.

Inputs

iq	Basic quality type flags, see table 1.2, page 23	Long (I32)
is	Substatus flags, see [1]	Long (I32)
il	Limits flags, see [1]	Long (I32)

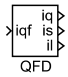
Output

iqf	Bit combination of the iq, is and il input signals	Long (I32)

QFD – Quality flags decoding

Block Symbol

Licence: STANDARD



Function Description

The QFD decomposes quality flags to individual components iq, is and il. The quality flags are part of each input or output signal in the REXYGEN system. Further details about quality flags can be found in chapter 1.4 of this manual. The RexLib function block library for Matlab-Simulink does not use any quality flags.

It is possible to use the QFD block together with the VIN block for detailed processing of quality flags of a given signal. Reversed function to the QFD block is performed by the QFC block.

Input

iqf	Quality flags to be decomposed to iq, is and il components	Long (I32)

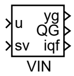
Outputs

iq	Basic quality type flags, see table 1.2, page 23	Long (I32)
is	Substatus flags, see [1]	Long (I32)
il	Limits flags, see [1]	Long (I32)

VIN – Validation of the input signal

Block Symbol

Licence: STANDARD



Function Description

The VIN block can be used for verification of the input signal quality in the REXYGEN system. Further details about quality flags can be found in chapter 1.4 of this manual.

The block continuously separates the quality flags from the input u and feeds them to the iqf output. Based on these quality flags and the GU parameter (Good if Uncertain), the input signals are processed in the following manner:

- For GU = off the output QG is set to on if the quality is GOOD. It is set to QG = off in case of BAD or UNCERTAIN quality.
- For GU = on the output QG is set to onif the quality is GOOD or UNCERTAIN. It is set to QG = off only in case of BAD quality.

The output yg is equal to the u input if QG = on. Otherwise it is set to yg = sv (substitution variable).

Inputs

u	Input signal whose quality is assessed. The type of the signal is determined upon the connected signal.	Any
sv	Substitute value for an error case	Any

Outputs

yg	Validated output signal (yg = u for QG = on or yg = sv for QG = off)	Any
QG	Indicator of input signal acceptability	Bool
iqf	Complete quality flag separated from the u input signal	Long (I32)

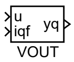
Parameter

GU	Acceptability of UNCERTAIN quality off ... Uncertain quality unacceptable on .... Uncertain quality acceptable	Bool

VOUT – Validation of the output signal

Block Symbol

Licence: STANDARD



Function Description

It is possible to use the VOUT block to force arbitrary quality flags for a given signal. The desired quality flags are given by the input signal `iqf`. Further details about quality flags can be found in chapter 1.4 of this manual.

Inputs

`u`	Input signal whose quality flags are being replaced. The type of the signal is determined upon the connected signal.	`Any`
`iqf`	Desired quality flags	`Long (I32)`

Output

`yq`	Resulting signal composed from input `u` and quality flags given by the `iqf` input	`Any`

Chapter 4

MATH – Math blocks

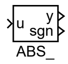
Contents

The MATH library offers a comprehensive collection of mathematical operations and functions. It includes basic arithmetic blocks like ADD, SUB, MUL, and DIV for standard calculations, and more specialized blocks such as ABS for absolute values, SQRT for square roots, and SQR for squaring. Advanced functionalities are provided by blocks like LIN for linear transformations, POL for polynomial evaluations, and FNX, FNXY for customizable mathematical functions. The library also features integer-specific operations through blocks like IADD, IMUL, IDIV, and IMOD.

ABS – Absolute value

Block Symbol

Licence: STANDARD



Function Description

The ABS block computes the absolute value of the analog input signal u. The output y is equal to the absolute value of the input and the sgn output denotes the sign of the input signal.

$$\mathtt{sgn} = \begin{cases} -1, & \text{for } \mathtt{u} < 0, \\ 0, & \text{for } \mathtt{u} = 0, \\ 1, & \text{for } \mathtt{u} > 0. \end{cases}$$

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)

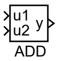
Output

y	Absolute value of the input signal	Double (F64)
sgn	Indication of the input signal sign	Long (I32)

`ADD` – Addition of two signals

Block Symbol

Licence: STANDARD



Function Description

The `ADD` blocks sums two analog input signals. The output is given by

$$\mathtt{y} = \mathtt{u1} + \mathtt{u2}.$$

Consider using the ADDOCT block for addition or subtraction of multiple signals.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

`u1`	First analog input of the block	`Double (F64)`
`u2`	Second analog input of the block	`Double (F64)`

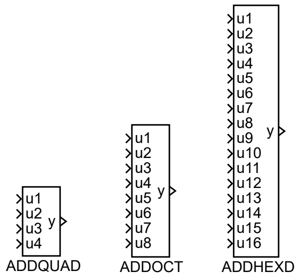
Output

`y`	Sum of the input signals	`Double (F64)`

ADDQUAD, ADDOCT, ADDHEXD – Multi-input addition

Block Symbols

Licence: STANDARD



Function Description

The ADDQUAD, ADDOCT and ADDHEXD blocks sum (or subtract) up to 16 input signals. The nl parameter defines the inputs which are subtracted instead of adding. For an empty nl parameter the block output is given by $y = u1 + u2 + u3 + u4 + u5 + u6 + u7 + \ldots + u16$. For e.g. nl=2,5,7, the block implements the function $y = u1 - u2 + u3 + u4 - u5 + u6 - u7 + \ldots + u16$.

Note that the ADD and SUB blocks are available for simple addition and subtraction operations.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	Analog input of the block	Double (F64)
u2	Analog input of the block	Double (F64)
u3	Analog input of the block	Double (F64)
u4	Analog input of the block	Double (F64)
u5	Analog input of the block	Double (F64)
u6	Analog input of the block	Double (F64)
u7	Analog input of the block	Double (F64)
u8	Analog input of the block	Double (F64)
u9	Analog input of the block	Double (F64)
u10	Analog input of the block	Double (F64)
u11	Analog input of the block	Double (F64)
u12	Analog input of the block	Double (F64)
u13	Analog input of the block	Double (F64)
u14	Analog input of the block	Double (F64)
u15	Analog input of the block	Double (F64)
u16	Analog input of the block	Double (F64)

Parameter

`nl`	List of signals to subtract	`Long (I32)`

Output

`y`	Sum of the input signals	`Double (F64)`

CNB – Boolean (logic) constant

Block Symbol

Licence: STANDARD

Function Description

The CNB block stands for a Boolean (logic) constant.

This block propagates the signal quality. More information can be found in the 1.4 section.

Parameter

YCN	Boolean constant off ... Disabled on .... Enabled	⊙on	Bool

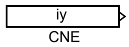
Output

Y	Logical output of the block	Bool

CNE – Enumeration constant

Block Symbol

Licence: STANDARD



Function Description

The CNE block allows selection of a constant from a predefined popup list. The popup list of constants is defined by the **pupstr** string, whose syntax is obvious from the default value shown below. The output value corresponds to the number at the beginning of the selected item. In case the **pupstr** string format is invalid, the output is set to 0.

There is a library called CNEs in Simulink, which contains CNE blocks with the most common lists of constants.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Parameter

yenum	Enumeration constant	⊙1: option A	String
pupstr	Popup list definition ⊙1: option A|2: option B|3: option C		String

Output

iy	Integer output of the block	Long (I32)

CNI – Integer constant

Block Symbol

Licence: STANDARD

Function Description

The CNI block stands for an integer constant.

This block propagates the signal quality. More information can be found in the 1.4 section.

Parameter

icn	Integer constant	⊙1	Long (I32)
vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)

Output

iy	Integer output of the block	Long (I32)

CNR – Real constant

Block Symbol

Licence: STANDARD

Function Description

The CNR block stands for a real constant.

This block propagates the signal quality. More information can be found in the 1.4 section.

Parameter

ycn	Real constant	⊙1.0	Double (F64)

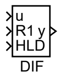
Output

y	Analog output of the block	Double (F64)

DIF – Difference

Block Symbol

Licence: STANDARD



Function Description

The DIF block differentiates the input signal u according to the following formula

$$y_k = u_k - u_{k-1},$$

where $u_k = u$, $y_k = y$ and u_{k-1} is the value of input u in the previous cycle (delay T_S, which is the execution period of the block).

The parameter ISSF sets the behavior of the block in the first cycle of task execution. If off, $y = u$ will be output in the first cycle. For the value on, the output will be $y = 0$ in the first cycle.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)
R1	Block reset	Bool
HLD	Hold	Bool

Parameter

ISSF	Zero output at start-up off . . . Non-zero output in the first cycle on . . . . Zero output in the first cycle	Bool

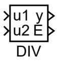
Output

y	Difference of the input signal	Double (F64)

DIV – Division of two signals

Block Symbol

Licence: STANDARD



Function Description

The DIV block divides two analog input signals y = u1/u2. In case u2 = 0, the output E is set to onand the output y is substituted by y = yerr.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)

Parameter

yerr	Substitute value for an error case	⊙1.0	Double (F64)

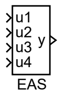
Output

y	Quotient of the inputs	Double (F64)
E	Error flag - division by zero off ... No error on .... An error occurred	Bool

EAS – Extended addition and subtraction

Block Symbol

Licence: STANDARD



Function Description

The EAS block sums input analog signals u1, u2, u3 and u4 with corresponding weights a, b, c and d. The output y is then given by

$$y = a * u1 + b * u2 + c * u3 + d * u4 + y0.$$

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)
u3	Third analog input of the block	Double (F64)
u4	Fourth analog input of the block	Double (F64)

Parameter

a	Weighting coefficient of the u1 input	⊙1.0	Double (F64)
b	Weighting coefficient of the u2 input	⊙1.0	Double (F64)
c	Weighting coefficient of the u3 input	⊙1.0	Double (F64)
d	Weighting coefficient of the u4 input	⊙1.0	Double (F64)
y0	Additive constant (bias)		Double (F64)

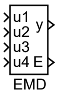
Output

y	Analog output of the block	Double (F64)

EMD – Extended multiplication and division

Block Symbol

Licence: STANDARD



Function Description

The EMD block multiplies and divides analog input signals u1, u2, u3 and u4 with corresponding weights a, b, c and d. The output y is then given by

$$\mathtt{y} = \frac{(\mathtt{a} * \mathtt{u1} + \mathtt{a0})(\mathtt{b} * \mathtt{u2} + \mathtt{b0})}{(\mathtt{c} * \mathtt{u3} + \mathtt{c0})(\mathtt{d} * \mathtt{u4} + \mathtt{d0})}. \tag{4.1}$$

The output E is set to on in the case that the denominator in the equation (4.1) is equal to 0 and the output y is substituted by y = yerr.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)
u3	Third analog input of the block	Double (F64)
u4	Fourth analog input of the block	Double (F64)

Parameter

a	Weighting coefficient of the u1 input	⊙1.0	Double (F64)
a0	Additive constant for u1 input		Double (F64)
b	Weighting coefficient of the u2 input	⊙1.0	Double (F64)
b0	Additive constant for u1 input		Double (F64)
c	Weighting coefficient of the u3 input	⊙1.0	Double (F64)
c0	Additive constant for u1 input		Double (F64)
d	Weighting coefficient of the u4 input	⊙1.0	Double (F64)
d0	Additive constant for u1 input		Double (F64)
yerr	Substitute value for an error case	⊙1.0	Double (F64)

Output

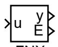
y	Analog output of the block	Double (F64)

`E`	Error flag - division by zero `off` ... No error `on` .... An error occurred	`Bool`

FNX – Evaluation of single-variable function

Block Symbol

Licence: STANDARD



Function Description

The FNX block evaluates basic math functions of single variable. The table below shows the list of supported functions with corresponding constraints. The ifn parameter determines the active function.
List of functions:

ifn: shortcut	function	constraints on u
1: acos	arccosine	u $\in < -1.0, 1.0 >$
2: asin	arcsine	u $\in < -1.0, 1.0 >$
3: atan	arctangent	–
4: ceil	rounding towards the nearest higher integer	–
5: cos	cosine	–
6: cosh	hyperbolic cosine	–
7: exp	exponential function $e^{\mathtt{u}}$	–
8: exp10	exponential function $10^{\mathtt{u}}$	–
9: fabs	absolute value	–
10: floor	rounding towards the nearest lower integer	–
11: log	logarithm	u > 0
12: log10	decimal logarithm	u > 0
13: random	arbitrary number $z \in < 0, 1 >$ (u independent)	–
14: sin	sine	–
15: sinh	hyperbolic sine	–
16: sqr	square function	–
17: sqrt	square root	u > 0
18: srand	changes the seed for the random function to u	u $\in \mathbb{N}$
19: tan	tangent	–
20: tanh	hyperbolic tangent	–

Note: All trigonometric functions process data in radians.

The error output is activated (E = on) in the case when the input value u falls out of its bounds or an error occurs during evaluation of the selected function (implementation dependent), e.g. square root of negative number. The output is set to substitute value in such case (y = yerr).

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block		Double (F64)

Parameter

ifn	Function type 1 ..... acos 2 ..... asin 3 ..... atan 4 ..... ceil 5 ..... cos 6 ..... cosh 7 ..... exp 8 ..... exp10 9 ..... fabs 10 .... floor 11 .... log 12 .... log10 13 .... random 14 .... sin 15 .... sinh 16 .... sqr 17 .... sqrt 18 .... srand 19 .... tan 20 .... tanh	⊙1	Long (I32)
yerr	Substitute value for an error case		Double (F64)

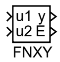
Output

y	Result of the selected function		Double (F64)
E	Error indicator off ... No error on .... An error occurred		Bool

FNXY – Evaluation of two-variables function

Block Symbol

Licence: STANDARD



Function Description

The FNXY block evaluates basic math functions of two variables. The table below shows the list of supported functions with corresponding constraints. The ifn parameter determines the active function.
List of functions:

ifn: shortcut	function	constraints on u1, u2
1: atan2	arctangent u1/u2	–
2: fmod	remainder after division u1/u2	$u2 \neq 0.0$
3: pow	exponentiation of the inputs $y = u1^{u2}$	–

The atan2 function result belongs to the interval $\langle -\pi, \pi \rangle$. The signs of both inputs u1 a u2 are used to determine the appropriate quadrant.

The fmod function computes the remainder after division u1/u2 such that $u1 = i \cdot u2 + y$, where i is an integer, the signs of the y output and the u1 input are the same and the following holds for the absolute value of the y output: $|y| < |u2|$.

The error output is activated (E = on) in the case when the input value u2 does not meet the constraints or an error occurs during evaluation of the selected function (implementation dependent), e.g. division by zero. The output is set to substitute value in such case (y = yerr).

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)

Parameter

ifn	Function type 1 ..... atan2 2 ..... fmod 3 ..... pow	⊙1	Long (I32)
yerr	Substitute value for an error case		Double (F64)

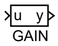
Output

`y`	Result of the selected function	`Double (F64)`
`E`	Error indicator `off` ... No error `on` .... An error occurred	`Bool`

GAIN – Multiplication by a constant

Block Symbol

Licence: STANDARD



Function Description

The GAIN block multiplies the analog input u by a real constant k. The output is then

$$y = ku.$$

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block		Double (F64)

Parameter

k	Gain	⊙1.0	Double (F64)

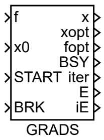
Output

y	Analog output of the block		Double (F64)

GRADS – Gradient search optimization

Block Symbol

Licence: ADVANCED



Function Description

The GRADS block performs one-dimensional optimization of the $f(\mathtt{x}, v)$ function by gradient method, where $\mathtt{x} \in \langle \mathtt{xmin}, \mathtt{xmax} \rangle$ is the optimized variable and v is an arbitrary vector variable. It is assumed that the value of the function $f(\mathtt{x}, v)$ for given x at time k is enumerated and fed to the f input at time $k + \mathtt{n} * T_S$, where T_S is the execution period of the GRADS block. This means that the individual optimization iterations have a period of $\mathtt{n} * T_S$. The length of step of the gradient method is given by

$$\begin{aligned} grad &= (\mathtt{f}_i - \mathtt{f}_{i-1}) * (dx)_{i-1} \\ (dx)_i &= -\mathtt{gamma} * grad, \end{aligned}$$

where i stands for i-th iteration. The step size is restricted to lie within the interval $\langle \mathtt{dmin}, \mathtt{dmax} \rangle$. The value of the optimized variable for the next iteration is given by

$$x_{i+1} = x_i + (dx)_i$$

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

f	Value of the optimized function f(.) for given x	Double (F64)
x0	Optimization starting point	Double (F64)
START	Starting signal (rising edge)	Bool
BRK	Termination signal	Bool

Parameter

xmin	Lower limit for the x variable		Double (F64)
xmax	Upper limit for the x variable	⊙10.0	Double (F64)
gamma	Step size coefficient	⊙0.3	Double (F64)
d0	Initial step size	⊙0.05	Double (F64)

`dmin`	Minimum step size	⊙0.01	`Double (F64)`
`dmax`	Maximum step size	⊙1.0	`Double (F64)`
`n`	Iteration period (in sampling periods Ts)	⊙100	`Long (I32)`
`itermax`	Maximum number of iterations	⊙20	`Long (I32)`

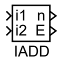
Output

`x`	Current value of the optimized variable	`Double (F64)`
`xopt`	Resulting optimal value of the x variable	`Double (F64)`
`fopt`	Resulting optimal value of the function f	`Double (F64)`
`BSY`	Busy flag	`Bool`
`iter`	Number of current iteration	`Long (I32)`
`E`	Error indicator `off` ... No error `on` .... An error occurred	`Bool`
`iE`	Error code `1` ..... x out of limits `2` ..... x at the limit	`Long (I32)`

IADD – Integer addition

Block Symbol

Licence: STANDARD



Function Description

The IADD block sums two integer input signals n = i1 + i2. The range of integer numbers in a computer is always restricted by the variable type. This block uses the vtype parameter to specify the type. If the sum fits in the range of the given type, the result is the ordinary sum. In the other cases the result depends on the SAT parameter.

The overflow is not checked for SAT = off, i.e. the output E = off and the output value n corresponds with the arithmetics of the processor. E.g. for the Short type, which has the range of -32768..+32767, we obtain 30000 + 2770 = -32766.

For SAT = on the overflow results in setting the error output to E = on and the n output to the nearest displayable value. For the above mentioned example we get 30000 + 2770 = 32767.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

i1	First integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)
i2	Second integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)

Parameter

vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)
SAT	Saturation (overflow) checking off ... Overflow is not checked on .... Overflow is checked		Bool

Output

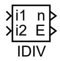
n	Integer sum of the input signals		Long (I32)

`E`	Error indicator `off` ... No error `on` .... An error occurred	`Bool`

IDIV – Integer division

Block Symbol

Licence: STANDARD



Function Description

The IDIV block performs an integer division of two integer input signals, n = i1 ÷ i2, where ÷ stands for integer division operator. If the ordinary (non-integer, normal) quotient of the two operands is an integer number, the result of integer division is the same. In other cases the resulting value is obtained by trimming the non-integer quotient's decimals (i.e. rounding towards lower integer number). In case i2 = 0, the output error is set to on and the output n is substituted by n = nerr.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

i1	First integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)
i2	Second integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)

Parameter

vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)
nerr	Substitute value for an error case	⊙1	Long (I32)

Output

n	Integer quotient of the inputs	Long (I32)
E	Error flag - division by zero off ... No error on .... An error occurred	Bool

IMOD – Remainder after integer division

Block Symbol

Licence: STANDARD

Function Description

The IMOD block divides two integer input signals, n = i1%i2, where % stands for remainder after integer division operator (modulo). If both numbers are positive and the divisor is greater than one, the result is either zero (for commensurable numbers) or a positive integer lower than the divisor. In the case that one of the numbers is negative, the result has the sign of the dividend, e.g. $15\%10 = 5$, $15\%(-10) = 5$, but $(-15)\%10 = -5$. In case i2 = 0, the output E is set to on and the output n is substituted by n = nerr.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

i1	First integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)
i2	Second integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)

Parameter

vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)
nerr	Substitute value for an error case	⊙1	Long (I32)

Output

n	Remainder after integer division	Long (I32)
E	Error flag - division by zero off ... No error on .... An error occurred	Bool

IMUL – Integer multiplication

Block Symbol

Licence: STANDARD

Function Description

The IMUL block multiplies two integer input signals n = i1 ∗ i2. The range of integer numbers in a computer is always restricted by the variable type. This block uses the vtype parameter to specify the type. If the multiple fits in the range of the given type, the result is the ordinary multiple. In the other cases the result depends on the SAT parameter.

The overflow is not checked for SAT = off, i.e. the output E = off and the output value n corresponds with the arithmetics of the processor. E.g. for the Short type, which has the range of -32768..+32767, we obtain 2000 * 20 = -25536.

For SAT = on the overflow results in setting the error output to E = on and the n output to the nearest displayable value. For the above mentioned example we get 2000 * 20 = 32767.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

i1	First integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)
i2	Second integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)

Parameter

vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)
SAT	Saturation (overflow) checking off ... Overflow is not checked on .... Overflow is checked		Bool

Output

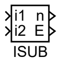
n	Integer product of the input signals	Long (I32)

`E`	Error indicator `off` ... No error `on` .... An error occurred	`Bool`

ISUB – Integer subtraction

Block Symbol

Licence: STANDARD



Function Description

The ISUB block subtracts two integer input signals n = i1 − i2. The range of integer numbers in a computer is always restricted by the variable type. This block uses the vtype parameter to specify the type. If the difference fits in the range of the given type, the result is the ordinary sum. In the other cases the result depends on the SAT parameter.

The overflow is not checked for SAT = off, i.e. the output E = off and the output value n corresponds with the arithmetics of the processor. E.g. for the Short type, which has the range of -32768..+32767, we obtain 30000 - -2770 = -32766

For SAT = on the overflow results in setting the error output to E = on and the n output to the nearest displayable value. For the above mentioned example we get 30000 - -2770 = 32767.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

i1	First integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)
i2	Second integer input of the block	↓-9.22E+18 ↑9.22E+18	Long (I32)

Parameter

vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)
SAT	Saturation (overflow) checking off ... Overflow is not checked on .... Overflow is checked		Bool

Output

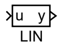
n	Integer difference between the input signals	Long (I32)

`E`	Error indicator `off` ... No error `on` .... An error occurred	`Bool`

LIN – Linear interpolation

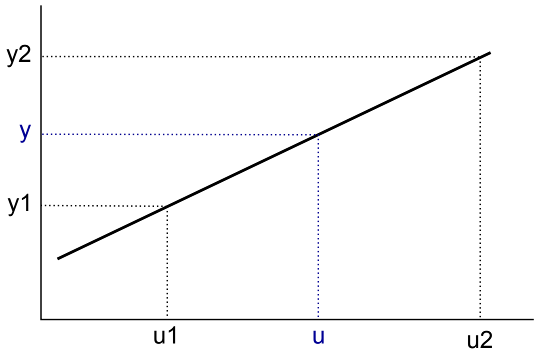
Block Symbol

Licence: STANDARD



Function Description

The LIN block performs linear interpolation. The following figure illustrates the influence of the input u and given interpolation points [u1, y1] and [u2, y2] on the output y.



This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)

Parameter

u1	x-coordinate of the 1st interpolation node		Double (F64)
y1	y-coordinate of the 1st interpolation node		Double (F64)
u2	x-coordinate of the 2nd interpolation node	⊙1.0	Double (F64)
y2	y-coordinate of the 2nd interpolation node	⊙1.0	Double (F64)

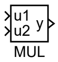
Output

y	Analog output of the block	Double (F64)

MUL – Multiplication of two signals

Block Symbol

Licence: STANDARD



Function Description

The MUL block multiplies two analog input signals $y = u1 \cdot u2$.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)

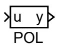
Output

y	Product of the input signals	Double (F64)

POL – Polynomial evaluation

Block Symbol

Licence: STANDARD



Function Description

The POL block evaluates the polynomial of the form:

$$y = a_0 + a_1 u + a_2 u^2 + a_3 u^3 + a_4 u^4 + a_5 u^5 + a_6 u^6 + a_7 u^7 + a_8 u^8.$$

The polynomial is internally evaluated by using the Horner scheme to

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block		Double (F64)

Parameter

a0	Coefficient u^0		Double (F64)
a1	Coefficient u^1	⊙1.0	Double (F64)
a2	Coefficient u^2		Double (F64)
a3	Coefficient u^3		Double (F64)
a4	Coefficient u^4		Double (F64)
a5	Coefficient u^5		Double (F64)
a6	Coefficient u^6		Double (F64)
a7	Coefficient u^7		Double (F64)
a8	Coefficient u^8		Double (F64)

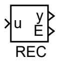
Output

y	Analog output of the block		Double (F64)

REC – Reciprocal value

Block Symbol

Licence: STANDARD



Function Description

The REC block computes the reciprocal value of the input signal u. The output is then

$$y = \frac{1}{u}.$$

In case $u = 0$, the error indicator is set to E = on and the output is set to the substitutional

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)

Parameter

yerr	Substitute value for an error case	⊙1.0	Double (F64)

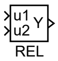
Output

y	Analog output of the block	Double (F64)
E	Error flag - division by zero off . . . No error on . . . . An error occurred	Bool

REL – Relational operator

Block Symbol

Licence: STANDARD



Function Description

The REL block evaluates the binary relation u1 ∘ u2 between the values of the input signals and sets the output Y according to the result of the relation "∘". The output is set to Y = on when relation holds, otherwise it is zero (relation does not hold). The binary operation codes are listed below.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)

Parameter

irel	Relation type 1 ..... equality (==) 2 ..... inequality (!=) 3 ..... less than (<) 4 ..... greater than (>) 5 ..... less or equal (<=) 6 ..... greater or equal (>=)	⊙1	Long (I32)

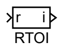
Output

Y	Logical output of the block	Bool

RTOI – Real to integer number conversion

Block Symbol

Licence: STANDARD



Function Description

The RTOI block converts the real number r to a signed integer number i. The resulting rounded value is defined by:

$$\mathtt{i} = \begin{cases} -2147483648, & \text{for} \quad \mathtt{r} \leq -2147483648.0, \\ \text{round}(\mathtt{r}), & \text{for} \quad -2147483648.0 < \mathtt{r} \leq 2147483647.0\,, \\ 2147483647, & \text{for} \quad \mathtt{r} > 2147483647.0, \end{cases}$$

where round(r) stands for rounding to the nearest integer number. The number of the form $n+0.5$ (n is integer) is rounded to the integer number with the higher absolute value, i.e. round(1.5) = 2, round(−2.5) = −3.

Note that the numbers −2147483648 and 2147483647 correspond with the lowest and the highest signed number representable in 32-bit format respectively (0x7FFFFFFF and 0x80000000 in hexadecimal form in the C language). This limits are valid if the vtype parameter has default value.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

r	Analog input of the block	Double (F64)

Parameter

vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)
SAT	Saturation (overflow) checking off ... Overflow is not checked on .... Overflow is checked	⊙on	Bool

Output

`i`	Rounded and converted input signal	`Long (I32)`

SQR – Square value

Block Symbol

Licence: STANDARD

Function Description

The SQR block raises the input u to the power of 2. The output is then

$$y = u^2.$$

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)

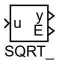
Output

y	Square of the input signal	Double (F64)

SQRT – Square root

Block Symbol

Licence: STANDARD



Function Description

The SQRT block computes the square root of the input u. The output is then

$$y = \sqrt{u}.$$

In case $u < 0$, the error indicator is activated (E = on) and the output y is set to the substitute value.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)

Parameter

yerr	Substitute value for an error case	⊙1.0	Double (F64)

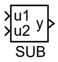
Output

y	Square root of the input signal	Double (F64)
E	Error indicator off ... No error on .... An error occurred	Bool

SUB – Subtraction of two signals

Block Symbol

Licence: STANDARD



Function Description

The SUB block subtracts two input signals. The output is given by

$$y = u1 - u2.$$

Consider using the ADDOCT block for addition or subtraction of multiple signals.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	Analog input of the block	Double (F64)
u2	Analog input of the block	Double (F64)

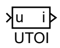
Output

y	Difference between input signals	Double (F64)

UTOI – Unsigned to signed integer number conversion

Block Symbol

Licence: STANDARD



Function Description

The UTOI block facilitates the conversion of an unsigned integer to a signed integer using two's complement representation, which is the common representation used in processors. For instance, in 8-bit representation, the number -1 is represented as 255, and in 16-bit representation as 65535. The parameter bits determines which bit representation is assumed.

This block is primarily used in scenarios where a value from a driver contains multiple signals extracted by masking (typically using INTSM or BITOP blocks). The result of this masking is always an unsigned (positive) number. However, if the signal from the driver is meant to be interpreted as a signed number, this block is used to obtain the correct value.

Since processors may vary in how they store multi-byte numbers (most commonly in little-endian format, where the less significant byte is stored at a lower address, but big-endian format processors also exist, where the opposite is true), the UTOI block offers the option to swap the byte order if it has not been handled by the driver. This adjustment is facilitated by the SWAP parameter.

Caution: Swapping the byte order (by setting SWAP=on) typically addresses issues with different byte orders in the processor only for bits=16 or bits=32 values.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Unsigned input signal	↓-9.22337E+18 ↑9.22337E+18	Large (I64)

Parameter

bits	Valid (LSB) bits in input signal	↓2 ↑64 ⊙16	Long (I32)
SWAP	Swap input byte order		Bool

Output

i	Converted (signed) input signal		Large (I64)

Chapter 5

ANALOG – Analog signal processing

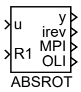
Contents

Library presents a versatile range of functional blocks, designed for control and signal processing applications. It includes blocks like ASW, AVG, BPF, and DEL, which provide functionalities from signal manipulation and averaging to filtering and complex conditional operations, catering to a broad spectrum of system requirements and scenarios.

ABSROT – Absolute rotation (multiturn extension of the position sensor)

Block Symbol

Licence: ADVANCED



Function Description

The ABSROT function block is intended for processing the data from absolute position sensor on rotary equipment, e.g. a shaft. The absolute sensor has a typical range of 5° to 355° (or -175° to +175°) but in some cases it is necessary to control the rotation over a range of more than one revolution. The function block assumes a continuous position signal, therefore the transition from 355° to 5° in the input signal means that one revolution has been completed and the angle is in fact 365°.

In the case of long-term unidirectional operation the precision of the estimated position y deteriorates due to the precision of the double data type. For that case the R1 input is available to reset the position y to the base range of the sensor. If the RESR flag is set to RESR = on, the irev revolutions counter is also reset by the R1 input. In all cases it is necessary to reset all accompanying signals (e.g. the sp input of the corresponding controller).

The MPI output indicates that the absolute sensor reading is near to the middle of the range, which may be the appropriate time to reset the block. On the other hand, the OLI output indicates that the sensor reached the so-called dead-angle where it cannot report valid data.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Signal from the absolute position sensor	Double (F64)
R1	Block reset	Bool

Parameter

lolim	Lower limit of the sensor reading	⊙-3.14159265	Double (F64)
hilim	Upper limit of the sensor reading	⊙3.14159265	Double (F64)
tol	Tolerance for the mid-point indicator	⊙0.5	Double (F64)
hys	Hysteresis for the mid-point indicator		Double (F64)

RESR	Flag for resetting the revolutions counter off . . . Reset only the estimated position on . . . . Reset also the revolutions counter	Bool

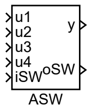
Output

y	Position output	Double (F64)
irev	Number of revolutions	Long (I32)
MPI	Mid-point indicator	Bool
OLI	Off-limits indicator	Bool

ASW – Switch with automatic selection of input

Block Symbol

Licence: ADVANCED



Function Description

The ASW block copies one of the inputs u1, ..., u4 or one of the parameters p1, ..., p4 to the output y. The appropriate input signal is copied to the output as long as the input signal iSW belongs to the set $\{1, 2, 3, 4\}$ and the parameters are copied when iSW belongs to the set $\{-1, -2, -3, -4\}$ (i.e. y = p1 for iSW $= -1$, y = u3 for iSW $= 3$ etc.). If the iSW input signal differs from any of these values (i.e. iSW $= 0$ or iSW < -4 or iSW > 4), the output is set to the value of input or parameter which has changed the most recently. The signal or parameter is considered changed when it differs by more than delta from its value at the moment of its last change (i.e. the changes are measured integrally, not as a difference from the last sample). The following priority order is used when changes occur simultaneously in more than one signal: p4, p3, p2, p1, u4, u3, u2, u1. The identifier of input signal or parameter which is copied to the output y is always available at the oSW output.

The ASW block has one special feature. The updated value of y is copied to all the parameters p1, ..., p4. This results in all external tools reading the same value y. This is particularly useful in higher-level systems which use the set&follow method (e.g. a slider in Iconics Genesis). This feature is not implemented in Simulink as there are no ways to read the values of inputs by external programs.

ATTENTION! One of the inputs u1, ..., u4 can be delayed by one step when the block is contained in a loop. This might result in an illusion, that the priority is broken (the oSW output then shows that the most recently changed signal is the delayed one). In such a situation the LPBRK block(s) must be used in appropriate positions.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)
u3	Third analog input of the block	Double (F64)
u4	Fourth analog input of the block	Double (F64)
iSW	Active signal or parameter selector	Long (I32)

Parameter

delta	Threshold for detecting a change	⊙1e-06	Double (F64)
p1	Parameter p1 to be selected		Double (F64)
p2	Parameter p2 to be selected		Double (F64)
p3	Parameter p3 to be selected		Double (F64)
p4	Parameter p4 to be selected		Double (F64)

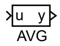
Output

y	The selected signal or parameter	Double (F64)
oSW	Identifier of the selected signal or parameter	Long (I32)

AVG – Moving average filter

Block Symbol

Licence: STANDARD



Function Description

The AVG block computes a moving average from the last n samples according to the formula

$$y_k = \frac{1}{n}(u_k + u_{k-1} + \cdots + u_{k-n+1}).$$

There is a limitation $n < N$, where N depends on the implementation. If the last n samples are not yet known, the average is computed from the samples available.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Input signal to be filtered	Double (F64)

Parameter

n	Number of samples for averaging	↓1 ↑10000000 ⊙10	Long (I32)
nmax	Allocated size of array	↓10 ↑10000000 ⊙100	Long (I32)

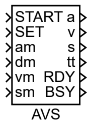
Output

y	Filtered output signal	Double (F64)

AVS – Motion control unit

Block Symbol

Licence: ADVANCED



Function Description

The AVS block generates time-optimal trajectory from initial steady position 0 to a final steady position sm while respecting the constraints on the maximal acceleration am, maximal deceleration dm and maximal velocity vm. When rising edge (off→on) occurs at the SET input, the block is initialized for current values of the inputs am, dm, vm and sm. The RDY output is set to offbefore the first initialization and during the initialization phase, otherwise it is set to 1. When rising edge (off→on) occurs at the START input, the block generates the trajectory at the outputs a, v, s and tt, where the signals correspond to acceleration, velocity, position and time respectively. The BSY output is set to on while the trajectory is being generated, otherwise it is off.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

START	Starting signal (rising edge)	Bool
SET	Initialize/compute the trajectory	Bool
am	Maximal allowed acceleration [m/s^2]	Double (F64)
dm	Maximal allowed deceleration [m/s^2]	Double (F64)
vm	Maximum allowed velocity [m/s]	Double (F64)
sm	Desired final position [m]	Double (F64)

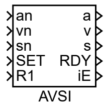
Output

a	Acceleration [m/s^2]	Double (F64)
v	Velocity [m/s]	Double (F64)
s	Position [m]	Double (F64)
tt	Time [s]	Double (F64)
RDY	Outputs valid (ready flag)	Bool
BSY	Busy flag	Bool

AVSI – Smooth trajectory interpolation

Block Symbol

Licence: ADVANCED



Function Description

The functional block **AVSI** - Acceleration (A), Velocity (V), Distance (S) Interpolation (I) - is designed for signal interpolation, especially in motion control applications. Its main purpose is to generate smooth sequences of position (distance), velocity, and acceleration based on discrete input values. This block is inspired by the functionality of RM_AxisSpline and offers similar interpolation methods.

The AVSI block accepts inputs **sn** (position), **vn** (velocity), and **an** (acceleration), which are generated by an external function (outside this block) with a certain period defined by the **RemTs** parameter. The values at the block's input are updated on the rising edge of the **SET** signal.

Interpolation between individual inputs is carried out with the aim of creating smooth transitions and ensuring continuous motion control or other applications requiring signal regulation and its derivatives. The block supports various interpolation methods determined by the **Mode** parameter, corresponding to the options in RM_AxisSpline. The supported methods include:

1: **linear**: Position is interpolated linearly, velocity as the derivative of position, acceleration is 0 (i.e., velocity is a piecewise constant function with jumps).

2: **cubic spline**: Position is a 3rd order polynomial calculated based on the position and velocity at the beginning and end of the interval; velocity is the derivative of position, acceleration is the derivative of velocity.

3: **quintic spline**: Position is a 5th order polynomial calculated based on the position, velocity, and acceleration at the beginning and end of the interval; velocity is the derivative of position, acceleration is the derivative of velocity.

4: **cubic aproximation (B-spline)**: Position is a 3rd order polynomial calculated based on two positions before and two positions after the current interval; the interpolated function may not exactly pass through the given points; velocity is the derivative of position, acceleration is the derivative of velocity.

5: **quintic aproximation (B-spline)**: Position is a 5th order polynomial calculated based on three positions before and three positions after the current interval; the interpolated function may not exactly pass through the given points; velocity is the derivative of position, acceleration is the derivative of velocity.

6: **all linear**: Position, velocity, and acceleration are independently interpolated linearly, i.e., velocity does not precisely correspond to the derivative of position, and acceleration does not precisely correspond to the derivative of velocity.

7: **all cubic**: Both position and velocity are interpolated by a 3rd order polynomial independently, i.e., velocity does not exactly correspond to the derivative of position.

8: *reserved for future use.*

9: *reserved for future use.*

Due to its operating principle, the `AVSI` block introduces signal delay, where active generation of values begins only after two complete `RemTs` periods from the first rising edge of the `SET` signal. For B-spline interpolation methods, a larger number of samples is required to start interpolation.

The `AVSI` block is primarily intended for motion control applications but can also be used for other types of signals and their derivatives. Its implementation allows for more efficient and smoother transitions between individual state values without the need for complex external control.

When using it, it is important to correctly set the `RemTs` period corresponding to the input value generator and choose the appropriate `Mode` for the desired type of interpolation.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

`an`	Next (remote) period acceleration [m/s^2]	`Double (F64)`
`vn`	Next (remote) period velocity [m/s]	`Double (F64)`
`sn`	Next (remote) period position [m]	`Double (F64)`
`SET`	Accept input on rising edge	`Bool`
`R1`	Block reset	`Bool`
`dm`	Maximal allowed deceleration in case of error[m/s^2]	`Double (F64)`

Parameter

`RemTs`	Remote signal generator period	⊙`0.0`	`Double (F64)`

`Mode`	Algorithm for interpolation 1 ..... linear 2 ..... cubic spline 3 ..... quintic spline 4 ..... cubic approximation (B-spline) 5 ..... quintic approximation (B-spline) 6 ..... all linear 7 ..... all cubic 8 ..... — 9 ..... —	⊙9	`Long (I32)`

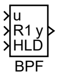
Output

`a`	Acceleration [m/s^2]	`Double (F64)`
`v`	Velocity [m/s]	`Double (F64)`
`s`	Position [m]	`Double (F64)`
`RDY`	Outputs valid (ready flag)	`Bool`
`iE`	Error code	`Bool`

BPF – Band-pass filter

Block Symbol

Licence: STANDARD



Function Description

The BPF implements a second order filter in the form

$$F_s = \frac{2\xi a s}{a^2 s^2 + 2\xi a s + 1},$$

where a and ξ are are the block parameters fm and xi respectively. The fm parameter defines the middle of the frequency transmission band and xi is the relative damping coefficient.

If ISSF = on, then the state of the filter is set to the steady value at the block initialization according to the input signal u.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Input signal to be filtered	Double (F64)
R1	Block reset	Bool
HLD	Hold	Bool

Parameter

fm	Peak frequency [Hz]	⊙1.0	Double (F64)
xi	Relative damping coefficient	⊙0.707	Double (F64)
ISSF	Steady state at start-up off ... Zero initial state on .... Initial steady state		Bool

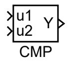
Output

y	Filtered output signal	Double (F64)

CMP – Comparator with hysteresis

Block Symbol

Licence: STANDARD



Function Description

The CMP block compares the inputs u1 and u2 with the hysteresis h as follows:

$$\begin{aligned} Y_{-1} &= 0, \\ Y_k &= hyst(e_k), \;\; k = 0, 1, 2, \ldots \end{aligned}$$

where

$$e_k = u1_k - u2_k$$

and

$$hyst(e_k) = \begin{cases} 0 & \text{for} \quad e_k \le -h \\ Y_{k-1} & \text{for} \quad e_k \in (-h, h) \\ 1 & \text{for} \quad e_k \ge h \quad (e_k > h \text{ for } h = 0) \end{cases}$$

The indexed variables refer to the values of the corresponding signal in the cycle defined by the index, i.e. Y_{k-1} denotes the value of output in the previous cycle/step. The value Y_{-1} is used only once when the block is initialized ($k = 0$) and the difference of the input signals e_k is within the hysteresis limits.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)

Parameter

hys	Hysteresis	↓0.0 ⊙0.5	Double (F64)

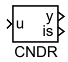
Output

Y	Logical output of the block	Bool

CNDR – Nonlinear conditioner

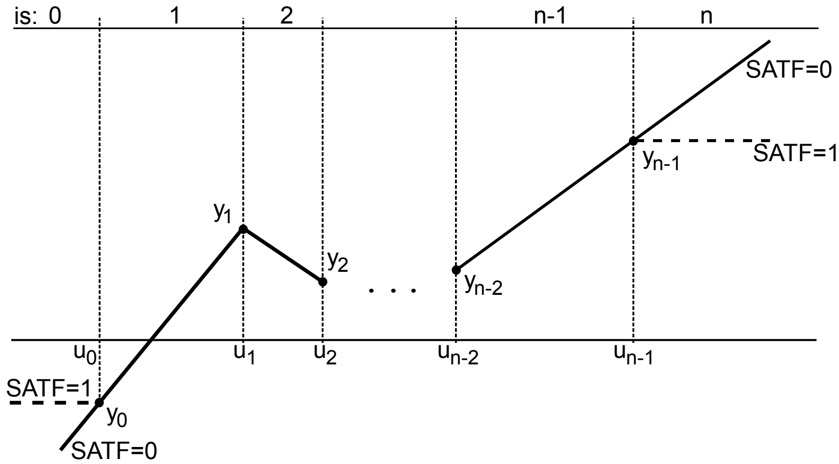
Block Symbol

Licence: STANDARD



Function Description

The CNDR block can be used for compensation of complex nonlinearities by a piecewise linear transformation which is depicted below.



It is important to note that in the case of $\mathtt{u} < u_0$ or $\mathtt{u} > u_{n-1}$ the output depends on the SATF parameter.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block		Double (F64)

Parameter

nmax	Allocated size of array	↓4 ⊙10	Long (I32)
SATF	Saturation flag off . . . Signal not limited on . . . . Saturation limits active	⊙on	Bool
up	Vector of increasing u-coordinates ⊙[0.0 3.9 3.9 9.0 14.5 20.0]		Double (F64)

yp	Vector of y-coordinates	⊙[0.0 0.0 15.8 38.4 72.0 115.0]	Double (F64)

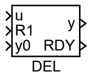
Output

y	Analog output of the block	Double (F64)
is	Active sector of nonlinearity	Long (I32)

DEL – Delay with initialization

Block Symbol

Licence: STANDARD



Function Description

The DEL block implements a delay of the input signal u. The signal is shifted n samples backwards, i.e.

$$y_k = u_{k-n}.$$

The corresponding time delay is $\mathtt{n} \cdot T_S$, where T_S is the block trigger period.

If the last n samples are not yet known, the output is set to

$$y_k = y_0,$$

where y_0 is the initialization input signal. This can happen after restarting the control system or after resetting the block (R1: off→on→off) and it is indicated by the output RDY = off.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)
R1	Block reset	Bool
y0	Initial output value	Double (F64)

Parameter

n	Delay [samples]	↓0 ↑10000000 ⊙10	Long (I32)
nmax	Allocated size of array	↓10 ↑10000000 ⊙100	Long (I32)

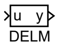
Output

y	Delayed input signal	Double (F64)
RDY	Outputs valid (ready flag)	Bool

DELM – Time delay

Block Symbol

Licence: STANDARD



Function Description

The DELM block implements a time delay of the input signal. The length of the delay is given by rounding the del parameter to the nearest integer multiple of the block execution period. The output signal is $y = 0$ for the first del seconds after initialization.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block		Double (F64)

Parameter

del	Time delay [s]	⊙1.0	Double (F64)
nmax	Allocated size of array	↓10 ↑10000000 ⊙100	Long (I32)

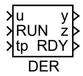
Output

y	Delayed input signal		Double (F64)

DER – Derivation, filtering and prediction from the last n+1 samples

Block Symbol

Licence: STANDARD



Function Description

The DER block interpolates the last $n + 1$ samples ($n \leq N - 1$, N is implementation dependent) of the input signal u by a line $y = at + b$ using the least squares method. The starting point of the time axis is set to the current sampling instant.

In case of RUN = on the outputs y and z are computed from the obtained parameters a and b of the linear interpolation as follows:

$$
\begin{array}{llll}
\text{Derivation:} & y & = & a \\
\text{Filtering:} & z & = & b, \ \text{for } t_p = 0 \\
\text{Prediction:} & z & = & at_p + b, \ \text{for } t_p > 0 \\
\text{Retrodiction:} & z & = & at_p + b, \ \text{for } t_p < 0
\end{array}
$$

In case of RUN = off or n+1 samples of the input signal are not yet available (RDY = off), the outputs are set to $y = 0$, $z = u$.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog output of the block	Double (F64)
RUN	Enable execution off . . . Tracking on . . . . Filtering	Bool
tp	Time instant for prediction/filtering	Double (F64)

Parameter

n	Number of samples for interpolation	↓1 ↑10000000 ⊙10	Long (I32)
nmax	Allocated size of array	↓10 ↑10000000 ⊙100	Long (I32)

Output

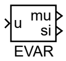
y	Estimate of input signal derivative	Double (F64)
z	Predicted/filtered input signal	Double (F64)

RDY	Outputs valid (ready flag)	Bool

EVAR – Moving mean value and standard deviation

Block Symbol

Licence: STANDARD



Function Description

The EVAR block estimates the mean value mu (μ) and standard deviation si (σ) from the last n samples of the input signal u according to the formulas

$$\mu_k = \frac{1}{\mathtt{n}} \sum_{i=0}^{n-1} \mathtt{u}_{k-i}$$

$$\sigma_k = \sqrt{\frac{1}{\mathtt{n}} \sum_{i=0}^{n-1} \mathtt{u}_{k-i}^2 - \mu_k^2}$$

where k stands for the current sampling instant.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)

Parameter

n	Number of samples for statistics	↓2 ↑10000000 ⊙100	Long (I32)
nmax	Allocated size of array	↓10 ↑10000000 ⊙200	Long (I32)

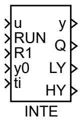
Output

mu	Mean value	Double (F64)
si	Standard deviation	Double (F64)

INTE – Controlled integrator

Block Symbol

Licence: STANDARD



Function Description

The INTE block implements a controlled integrator with variable integral time constant ti and two indicators of the output signal level (ymin a ymax). If RUN = on and R1 = off then

$$y(t) = \frac{1}{T_i}\int_0^t u(\tau)d\tau + C,$$

where $C = y0$. If RUN = off and R1 = off then the output y is frozen to the last value before the falling edge at the RUN input signal. If R1 = on then the output y is set to the initial value y0. The integration uses the trapezoidal method as follows

$$y_k = y_{k-1} + \frac{T_S}{2T_i}(u_k + u_{k-1}),$$

where T_S is the block execution period. If $T_i = 0$, the block realize summation by following equation

$$y_k = y_{k-1} + u_k.$$

If $T_i < 0$, the block behaviour is undefined.

Consider using the SINT block, whose simpler structure and functionality might be sufficient for elementary tasks.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)
RUN	Enable execution off . . . Integration stopped on . . . . Integration running	Bool
R1	Block reset	Bool
y0	Initial output value	Double (F64)
ti	Integral time constant	Double (F64)

Parameter

ymin	Lower level definition	⊙-1.0	Double (F64)
ymax	Upper level definition	⊙1.0	Double (F64)
SAT	Limit output if level limit is reach		Bool

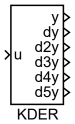
Output

y	Integrator output	Double (F64)
Q	Running integration indicator	Bool
LY	Lower saturation indicator	Bool
HY	Upper saturation indicator	Bool

KDER – Derivation and filtering of the input signal

Block Symbol

Licence: ADVANCED



Function Description

The KDER block is a Kalman-type filter of the norder-th order aimed at estimation of derivatives of locally polynomial signals corrupted by noise. The order of derivatives ranges from 0 to norder $-$ 1. The block can be used for derivation of almost arbitrary input signal u $= u_0(t) + v(t)$, assuming that the frequency spectrums of the signal and noise differ.

The block is configured by only two parameters pbeta and norder. The pbeta parameter depends on the sampling period T_S, frequency properties of the input signal u and also the noise to signal ratio. An approximate formula pbeta $\approx T_S\omega_0$ can be used. The frequency spectrum of the input signal u should be located deep down below the cutoff frequency ω_0. But at the same time, the frequency spectrum of the noise should be as far away from the cutoff frequency ω_0 as possible. The cutoff frequency ω_0 and thus also the pbeta parameter must be lowered for strengthening the noise rejection.

The other parameter norder must be chosen with respect to the order of the estimated derivations. In most cases the 2nd or 3rd order filter is sufficient. Higher orders of the filter produce better derivation estimates for non-polynomial signals at the cost of slower tracking and higher computational cost.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Input signal to be filtered	Double (F64)

Parameter

norder	Order of the derivative filter	↓2 ↑10 ⊙3	Long (I32)
pbeta	Bandwidth of the derivative filter	↓0.0 ⊙0.1	Double (F64)

Output

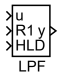
y	Filtered input signal	Double (F64)
dy	Estimated 1st order derivative	Double (F64)

`d2y`	Estimated 2nd order derivative	`Double (F64)`
`d3y`	Estimated 3rd order derivative	`Double (F64)`
`d4y`	Estimated 4th order derivative	`Double (F64)`
`d5y`	Estimated 5th order derivative	`Double (F64)`

LPF – Low-pass filter

Block Symbol

Licence: STANDARD



Function Description

The LPF block implements a second order filter in the form

$$F_s = \frac{1}{a^2s^2 + 2\xi as + 1},$$

where

$$a = \frac{\sqrt{\sqrt{2}\sqrt{2\xi^4 - 2\xi^2 + 1} - 2\xi^2 + 1}}{2\pi f_b}$$

and fb and ξ = xi are the block parameters. The fb [Hz] parameter defines the filter bandwidth and xi is the relative damping coefficient. Attenuation at frequency fb is 3 dB, at $10 \cdot$ fb approximately 40 dB. For the correct function of the filter, $f_b < \frac{1}{10T_S}$ must hold, where T_S is the block triggering period. The recommended value is xi = 0.71 for the Butterworth filter and xi = 0.87 for the Bessel filter.

If ISSF = on, then the state of the filter is set to the steady value at the block initialization according to the input signal u.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Input signal to be filtered	Double (F64)
R1	Block reset	Bool
HLD	Hold	Bool

Parameter

fb	Filter bandwidth [Hz]	⊙1.0	Double (F64)
xi	Relative damping coefficient	⊙0.707	Double (F64)
ISSF	Steady state at start-up off . . . Zero initial state on . . . . Initial steady state		Bool

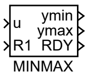
Output

`y`	Filtered output signal	`Double (F64)`

MINMAX – Running minimum and maximum

Block Symbol

Licence: STANDARD



Function Description

The MINMAX function block evaluates minimum and maximum from the last n samples of the u input signal. The output RDY = off indicates that the buffer contains less than n samples. In such a case the minimum and maximum are found among the available samples.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)
R1	Block reset	Bool

Parameter

n	Number of samples for analysis	↓1 ↑10000000 ⊙100	Long (I32)
nmax	Allocated size of array	↓10 ↑10000000 ⊙200	Long (I32)

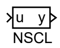
Output

ymin	Minimal value found	Double (F64)
ymax	Maximal value found	Double (F64)
RDY	Outputs valid (ready flag)	Bool

NSCL – Nonlinear scaling factor

Block Symbol

Licence: STANDARD

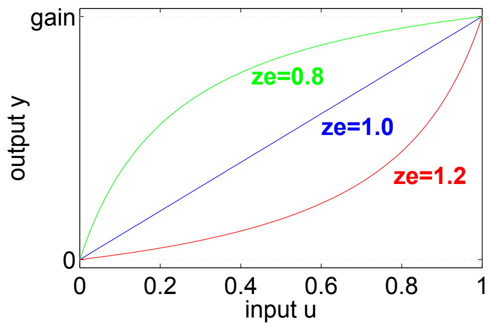


Function Description

The NSCL block compensates common nonlinearities of the real world (e.g. the servo valve nonlinearity) by using the formula

$$y = \mathtt{gain} \frac{u}{\mathtt{ze} + (1 - \mathtt{ze}) \cdot u},$$

where gain and ze are the parameters of the block. The choice of ze within the interval $(0, 1)$ leads to concave transformation, while $\mathtt{ze} > 1$ gives a convex transformation.



This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)

Parameter

gain	Signal gain	⊙1.0	Double (F64)
ze	Shaping parameter	⊙1.0	Double (F64)

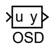
Output

y	Analog output of the block	Double (F64)

OSD – One Step Delay

Block Symbol

Licence: STANDARD



Function Description

The OSD block implements a one step delay of the input signal u. The length of the step delay (in seconds) is given by the task period (see the EXEC function block description for details).

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Any

Parameter

LB	Act as loopbreak	Bool

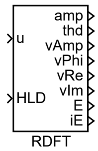
Output

y	Analog output of the block	Any

RDFT – Running discrete Fourier transform

Block Symbol

Licence: ADVANCED



Function Description

The RDFT function block analyzes the analog input signal using the discrete Fourier transform with the fundamental frequency **freq** and optional higher harmonic frequencies. The computations are performed over the last m samples of the input signal u, where m = nper/freq/T_S, i.e. from the time-window of the length equivalent to nper periods of the fundamental frequency.

If nharm > 0 the number of monitored higher harmonic frequencies is given solely by this parameter. On the contrary, for nharm $= 0$ the monitored frequencies are given by the user-defined vector parameter freq2.

For each frequency the amplitude (vAmp output), phase-shift (vPhi output), real/cosine part (vRe output) and imaginary/sine part (vIm output). The output signals have the vector form, therefore the computed values for all the frequencies are contained within. Use the VTOR function block to disassemble the vector signals. The output thd indicates the total harmonic distortion, i.e. the part of fundamental and higher harmonic frequencies (only if nharm ≥ 1).

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)
HLD	Hold	Bool

Parameter

freq	Fundamental frequency	↓1e-09 ↑1e+09 ⊙1.0	Double (F64)
nper	Number of periods to calculate upon	↓1 ↑10000 ⊙10	Long (I32)
nharm	Number of monitored harmonic frequencies	↓0 ↑16 ⊙3	Long (I32)
ifrunit	Frequency units 1 ..... Hz 2 ..... rad/s	⊙1	Long (I32)

iphunit	Phase shift units 1 ..... degrees 2 ..... radians	⊙1	Long (I32)
nmax	Allocated size of array	↓10 ↑10000000 ⊙8192	Long (I32)
freq2	Vector of user-defined monitored frequencies	⊙[2.0 3.0 4.0]	Double (F64)

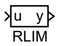
Output

amp	Amplitude of the fundamental frequency	Double (F64)
thd	Total harmonic distortion	Double (F64)
vAmp	Vector of amplitudes at given frequencies	Reference
vPhi	Vector of phase-shifts at given frequencies	Reference
vRe	Vector of real parts at given frequencies	Reference
vIm	Vector of imaginary parts at given frequencies	Reference
E	Error indicator	Bool
iE	Error code	Error

RLIM – Rate limiter

Block Symbol

Licence: STANDARD



Function Description

The RLIM block copies the input signal u to the output y, but the maximum allowed rate of change is limited. The limits are given by the time constants tp and tn:

the steepest rise per second:	$1/\texttt{tp}$
the steepest descent per second:	$-1/\texttt{tn}$

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Input signal to be filtered	Double (F64)

Parameter

tp	Time constant - maximum rise	⊙2.0	Double (F64)
tn	Time constant - maximum descent	⊙2.0	Double (F64)

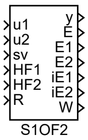
Output

y	Filtered output signal	Double (F64)

S1OF2 – One of two analog signals selector

Block Symbol

Licence: ADVANCED



Function Description

The S1OF2 block assesses the validity of two input signals u1 and u2 separately. The validation method is equal to the method used in the SAI block. If the signal u1 (or u2) is marked invalid, the output E1 (or E2) is set to on and the error code is sent to the iE1 (or iE2) output. The S1OF2 block also evaluates the difference between the two input signals. The internal flag D is set to on if the differences $|\mathtt{u1}-\mathtt{u2}|$ in the last nd samples exceed the given limit, which is given by the following inequation:

$$|\mathtt{u1}-\mathtt{u2}| > \mathtt{pdev}\frac{\mathtt{vmax}-\mathtt{vmin}}{100},$$

where vmin and vmax are the minimal and maximal limits of the inputs u1 and u2 and pdev is the allowed percentage difference with respect to the overall range of the input signals. The value of the output y depends on the validity of the input signals (flags E1 and E2) and the internal difference flag D as follows:

(i) If $\mathtt{E1}=\mathtt{off}$ **and** $\mathtt{E2}=\mathtt{off}$ **and** $\mathtt{D}=\mathtt{off}$, then the output y depends on the mode parameter:

$$\mathtt{y} = \begin{cases} \frac{\mathtt{u1}+\mathtt{u2}}{2}, & \text{for } \textit{codemode} = 1, \\ \min(\mathtt{u1},\mathtt{u2}), & \text{for } \mathtt{mode} = 2, \\ \max(\mathtt{u1},\mathtt{u2}), & \text{for } \mathtt{mode} = 3. \end{cases}$$

and the output E is set to off unless set to on earlier.

(ii) If $\mathtt{E1}=\mathtt{off}$ **and** $\mathtt{E2}=\mathtt{off}$ **and** $\mathtt{D}=\mathtt{on}$, then $\mathtt{y}=\mathtt{sv}$ and $\mathtt{E}=\mathtt{on}$.

(iii) If $\mathtt{E1}=\mathtt{on}$ **and** $\mathtt{E2}=\mathtt{off}$ ($\mathtt{E1}=\mathtt{off}$ **and** $\mathtt{E2}=\mathtt{on}$) , then $\mathtt{y}=\mathtt{u2}$ ($\mathtt{y}=\mathtt{u1}$) and the output E is set to off unless set to on earlier.

(iv) If $\mathtt{E1}=\mathtt{on}$ **and** $\mathtt{E2}=\mathtt{on}$, then $\mathtt{y}=\mathtt{sv}$ and $\mathtt{E}=\mathtt{on}$.

The input R resets the inner error flags F1–F4 (see the SAI block) and the D flag. For the input R set permanently to on, the invalidity indicator E1 (E2) is set to on for only one cycle period whenever some invalidity condition is fulfilled. On the other hand, for $\mathtt{R}=0$, the output E1 (E2) is set to on and remains true until the reset (R: off→on). A similar rule holds for the E output. For the input R set permanently to on, the E output is set to `on` for only one cycle period whenever a rising edge occurs in the internal `D` flag (`D` = `off` → `on`). On the other hand, for `R` = 0, the output `E` is set to `on` and remains true until the reset (rising edge `R`: `off`→`on`). The output `W` is set to `on` only in the (iii) or (iv) cases, i.e. at least one input signal is invalid.

The parameter `nb` specifies the number of samples after restart during which signal validity detection for `u1` and `u2` is suppressed. The parameter `nc` indicates the number of samples for testing immutability (see the `SAI` block, condition `F2`). The number of samples for testing variability (see the `SAI` block, condition `F3`) is given by the parameter `nr`. The maximum expected percentage change in input `u1` (`u2`) from the total range `vmax` − `vmin` over `nr` samples of input `u1` (`u2`) (see the `SAI` block) is determined by `prate`. The parameter `nv` represents the number of samples for testing range exceedance (see the `SAI` block, condition `F4`).

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`u1`	First analog input of the block	`Double (F64)`
`u2`	Second analog input of the block	`Double (F64)`
`sv`	Substitute value for an error case	`Double (F64)`
`HF1`	Hardware error flag for signal u1 `off` ... The input module of the signal works normally `on` .... Hardware error of the input module occurred	`Bool`
`HF2`	Hardware error flag for signal u2 `off` ... The input module of the signal works normally `on` .... Hardware error of the input module occurred	`Bool`
`R`	Reset inner error flags	`Bool`

Parameter

`nb`	Number of samples to skip at startup	⊙10	`Long (I32)`
`nc`	Number of samples for invariability testing	⊙10	`Long (I32)`
`nbits`	Number of A/D converter bits	⊙12	`Long (I32)`
`nr`	Number of samples for variability testing	⊙10	`Long (I32)`
`prate`	Maximum allowed percentage change	⊙10.0	`Double (F64)`
`nv`	Number of samples for out-of-range testing	⊙1	`Long (I32)`
`vmin`	Lower limit for the input signal	⊙-1.0	`Double (F64)`
`vmax`	Upper limit for the input signal	⊙1.0	`Double (F64)`
`nd`	Number of samples for deviation testing	⊙5	`Long (I32)`
`pdev`	Maximum allowed percentage deviation of inputs	⊙10.0	`Double (F64)`
`mode`	Computation of output when both inputs are valid `1` ..... Average `2` ..... Minimum `3` ..... Maximum	⊙1	`Long (I32)`

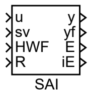
Output

y	Analog output of the block	Double (F64)
E	Output signal invalidity indicator off ... Signal is valid on .... Signal is invalid	Bool
E1	Invalidity indicator for input u1 off ... Signal is valid on .... Signal is invalid	Bool
E2	Invalidity indicator for input u2 off ... Signal is valid on .... Signal is invalid	Bool
iE1	Reason of input u1 invalidity 0 ..... Signal valid 1 ..... Signal out of range 2 ..... Signal varies too much 3 ..... Signal varies too much and signal out of range 4 ..... Signal varies too little 5 ..... Signal varies too little and signal out of range 6 ..... Signal varies too much and too little 7 ..... Signal varies too much and too little and signal out of range 8 ..... Hardware error	Long (I32)
iE2	Reason of input u2 invalidity 0 ..... Signal valid 1 ..... Signal out of range 2 ..... Signal varies too much 3 ..... Signal varies too much and signal out of range 4 ..... Signal varies too little 5 ..... Signal varies too little and signal out of range 6 ..... Signal varies too much and too little 7 ..... Signal varies too much and too little and signal out of range 8 ..... Hardware error	Long (I32)
W	Warning flag (invalid input signal) off ... Both input signals are valid on .... At least one of the input signals is invalid	Bool

SAI – Safety analog input

Block Symbol

Licence: ADVANCED



Function Description

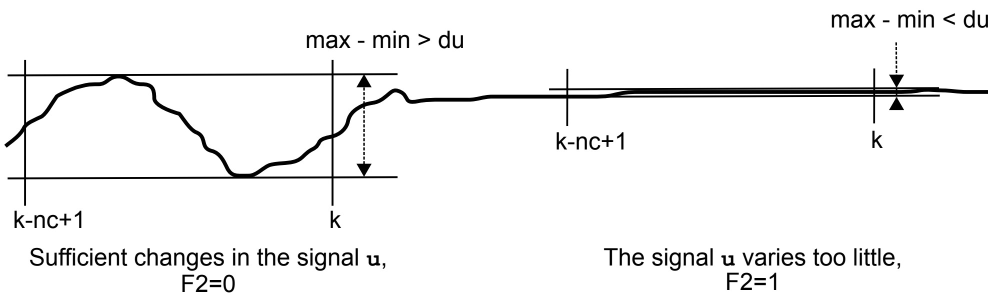
The SAI block tests the input signal u and assesses its validity. The input signal u is considered invalid (the output $\mathtt{E} = \mathtt{on}$) in the following cases:

F1: Hardware error. The input signal $\mathtt{HWF} = \mathtt{on}$.

F2: The input signal u varies too little. The last nc samples of the input u lies within the interval of width du,

$$\mathtt{du} = \begin{cases} \frac{\mathtt{vmax}-\mathtt{vmin}}{2^{\mathtt{nbits}}}, & \text{for } \mathtt{nbits} \in \{8, 9, ..., 16\} \\ 0, & \text{for } \mathtt{nbits} \notin \{8, 9, ..., 16\}. \end{cases}$$

where vmin and vmax are the lower and upper limits of the input u, respectively, and nbits is the number of A/D converter bits. The situation when the input signal u varies too little is shown in the following picture:

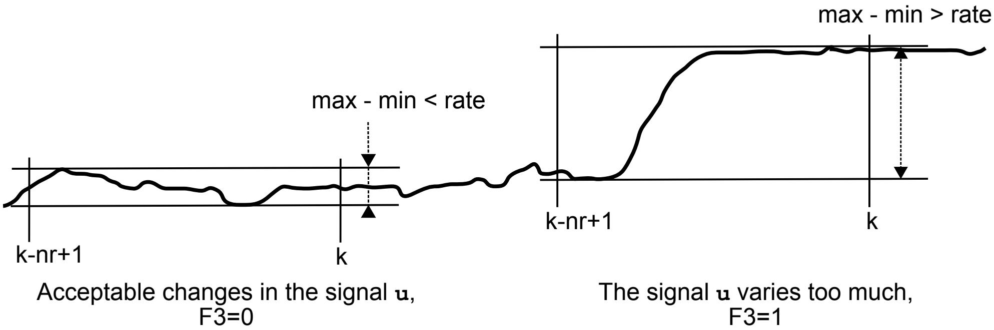


If the parameter nc is set to $\mathtt{nc} = 0$, the condition F2 is never fulfilled.

F3: The input signal u varies too much. The last nr samples of the input u filtered by the SPIKE filter have a span which is greater than rate,

$$\mathtt{rate} = \mathtt{prate}\frac{\mathtt{vmax} - \mathtt{vmin}}{100},$$

where prate defines the allowed percentage change in the input signal u within the last nr samples (with respect to the overall range of the input signal $\mathtt{u} \in \langle \mathtt{vmin}, \mathtt{vmax} \rangle$). The block includes a SPIKE filter with fixed parameters $\mathtt{mingap} = \frac{\mathtt{vmax}-\mathtt{vmin}}{100}$ and q = 2 suppressing peaks in the input signal to avoid undesirable fulfilling of this condition. See the SPIKE block description for more details. The situation when the input signal u varies too much is shown in the following picture:



If the parameter nr is set to nr = 0, the condition F3 is never fulfilled.

F4: The input signal u is out of range. The last nv samples of the input signal u lie out of the allowed range ⟨vmin, vmax⟩. If the parameter nv is set to nv = 0, the condition F4 is never fulfilled.

The signal u is copied to the output y without any modification when it is considered valid. In the other case, the output y is determined by a substitute value from the sv input. In such a case the output E is set to on and the output iE provides the error code. The input R resets the inner error flags F1–F4. For the input R set permanently to on, the invalidity indicator E is set to on for only one cycle period whenever some invalidity condition is fulfilled. On the other hand, for R = off, the output E is set to on and remains true until the reset (rising edge R: off→on).

The table of error codes iE resulting from the inner error flags F1–F4:

F1	F2	F3	F4	iE
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	*	*	*	8

The nb parameter defines the number of samples which are not included in the validity assessment after initialization of the block (restart). Recommended setting is nb ≥ 5 to allow the SPIKE filter initial conditions to fade away.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`u`	Analog input of the block	`Double (F64)`
`sv`	Substitute value for an error case	`Double (F64)`
`HWF`	Hardware error indicator `off` ... The input module of the signal works normally `on` .... Hardware error of the input module occurred	`Bool`
`R`	Reset inner error flags	`Bool`

Parameter

`nb`	Number of samples to skip at startup	⊙10	`Long (I32)`
`nc`	Number of samples for invariability testing	⊙10	`Long (I32)`
`nbits`	Number of A/D converter bits	⊙12	`Long (I32)`
`nr`	Number of samples for variability testing	⊙10	`Long (I32)`
`prate`	Maximum allowed percentage change	⊙10.0	`Double (F64)`
`nv`	Number of samples for out-of-range testing	⊙1	`Long (I32)`
`vmin`	Lower limit for the input signal	⊙-1.0	`Double (F64)`
`vmax`	Upper limit for the input signal	⊙1.0	`Double (F64)`

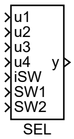
Output

`y`	Analog output of the block	`Double (F64)`
`yf`	Filtered output signal (SPIKE)	`Double (F64)`
`E`	Output signal invalidity indicator `off` ... Signal is valid `on` .... Signal is invalid	`Bool`
`iE`	Reason of invalidity `0` ..... Signal valid `1` ..... Signal out of range `2` ..... Signal varies too much `3` ..... Signal varies too much and signal out of range `4` ..... Signal varies too little `5` ..... Signal varies too little and signal out of range `6` ..... Signal varies too much and too little `7` ..... Signal varies too much and too little and signal out of range `8` ..... Hardware error	`Long (I32)`

SEL – Selector switch for analog signals

Block Symbol

Licence: STANDARD



Function Description

The SEL block is obsolete, replace it by the SELQUAD, SELOCT or SELHEXD block. Note the difference in binary selector signals SWn.

The SEL block selects one of the four input signals u1, u2, u3 and u4 and copies it to the output signal y. The selection is based on the iSW input or the binary inputs SW1 and SW2. These two modes are distinguished by the BINF binary flag. The signal is selected according to the following table:

iSW	SW1	SW2	y
0	off	off	u1
1	off	on	u2
2	on	off	u3
3	on	on	u4

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)
u3	Third analog input of the block	Double (F64)
u4	Fourth analog input of the block	Double (F64)
iSW	Active signal selector	Long (I32)
SW1	Binary signal selector	Bool
SW2	Binary signal selector	Bool

Parameter

BINF Enable the binary selectors Bool

- off . . . Disabled (analog selector)
- on . . . . Enabled (binary selectors)

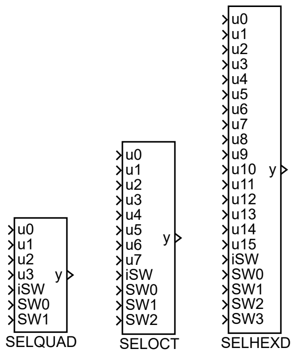
Output

`y`	The selected input signal	`Double (F64)`

SELQUAD, SELOCT, SELHEXD – Selector switch for analog signals

Block Symbols

Licence: STANDARD



Function Description

The SELQUAD, SELOCT and SELHEX blocks select one of the input signals and copy it to the output signal y. Please note that the only difference among the blocks is the number of inputs. The selection of the active signal u0...u15 is based on the iSW input or the binary inputs SW0...SW3. These two modes are distinguished by the BINF binary flag. The signal is selected according to the following table:

iSW	SW0	SW1	SW2	SW3	y
0	off	off	off	off	u0
1	on	off	off	off	u1
2	off	on	off	off	u2
3	on	on	off	off	u3
4	off	off	on	off	u4
5	on	off	on	off	u5
6	off	on	on	off	u6
7	on	on	on	off	u7
8	off	off	off	on	u8
9	on	off	off	on	u9
10	off	on	off	on	u10
11	on	on	off	on	u11
12	off	off	on	on	u12
13	on	off	on	on	u13
14	off	on	on	on	u14
15	on	on	on	on	u15

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u0	Analog input of the block	Double (F64)
u1	Analog input of the block	Double (F64)
u2	Analog input of the block	Double (F64)
u3	Analog input of the block	Double (F64)
u4	Analog input of the block	Double (F64)
u5	Analog input of the block	Double (F64)
u6	Analog input of the block	Double (F64)
u7	Analog input of the block	Double (F64)
u8	Analog input of the block	Double (F64)
u9	Analog input of the block	Double (F64)
u10	Analog input of the block	Double (F64)
u11	Analog input of the block	Double (F64)
u12	Analog input of the block	Double (F64)
u13	Analog input of the block	Double (F64)
u14	Analog input of the block	Double (F64)
u15	Analog input of the block	Double (F64)
iSW	Active signal selector	Long (I32)
SW0	Binary signal selector	Bool
SW1	Binary signal selector	Bool
SW2	Binary signal selector	Bool
SW3	Binary signal selector	Bool

Parameter

BINF	Enable the binary selectors	Bool

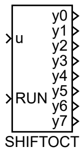
Output

y	The selected input signal	Double (F64)

SHIFTOCT – Data shift register

Block Symbol

Licence: STANDARD



Function Description

The SHIFTOCT block works as a shift register with eight outputs of arbitrary data type.

If the RUN input is active, the following assignment is performed with each algorithm tick:

$$\begin{aligned} \mathtt{y}_i &= \mathtt{y}_{i-1},\ i = 1..7 \\ \mathtt{y0} &= \mathtt{u} \end{aligned}$$

Thus the value on each output y0 to y6 is shifted to the following output and the value on input u is assigned to output y0.

The block works with any data type of signal connected to the input u. Data type has to be specified by the vtype parameter. Outputs y0 to y7 then have the same data type.

If you need a triggered shift register, place the EDGE block in front of the RUN input.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Any
RUN	Enables outputs shift	Bool

Parameter

`vtype`	Output data type `1` ..... Bool `2` ..... Byte (U8) `3` ..... Short (I16) `4` ..... Long (I32) `5` ..... Word (U16) `6` ..... DWord (U32) `7` ..... Float (F32) `8` ..... Double (F64) `10` .... Large (I64)	⊙8	`Long (I32)`

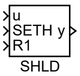
Output

`y0`	First analog output of the block	`Any`
`y1`	Second analog output of the block	`Any`
`y2`	Third analog output of the block	`Any`
`y3`	Fourth analog output of the block	`Any`
`y4`	Fifth analog output of the block	`Any`
`y5`	Sixth analog output of the block	`Any`
`y6`	Seventh analog output of the block	`Any`
`y7`	Eighth analog output of the block	`Any`

SHLD – Sample and hold

Block Symbol

Licence: STANDARD



Function Description

The SHLD block is intended for holding the value of the input signal. It processes the input signal according to the mode parameter.

In *Triggered sampling* mode the block sets the output signal y to the value of the input signal u when rising edge (off→on) occurs at the SETH input. The output is held constant unless a new rising edge occurs at the SETH input.

If *Hold last value* mode is selected, the output signal y is set to the last value of the input signal u before the rising edge at the SETH input occured. It is kept constant as long as SETH = on. For SETH = off the input signal u is simply copied to the output y.

In *Hold current value* mode the u input is sampled right when the rising edge (off→on) occurs at the SETH input. It is kept constant as long as SETH = on. For SETH = off the input signal u is simply copied to the output y.

The binary input R1 sets the output y to the value y0, it overpowers the SETH input signal.

See also the PARR block, which can be used for storing a numeric value as well.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)
SETH	Set and hold the output signal	Bool
R1	Block reset	Bool

Parameter

y0	Initial output value		Double (F64)
mode	Sampling mode 1 ..... Triggered sampling 2 ..... Hold last value 3 ..... Hold current value	⊙3	Long (I32)

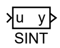
Output

y	Analog output of the block	Double (F64)

SINT – Simple integrator

Block Symbol

Licence: STANDARD



Function Description

The SINT block implements a discrete integrator described by the following difference equation

$$y_k = y_{k-1} + \frac{T_S}{2T_i}(u_k + u_{k-1}),$$

where T_S is the block execution period and T_i is the integral time constant. If $T_i = 0$, the block realize summation by following equation

$$y_k = y_{k-1} + u_k.$$

If $T_i < 0$, the block behaviour is undefined.

If y_k falls out of the saturation limits ymin and ymax, the output and state of the block are appropriately modified.

For more complex tasks, consider using the INTE block, which provides extended functionality.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)

Parameter

ti	Integral time constant	⊙1.0	Double (F64)
y0	Initial output value		Double (F64)
ymax	Upper limit of the output signal	⊙1.0	Double (F64)
ymin	Lower limit of the output signal	⊙-1.0	Double (F64)

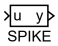
Output

y	Analog output of the block	Double (F64)

SPIKE – Spike filter

Block Symbol

Licence: ADVANCED



Function Description

The SPIKE block implements a nonlinear filter for suppressing isolated peaks (pulses) in the input signal u. One cycle of the SPIKE filter performs the following transformation $(u, y) \rightarrow y$:

```
delta := y - u;
if abs(delta) < gap
  then
     begin
        y := u;
        gap := gap/q;
        ifgap < mingap then gap:= mingap;
     end
  else
     begin
       if delta < 0
          then y := y + gap
          else y := y - gap;
       gap := gap * q;
     end
```

where mingap and q are the block parameters.

The signal passes through the filter unaffected for sufficiently large mingap parameter, which defines the minimal size of the tolerance window. By lowering this parameter it is possible to find an appropriate value, which leads to suppression of the undesirable peaks but leaves the input signal intact otherwise. The recommended value is 1 % of the overall input signal range. The q parameter determines the adaptation speed of the tolerance window.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Input signal to be filtered	Double (F64)

Parameter

`mingap`	Minimum size of the tolerance window	⊙0.01	`Double (F64)`
`q`	Tolerance window adaptation speed	↓1.0 ⊙2.0	`Double (F64)`

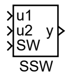
Output

`y`	Filtered output signal		`Double (F64)`

SSW – Simple switch

Block Symbol

Licence: STANDARD



Function Description

The SSW block selects one of two input signals u1 and u2 with respect to the binary input SW. The selected input is copied to the output y. If SW = off (SW = on), then the selected signal is u1 (u2).

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Any
u2	Second analog input of the block	Any
SW	Signal selector off . . . The u1 signal is selected on . . . . The u2 signal is selected	Bool

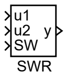
Output

y	Analog output of the block	Any

SWR – Selector with ramp

Block Symbol

Licence: STANDARD



Function Description

The SWR block selects one of two input signals u1 and u2 with respect to the binary input SW. The selected input is copied to the output y. If SW = off (SW = on), then the selected signal is u1 (u2). The output signal is not set immediately to the value of the selected input signal but tracks the selected input with given rate constraint (i.e. it follows a ramp). This rate constraint is configured independently for each input u1, u2 and is defined by time constants t1 and t2. As soon as the output reaches the level of the selected input signal, the rate limiter is disabled and remains inactive until the next signal switching.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	First analog input of the block	Double (F64)
u2	Second analog input of the block	Double (F64)
SW	Signal selector off . . . The u1 signal is selected on . . . . The u2 signal is selected	Bool

Parameter

t1	Rate limiter time constant, u2 –> u1	⊙1.0	Double (F64)
t2	Rate limiter time constant, u1 –> u2	⊙1.0	Double (F64)
y0	Initial output value		Double (F64)

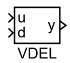
Output

y	Analog output of the block	Double (F64)

VDEL – Variable time delay

Block Symbol

Licence: STANDARD



Function Description

The VDEL block delays the input signal u by the time defined by the input signal d. More precisely, the delay is given by rounding the input signal d to the nearest integer multiple of the block execution period $(n \cdot T_S)$. A substitute value y0 is used until n previous samples are available after the block initialization.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block		Double (F64)
d	Time delay [s]		Double (F64)

Parameter

y0	Initial output value		Double (F64)
nmax	Allocated size of array	↓10 ↑10000000 ⊙1000	Long (I32)

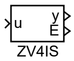
Output

y	Delayed input signal		Double (F64)

ZV4IS – Zero vibration input shaper

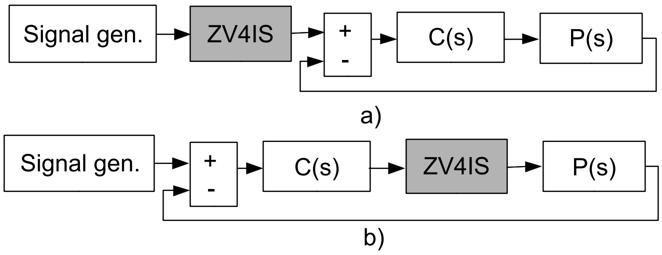
Block Symbol

Licence: ADVANCED



Function Description

The function block ZV4IS implements a band-stop frequency filter. The main field of application is in motion control of flexible systems where the low stiffness of mechanical construction causes an excitation of residual vibrations which can be observed in form of mechanical oscillations. Such vibration can cause significant deterioration of quality of control or even instability of control loops. They often lead to increased wear of mechanical components. Generally, the filter can be used in arbitrary application for a purpose of control of an oscillatory system or in signal processing for selective suppression of particular frequency.



The input shaping filter can be used in two different ways. By using an *open loop connection*, the input reference signal for an feedback loop coming from human operator or higher level of control structure is properly shaped in order to attenuate any unwanted oscillations. The internal dynamics of the filter does not influence a behaviour of the inferior loop. The only condition is correct tuning of feedback compensator $C(s)$, which has to work in linear mode. Otherwise, the frequency spectrum of the manipulating variable gets corrupted and unwanted oscillations can still be excited in a plant $P(s)$. The main disadvantage is passive vibration damping which works only in reference signal path. In case of any external disturbances acting on the plant, the vibrations may still arise. The second possible way of use is *feedback connection*. The input shaper is placed on the output side of feedback compensator $C(s)$ and modifies the manipulating variable acting on the plant. An additional dynamics of the filter is introduced and the compensator $C(s)$ needs to be properly tuned.

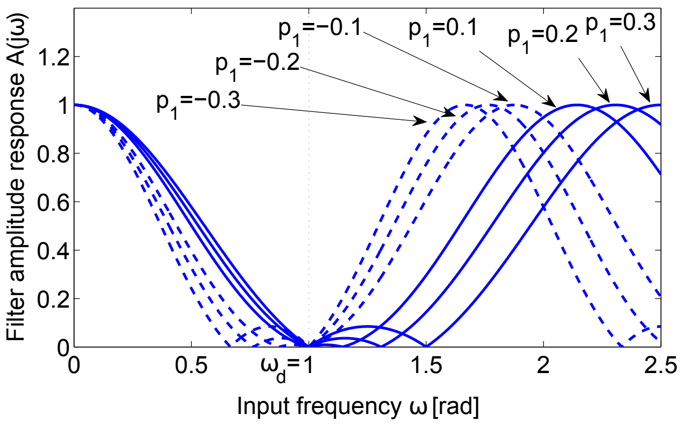
The algorithm of input shaper can be described in time domain

$$\mathtt{y}(t) = A_1\mathtt{u}(t-t_1) + A_2\mathtt{u}(t-t_2) + A_3\mathtt{u}(t-t_3) + A_4\mathtt{u}(t-t_4)$$

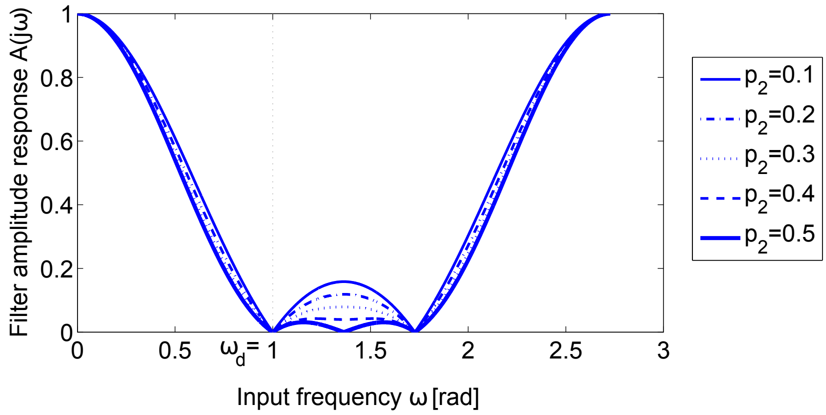
Thus, the filter has a structure of sum of weighted time delays of an input signal. The gains $A_1..A_4$ and time delay values $t_1..t_4$ depend on a choice of filter type, natural frequency and damping of controlled oscillatory mode of the system. The main advantage of this structure compared to commonly used notch filters is finite impulse response (which is especially important in motion control applications), warranted stability and monotone step response of the filter and generally lower dynamic delay introduced into a signal path.

For correct function of the filter, natural frequency `omega` and damping `xi` of the oscillatory mode need to be set. The parameter `ipar` sets a filter type. For `ipar` = `1`, one of ten basic filter types chosen by `istype` is used. Particular basic filters differ in shape and width of stop band in frequency domain. In case of precise knowledge of natural frequency and damping, the ZV (Zero Vibration) or ZVD filters can be used, because their response to input signal is faster compared to the other filters. In case of large uncertainty in system/signal model, robust UEI (Extra Insensitive) or UTHEI filters are good choice. Their advantage is wider stopband at the cost of slower response. The number on the end of the name has the meaning of maximum allowed level of excited vibrations for the given `omega` and `xi` (one, two or five percent).

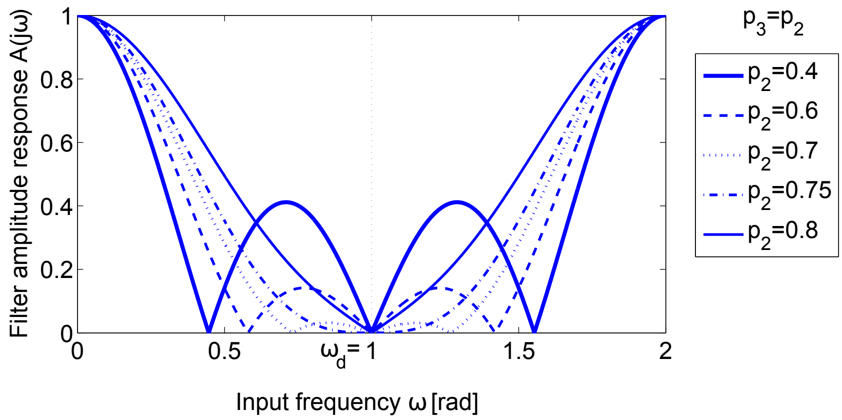
For precise tuning of the filter, complete parameterization `ipar` = `2` can be selected. For this choice, three parameters `p_alpha`,`p_a2` and `p_a3` which affect the shape of the filter frequency response can freely be assigned. These parameters can be used for finding of optimal compromise between robustness of the filter and introduced dynamical delay.



The asymmetry parameter `p_alpha` determines relative location of the stopband of filter frequency response with respect to chosen natural frequency. Positive values mean a shift to higher frequency range, negative values to lower frequency range, zero value leads to symmetrical shape of the characteristic (see the figure above). The parameter `p_alpha` also affects the overall filter length, thus the overall delay introduced into a signal path. Lower values result in slower filters and higher delay. Asymmetric filters can be used in cases where a lower or higher bound of the uncertainty in natural frequency parameter is known.



Insensitivity parameter p_a2 determines the width and attenuation level of the filter stopband. Higher values result in wider stopband and higher attenuation. For most applications, the value p_a2 $= 0.5$ is recommended for highest achievable robustness with respect to modeling errors.



The additional parameter p_a3 needs to be chosen for symmetrical filters (p_alpha $=$ 0). A rule for the most of the practical applications is to chose *equal values* p_a2 $=$ p_a3 from interval $< 0, 0.75 >$. Overall filter length is constant for this choice and only the shape of filter stopband is affected. Lower values lead to robust shapers with wide stopband and frequency response shape similar to standard THEI (Two-hump extra insensitive) filters. Higher values lead to narrow stopband and synchronous drop of two stopband peaks. The choice p_a2 $=$ p_a3 $= 0.75$ results in standard ZVDD filter with maximally flat and symmetric stopband shape. The proposed scheme can be used for systematic tuning of the filter.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Input signal to be filtered		Double (F64)

Parameter

omega	Natural frequency	⊙1.0	Double (F64)
xi	Relative damping coefficient		Double (F64)
ipar	Specification 1 ..... Basic types of IS 2 ..... Complete parametrization	⊙1	Long (I32)
istype	Type 1 ..... ZV 2 ..... ZVD 3 ..... ZVDD 4 ..... MISZV 5 ..... UEI1 6 ..... UEI2 7 ..... UEI5 8 ..... UTHEI1 9 ..... UTHEI2 10 .... UTHEI5	⊙2	Long (I32)
p_alpha	Shaper duration/assymetry parameter	⊙0.2	Double (F64)
p_a2	Insensitivity parameter	⊙0.5	Double (F64)
p_a3	Additional parameter (only for p_alpha=0)	⊙0.5	Double (F64)
nmax	Allocated size of array	↓10 ↑10000000 ⊙1000	Long (I32)

Output

y	Filtered output signal		Double (F64)
E	Error indicator off ... No error on .... An error occurred		Bool

Chapter 6

GEN – Signal generators

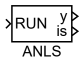
Contents

The GEN library is specialized in signal generation. It includes blocks like ANLS for generating a piecewise linear function of time or binary sequence generators BINS, BIS, BISR. The library also features MP for manual pulse signal generation, PRBS for pseudo-random binary sequence generation, and SG for periodic signals generation. This library provides essential tools for creating and manipulating various signal types.

ANLS – Controlled generator of piecewise linear function

Block Symbol

Licence: STANDARD



Function Description

The ANLS block generates a piecewise linear function of time given by nodes t1,y1; t2,y2; t3,y3; t4,y4. The initial value of output y is defined by the y0 parameter. The generation of the function starts when a rising edge occurs at the RUN input (and the internal timer is set to 0). The output y is then given by

$$y = y_i + \frac{y_{i+1} - y_i}{t_{i+1} - t_i}(t - t_i)$$

within the time intervals $\langle t_i, t_{i+1} \rangle, i = 0, \ldots, 3, t_0 = 0$.

To generate a step change in the output signal, it is necessary to to define two nodes in the same time instant (i.e. $t_i = t_{i+1}$). The generation ends when time t4 is reached or when time t_i is reached and the following node precedes the active one (i.e. $t_{i+1} < t_i$). The output holds its final value afterwards. But for the RPT parameter set to on, instead of holding the final value, the block returns to its initial state y0, the internal block timer is set to 0 and the sequence is generated repeatedly. This can be used to generate square or sawtooth functions. The generation can also be prematurely terminated by the RUN input signal set to off. In that case the block returns to its initial state y0, the internal block timer is set to 0 and is $= 0$ becomes the active time interval.

Input

RUN	Enable execution, run the analog sequence generation		Bool

Outputs

y	Analog output of the block		Double (F64)
is	Index of the active time interval		Long (I32)

Parameters

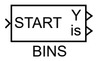
y0	Initial output value		Double (F64)
t1	Node 1 time	⊙1.0	Double (F64)
y1	Node 1 value		Double (F64)
t2	Node 2 time	⊙1.0	Double (F64)
y2	Node 2 value	⊙1.0	Double (F64)

t3	Node 3 time	⊙2.0	Double (F64)
y3	Node 3 value	⊙1.0	Double (F64)
t4	Node 4 time	⊙2.0	Double (F64)
y4	Node 4 value		Double (F64)
RPT	Repeating sequence off . . . Disabled on . . . . Enabled		Bool

BINS – Controlled binary sequence generator

Block Symbol

Licence: STANDARD



Function Description

The BINS block generates a binary sequence at the Y output, similarly to the BIS block. The binary sequence is given by the block parameters.

- The initial value of the output is given by the Y0 parameter.
- Whenever a rising edge (off→on) occurs at the START input (even when a binary sequence is being generated), the internal timer of the block is set to 0 and started.
- Whenever a rising edge occurs at the START input, the output Y is set to Y0.
- The output value is inverted at time instants t1, t2, ..., t8 (off→on, on→off).
- For RPT = off, the last switching of the output occurs at time t_i, where $t_{i+1} = 0$ and the output then holds its value until another rising edge (off→on) occurs at the START input.
- For RPT = on, instead of switching the output for the last time, the block returns to its initial state, the Y output is set to Y0, the internal block timer is set to 0 and started. As a result, the binary sequence is generated repeatedly.

On the contrary to the BIS block the changes in parameters t1...t8 are accepted only when a rising edge occurs at the START input.

The switching times are internally rounded to the nearest integer multiple of the execution period, which may result in e.g. disappearing of very thin pulses ($< T_S/2$) or melting successive thin pulses into one thick pulse. Therefore it is strongly recommended to use integer multiples of the execution period as the switching times.

Input

START	Starting signal (rising edge)	Bool

Outputs

Y	Logical output of the block	Bool
is	Index of the active time interval	Long (I32)

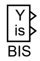
Parameters

`Y0`	Initial output value `off` ... Disabled/false `on` .... Enabled/true		`Bool`
`t1`	Switching time 1 [s]	↓0.0 ⊙1.0	`Double (F64)`
`t2`	Switching time 2 [s]	↓0.0 ⊙2.0	`Double (F64)`
`t3`	Switching time 3 [s]	↓0.0 ⊙3.0	`Double (F64)`
`t4`	Switching time 4 [s]	↓0.0 ⊙4.0	`Double (F64)`
`t5`	Switching time 5 [s]	↓0.0 ⊙5.0	`Double (F64)`
`t6`	Switching time 6 [s]	↓0.0 ⊙6.0	`Double (F64)`
`t7`	Switching time 7 [s]	↓0.0 ⊙7.0	`Double (F64)`
`t8`	Switching time 8 [s]	↓0.0 ⊙8.0	`Double (F64)`
`RPT`	Repeating sequence `off` ... Disabled `on` .... Enabled		`Bool`

BIS – Binary sequence generator

Block Symbol

Licence: STANDARD



Function Description

The BIS block generates a binary sequence at the Y output. The sequence is given by the block parameters.

- The initial value of the output is given by the Y0 parameter.
- The internal timer of the block is set to 0 when the block initializes.
- The internal timer of the block is immediately started when the block initializes.
- The output value is inverted at time instants t1, t2, ..., t8 (off→on, on→off).
- For RPT = off, the last switching of the output occurs at time t_i, where $t_{i+1} = 0$ and the output then holds its value indefinitely.
- For RPT = on, instead of switching the output for the last time, the block returns to its initial state, the Y output is set to Y0, the internal block timer is set to 0 and started. As a result, the binary sequence is generated repeatedly.

All the parameters t1...t8 can be changed in runtime and all changes are immediately accepted.

The switching times are internally rounded to the nearest integer multiple of the execution period, which may result in e.g. disappearing of very thin pulses ($< T_S/2$) or melting successive thin pulses into one thick pulse. Therefore it is strongly recommended to use integer multiples of the execution period as the switching times.

See also the BINS block, which allows for triggering the sequence by external signal.

Outputs

Y	Logical output of the block	Bool
is	Index of the active time interval	Long (I32)

Parameters

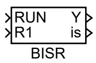
Y0	Initial output value off ... Disabled/false on .... Enabled/true		Bool
t1	Switching time 1 [s]	↓0.0 ⊙1.0	Double (F64)

t2	Switching time 2 [s]	↓0.0 ⊙2.0	Double (F64)
t3	Switching time 3 [s]	↓0.0 ⊙3.0	Double (F64)
t4	Switching time 4 [s]	↓0.0 ⊙4.0	Double (F64)
t5	Switching time 5 [s]	↓0.0 ⊙5.0	Double (F64)
t6	Switching time 6 [s]	↓0.0 ⊙6.0	Double (F64)
t7	Switching time 7 [s]	↓0.0 ⊙7.0	Double (F64)
t8	Switching time 8 [s]	↓0.0 ⊙8.0	Double (F64)
RPT	Repeating sequence off . . . Disabled on . . . . Enabled		Bool

BISR – Binary sequence generator with reset

Block Symbol

Licence: STANDARD



Function Description

The BISR block generates a binary sequence at the Y output. The RUN input must be set to on for the whole duration of the sequence. When RUN is off, the sequence is paused and so is the internal timer.

The binary sequence is given by the block parameters. The initial value of the output is given by the Y0 parameter. The output value Y is inverted (off→on, on→off) at time instants t1, t2, ..., t8. The ADDT parameter defines whether the t_i instants are relative to the first rising edge at the RUN input or relative to the last switching of the Y output.

If there is less than 8 edges in the desired binary sequence, set any of the t_i parameters to zero and the remaining ones will be ignored.

Whenever a rising edge occurs at the R1 input, the output Y is set to Y0 and the internal timer is reset. The R1 input overpowers the RUN input.

For RPT = off, the last switching of the output occurs at time t_i, where $t_{i+1} = 0$ and the output then holds its value until another rising edge (off→on) occurs at the START input. For RPT = on, instead of switching the output for the last time, the block returns to its initial state, the Y output is set to Y0, the internal block timer is set to 0 and started. As a result, the binary sequence is generated repeatedly.

The BISR block is an extended version of the BINS block.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

RUN	Enable execution	Bool
R1	Block reset	Bool

Parameter

Y0	Initial output value off ... Disabled/false on .... Enabled/true	Bool
ADDT	Additive timing off ... Absolute timing (sequence as a whole) on .... Additive timing (segment by segment)	Bool

RPT	Repeating sequence off ... Disabled on .... Enabled		Bool
t1	Switching time 1 [s]	↓0.0 ⊙1.0	Double (F64)
t2	Switching time 2 [s]	↓0.0 ⊙2.0	Double (F64)
t3	Switching time 3 [s]	↓0.0 ⊙3.0	Double (F64)
t4	Switching time 4 [s]	↓0.0 ⊙4.0	Double (F64)
t5	Switching time 5 [s]	↓0.0 ⊙5.0	Double (F64)
t6	Switching time 6 [s]	↓0.0 ⊙6.0	Double (F64)
t7	Switching time 7 [s]	↓0.0 ⊙7.0	Double (F64)
t8	Switching time 8 [s]	↓0.0 ⊙8.0	Double (F64)

Output

Y	Logical output of the block	Bool
is	Index of the active time interval	Long (I32)

MP – Manual pulse generator

Block Symbol

Licence: STANDARD

Function Description

The MP block generates a pulse of width pwidth when a rising edge occurs at the BSTATE parameter (off→on). The algorithm immediately reverts the BSTATE parameter back to off (BSTATE stands for a shortly pressed button). If repetition is enabled (RPTF = on), it is possible to extend the pulse by repeated setting the BSTATE parameter to on. When repetition is disabled, the parameter BSTATE is not taken into account during generation of a pulse, i.e. the output pulses have always the specified width of pwidth.

The MP block reacts only to rising edge of the BSTATE parameter, therefore it cannot be used for generating a pulse immediately at the start of the REXYGEN system executive. Use the BIS block for such a purpose.

Output

Y	Logical output of the block		Bool

Parameters

pwidth	Pulse width [s] (0 means one pulse)	⊙1.0	Double (F64)
BSTATE	Output pulse activation off . . . No action on . . . . Generate output pulse		Bool
RPTF	Allow pulse extension off . . . Disabled on . . . . Enabled		Bool

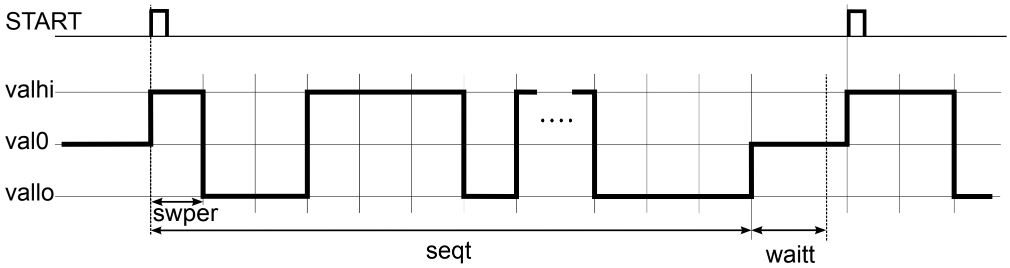
PRBS – **Pseudo-random binary sequence generator**

Block Symbol

Licence: STANDARD

Function Description

The PRBS block generates a pseudo-random binary sequence. The figure below displays how the sequence is generated.



The initial and final values of the sequence are val0. The sequence starts from this value when rising edge occurs at the START input (off→on), the output y is immediately switched to the valhi value. The generator then switches the output to the other limit value with the period of swper seconds and the probability of switching swprob. After seqt seconds the output is set back to val0. A waitt-second period follows to allow the settling of the controlled system response. Only then it is possible to start a new sequence. It is possible to terminate the sequence prematurely by the BRK = on input when necessary.

Inputs

START	Starting signal (rising edge)		Bool
BRK	Termination signal		Bool

Outputs

y	Generated pseudo-random binary sequence		Double (F64)
BSY	Busy flag		Bool

Parameters

val0	Initial and final value		Double (F64)
valhi	Upper level of the y output	⊙1.0	Double (F64)
vallo	Lower level of the y output	⊙-1.0	Double (F64)

`swper`	Period of random output switching [s]	⊙1.0	`Double (F64)`
`swprob`	Probability of switching	↓0.0 ↑1.0 ⊙0.2	`Double (F64)`
`seqt`	Length of the sequence [s]	⊙10.0	`Double (F64)`
`waitt`	Settling period [s]	⊙2.0	`Double (F64)`

SG, SGI – Signal generators

Block Symbols

Licence: STANDARD

Function Description

The SG and SGI blocks generate periodic signals of chosen type (isig parameter): sine wave, square, sawtooth and white noise with uniform distribution. The amplitude and frequency of the output signal y are given by the amp and freq parameter respectively. The output y can have a phase shift of phase $\in (0, 2\pi)$ in the deterministic signals (isig $\in \{1, 2, 3\}$).

The SGI block allows synchronization of multiple generators using the RUN and SYN inputs. The RUN parameter must be set to on to enable the generator, the SYN input synchronizes the generators during the output signal generation.

Inputs

RUN	Enable execution, run the binary sequence generation	Bool
SYN	Synchronization signal	Bool

Output

y	Analog output of the block	Double (F64)

Parameters

isig	Generated signal type 1 ..... Sine wave 2 ..... Symmetrical rectangular signal 3 ..... Sawtooth signal 4 ..... White noise with uniform distribution 5 ..... Triangular signal	⊙1	Long (I32)
amp	Amplitude of the generated signal	⊙1.0	Double (F64)
freq	Frequency of the generated signal	⊙1.0	Double (F64)
phase	Phase shift of the generated signal		Double (F64)
offset	Value added to the generated signal	⊙1.0	Double (F64)
ifrunit	Frequency units 1 ..... Hz 2 ..... rad/s	⊙1	Long (I32)

`iphunit`	Phase shift units `1` ..... degrees `2` ..... radians	⊙1	`Long (I32)`

Chapter 7

REG – Function blocks for control

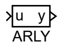
Contents

The control function blocks form the most extensive sub-library of the RexLib library. Blocks ranging from simple dynamic compensators to several modifications of PID (P, I, PI, PD a PID) controller and some advanced controllers are included. The blocks for control schemes switching and conversion of output signals for various types of actuators can be found in this sub-library. The involved controllers include the PIDGS block, enabling online switching of parameter sets (the so-called *gain scheduling*), the PIDMA block with built-in moment autotuner, the PIDAT block with built in relay autotuner, the FLCU fuzzy controller or the PSMPC predictive controller, etc.

ARLY – Advance relay

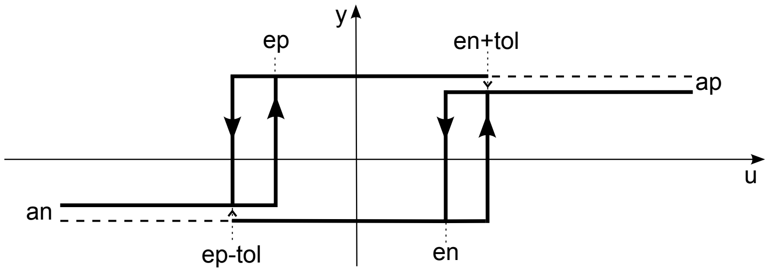
Block Symbol

Licence: STANDARD



Function Description

The ARLY block is a modification of the RLY block, which allows lowering the amplitude of steady state oscillations in relay feedback control loops. The block transforms the input signal u to the output signal y according to the diagram below.



Input

u	Analog input of the block		Double (F64)

Output

y	Analog output of the block		Double (F64)

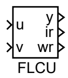
Parameters

ep	Value for switching the output to the "On" state	⊙-1.0	Double (F64)
en	Value for switching the output to the "Off" state	⊙1.0	Double (F64)
tol	Tolerance limit for the superposed noise of the input signal u	↓0.0 ⊙0.5	Double (F64)
ap	Value of the y output in the "On" state	⊙1.0	Double (F64)
an	Value of the y output in the "Off" state	⊙-1.0	Double (F64)
y0	Initial output value		Double (F64)

FLCU – Fuzzy logic controller unit

Block Symbol

Licence: ADVANCED



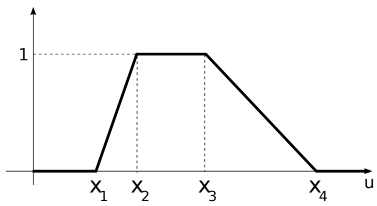
Function Description

The FLCU block implements a simple fuzzy logic controller with two inputs and one output. Introduction to fuzzy logic problems can be found in [3].

The output is defined by trapezoidal membership functions of linguistic terms of the u and v inputs, impulse membership functions of linguistic terms of the y output and inference rules in the form

$$\text{If } (\mathtt{u} \text{ is } U_i) \text{ AND } (\mathtt{v} \text{ is } V_j), \text{ then } (\mathtt{y} \text{ is } Y_k),$$

where $U_i, i = 1, \ldots, \mathtt{nu}$ are the linguistic terms of the u input; $V_j, j = 1, \ldots, \mathtt{nv}$ are the linguistic terms of the v input and $Y_k, k = 1, \ldots, \mathtt{ny}$ are the linguistic terms of the y output. Trapezoidal (triangular) membership functions of the u and v inputs are defined by four numbers as depicted below.



Not all numbers $x_1, \ldots, x_4$ are mutually different in triangular functions. The matrices of membership functions of the u and v input are composed of rows $[x_1, x_2, x_3, x_4]$. The dimensions of matrices mfu and mfv are $(\mathtt{nu} \times 4)$ and $(\mathtt{nv} \times 4)$ respectively.

The impulse 1st order membership functions of the y output are defined by the triplet

$$\mathtt{y}_k,\ a_k,\ b_k,$$

where $\mathtt{y}_k$ is the value assigned to the linguistic term $Y_k, k = 1, \ldots, \mathtt{ny}$ in the case of $a_k = b_k = 0$. If $a_k \neq 0$ and $b_k \neq 0$, then the term Y_k is assigned the value of $\mathtt{y}_k + a_k \mathtt{u} + b_k \mathtt{v}$. The output membership function matrix sty has a dimension of $(\mathtt{ny} \times 3)$ and contains the rows $[\mathtt{y}_k, a_k, b_k], k = 1, \ldots, \mathtt{ny}$.

The set of inference rules is also a matrix whose rows are $[i_l, j_l, k_l, w_l], l = 1, \ldots, \mathtt{nr}$, where i_l, j_l and k_l defines a particular linguistic term of the u and v inputs and y output respectively. The number w_l defines the weight of the rule in percents $w_l \in \{0, 1, \ldots, 100\}$. It is possible to suppress or emphasize a particular inference rule if necessary.

Inputs

`u`	First analog input of the block	`Double (F64)`
`v`	Second analog input of the block	`Double (F64)`

Outputs

`y`	Analog output of the block	`Double (F64)`
`ir`	Dominant rule	`Long (I32)`
`wr`	Degree of truth of the dominant rule	`Double (F64)`

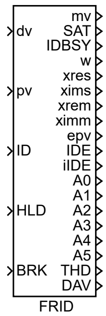
Parameters

`umax`	Upper limit of the `u` input	⊙`1.0`	`Double (F64)`
`umin`	Lower limit of the `u` input	⊙`-1.0`	`Double (F64)`
`vmax`	Upper limit of the `v` input	⊙`1.0`	`Double (F64)`
`vmin`	Lower limit of the `v` input	⊙`-1.0`	`Double (F64)`
`nmax`	Number of reserved (allocated) membership functions (for each inputs and output)	↓4 ↑10000 ⊙10	`Long (I32)`
`mfu`	Matrix of membership functions of the input `u`	⊙`[-1 -1 -1 0; -1 0 0 1; 0 1 1 1]`	`Double (F64)`
`mfv`	Matrix of membership functions of the input `v`	⊙`[-1 -1 -1 0; -1 0 0 1; 0 1 1 1]`	`Double (F64)`
`sty`	Matrix of membership functions of the output `y`	⊙`[-1 0 0; 0 0 0; 1 0 0]`	`Double (F64)`
`rls`	Matrix of inference rules	⊙`[1 2 3 100; 1 1 1 100; 1 0 3 100]`	`Byte (U8)`

FRID – * **Frequency response identification**

Block Symbol

Licence: ADVANCED



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

dv	Feedforward control variable	Double (F64)
pv	Process variable	Double (F64)
ID	Start the tuning experiment	Bool
HLD	Hold	Bool
BRK	Stop the tuning experiment	Bool

Parameters

ubias	Static component of the exciting signal		Double (F64)
uamp	Amplitude of the exciting signal	⊙1.0	Double (F64)
wb	Frequency interval lower limit [rad/s]	⊙1.0	Double (F64)
wf	Frequency interval higher limit [rad/s]	⊙10.0	Double (F64)
isweep	Frequency sweeping mode 1 ..... Logarithmic 2 ..... Linear	⊙1	Long (I32)
cp	Sweeping Rate	⊙0.995	Double (F64)
iavg	Number of values for averaging	⊙10	Long (I32)
obw	Observer bandwith 1 ..... LOW 2 ..... NORMAL 3 ..... HIGH	⊙2	Long (I32)
stime	Settling period [s]	⊙10.0	Double (F64)

`umax`	Maximum generator amplitude	$\odot$1.0	Double (F64)
`thdmin`	Minimum demanded THD treshold	$\odot$0.1	Double (F64)
`adapt_rc`	Maximum rate of amplitude variation	$\odot$0.001	Double (F64)
`pv_max`	Maximum desired process value	$\odot$1.0	Double (F64)
`pv_sat`	Maximum allowed process value	$\odot$2.0	Double (F64)
`ADAPT_EN`	Enable automatic amplitude adaptation	$\odot$on	Bool
`immode`	Mesurement mode 1 ..... Manual specification of frequency points 2 ..... Linear series of nmw points in the interval <wb;wf> 3 ..... Logarithmic series of nmw points in the interval <wb;wf> 4 ..... Automatic detection of important frequencies (N/A)	$\odot$1	Long (I32)
`nwm`	Number of frequency response point for automatic mode		Long (I32)
`wm`	Frequency measurement points for manual meas. mode [array of rad/s]	$\odot$[2.0 4.0 6.0 8.0]	Double (F64)

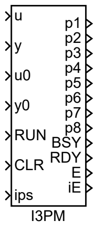
Outputs

`mv`	Manipulated variable (controller output)	Double (F64)
`SAT`	Saturation flag	Bool
`IDBSY`	Tuner busy flag	Bool
`w`	Actual frequency [rad/s]	Double (F64)
`xres`	real part of frequency response (sweeping)	Double (F64)
`xims`	imaginary part of frequency response (sweeping)	Double (F64)
`xrem`	real part of frequency response (measurement)	Double (F64)
`ximm`	imaginary part of frequency response (measurement)	Double (F64)
`epv`	Estimated process value	Double (F64)
`IDE`	Error indicator	Bool
`iIDE`	Error code	Long (I32)
`A0`	Estimated DC value	Double (F64)
`A1`	Estimated 1st harmonics amlitude	Double (F64)
`A2`	Estimated 2nd harmonics amlitude	Double (F64)
`A3`	Estimated 3rd harmonics amlitude	Double (F64)
`A4`	Estimated 4th harmonics amlitude	Double (F64)
`A5`	Estimated 5th harmonics amlitude	Double (F64)
`THD`	Total harmonic distorsion	Double (F64)
`DAV`	Data Valid	Bool

I3PM – Identification of a three parameter model

Block Symbol

Licence: ADVANCED



Function Description

The I3PM block is based on the generalized moment identification method. It provides a three parameter model of the system.

Inputs

u	Input of the identified system	Double (F64)
y	Output of the identified system	Double (F64)
u0	Input steady state	Double (F64)
y0	Output steady state	Double (F64)
RUN	Execute identification	Bool
CLR	Block reset	Bool
ips	Meaning of the output signals	Long (I32)

- 0 ..... FOPDT model
  - p1 ... gain
  - p2 ... time delay
  - p3 ... time constant
- 1 ..... moments of input and output
  - p1 ... parameter $mu0$
  - p2 ... parameter $mu1$
  - p3 ... parameter $mu2$
  - p4 ... parameter $my0$
  - p5 ... parameter $my1$
  - p6 ... parameter $my2$
- 2 ..... process moments
  - p1 ... parameter $mp0$
  - p2 ... parameter $mp1$
  - p3 ... parameter $mp2$
- 3 ..... characteristic numbers
  - p1 ... parameter κ
  - p2 ... parameter μ
  - p3 ... parameter σ^2
  - p4 ... parameter σ

Outputs

`p`i	Identified parameters with respect to `ips`, $i = 1, \ldots, 8$		`Double (F64)`
`BSY`	Busy flag		`Bool`
`RDY`	Ready flag		`Bool`
`E`	Error flag		`Bool`
`iE`	Error code `1` ..... Premature termination (`RUN` = `off`) `2` ..... `mu0` $= 0$ `3` ..... `mp0` $= 0$ `4` ..... $\sigma^2 < 0$		`Long (I32)`

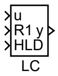
Parameters

`tident`	Duration of identification [s]	⊙`100.0`	`Double (F64)`
`irtype`	Controller type (control law) `1` ..... D `3` ..... ID `5` ..... PD `7` ..... PID `2` ..... I `4` ..... P `6` ..... PI	⊙`6`	`Long (I32)`
`ispeed`	Desired closed loop speed `1` ..... Slow closed loop `2` ..... Normal (middle fast) closed loop `3` ..... Fast closed loop	⊙`2`	`Long (I32)`

LC – Lead compensator

Block Symbol

Licence: STANDARD



Function Description

The LC block is a discrete simulator of derivative element

$$C(s) = \frac{\mathtt{td} * s}{\frac{\mathtt{td}}{\mathtt{nd}} * s + 1},$$

where td is the derivative constant and nd determines the influence of parasite 1st order filter. It is recommended to use $2 \leq \mathtt{nd} \leq 10$. If ISSF = on, then the state of the parasite filter is set to the steady value at the block initialization according to the input signal u.

The exact discretization at the sampling instants is used for discretization of the $C(s)$ transfer function.

Input

u	Analog input of the block	Double (F64)
R1	Block reset (same state as after init)	Bool
HLD	Hold block execution	Bool

Output

y	Analog output of the block	Double (F64)

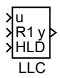
Parameters

td	Derivative time constant	⊙1.0	Double (F64)
nd	Derivative filtering parameter	⊙10.0	Double (F64)
ISSF	Steady state at start-up off . . . Zero initial state on . . . . Initial steady state		Bool

LLC – Lead-lag compensator

Block Symbol

Licence: STANDARD



Function Description

The LLC block is a discrete simulator of integral-derivative element

$$C(s) = \frac{\mathtt{a} * \mathtt{tau} * s + 1}{\mathtt{tau} * s + 1},$$

where tau is the denominator time constant and the time constant of numerator is an a-multiple of tau ($\mathtt{a} * \mathtt{tau}$). If $\mathtt{ISSF} = \mathtt{on}$, then the state of the filter is set to the steady value at the block initialization according to the input signal u.

The exact discretization at the sampling instants is used for discretization of the $C(s)$ transfer function. The sampling period used for discretization is equivalent to the execution period of the LLC block.

Input

u	Analog input of the block	Double (F64)
R1	Block reset (same state as after init)	Bool
HLD	Hold block execution	Bool

Output

y	Analog output of the block	Double (F64)

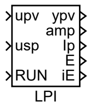
Parameters

tau	Time constant	⊙1.0	Double (F64)
a	Numerator time constant coefficient		Double (F64)
ISSF	Steady state at start-up off . . . Zero initial state on . . . . Initial steady state		Bool

LPI – **Loop performance index**

Block Symbol

Licence: ADVANCED



Function Description

The LPI (*L*oop *P*erformance *I*ndex) functional block is designed to evaluate the quality of feedback control by influencing the signal value before it is fed into the controller and measures the system's response. This block is useful for analyzing and identifying the behavior of the control loop in real-time.

The process variable `pv` of the control loop is connected to the `upv` input and from the `ypv` output to the controller. The setpoint `sp` of the control loop is fed to the `usp` input. The block is activated by the `RUN` signal only in the automatic mode of the controller when it is desired to perform identification of the control loop.

Upon activation (`RUN`=1), the LPI block injects a sinusoidal signal into the process variable with a defined amplitude `ad` and frequency `fd`, allowing the measurement of the system's response. The output signal is further processed by a BandPass filter and Fourier transform to determine the average signal amplitude. The resulting performance index `Ip` is calculated based on the ratio between the set parameters and the measured amplitude, providing a quantitative evaluation of the control system's disturbance suppression.

The output `Ip` reflects how effectively the control system suppresses disturbances in the defined frequency band `fa`. A value of `Ip`=1 indicates that the system suppresses disturbances in accordance with expectations; values higher than 1 indicate better performance; lower values indicate poorer control loop settings.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`upv`	Input process variable	Double (F64)
`usp`	Input setpoint variable	Double (F64)
`RUN`	Enable execution	Bool

Parameter

`ms`	Sensitivity function upper limit	↓1.00001 ↑1000.0 ⊙2.0	Double (F64)
`fa`	Available bandwidth	↓1e-10 ↑1e+10 ⊙10.0	Double (F64)
`fd`	Excitation/measured frequency	↓1e-10 ↑1e+10 ⊙1.0	Double (F64)

`ad`	Excitation amplitude	⊙0.01	`Double (F64)`
`nper`	Window size (number of periods of fd)	↓1 ⊙4	`Long (I32)`
`ifrunit`	Frequency units 1 ..... Hz 2 ..... rad/s	⊙1	`Long (I32)`
`xi`	Filter damping ratio	↓0.001 ↑100.0 ⊙1.0	`Double (F64)`
`nmax`	Allocated size of array	↓10 ↑10000000 ⊙256	`Long (I32)`

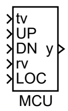
Output

`ypv`	Output process variable	`Double (F64)`
`amp`	Signal amplitude after filtering	`Double (F64)`
`Ip`	Control loop performance index	`Double (F64)`
`E`	Error indicator	`Bool`
`iE`	Error code	`Error`

MCU – Manual control unit

Block Symbol

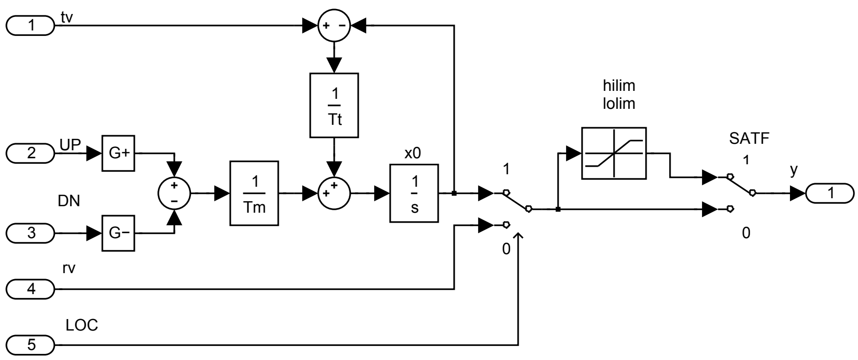
Licence: STANDARD



Function Description

The MCU block is suitable for manual setting of the numerical output value y, e.g. a setpoint. In the local mode (LOC = on) the value is set using the buttons UP and DN. The rate of increasing/decreasing of the output y from the initial value y0 is determined by the integration time constant tm and pushing time of the buttons. After elapsing ta seconds while a button is pushed, the rate is always multiplied by the factor q until the time tf is elapsed. Optionally, the output y range can be constrained (SATF = on) by saturation limits lolim and hilim. If none of the buttons is pushed (UP = off and DN = off), the output y tracks the input value tv. The tracking speed is controlled by the integration time constant tt.

In the remote mode (LOC = off), the input rv is optionally saturated (SATF = on) and copied to the output y. The detailed function of the block is depicted in the following diagram.



Inputs

tv	Tracking variable	Double (F64)
UP	The "up" signal	Bool
DN	The "down" signal	Bool
rv	Remote output value in the mode LOC = off	Double (F64)
LOC	Local or remote mode	Bool

Output

`y`	Analog output of the block		`Double (F64)`

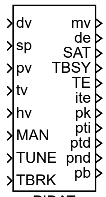
Parameters

`tt`	Tracking time constant of the input `tv`	⊙1.0	`Double (F64)`
`tm`	Initial value of integration time constant	⊙100.0	`Double (F64)`
`y0`	Initial output value		`Double (F64)`
`q`	Multiplication quotient	⊙5.0	`Double (F64)`
`ta`	Interval after which the rate is changed [s]	⊙4.0	`Double (F64)`
`tf`	Interval after which the rate changes no more [s]	⊙8.0	`Double (F64)`
`SATF`	Saturation flag `off` ... Signal not limited `on` .... Saturation limits active		`Bool`
`hilim`	Upper limit of the output signal	⊙1.0	`Double (F64)`
`lolim`	Lower limit of the output signal	⊙-1.0	`Double (F64)`

PIDAT – PID controller with relay autotuner

Block Symbol

Licence: AUTOTUNING



Function Description

The PIDAT block has the same control function as the PIDU block. Additionally it is equipped with the relay autotuning function.

In order to perform the autotuning experiment, it is necessary to drive the system to approximately steady state (at a suitable working point), choose the type of controller to be autotuned (PI or PID) and activate the TUNE input by setting it to on. The controlled process is regulated by special adaptive relay controller in the experiment which follows. One point of frequency response is estimated from the data measured during the experiment. Based on this information the controller parameters are computed. The amplitude of the relay controller (the level of system excitation) and its hysteresis is defined by the amp and hys parameters. In case of hys=0 the hysteresis is determined automatically according to the measurement noise properties on the controlled variable signal. The signal TBSY is set to onduring the tuning experiment. A successful experiment is indicated by and the controller parameters can be found on the outputs pk, pti, ptd, pnd and pb. The c weighting factor is assumed (and recommended) c=0. A failure during the experiment causes TE = on and the output ite provides further information about the problem. It is recommended to increase the amplitude amp in the case of error. The controller is equipped with a built-in function which decreases the amplitude when the deviation of output from the initial steady state exceeds the maxdev limit. The tuning experiment can be prematurely terminated by activating the TBRK input.

Inputs

dv	Feedforward control variable	Double (F64)
sp	Setpoint variable	Double (F64)
pv	Process variable	Double (F64)
tv	Tracking variable	Double (F64)
hv	Manual value	Double (F64)
MAN	Manual or automatic mode off . . . Automatic mode on . . . . Manual mode	Bool

`TUNE`	Start the tuning experiment	`Bool`
`TBRK`	Stop the tuning experiment	`Bool`

Outputs

`mv`	Manipulated variable (controller output)	`Double (F64)`
`de`	Deviation error	`Double (F64)`
`SAT`	Saturation flag `off` ... The controller implements a linear control law `on` .... The controller output is saturated	`Bool`
`TBSY`	Tuner busy flag	`Bool`
`TE`	Tuning error `off` ... Autotuning successful `on` .... An error occurred during the experiment	`Bool`
`ite`	Error code; expected time (in seconds) to finishing the tuning experiment while the tuning experiment is active `1000` .. Signal/noise ratio too low `1001` .. Hysteresis too high `1002` .. Too tight termination rule `1003` .. Phase out of interval	`Long (I32)`
`pk`	Proposed controller gain	`Double (F64)`
`pti`	Proposed integral time constant	`Double (F64)`
`ptd`	Proposed derivative time constant	`Double (F64)`
`pnd`	Proposed derivative component filtering	`Double (F64)`
`pb`	Proposed weighting factor – proportional component	`Double (F64)`

Parameters

`irtype`	Controller type (control law) ⊙6 `1` ..... D `4` ..... P `7` ..... PID `2` ..... I `5` ..... PD `3` ..... ID `6` ..... PI	`Long (I32)`

`RACT`	Reverse action flag
	`off` ... Higher `mv` → higher `pv`
	`on` .... Higher `mv` → lower `pv`
		`Bool`

`k`	Controller gain K. By definition, the value 0 turns the controller off. Negative values are not allowed, use the `RACT` parameter for such a purpose. ↓`0.0` ⊙`1.0`	`Double (F64)`
`ti`	Integral time constant T_i. The value 0 disables the integrating part (the same effect as disabling it by the `irtype` parameter). ↓`0.0` ⊙`4.0`	`Double (F64)`
`td`	Derivative time constant T_d. The value 0 disables the derivative part (the same effect as disabling it by the `irtype` parameter). ↓`0.0` ⊙`1.0`	`Double (F64)`
`nd`	Derivative filtering parameter N. The value 0 disables the derivative part (the same effect as disabling it by the `irtype` parameter). ↓`0.0` ⊙`10.0`	`Double (F64)`

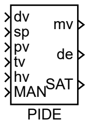
`b`	Setpoint weighting – proportional part	↓0.0 ⊙1.0	`Double (F64)`
`c`	Setpoint weighting – derivative part	↓0.0	`Double (F64)`
`tt`	Tracking time constant.	↓0.0 ⊙1.0	`Double (F64)`
`hilim`	Upper limit of the controller output	⊙1.0	`Double (F64)`
`lolim`	Lower limit of the controller output	⊙-1.0	`Double (F64)`
`iainf`	Type of apriori information `1` ..... No apriori information `2` ..... Astatic process (process with integration) `3` ..... Low order process `4` ..... Static process + slow closed loop step response `5` ..... Static process + middle fast (normal) closed loop step response `6` ..... Static process + fast closed loop step response	⊙1	`Long (I32)`
`k0`	Static gain of the process (must be provided in case of `iainf` = `3,4,5`)	⊙1.0	`Double (F64)`
`n1`	Maximum number of half-periods for estimation of frequency response point	⊙20	`Long (I32)`
`mm`	Maximum number of half-periods for averaging	⊙4	`Long (I32)`
`amp`	Relay controller amplitude	⊙0.1	`Double (F64)`
`uhys`	Relay controller hysteresis		`Double (F64)`
`ntime`	Length of noise amplitude estimation period at the beginning of the tuning experiment [s]	⊙5.0	`Double (F64)`
`rerrap`	Termination value of the oscillation amplitude relative error	⊙0.1	`Double (F64)`
`aerrph`	Termination value of the absolute error in oscillation phase	⊙10.0	`Double (F64)`
`maxdev`	Maximal admissible deviation error from the initial steady state	⊙1.0	`Double (F64)`

It is recommended not to change the parameters `n1`, `mm`, `ntime`, `rerrap` and `aerrph`.

PIDE – PID controller with defined static error

Block Symbol

Licence: ADVANCED



Function Description

The PIDE block is a basis for creating a modified PI(D) controller which differs from the standard PI(D) controller (the PIDU block) by having a finite static gain (in fact, the value ε which causes the saturation of the output is entered). In the simplest case it can work autonomously and provide the standard functionality of the modified PID controller with two degrees of freedom in the automatic (MAN = off) or manual mode (MAN = on).

If in automatic mode and if the saturation limits are not active, the controller implements a linear control law given by

$$U(s) = \pm K \left[bW(s) - Y(s) + \frac{1}{T_i s + \beta} E(s) + \frac{T_d s}{\frac{T_d s}{N} + 1} (cW(s) - Y(s)) \right] + Z(s),$$

where

$$\beta = \frac{K\varepsilon}{1 - K\varepsilon}$$

$U(s)$ is the Laplace transform of the manipulated variable mv, $W(s)$ is the Laplace transform of the setpoint sp, $Y(s)$ is the Laplace transform of the process variable pv, $E(s)$ is the Laplace transform of the deviation error, $Z(s)$ is the Laplace transform of the feedforward control variable dv and K, T_i, T_d, N, ε $(= b_p/100)$, b and c are the controller parameters. The sign of the right hand side depends on the parameter RACT. The range of the manipulated variable mv (position controller output) is limited by parameters hilim, lolim.

By connecting the output mv of the controller to the controller input tv and properly setting the tracking time constant tt we obtain the bumpless operation of the controller in the case of the mode switching (manual, automatic) and also the correct operation of the controller when saturation of the output mv occurs (antiwindup).

In the manual mode (MAN = on), the input hv is copied to the output mv unless saturated. In this mode the inner controller state tracks the signal connected to the tv input so the successive switching to the automatic mode is bumpless. But the tracking is not precise for $\varepsilon > 0$.

Inputs

`dv`	Feedforward control variable		`Double (F64)`
`sp`	Setpoint variable		`Double (F64)`
`pv`	Process variable		`Double (F64)`
`tv`	Tracking variable		`Double (F64)`
`hv`	Manual value		`Double (F64)`
`MAN`	Manual or automatic mode `off` ... Automatic mode `on` .... Manual mode		`Bool`

Outputs

`mv`	Manipulated variable (controller output)		`Double (F64)`
`de`	Deviation error		`Double (F64)`
`SAT`	Saturation flag `off` ... The controller implements a linear control law `on` .... The controller output is saturated		`Bool`

Parameters

`irtype`	Controller type (control law) `1` ..... D `4` ..... P `7` ..... PID `2` ..... I `5` ..... PD `3` ..... ID `6` ..... PI	⊙6	`Long (I32)`

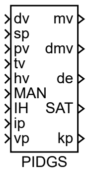
`RACT`	Reverse action flag
	`off` ... Higher `mv` → higher `pv`
	`on` .... Higher `mv` → lower `pv`
			`Bool`

`k`	Controller gain K	↓0.0 ⊙1.0	`Double (F64)`
`ti`	Integral time constant T_i	↓0.0 ⊙4.0	`Double (F64)`
`td`	Derivative time constant T_d	↓0.0 ⊙1.0	`Double (F64)`
`nd`	Derivative filtering parameter N	↓0.0 ⊙10.0	`Double (F64)`
`b`	Setpoint weighting – proportional part	↓0.0 ⊙1.0	`Double (F64)`
`c`	Setpoint weighting – derivative part	↓0.0	`Double (F64)`
`tt`	Tracking time constant. No meaning for controllers without integrator.	↓0.0 ⊙1.0	`Double (F64)`
`bp`	Static error coefficient		`Double (F64)`
`hilim`	Upper limit of the controller output	⊙1.0	`Double (F64)`
`lolim`	Lower limit of the controller output	⊙-1.0	`Double (F64)`

PIDGS – PID controller with gain scheduling

Block Symbol

Licence: ADVANCED



Function Description

The functionality of the PIDGS block is completely equivalent to the PIDU block. The only difference is that the PIDGS block has a at most six sets of basic PID controller parameters and allow bumpless switching of these sets by the ip (parameter set index) or vp inputs. In the latter case it is necessary to set GSCF = on and provide an array of threshold values thsha. The following rules define the active parameter set: the set 0 is active for vp $<$ thrsha(0), the set 1 for thrsha$(0) <$ vp $<$ thrsha(1) etc. till the set 5 for thrsha$(4) <$ vp. The index of the active parameter set is available at the kp output.

Inputs

dv	Feedforward control variable		Double (F64)
sp	Setpoint variable		Double (F64)
pv	Process variable		Double (F64)
tv	Tracking variable		Double (F64)
hv	Manual value		Double (F64)
MAN	Manual or automatic mode off . . . Automatic mode on . . . . Manual mode		Bool
IH	Integrator hold off . . . Integration enabled on . . . . Integration disabled		Bool
ip	Parameter set index	↓0 ↑5	Long (I32)
vp	Switching analog signal		Double (F64)

Outputs

mv	Manipulated variable (controller output)	Double (F64)
dmv	Controller velocity output (difference)	Double (F64)
de	Deviation error	Double (F64)
SAT	Saturation flag off . . . The controller implements a linear control law on . . . . The controller output is saturated	Bool

`kp`	Active parameter set index		`Long (I32)`

Parameters

`hilim`	Upper limit of the controller output	⊙1.0	`Double (F64)`
`lolim`	Lower limit of the controller output	⊙-1.0	`Double (F64)`
`dz`	Dead zone		`Double (F64)`
`icotype`	Controller output type `1` ..... Analog output `2` ..... Pulse width modulation (`PWM`) `3` ..... Step controller unit with position feedback (`SCU`) `4` ..... Step controller unit without position feedback (`SCUV`)	⊙1	`Long (I32)`
`nmax`	Reserved number of controller parameter sets	↓4 ↑10000 ⊙10	`Long (I32)`
`GSCF`	Switch parameters by analog signal `vp` `off` ... Index-based switching `on` .... Analog signal based switching		`Bool`
`hys`	Hysteresis for controller parameters switching		`Double (F64)`
`irtypea`	Vector of controller types (control laws) `1` ..... D `4` ..... P `7` ..... PID `2` ..... I `5` ..... PD `3` ..... ID `6` ..... PI	⊙`[6 6 6 6 6 6]`	`Byte (U8)`

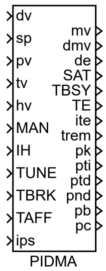
`RACTA`	Vector of reverse action flags
	`0` ..... Higher `mv` → higher `pv`
	`1` ..... Higher `mv` → lower `pv`
		⊙`[0 0 0 0 0 0]`	`Bool`

`ka`	Vector of controller gains K	⊙`[1.0 1.0 1.0 1.0 1.0 1.0]`	`Double (F64)`
`tia`	Vector of integral time constants T_i	⊙`[4.0 4.0 4.0 4.0 4.0 4.0]`	`Double (F64)`
`tda`	Vector of derivative time constants T_d	⊙`[1.0 1.0 1.0 1.0 1.0 1.0]`	`Double (F64)`
`nda`	Vector of derivative filtering parameters N	⊙`[10.0 10.0 10.0 10.0 10.0 10.0]`	`Double (F64)`
`ba`	Setpoint weighting factors – proportional part	⊙`[1.0 1.0 1.0 1.0 1.0 1.0]`	`Double (F64)`
`ca`	Setpoint weighting factors – derivative part	⊙`[0.0 0.0 0.0 0.0 0.0 0.0]`	`Double (F64)`
`tta`	Vector of tracking time constants	⊙`[1.0 1.0 1.0 1.0 1.0 1.0]`	`Double (F64)`
`thrsha`	Vector of thresholds for switching the parameters	⊙`[0.1 0.2 0.3 0.4 0.5 0]`	`Double (F64)`

PIDMA – PID controller with moment autotuner

Block Symbol

Licence: AUTOTUNING



Function Description

The PIDMA block has the same control function as the PIDU block. Additionally it is equipped with the moment autotuning function.

In the automatic mode (MAN = off), the block PIDMA implements the PID control law with two degrees of freedom in the form

$$U(s) = \pm K \left\{ bW(s) - Y(s) + \frac{1}{T_i s} [W(s) - Y(s)] + \frac{T_d s}{\frac{T_d}{N} s + 1} [cW(s) - Y(s)] \right\} + Z(s)$$

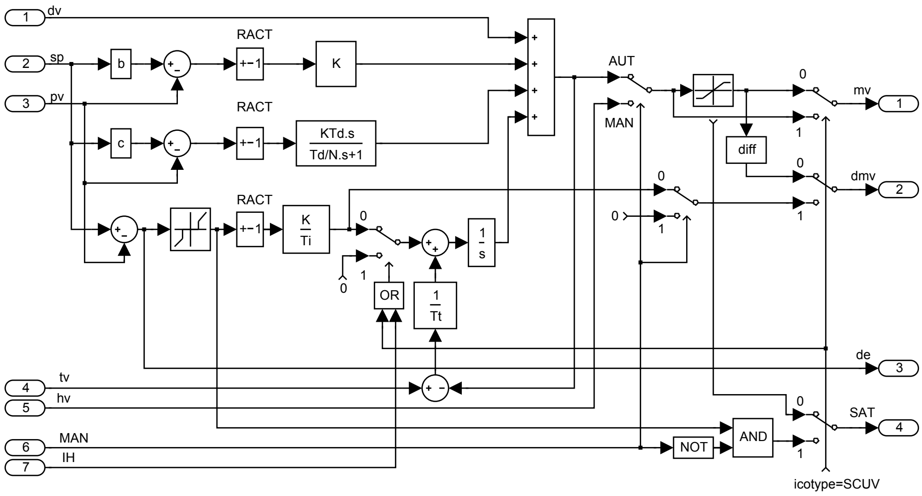
where $U(s)$ is Laplace transform of the manipulated variable mv, $W(s)$ is Laplace transform of the setpoint variable sp, $Y(s)$ is Laplace transform of the process variable pv, $Z(s)$ is Laplace transform of the feedforward control variable dv and K, T_i, T_d, N, b and c are the parameters of the controller. The sign of the right hand side depends on the parameter RACT. The range of the manipulated variable mv (position controller output) is limited by parameters hilim, lolim. The parameter dz determines the dead zone in the integral part of the controller. The integral part of the control law can be switched off and fixed on the current value by the integrator hold input IH = on. For the proper function of the controller it is necessary to connect the output mv of the controller to the controller input tv and properly set the tracking time constant tt.

The rule of thumb for a PID controller is tt $\approx \sqrt{T_i T_d}$. For a PI controller the formula is tt $\approx T_i/2$. In this way we obtain the bumpless operation of the controller in the case of the mode switching (manual, automatic) and also the correct operation of the controller when saturation of the output mv occurs (antiwindup).

The additional outputs dmv, de and SAT generate the velocity output (difference of mv), deviation error and saturation flag, respectively.

If the PIDMA block is connected with the block SCUV to configure the 3-point step controller without the positional feedback, then the parameter icotype must be set to 4 and the meaning of the outputs mv and dmv and SAT is modified in the following way: mv and `dmv` give the PD part and difference of I part of the control law, respectively, and `SAT` provides the information for the `SCUV` block whether the deviation error is less than the dead zone `dz` in the automatic mode. In this case, the setpoint weighting factor `c` should be zero.

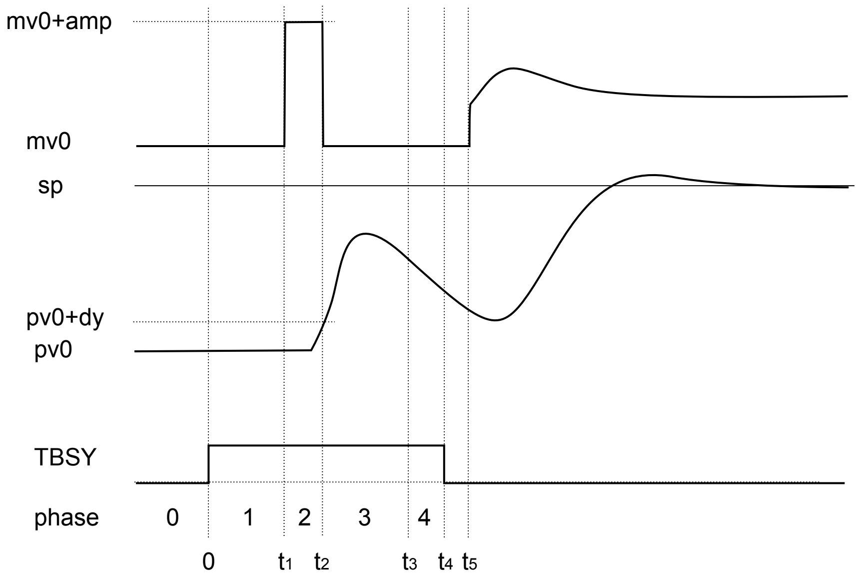
In the manual mode (`MAN` = `on`), the input `hv` is copied to the output `mv` unless saturated. The overall control function of the `PIDMA` block is quite clear from the following diagram:



The block `PIDMA` extends the control function of the standard PID controller by the built in autotuning feature. Before start of the autotuner the operator have to reach the steady state of the process at a suitable working point (in manual or automatic mode) and specify the required type of the controller `ittype` (`PI` or `PID`) and other tuning parameters (`iainf`, `DGC`, `tdg`, `tn`, `amp`, `dy` and `ispeed`). The identification experiment is started by the input `TUNE` (input `TBRK` finishes the experiment). In this mode (`TBSY` = `on`), first of all the noise and possible drift gradient (`DGC` = `on`) are estimated during the user specified time (`tdg`+`tn`) and then the rectangle pulse is applied to the input of the process and the first three process moments are identified from the pulse response. The amplitude of the pulse is set by the parameter `amp`. The pulse is finished when the process variable `pv` deviates from the steady value more than the `dy` threshold defines. The threshold is an absolute difference, therefore it is always a positive value. The duration of the tuning experiment depends on the dynamic behavior of the process. The remaining time to the end of the tuning is provided by the output `trem`.

If the identification experiment is properly finished (`TE` = `off`) and the input `ips` is equal to zero, then the optimal parameters immediately appear on the block outputs `pk`, `pti`, `ptd`, `pnd`, `pb`, `pc`. In the opposite case (`TE` = `on`) the output `ite` specifies the experiment error more closely. Other values of the `ips` input are reserved for custom specific purposes.

The function of the autotuner is illustrated in the following picture.



During the experiment, the output `ite` indicates the autotuner phases. In the phase of estimation of the response decay rate (`ite` = `-4`) the tuning experiment may be finished manually before its regular end. In this case the controller parameters are designed but the potential warning is indicated by setting the output `ite=100`.

At the end of the experiment (`TBSY` `on`→`off`), the function of the controller depends on the current controller mode. If the `TAFF` = `on` the designed controller parameters are immediately accepted.

Inputs

`dv`	Feedforward control variable	`Double (F64)`
`sp`	Setpoint variable	`Double (F64)`
`pv`	Process variable	`Double (F64)`
`tv`	Tracking variable	`Double (F64)`
`hv`	Manual value	`Double (F64)`
`MAN`	Manual or automatic mode `off` ... Automatic mode `on` .... Manual mode	`Bool`
`IH`	Integrator hold `off` ... Integration enabled `on` .... Integration disabled	`Bool`
`TUNE`	Start the tuning experiment (`off`→`on`) or force transition to the next tuning phase (see the description of the `ite` output)	`Bool`
`TBRK`	Stop the tuning experiment	`Bool`
`TAFF`	Tuning affirmation; determines the way the computed parameters are handled `off` ... Parameters are only computed `on` .... Parameters are set into the control law	`Bool`

`ips` Meaning of the output signals `pk`, `pti`, `ptd`, `pnd`, `pb` and `pc` — Long (I32)

- `0` ..... Designed parameters `k`, `ti`, `td`, `nd`, `b` and `c` of the PID control law
- `1` ..... Process moments: static gain (`pk`), resident time constant (`pti`), measure of the system response length (`ptd`)
- `2` ..... Three-parameter first-order plus dead-time model: static gain (`pk`), dead-time (`pti`), time constant (`ptd`)
- `3` ..... Three-parameter second-order plus dead-time model with double time constant: static gain (`pk`), dead-time (`pti`), time constant (`ptd`)
- `4` ..... Estimated boundaries for manual fine-tuning of the PID controller (`irtype` = 7) gain `k`: upper boundary k_{hi} (`pk`), lower boundary k_{lo} (`pti`)
- `>99` ... Reserved for diagnostic purposes

Outputs

`mv` Manipulated variable (controller output) — Double (F64)

`dmv` Controller velocity output (difference) — Double (F64)

`de` Deviation error — Double (F64)

`SAT` Saturation flag — Bool

- `off` ... The controller implements a linear control law
- `on` .... The controller output is saturated

`TBSY` Tuner busy flag — Bool

`TE` Tuning error — Bool

- `off` ... Autotuning successful
- `on` .... An error occurred during the experiment

`ite` Error code — Long (I32)

Tuning error codes (after the experiment):

- `0` ..... No error or waiting for steady state
- `1` ..... Too small pulse getdown threshold
- `2` ..... Too large pulse amplitude
- `3` ..... Steady state condition violation
- `4` ..... Too small pulse aplitude
- `5` ..... Peak search procedure failure
- `6` ..... Output saturation occurred during experiment
- `7` ..... Selected controller type not supported
- `8` ..... Process not monotonous
- `9` ..... Extrapolation failure
- `10` .... Unexpected values of moments (fatal)
- `11` .... Abnormal manual termination of tuning
- `12` .... Wrong direction of manipulated variable
- `100` ... Manual termination of tuning (warning)

Tuning phases codes (during the experiment):

- `0` ..... Steady state reaching before the start of the experiment
- `-1` .... Drift gradient and noise estimation phase
- `-2` .... Pulse generation phase
- `-3` .... Searching the peak of system response
- `-4` .... Estimation of the system response decay rate

Remark about terminating the tuning phases

- `TUNE` .. The rising edge of the `TUNE` input during the phases `-2`, `-3` and `-4` causes the finishing of the current phase and transition to the next one (or finishing the experiment in the phase `-4`).

`trem`	Estimated time to finish the tuning experiment [s]	`Double (F64)`
`pk`	Proposed controller gain K (`ips` = `0`)	`Double (F64)`
`pti`	Proposed integral time constant T_i (`ips` = `0`)	`Double (F64)`
`ptd`	Proposed derivative time constant T_d (`ips` = `0`)	`Double (F64)`
`pnd`	Proposed derivative component filtering N (`ips` = `0`)	`Double (F64)`
`pb`	Proposed weighting factor – proportional component (`ips` = `0`)	`Double (F64)`
`pc`	Proposed weighting factor – derivative component (`ips` = `0`)	`Double (F64)`

Parameters

`irtype` Controller type (control law) ⊙`6` — `Long (I32)`

- `1` ..... D
- `2` I
- `3` ..... ID
- `4` ..... P
- `5` ..... PD
- `6` ..... PI
- `7` ..... PID

`RACT` Reverse action flag — `Bool`

- `off` ... Higher `mv` → higher `pv`
- `on` .... Higher `mv` → lower `pv`

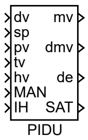
`k`	Controller gain K. By definition, the value 0 turns the controller off. Negative values are not allowed, use the `RACT` parameter for such a purpose. ↓`0.0` ⊙`1.0`	`Double (F64)`
`ti`	Integral time constant T_i. The value 0 disables the integrating part (the same effect as disabling it by the `irtype` parameter). ↓`0.0` ⊙`4.0`	`Double (F64)`
`td`	Derivative time constant T_d. The value 0 disables the derivative part (the same effect as disabling it by the `irtype` parameter). ↓`0.0` ⊙`1.0`	`Double (F64)`
`nd`	Derivative filtering parameter N. The value 0 disables the derivative part (the same effect as disabling it by the `irtype` parameter). ↓`0.0` ⊙`10.0`	`Double (F64)`
`b`	Setpoint weighting – proportional part ↓`0.0` ↑`2.0` ⊙`1.0`	`Double (F64)`
`c`	Setpoint weighting – derivative part ↓`0.0` ↑`2.0`	`Double (F64)`

`tt`	Tracking time constant. The value 0 stands for an implicit value, which is $T_i/2$ or $\sqrt{T_i T_d}$ (see above) for controllers with integrating part. For controllers without integrating part, the value 0 disables tracking. If tracking is needed for a `P` or `PD` controller, it can be enabled by entering a positive value greater than the sampling time. It is not possible to turn off tracking for controllers with the integrating part (due to the windup effect). ↓`0.0` ⊙`1.0`	`Double (F64)`
`hilim`	Upper limit of the controller output ⊙`1.0`	`Double (F64)`
`lolim`	Lower limit of the controller output ⊙`-1.0`	`Double (F64)`
`dz`	Dead zone	`Double (F64)`
`icotype`	Controller output type ⊙`1` `1` ..... Analog output `2` ..... Pulse width modulation (`PWM`) `3` ..... Step controller unit with position feedback (`SCU`) `4` ..... Step controller unit without position feedback (`SCUV`)	`Long (I32)`
`ittype`	Controller type to be designed ⊙`6` `6` ..... PI controller `7` ..... PID controller	`Long (I32)`
`iainf`	Type of apriori information ⊙`1` `1` ..... Static process `2` ..... Astatic process	`Long (I32)`
`DGC`	Drift gradient compensation ⊙`on` `off` ... Disabled `on` .... Enabled	`Bool`
`tdg`	Drift gradient estimation time [s] ⊙`60.0`	`Double (F64)`
`tn`	Length of noise estimation period [s] ⊙`5.0`	`Double (F64)`
`amp`	Tuning pulse amplitude ⊙`0.5`	`Double (F64)`
`dy`	Tuning pulse get down threshold (absolute difference from the steady `pv` value) ↓`0.0` ⊙`0.1`	`Double (F64)`
`ispeed`	Desired closed loop speed ⊙`2` `1` ..... Slow closed loop `2` ..... Normal (middle fast) closed loop `3` ..... Fast closed loop	`Long (I32)`
`ipid`	PID controller form ⊙`1` `1` ..... Parallel form `2` ..... Series form	`Long (I32)`

PIDU – PID controller unit

Block Symbol

Licence: STANDARD



Function Description

The PIDU block is a basic block for creating a complete PID controller (or P, I, PI, PD, PID, PI+S). In the most simple case it works as a standalone unit with the standard PID controller functionality with two degrees of freedom. It can operate in automatic mode (MAN = off) or manual mode (MAN = on).

In the automatic mode (MAN = off), the block PIDU implements the PID control law with two degrees of freedom in the form

$$U(s) = \pm K \left\{ bW(s) - Y(s) + \frac{1}{T_i s}\left[W(s) - Y(s)\right] + \frac{T_d s}{\frac{T_d}{N}s + 1}\left[cW(s) - Y(s)\right] \right\} + Z(s)$$

where $U(s)$ is Laplace transform of the manipulated variable mv, $W(s)$ is Laplace transform of the setpoint variable sp, $Y(s)$ is Laplace transform of the process variable pv, $Z(s)$ is Laplace transform of the feedforward control variable dv and K, T_i, T_d, N, b and c are the parameters of the controller. The sign of the right hand side depends on the parameter RACT. The range of the manipulated variable mv (position controller output) is limited by parameters hilim, lolim. The parameter dz determines the dead zone in the integral part of the controller. The integral part of the control law can be switched off and fixed on the current value by the integrator hold input IH (IH = on). For the proper function of the controller it is necessary to connect the output mv of the controller to the controller input tv and properly set the tracking time constant tt.

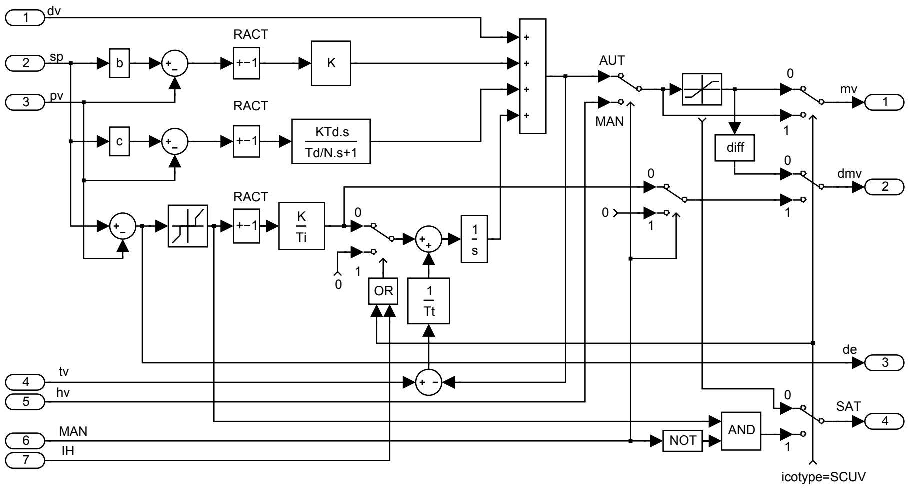
The rule of thumb for a PID controller is tt $\approx \sqrt{T_i T_d}$. For a PI controller the formula is tt $\approx T_i/2$. In this way we obtain the bumpless operation of the controller in the case of the mode switching (manual, automatic) and also the correct operation of the controller when saturation of the output mv occurs (antiwindup).

By adjusting the tt parameter, it is possible to tune the behaviour at saturation limits (so-called bouncing from limits due to noise) and when switching multiple controllers (bump in the controller output occurs when switching controllers while the control error is non-zero).

The additional outputs dmv, de and SAT generate the velocity output (difference of mv), deviation error and saturation flag, respectively.

If the `PIDU` block is connected with the `SCUV` block to configure the 3-point step controller without the positional feedback, then the parameter `icotype` must be set to `4` and the meaning of the outputs `mv` and `dmv` and `SAT` is modified in the following way: `mv` and `dmv` give the PD part and difference of I part of the control law, respectively, and `SAT` provides the information for the `SCUV` block whether the deviation error is less than the dead zone `dz` in the automatic mode. In this case, the setpoint weighting factor `c` should be zero.

In the manual mode (`MAN` = `on`), the input `hv` is copied to the output `mv` unless saturated. The overall control function of the `PIDU` block is quite clear from the following diagram:



Inputs

`dv`	Feedforward control variable	`Double (F64)`
`sp`	Setpoint variable	`Double (F64)`
`pv`	Process variable	`Double (F64)`
`tv`	Tracking variable	`Double (F64)`
`hv`	Manual value	`Double (F64)`
`MAN`	Manual or automatic mode `off` . . . Automatic mode `on` . . . . Manual mode	`Bool`
`IH`	Integrator hold `off` . . . Integration enabled `on` . . . . Integration disabled	`Bool`

Outputs

`mv`	Manipulated variable (controller output)	`Double (F64)`
`dmv`	Controller velocity output (difference)	`Double (F64)`
`de`	Deviation error	`Double (F64)`

`SAT`	Saturation flag `off` ... The controller implements a linear control law `on` .... The controller output is saturated		`Bool`

Parameters

`irtype`	Controller type (control law) `1` ..... D `4` ..... P `7` ..... PID `2` ..... I `5` ..... PD `3` ..... ID `6` ..... PI	⊙6	`Long (I32)`

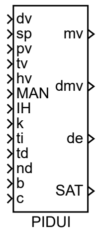
`RACT`	Reverse action flag
	`off` ... Higher `mv` → higher `pv`
	`on` .... Higher `mv` → lower `pv`
			`Bool`

`k`	Controller gain K. By definition, the value 0 turns the controller off. Negative values are not allowed, use the `RACT` parameter for such a purpose.	↓0.0 ⊙1.0	`Double (F64)`
`ti`	Integral time constant T_i. The value 0 disables the integrating part (the same effect as disabling it by the `irtype` parameter).	↓0.0 ⊙4.0	`Double (F64)`
`td`	Derivative time constant T_d. The value 0 disables the derivative part (the same effect as disabling it by the `irtype` parameter).	↓0.0 ⊙1.0	`Double (F64)`
`nd`	Derivative filtering parameter N. The value 0 disables the derivative part (the same effect as disabling it by the `irtype` parameter).	↓0.0 ⊙10.0	`Double (F64)`
`b`	Setpoint weighting – proportional part	↓0.0 ↑2.0 ⊙1.0	`Double (F64)`
`c`	Setpoint weighting – derivative part	↓0.0 ↑2.0	`Double (F64)`
`tt`	Tracking time constant. The value 0 stands for an implicit value, which is $T_i/2$ or $\sqrt{T_i T_d}$ (see above) for controllers with integrating part. For controllers without integrating part, the value 0 disables tracking. If tracking is needed for a `P` or `PD` controller, it can be enabled by entering a positive value greater than the sampling time. It is not possible to turn off tracking for controllers with the integrating part (due to the windup effect).	↓0.0 ⊙1.0	`Double (F64)`
`hilim`	Upper limit of the controller output	⊙1.0	`Double (F64)`
`lolim`	Lower limit of the controller output	⊙-1.0	`Double (F64)`
`dz`	Dead zone		`Double (F64)`
`icotype`	Controller output type `1` ..... Analog output `2` ..... Pulse width modulation (`PWM`) `3` ..... Step controller unit with position feedback (`SCU`) `4` ..... Step controller unit without position feedback (`SCUV`)	⊙1	`Long (I32)`

PIDUI – PID controller unit with variable parameters

Block Symbol

Licence: ADVANCED



Function Description

The functionality of the PIDUI block is completely equivalent to the PIDU block. The only difference is that the PID control algorithm parameters are defined by the input signals and therefore they can depend on the outputs of other blocks. This allows creation of special adaptive PID controllers.

Inputs

dv	Feedforward control variable	Double (F64)
sp	Setpoint variable	Double (F64)
pv	Process variable	Double (F64)
tv	Tracking variable	Double (F64)
hv	Manual value	Double (F64)
MAN	Manual or automatic mode off . . . Automatic mode on . . . . Manual mode	Bool
IH	Integrator hold off . . . Integration enabled on . . . . Integration disabled	Bool
k	Controller gain K	Double (F64)
ti	Integral time constant T_i	Double (F64)
td	Derivative time constant T_d	Double (F64)
nd	Derivative filtering parameter N	Double (F64)
b	Setpoint weighting – proportional part	Double (F64)
c	Setpoint weighting – derivative part	Double (F64)

Outputs

mv	Manipulated variable (controller output)	Double (F64)
dmv	Controller velocity output (difference)	Double (F64)
de	Deviation error	Double (F64)

SAT	Saturation flag off ... The controller implements a linear control law on .... The controller output is saturated		Bool

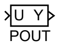
Parameters

irtype	Controller type (control law) 1 ..... D 4 ..... P 7 ..... PID 2 ..... I 5 ..... PD 3 ..... ID 6 ..... PI	⊙6	Long (I32)
RACT	Reverse action flag off ... Higher mv → higher pv on .... Higher mv → lower pv		Bool
tt	Tracking time constant	⊙1.0	Double (F64)
hilim	Upper limit of the controller output	⊙1.0	Double (F64)
lolim	Lower limit of the controller output	⊙-1.0	Double (F64)
dz	Dead zone		Double (F64)
icotype	Controller output type 1 ..... Analog output 2 ..... Pulse width modulation (PWM) 3 ..... Step controller unit with position feedback (SCU) 4 ..... Step controller unit without position feedback (SCUV)	⊙1	Long (I32)

POUT – Pulse output

Block Symbol

Licence: STANDARD



Function Description

The POUT block shapes the input pulses U in such a way, that the output pulse Y has a duration of at least dtime seconds and the idle period between two successive output pulses is at least btime seconds. The input pulse occuring sooner than the period of btime seconds since the last falling edge of the output signal elapses has no effect on the output signal Y.

Input

U	Logical input of the block	Bool

Output

Y	Logical output of the block	Bool

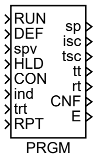
Parameters

dtime	Minimum width of the output pulse [s]	⊙1.0	Double (F64)
btime	Minimum delay between two successive output pulses [s]	⊙1.0	Double (F64)

PRGM – Setpoint programmer

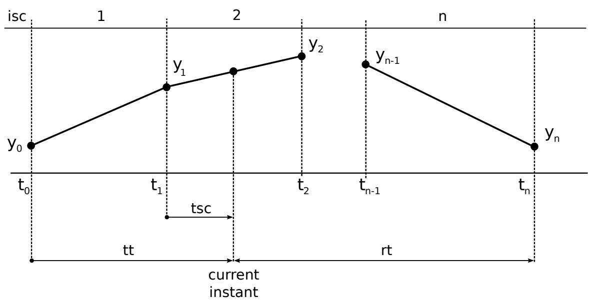
Block Symbol

Licence: STANDARD



Function Description

The PRGM block generates functions of time (programs) composed of n linear parts defined by (n + 1)-dimensional vectors of time (tm = $[t_0, \ldots, t_n]$) and output values (y = $[y_0, \ldots, y_n]$). The generated time-course is continuous piecewise linear, see figure below. This block is most commonly used as a setpoint generator for a controller. The program generation starts when RUN = on. In the case of RUN = off the programmer is set back to the initial state. The input DEF = on sets the output sp to the value spv. It follows a ramp to the nearest future node of the time function when DEF = off. The internal time of the generator is not affected by this input. The input HLD = on freezes the output sp and the internal time, thus also the outputs tsc, tt and rt. The program follows from freezing point as planned when HLD = off unless the input CON = on at the moment when the signal HLD on→off. In that case the program follows a ramp to reach the node with index ind in time trt. The node index ind must be equal to or higher than the index of current sector isc (at the moment when HLD on→off). If RPT = on, the program is generated repeatedly.



Inputs

RUN	Enable execution	Bool
DEF	Initialize sp to the value of spv	Bool
spv	Initializing constant	Double (F64)
HLD	Output and timer freezing	Bool

`CON`	Continue from defined node	`Bool`
`ind`	Index of the node to continue from	`Long (I32)`
`trt`	Time to reach the defined node with index `ind`	`Double (F64)`
`RPT`	Repetition flag	`Bool`

Outputs

`sp`	Setpoint variable (function value of the time function at given time)	`Double (F64)`
`isc`	Current function sector	`Long (I32)`
`tsc`	Time elapsed since the start of current sector	`Double (F64)`
`tt`	Time elapsed since the start of program generation	`Double (F64)`
`rt`	Remaining time till the end of program	`Double (F64)`
`CNF`	Flag indicating that the configured curve is being followed	`Bool`
`E`	Error flag – the node times are not ascending	`Bool`

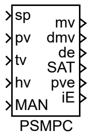
Parameters

`nmax`	Reserved (allocated) size of the `tm, y` vectors ↓4 ↑10000000 ⊙10	`Long (I32)`
`tmunits`	Time units ⊙1 `1` ..... seconds `2` ..... minutes `3` ..... hours	`Long (I32)`
`tm`	$(\mathtt{n}+1)$-dimensional vector of ascending node times ⊙`[0 1 2]`	`Double (F64)`
`y`	$(\mathtt{n}+1)$-dimensional vector of node values (values of the time function) ⊙`[0 1 0]`	`Double (F64)`

PSMPC – Pulse-step model predictive controller

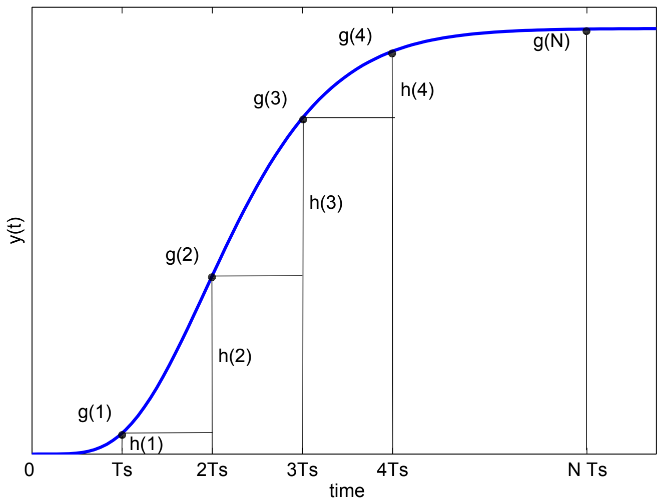
Block Symbol

Licence: ADVANCED



Function Description

The PSMPC block can be used for control of hardly controllable linear time-invariant systems with manipulated value constraints (e.g. time delay or non-minimum phase systems). It is especially well suited for the case when fast transition without overshoot from one level of controlled variable to another is required. In general, the PSMPC block can be used where the PID controllers are commonly used.



The PSMPC block is a predictive controller with explicitly defined constraints on the amplitude of manipulated variable.

The prediction is based on the discrete step response $g(j),\ j = 1, \ldots, N$ is used. The figure above shows how to obtain the discrete step response $g(j),\ j = 0, 1, \ldots, N$ and the discrete impulse response $h(j),\ j = 0, 1, \ldots, N$ with sampling period T_S from continuous step response. Note that N must be chosen such that $N \cdot T_S > t_{95}$, where t_{95} is the time to reach 95 % of the final steady state value.

For stable, linear and t-invariant systems with monotonous step response it is also possible to use the moment model set approach [4] and describe the system by only 3 characteristic numbers κ, μ, and σ^2, which can be obtained easily from a very short and simple experiment. The controlled system can be approximated by first order plus dead-time system

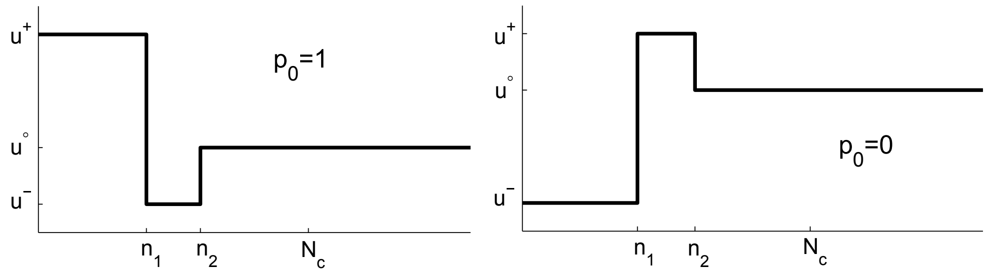
$$F_{FOPDT}(s) = \frac{K}{\tau s + 1} \cdot e^{-Ds}, \quad \kappa = K, \quad \mu = \tau + D, \quad \sigma^2 = \tau^2 \tag{7.1}$$

or second order plus dead-time system

$$F_{SOPDT}(s) = \frac{K}{(\tau s + 1)^2} \cdot e^{-Ds}, \quad \kappa = K, \quad \mu = 2\tau + D, \quad \sigma^2 = 2\tau^2 \tag{7.2}$$

with the same characteristic numbers. The type of approximation is selected by the `imtype` parameter.

To lower the computational burden of the open-loop optimization, the family of admissible control sequences contains only sequences in the so-called pulse-step shape depicted below:



Note that each of these sequences is uniquely defined by only four numbers $n_1, n_2 \in \{0, \ldots, N_C\}$, p_0 and $u^\infty \in \langle u^-, u^+ \rangle$, where $N_C \in \{0, 1, \ldots\}$ is the control horizon and u^-, u^+ stand for the given lower and upper limit of the manipulated variable. The on-line optimization (with respect to p_0, n_1, n_2 and u^∞) minimizes the criterion

$$I = \sum_{i=N_1}^{N_2} \hat{e}(k+i|k)^2 + \lambda \sum_{i=0}^{N_C} \Delta\hat{u}(k+i\,|k)^2 \to \min, \tag{7.3}$$

where $\hat{e}(k+i|k)$ is the predicted control error at time k over the coincidence interval $i \in \{N_1, N_2\}$, $\Delta\hat{u}(k+i|k)$ are the differences of the control signal over the interval $i \in \{0, N_C\}$ and λ penalizes the changes in the control signal. The algorithm used for solving the optimization task (7.3) combines brute force and the least squares method. The value u^∞ is determined using the least squares method for all admissible combinations of p_0, n_1 and n_2 and the optimal control sequence is selected afterwards. The selected sequence in the pulse-step shape is optimal in the open-loop sense. To convert from open-loop to closed-loop control strategy, only the first element of the computed control sequence is applied and the whole optimization procedure is repeated in the next sampling instant.

The parameters N_1, N_2, H_C, and λ in the criterion (7.3) take the role of design parameters. Only the last parameter λ is meant for manual tuning of the controller. In the case the model in the form (7.1) or (7.2) is used, the parameters N_1 and N_2 are determined automatically with respect to the μ and σ^2 characteristic numbers. The controller can be then effectively tuned by adjusting the characteristic numbers κ, μ and σ^2.

Warning

It is necessary to set the **sr** array sufficiently large to avoid Matlab/Simulink crash when using the PSMPC block for simulation purposes. Especially when using FOPDT or SOPDT model, the **sr** array size must be greater than the length of the internally computed discrete step response.

Inputs

sp	Setpoint variable	Double (F64)
pv	Process variable	Double (F64)
tv	Tracking variable (applied control signal)	Double (F64)
hv	Manual value	Double (F64)
MAN	Manual or automatic mode off ... Automatic mode on .... Manual mode	Bool

Outputs

mv	Manipulated variable (controller output)	Double (F64)
dmv	Controller velocity output (difference)	Double (F64)
de	Deviation error	Double (F64)
SAT	Saturation flag off ... The controller implements a linear control law on .... The controller output is saturated	Bool
pve	Predicted process variable based on the controlled process model	Double (F64)
iE	Error code 0 ..... No error 1 ..... Incorrect FOPDT model 2 ..... Incorrect SOPDT model 3 ..... Invalid step response sequence	Long (I32)

Parameters

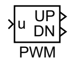
nc	Control horizon length (N_C)	⊙5	Long (I32)
np1	Start of coincidence interval (N_1)	⊙1	Long (I32)
np2	End of coincidence interval (N_2)	⊙10	Long (I32)
lambda	Control signal penalization coefficient (λ)	⊙0.05	Double (F64)
umax	Upper limit of the controller output (u^+)	⊙1.0	Double (F64)
umin	Lower limit of the controller output (u^-)	⊙-1.0	Double (F64)

`imtype`	Controlled process model type 1 ..... FOPDT model (7.1) 2 ..... SOPDT model (7.2) 3 ..... Discrete step response	⊙3	Long (I32)
`kappa`	Static gain (κ)	⊙1.0	Double (F64)
`mu`	Resident time constant (μ)	⊙20.0	Double (F64)
`sigma`	Measure of the system response length ($\sqrt{\sigma^2}$)	⊙10.0	Double (F64)
`nmax`	Reserved size of the *sr* array	↓10 ↑10000 ⊙32	Long (I32)
`sr`	Discrete step response sequence ($[g(1), \ldots, g(N)]$) ⊙[0 0.2642 0.5940 0.8009 0.9084 0.9596 0.9826 0.9927 0.9970 0.9988 0.9995]		Double (F64)

PWM – Pulse width modulation

Block Symbol

Licence: STANDARD



Function Description

The PWM block implements a pulse width modulation algorithm for proportional actuators. In the general, it is assumed the input signal u ranges in the interval from -1 to +1. The width L of the output pulse is computed by the expression:

$$L = \texttt{pertm} * |\texttt{u}|\,,$$

where pertm is the modulation time period. If $\texttt{u} > \texttt{0}$ ($\texttt{u} < \texttt{0}$), the pulse is generated in the output UP (DN). However, the width of the generated pulses are affected by other parameters of the block. The asymmetry factor asyfac determines the ratio of negative pulses duration to positive pulses duration. The modified pulse widths are given by:

$$\text{if} \quad \texttt{u} > \texttt{0} \quad \text{then} \quad L(\texttt{UP}) := \begin{cases} L & \text{for} \quad \texttt{asyfac} \leq 1.0 \\ L/\texttt{asyfac} & \text{for} \quad \texttt{asyfac} > 1.0 \end{cases}$$

$$\text{if} \quad \texttt{u} < \texttt{0} \quad \text{then} \quad L(\texttt{DN}) := \begin{cases} L * \texttt{asyfac} & \text{for} \quad \texttt{asyfac} \leq 1.0 \\ L & \text{for} \quad \texttt{asyfac} > 1.0 \end{cases}$$

Further, if the computed width is less than minimum pulse duration dtime the width is set to zero. If the pulse width differs from the modulation period pertm less than minimum pulse break time btime then width of the pulse is set to pertm. In the case the positive pulse is succeeded by the negative one (or vice versa) the latter pulse is possibly shifted in such a way that the distance between these pulses is at least equal to the minimum off time offtime. If SYNCH = on, then the change of the input value u causes the immediate recalculation of the current pulse widths if a synchronization condition is violated.

Input

u	Analog input of the block	Double (F64)

Outputs

UP	The "up" signal	Bool
DN	The "down" signal	Bool

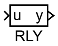
Parameters

`pertm`	Modulation period length [s]	⊙10.0	`Double (F64)`
`dtime`	Minimum width of the output pulse [s]	⊙0.1	`Double (F64)`
`btime`	Minimum delay between output pulses [s]	⊙0.1	`Double (F64)`
`offtime`	Minimum delay when altering direction [s]	⊙1.0	`Double (F64)`
`asyfac`	Asymmetry factor	⊙1.0	`Double (F64)`
`SYNCH`	Synchronization flag of the period start `off` ... Synchronization disabled `on` .... Synchronization enabled		`Bool`

RLY – Relay with hysteresis

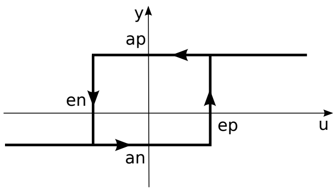
Block Symbol

Licence: STANDARD



Function Description

The RLY block transforms the input signal u to the output signal y according to the figure below.



Input

u	Analog input of the block	Double (F64)

Output

y	Analog output of the block	Double (F64)

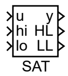
Parameters

ep	The value u > ep causes y = ap ("On")	⊙1.0	Double (F64)
en	The value u < en causes y = an ("Off")	⊙-1.0	Double (F64)
ap	Output value y in the "On" state	⊙1.0	Double (F64)
an	Output value y in the "Off" state	⊙-1.0	Double (F64)
y0	Initial output value at start-up		Double (F64)

SAT – Saturation with variable limits

Block Symbol

Licence: STANDARD



Function Description

The SAT block copies the input u to the output y if the input signal satisfies lolim $\leq$ u and u $\leq$ hilim, where lolim and hilim are state variables of the block. If u < lolim (u > hilim), then y = lolim (y = hilim). The upper and lower limits are either constants (HLD = on) defined by parameters hilim0 and lolim0 respectively or input-driven variables (HLD = off, hi and lo inputs). The maximal rate at which the active limits may vary is given by time constants tp (positive slope) and tn (negative slope). These rates are active even if the saturation limits are changed manually (HLD = on) using the hilim0 and lolim0 parameters. To allow immediate changes of the saturation limits, set tp = 0 and tn = 0. The HL and LL outputs indicate the upper and lower saturation respectively.

If necessary, the hilim0 and lolim0 parameters are used as initial values for the input-driven saturation limits.

Inputs

u	Analog input of the block	Double (F64)
hi	Upper limit of the output signal (for the case HLD = off)	Double (F64)
lo	Lower limit of the output signal (for the case HLD = off)	Double (F64)

Outputs

y	Analog output of the block	Double (F64)
HL	Upper limit saturation indicator	Bool
LL	Lower limit saturation indicator	Bool

Parameters

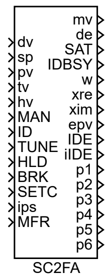
tp	Time constant defining the maximal positive slope of active limit changes ⊙1.0	Double (F64)
tn	Time constant defining the maximum negative slope of active limit changes ⊙1.0	Double (F64)
hilim0	Upper limit of the output (valid for HLD = on) ⊙1.0	Double (F64)
lolim0	Lower limit of the output (valid for HLD = on) ⊙-1.0	Double (F64)

`HLD`	Fixed saturation limits `off` ... Variable limits `on` .... Fixed limits	⊙`on`	`Bool`

SC2FA – State controller for 2nd order system with frequency autotuner

Block Symbol

Licence: AUTOTUNING



Function Description

The SC2FA block implements a state controller for 2nd order system (7.4) with frequency autotuner. It is well suited especially for control (active damping) of lightly damped systems ($\xi < 0.1$). But it can be used as an autotuning controller for arbitrary system which can be described with sufficient precision by the transfer function

$$F(s) = \frac{b_1 s + b_0}{s^2 + 2\xi\Omega s + \Omega^2}, \tag{7.4}$$

where $\Omega > 0$ is the natural (undamped) frequency, ξ, $0 < \xi < 1$, is the damping coefficient and b_1, b_0 are arbitrary real numbers. The block has two operating modes: "Identification and design mode" and "Controller mode".

The "Identification and design mode" is activated by the binary input ID = on. Two points of frequency response with given phase delay are measured during the identification experiment. Based on these two points a model of the controlled system is built. The experiment itself is initiated by the rising edge of the RUN input. A harmonic signal with amplitude uamp, frequency ω and bias ubias then appears at the output mv. The frequency runs through the interval $\langle \mathtt{wb}, \mathtt{wf} \rangle$, it increases gradually. The current frequency is copied to the output w. The rate at which the frequency changes (sweeping) is determined by the cp parameter, which defines the relative shrinking of the initial period $T_b = \frac{2\pi}{\mathtt{wb}}$ of the exciting sine wave in time T_b, thus

$$c_p = \frac{\mathtt{wb}}{\omega(T_b)} = \frac{\mathtt{wb}}{\mathtt{wb} e^{\gamma T_b}} = e^{-\gamma T_b}.$$

The cp parameter usually lies within the interval $\mathtt{cp} \in \langle 0{,}95; 1)$. The lower the damping coefficient ξ of the controlled system is, the closer to one the cp parameter must be.

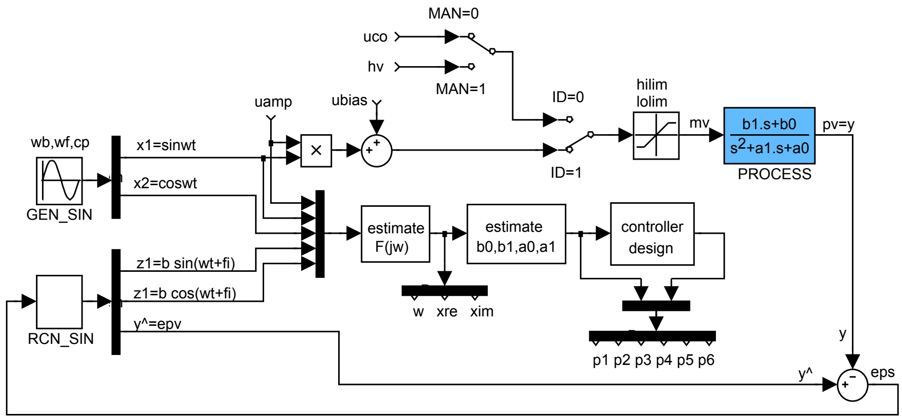
At the beginning of the identification period the exciting signal has a frequency of $\omega =$ wb. After a period of stime seconds the estimation of current frequency response point starts. Its real and imaginary parts are available at the xre and xim outputs. If the MANF parameter is set to 0, then the frequency sweeping is stopped two times during the identification period. This happens when points with phase delay of ph1 and ph2 are reached for the first time. The breaks are stime seconds long. Default phase delay values are $-60°$ and $-120°$, respectively, but these can be changed to arbitrary values within the interval $(-360°, 0°)$, where ph1 > ph2. At the end of each break an arithmetic average is computed from the last iavg frequency point estimates. Thus we get two points of frequency response which are successively used to compute the controlled process model in the form of (7.4). If the MANF parameter is set to 1, then the selection of two frequency response points is manual. To select the frequency, set the input HLD = on, which stops the frequency sweeping. The identification experiment continues after returning the input HLD to 0. The remaining functionality is unchanged.

It is possible to terminate the identification experiment prematurely in case of necessity by the input BRK = on. If the two points of frequency response are already identified at that moment, the controller parameters are designed in a standard way. Otherwise the controller design cannot be performed and the identification error is indicated by the output signal IDE = on.

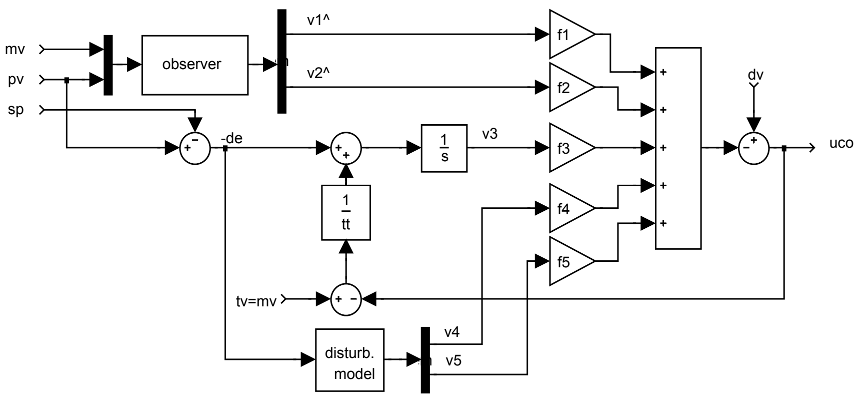
The IDBSY output is set to 1 during the "identification and design" phase. It is set back to 0 after the identification experiment finishes. A successful controller design is indicated by the output IDE = off. During the identification experiment the output iIDE displays the individual phases of the identification: iIDE = −1 means approaching the first point, iIDE = 1 means the break at the first point, iIDE = −2 means approaching the second point, iIDE = 2 means the break at the second point and iIDE = −3 means the last phase after leaving the second frequency response point. An error during the identification phase is indicated by the output IDE = on and the output iIDE provides more information about the error.

The computed state controller parameters are taken over by the control algorithm as soon as the SETC input is set to 1 (i.e. immediately if SETC is constantly set to on). The identified model and controller parameters can be obtained from the p1, p2, . . . , p6 outputs after setting the ips input to the appropriate value. After a successful identification it is possible to generate the frequency response of the controlled system model, which is initiated by a rising edge at the MFR input. The frequency response can be read from the w, xre and xim outputs, which allows easy confrontation of the model and the measured data.

The "Controller mode" (binary input ID = off) has manual (MAN = on) and automatic (MAN = off) submodes. After a cold start of the block with the input ID = off it is assumed that the block parameters mb0, mb1, ma0 and ma1 reflect formerly identified coefficients b_0, b_1, a_0 and a_1 of the controlled system transfer function and the state controller design is performed automatically. Moreover if the controller is in the automatic mode and SETC = on, then the control law uses the parameters from the very beginning. In this way the identification phase can be skipped when starting the block repeatedly.



The diagram above is a simplified inner structure of the frequency autotuning part of the controller. The diagram below shows the state feedback, observer and integrator anti-wind-up. The diagram does not show the fact, that the controller design block automatically adjusts the observer and state feedback parameters $f1, \ldots, f5$ after identification experiment (and `SETC` = `on`).



The controlled system is assumed in the form of (7.4). Another forms of this transfer function are

$$F(s) = \frac{(b_1 s + b_0)}{s^2 + a_1 s + a_0} \tag{7.5}$$

and

$$F(s) = \frac{K_0 \Omega^2 (\tau s + 1)}{s^2 + 2\xi \Omega s + \Omega^2}. \tag{7.6}$$

The coefficients of these transfer functions can be found at the outputs `p1`,...,`p6` after the identification experiment (`IDBSY` = `off`). The output signals meaning is switched when a change occurs at the `ips` input.

Inputs

`dv`	Feedforward control variable	`Double (F64)`
`sp`	Setpoint variable	`Double (F64)`
`pv`	Process variable	`Double (F64)`
`tv`	Tracking variable	`Double (F64)`
`hv`	Manual value	`Double (F64)`

MAN	Manual or automatic mode off . . . Automatic mode on . . . . Manual mode	Bool
ID	Identification or controller operating mode off . . . Controller mode mode on . . . . Identification and design	Bool
TUNE	Start the tuning experiment (off→on), the exciting harmonic signal is generated	Bool
HLD	Stop frequency sweeping	Bool
BRK	Termination signal	Bool
SETC	Flag for accepting the new controller parameters and updating the control law off . . . Parameters are only computed on . . . . Parameters are accepted as soon as computed off→on One-shot confirmation of the computed parameters	Bool
ips	Switch for changing the meaning of the output signals 0 . . . . . Two points of frequency response p1 . . . frequency of the 1st measured point in rad/s p2 . . . real part of the 1st point p3 . . . imaginary part of the 1st point p4 . . . frequency of the 2nd measured point in rad/s p5 . . . real part of the 2nd point p6 . . . imaginary part of the 2nd point 1 . . . . . Second order model in the form (7.5) p1 . . . b_1 parameter p2 . . . b_0 parameter p3 . . . a_1 parameter p4 . . . a_0 parameter 2 . . . . . Second order model in the form (7.6) p1 . . . K_0 parameter p2 . . . τ parameter p3 . . . Ω parameter in rad/s p4 . . . ξ parameter p5 . . . Ω parameter in Hz p6 . . . resonance frequency in Hz 3 . . . . . State feedback parameters p1 . . . f_1 parameter p2 . . . f_2 parameter p3 . . . f_3 parameter p4 . . . f_4 parameter p5 . . . f_5 parameter	Long (I32)
MFR	Generation of the parametric model frequency response at the w, xre and xim outputs (off→on triggers the generator)	Bool

Outputs

mv	Manipulated variable (controller output)	Double (F64)
de	Deviation error	Double (F64)

`SAT`	Saturation flag `off` ... The controller implements a linear control law `on` .... The controller output is saturated		`Bool`
`IDBSY`	Identification running `off` ... Identification not running `on` .... Identification in progress		`Bool`
`w`	Frequency response point estimate - frequency in rad/s		`Double (F64)`
`xre`	Frequency response point estimate - real part		`Double (F64)`
`xim`	Frequency response point estimate - imaginary part		`Double (F64)`
`epv`	Reconstructed `pv` signal		`Double (F64)`
`IDE`	Identification error indicator `off` ... Successful identification experiment `on` .... Identification error occurred		`Bool`
`iIDE`	Error code `101` ... Sampling period too low `102` ... Error identifying one or both frequency response point(s) `103` ... Manipulated variable saturation occurred during the identification experiment `104` ... Invalid process model		`Long (I32)`
`p1..p6`	Results of identification and design phase		`Double (F64)`

Parameters

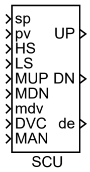
`ubias`	Static component of the exciting harmonic signal		`Double (F64)`
`uamp`	Amplitude of the exciting harmonic signal	⊙`1.0`	`Double (F64)`
`wb`	Frequency interval lower limit [rad/s]	⊙`1.0`	`Double (F64)`
`wf`	Frequency interval upper limit [rad/s]	⊙`10.0`	`Double (F64)`
`isweep`	Frequency sweeping mode `1` ..... Logarithmic `2` ..... Linear (not implemented yet)	⊙`1`	`Long (I32)`
`cp`	Sweeping rate	↓`0.5` ↑`1.0` ⊙`0.995`	`Double (F64)`
`iavg`	Number of values for averaging	⊙`10`	`Long (I32)`
`alpha`	Relative positioning of the observer poles (in identification phase)	⊙`2.0`	`Double (F64)`
`xi`	Observer damping coefficient (in identification phase)	⊙`0.707`	`Double (F64)`
`MANF`	Manual frequency response points selection `off` ... Disabled `on` .... Enabled		`Bool`
`ph1`	Phase delay of the 1st point in degrees	⊙`-60.0`	`Double (F64)`
`ph2`	Phase delay of the 2nd point in degrees	⊙`-120.0`	`Double (F64)`
`stime`	Settling period [s]	⊙`10.0`	`Double (F64)`
`ralpha`	Relative positioning of the observer poles	⊙`4.0`	`Double (F64)`
`rxi`	Observer damping coefficient	⊙`0.707`	`Double (F64)`
`acl1`	Relative positioning of the 1st closed-loop poles couple	⊙`1.0`	`Double (F64)`
`xicl1`	Damping of the 1st closed-loop poles couple	⊙`0.707`	`Double (F64)`

INTGF	Integrator flag off ... State-space model without integrator on .... Integrator included in the state-space model	⊙on	Bool
apcl	Relative position of the real pole	⊙1.0	Double (F64)
DISF	Disturbance flag off ... State space model without disturbance model on .... Disturbance model is included in the state space model		Bool
dom	Disturbance model natural frequency	⊙1.0	Double (F64)
dxi	Disturbance model damping coefficient		Double (F64)
acl2	Relative positioning of the 2nd closed-loop poles couple	⊙2.0	Double (F64)
xicl2	Damping of the 2nd closed-loop poles couple	⊙0.707	Double (F64)
tt	Tracking time constant	⊙1.0	Double (F64)
hilim	Upper limit of the controller output	⊙1.0	Double (F64)
lolim	Lower limit of the controller output	⊙-1.0	Double (F64)
mb1p	Controlled system transfer function coefficient b_1		Double (F64)
mb0p	Controlled system transfer function coefficient b_0	⊙1.0	Double (F64)
ma1p	Controlled system transfer function coefficient a_1	⊙0.2	Double (F64)
ma0p	Controlled system transfer function coefficient a_0	⊙1.0	Double (F64)

SCU – Step controller with position feedback

Block Symbol

Licence: STANDARD



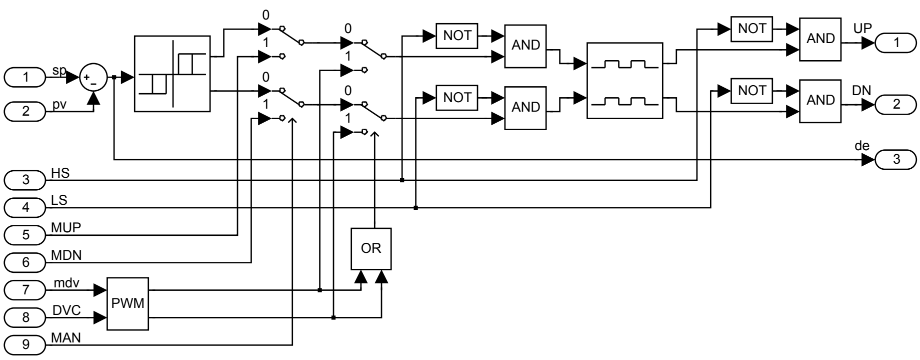
Function Description

The SCU block implements the secondary (inner) position controller of the step controller loop. PIDU function block or some of the derived function blocks (PIDMA, etc.) is assumed as the primary controller.

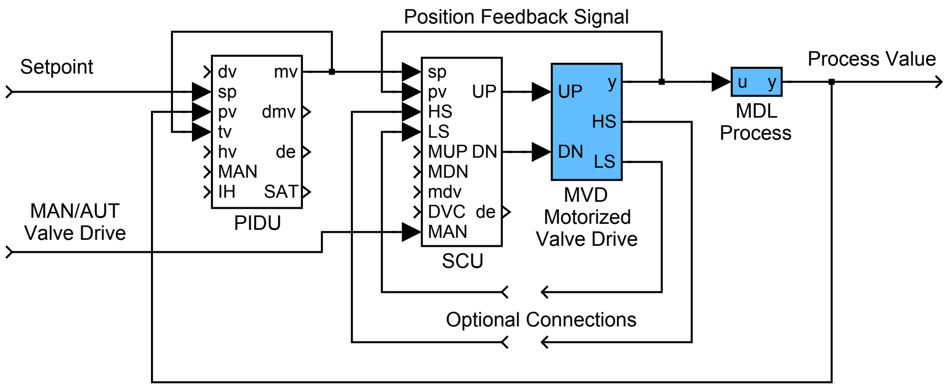
The SCU block processes the control deviation sp − pv by a three state element with parameters (thresholds) thron and throff (see the TSE block, use parameters ep = thron, epoff = throff, en = -thron and enoff = -throff). The parameter RACT determines whether the UP or DN pulse is generated for positive or negative value of the controller deviation. Two pulse outputs of the three state element are further shaped so that minimum pulse duration dtime and minimum pulse break time btime are guaranteed at the block UP and DN outputs. If signals from high and low limit switches of the valve are available, they should be connected to the HS and LS inputs.

There is also a group of input signals for manual control available. The manual mode is activated by the MAN = on input signal. Then it is possible to move the motor back and forth by the MUP and MDN input signals. It is also possible to specify a position increment/decrement request by the mdv input. In this case the request must be confirmed by a rising edge (off→on) in the DVC input signal.

The control function of the SCU block is quite clear from the following diagram.



The complete structure of the three-state step controller is depicted in the following figure.



Inputs

`sp`	Setpoint (output of the primary controller)	`Double (F64)`
`pv`	Controlled variable (position of the motorized valve drive)	`Double (F64)`
`HS`	Upper end switch (detects the upper limit position of the valve)	`Bool`
`LS`	Lower end switch (detects the lower limit position of the valve)	`Bool`
`MUP`	Manual `UP` signal	`Bool`
`MDN`	Manual `DN` signal	`Bool`
`mdv`	Manual differential value (requested position increment/decrement with higher priority than direct signals `MUP`/`MDN`)	`Double (F64)`
`DVC`	Differential value change command (`off`→`on`)	`Bool`
`MAN`	Manual or automatic mode `off` ... Automatic mode `on` .... Manual mode	`Bool`

Outputs

`UP`	The "up" signal	`Bool`
`DN`	The "down" signal	`Bool`
`de`	Deviation error	`Double (F64)`

Parameters

`thron`	Switch-on value	↓`0.0` ⊙`0.02`	`Double (F64)`
`throff`	Switch-off value	↓`0.0` ⊙`0.01`	`Double (F64)`
`dtime`	Minimum width of the output pulse [s]	↓`0.0` ⊙`0.1`	`Double (F64)`
`btime`	Minimum delay between two subsequent output pulses [s] to do	↓`0.0` ⊙`0.1`	`Double (F64)`

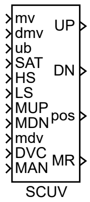
`RACT`	Reverse action flag
	`off` ... Higher `mv` → higher `pv`
	`on` .... Higher `mv` → lower `pv`
		`Bool`

`trun`	Motor time constant (determines the time during which the motor position changes by one unit) ↓`0.0` ⊙`10.0`	`Double (F64)`

SCUV – Step controller unit with velocity input

Block Symbol

Licence: STANDARD



Function Description

The block SCUV substitutes the secondary position controller SCU in the step controller loop when the position signal is not available. The primary controller PIDU (or some of the derived function blocks) is connected with the block SCUV using the block inputs mv, dmv and SAT.

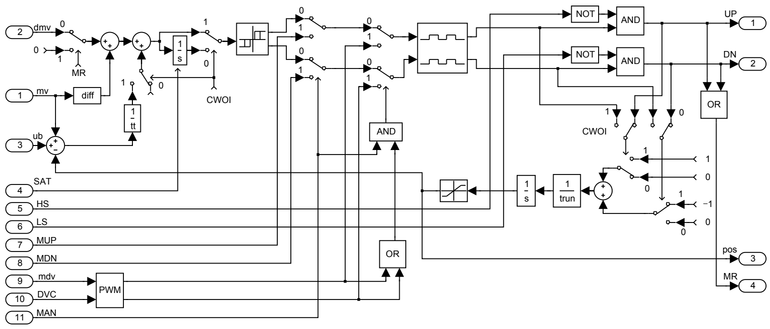
If the primary controller uses PI or PID control law (CWOI = off), then all three inputs mv, dmv and SAT of the block SCUV are sequentially processed by the special integration algorithm and by the three state element with parameters thron and throff (see the TSE block, use parameters ep = thron, epoff = throff, en = -thron and enoff = -throff). Pulse outputs of the three state element are further shaped in such a way that the minimum pulse duration time dtime and minimum pulse break time btime are guaranteed at the block outputs UP and DN. The parameter RACT determines the direction of motor moving. Note, the velocity output of the primary controller is reconstructed from input signals mv and dmv. Moreover, if the deviation error of the primary controller with icotype = 4 (working in automatic mode) is less than its dead zone (SAT = on), then the output of the corresponding internal integrator is set to zero.

The position pos of the valve is estimated by an integrator with the time constant trun. If signals from high and low limit switches of the valve are available, they should be connected to the inputs HS and LS.

If the primary controller uses P or PD control law (CWOI = on), then the deviation error of the primary controller can be eliminated by the bias ub manually. In this case, the control algorithm is slightly modified, the position of the motor pos is used and the proper settings of thron, throff and the tracking time constant tt are necessary for the suppressing of up/down pulses in the steady state.

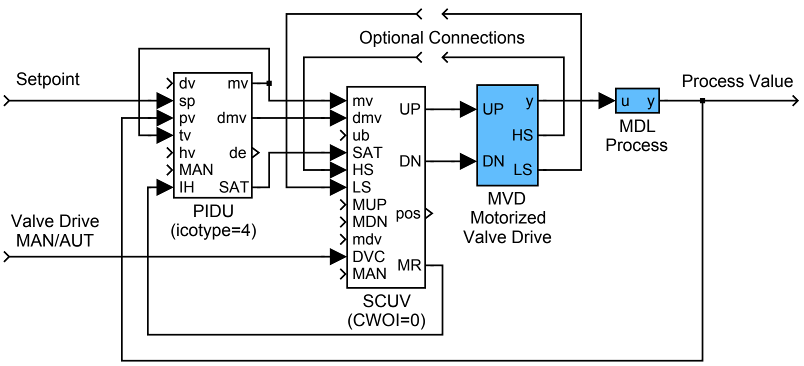
There is also a group of input signals for manual control available. The manual mode is activated by the MAN = on input signal. Then it is possible to move the motor back and forth by the MUP and MDN input signals. It is also possible to specify a position increment/decrement request by the mdv input. In this case the request must be confirmed by a rising edge (off→on) in the DVC input signal.

The overall control function of the SCUV block is obvious from the following diagram:

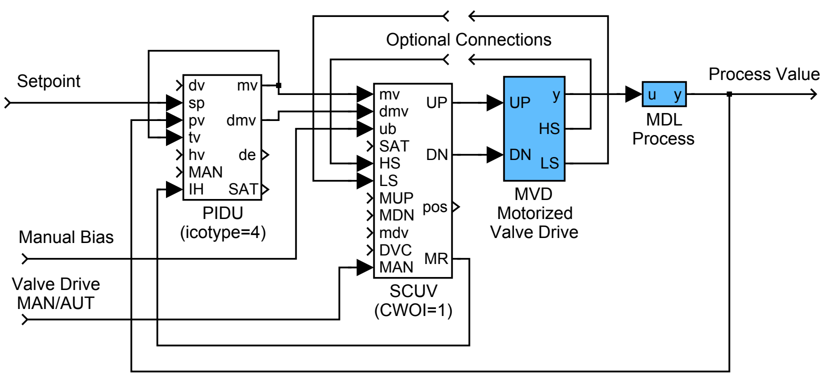


The complete structures of the three-state controllers are depicted in the following figures:

Primary controller with integration: I, PI, PID



Primary controller without integration: P, PD



Inputs

mv	Manipulated variable (controller output)	Double (F64)
dmv	Controller velocity output (difference)	Double (F64)

`ub`	Bias (only for P or PD primary controller)	`Double (F64)`
`SAT`	Internal integrator reset (connected to the `SAT` output of the primary controller)	`Bool`
`HS`	Upper end switch (detects the upper limit position of the valve)	`Bool`
`LS`	Lower end switch (detects the lower limit position of the valve)	`Bool`
`MUP`	Manual `UP` signal	`Bool`
`MDN`	Manual `DN` signal	`Bool`
`mdv`	Manual differential value (requested position increment/decrement with higher priority than direct signals `MUP`/`MDN`)	`Double (F64)`
`DVC`	Differential value change command (`off`→`on`)	`Bool`
`MAN`	Manual or automatic mode `off` ... Automatic mode `on` .... Manual mode	`Bool`

Outputs

`UP`	The "up" signal	`Bool`
`DN`	The "down" signal	`Bool`
`pos`	Position output of motor simulator	`Double (F64)`
`MR`	Request to move the motor `off` ... Motor idle (`UP` = `off` and `DN` = `off`) `on` .... Request to move (`UP` = `on` or `DN` = `on`)	`Bool`

Parameters

`thron`	Switch-on value ↓`0.0` ⊙`0.02`	`Double (F64)`
`throff`	Switch-off value ↓`0.0` ⊙`0.01`	`Double (F64)`
`dtime`	Minimum width of the output pulse [s] ↓`0.0` ⊙`0.1`	`Double (F64)`
`btime`	Minimum delay between two subsequent output pulses [s] ↓`0.0` ⊙`0.1`	`Double (F64)`

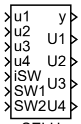
`RACT`	Reverse action flag
	`off` ... Higher `mv` → higher `pv`
	`on` .... Higher `mv` → lower `pv`
		`Bool`

`trun`	Motor time constant (determines the time during which the motor position changes by one unit) ↓`0.0` ⊙`10.0`	`Double (F64)`
`CWOI`	Controller without integration flag `off` ... The primary controller has an integrator (I, PI, PID) `on` .... The primary controller does not have an integrator (P, PD)	`Bool`
`tt`	Tracking time constant ↓`0.0` ⊙`1.0`	`Double (F64)`

SELU – Controller selector unit

Block Symbol

Licence: STANDARD



SELU

Function Description

The SELU block is tailored for selecting the active controller in selector control. It chooses one of the input signals u1, u2, u3, u4 and copies it to the output y. For BINF = off the active signal is selected by the iSW input. In the case of BINF = on the selection is based on the binary inputs SW1 and SW2 according to the following table:

iSW	SW1	SW2	y	U1	U2	U3	U4
0	off	off	u1	off	on	on	on
1	off	on	u2	on	off	on	on
2	on	off	u3	on	on	off	on
3	on	on	u4	on	on	on	off

This table also explains the meaning of the binary outputs U1, U2, U3 and U4, which are used by the inactive controllers in selector control for tracking purposes (via the SWU blocks).

Inputs

u1..u4	Signals to be selected from	Double (F64)
iSW	Active signal selector in case of BINF = off	Long (I32)
SW1	Binary signal selector, used when BINF = on	Bool
SW2	Binary signal selector, used when BINF = on	Bool

Outputs

y	Analog output of the block	Double (F64)
U1..U4	Binary output signal for selector control	Bool

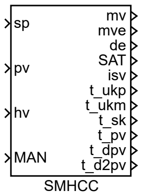
Parameter

BINF	Enable the binary selectors off ... Disabled (analog selector) on .... Enabled (binary selectors)	Bool

SMHCC – Sliding mode heating/cooling controller

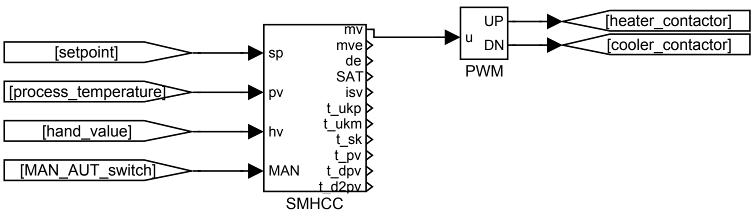
Block Symbol

Licence: ADVANCED



Function Description

The sliding mode heating/cooling controller SMHCC is a novel high quality control algorithm intended for temperature control of heating-cooling (possibly asymmetrical) processes with ON-OFF heaters and/or ON-OFF coolers. The plastic extruder is a typical example of such process. However, it can also be applied to many similar cases, for example in thermal systems where a conventional thermostat is employed. To provide the proper control function the block SMHCC must be combined with the block PWM (Pulse Width Modulation) as depicted in the following figure.



It is important to note that the block SMHCC works with two time periods. The first period T_S is the sampling time of the process temperature, and this period is equal to the period with which the block SMHCC itself is executed. The second period $T_C = i_{pwmc}T_S$ is the control period with which the block SMHCC generates manipulated variable. This period T_C is also equal to the cycle time of PWM block. At every instant when the manipulated variable mv is changed by SMHCC the PWM algorithm recalculates the width of the output pulse and starts a new PWM cycle. The time resolution T_R of the PWM block is third time period involved with. This period is equal to the period with which the block PWM is run and generally may be different from T_S. To achieve the high quality of control it is recommended to choose T_S as minimal as possible (i_{pwmc} as maximal as possible), the ratio T_C/T_S as maximal as possible but T_C should be sufficiently small with respect to the process dynamics. An example of reasonable values for an extruder temperature control is as follows:

$$T_S = 0.1,\ i_{pwmc} = 100,\ T_C = 10s,\ T_R = 0.01s.$$

The control law of the block SMHCC in automatic mode (MAN = off) is based on the discrete dynamic sliding mode control technique and special 3rd order filters for estimation of the first and second derivatives of the control error.

The first control stage, after a setpoint change or upset, is the *reaching phase* when the dynamic sliding variable

$$s_k \stackrel{\triangle}{=} \ddot{e}_k + 2\xi\Omega\dot{e}_k + \Omega^2 e_k$$

is forced to zero. In the above definition of the sliding variable, $e_k, \dot{e}_k, \ddot{e}_k$ denote the filtered deviation error (pv − sp) and its first and second derivatives in the control period k, respectively, and ξ, Ω are the control parameters described below. In the second phase, s_k is hold at the zero value (*the sliding phase*) by the proper control "bangs". Here, the heating action is alternated by cooling action and *vice versa* rapidly. The amplitudes of control actions are adapted appropriately to guarantee $s_k = 0$ approximately. Thus, the hypothetical continuous dynamic sliding variable

$$s \stackrel{\triangle}{=} \ddot{e} + 2\xi\Omega\dot{e} + \Omega^2 e$$

is approximately equal to zero at any time. Therefore the control deviation behaves according to the second order differential equation

$$s \stackrel{\triangle}{=} \ddot{e} + 2\xi\Omega\dot{e} + \Omega^2 e = 0$$

describing so called *zero sliding dynamics*. From it follows that the evolution of e can be prescribed by the parameters ξ, Ω. For stable behavior, it must hold $\xi > 0, \Omega > 0$. A typical optimal value of ξ ranges in the interval $[4, 8]$ and ξ about 6 is often a satisfactory value. The optimal value of Ω strongly depends on the controlled process. The slower processes the lower optimal Ω. The recommended value of Ω for start of tuning is $\pi/(5T_C)$.
The manipulated variable mv usually ranges in the interval $[-1, 1]$. The positive (negative) value corresponds to heating (cooling). For example, mv = 1 means the full heating. The limits of mv can be reduced when needed by the controller parameters hilim_p and hilim_m. This reduction is probably necessary when the asymmetry between heating and cooling is significant. For example, if in the working zone the cooling is much more aggressive than heating, then these parameters should be set as hilim_p = 1 and hilim_m < 1. If we want to apply such limitation only in some time interval after a change of setpoint (during the transient response) then it is necessary to set initial value of the heating (cooling) action amplitude u0_p (u0_m) to the suitable value less than hilim_p (hilim_m). Otherwise set u0_p = hilim_p and u0_m = hilim_m.

The current amplitudes of heating and cooling uk_p, uk_m, respectively, are automatically adapted by the special algorithm to achieve so called *quasi sliding mode*, where the sign of s_k alternately changes its value. In such a case the controller output isv alternates the values 1 and −1. The rate of adaptation of the heating (cooling) amplitude is given by the time constant taup (taum). Both of these time constants have to be sufficiently high to provide the proper function of adaptation but the fine tuning is not necessary.

Note for completeness that the manipulated variable mv is determined from the action amplitudes uk_p, uk_m by the following expression

$$\text{if} \quad (s_k < 0.0) \quad \text{then} \quad \texttt{mv} = \texttt{uk\_p} \quad \text{else} \quad \texttt{mv} = -\texttt{uk\_m}.$$

Further, it is important to note that quasi sliding is seldom achievable because of a process dead time or disturbances. The suitable indicator of the quality of sliding is again the output isv. If the extraordinary fine tuning is required then it may be tried to find the better value for the bandwidth parameter beta of derivative filter, otherwise the default value 0.1 is preferred. In the manual mode (MAN = on) the controller input hv is (after limitation to the range [−hilim_m, hilim_p]) copied to the manipulated variable mv.

Inputs

sp	setpoint variable	Double (F64)
pv	process variable	Double (F64)
hv	manual value	Double (F64)
MAN	controller mode 0 ..... automatic mode 1 ..... manual mode	Bool

Outputs

mv	manipulated variable (position controller output)	Double (F64)
mve	equivalent manipulated variable	Double (F64)
de	deviation error	Double (F64)
SAT	saturation flag 0 ..... the controller implements a linear control law 1 ..... the controller output is saturated, mv $\geq$ hilim_p or mv $\leq$ -hilim_m	Bool
isv	number of the positive (+) or negative (−) sliding variable steps	Long (I32)
t_ukp	current amplitude of heating	Double (F64)
t_ukm	current amplitude of cooling	Double (F64)
t_sk	discrete dynamic sliding variable s_k	Double (F64)
t_pv	filtered control error -de	Double (F64)
t_dpv	filtered first derivative of the control error t_ek	Double (F64)
t_d2pv	filtered second derivative of the control error t_ek	Double (F64)

Parameters

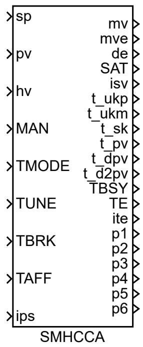
ipwmc	PWM cycle in the sampling periods of SMHCC (T_C/T_S)	Long (I32)
xi	relative damping ξ of sliding zero dynamics xi ≥ 0	Double (F64)
om	natural frequency Ω of sliding zero dynamics ↓(0.0)	Double (F64)
taup	time constant for adaptation of heating action amplitude in seconds	Double (F64)

taum	time constant for adaptation of cooling action amplitude in seconds		Double (F64)
beta	bandwidth parameter of the derivative filter	↓0	Double (F64)
hilim_p	high limit of the heating action amplitude	↓0.0 ↑1.0	Double (F64)
hilim_m	high limit of the cooling action amplitude	↓0.0 ↑1.0	Double (F64)
u0_p	initial value of the heating action amplitude after setpoint change and start of the block		Double (F64)
u0_m	initial value of the cooling action amplitude after setpoint change and start of the block		Double (F64)
sp_dif	Setpoint difference threshold	⊙10.0	Double (F64)
tauf	Equivalent manipulated variable filter time constant	⊙400.0	Double (F64)

SMHCCA – Sliding mode heating/cooling controller with autotuner

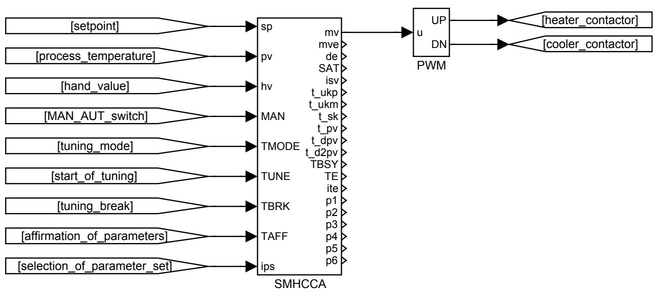
Block Symbol

Licence: AUTOTUNING



Function Description

The sliding mode heating/cooling controller (SMHCCA) is a novel high quality control algorithm with a built-in autotuner for automatic tuning of the controller parameters. The controller is mainly intended for temperature control of heating-cooling (possibly asymmetrical) processes with ON-OFF heaters and/or ON-OFF coolers. The plastic extruder heating/cooling system is a typical example of such process. However, it can also be applied to many similar cases, for example, to thermal systems where a conventional thermostat is normally employed. To provide the proper control function, the SMHCCA block must be combined with the PWM block (Pulse Width Modulation) as depicted in the following figure.



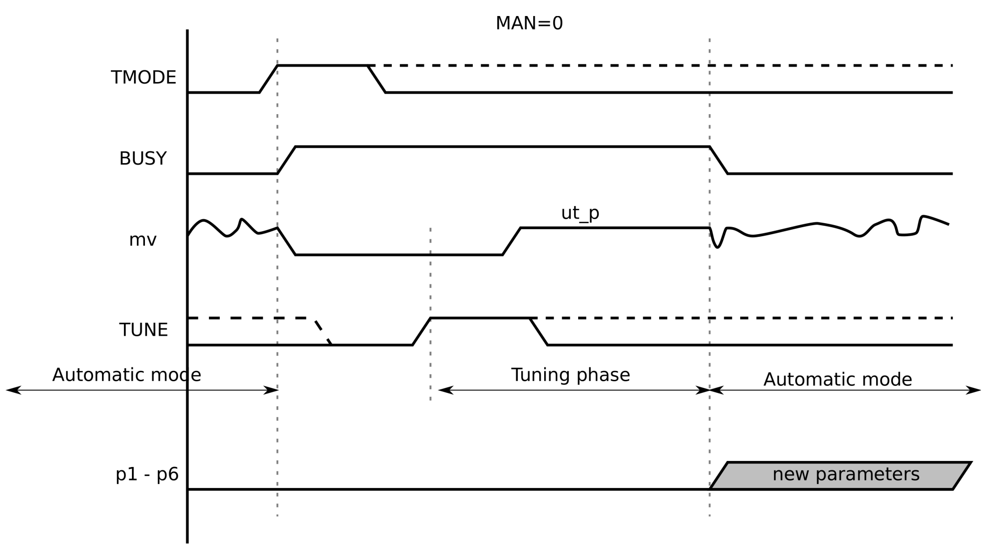
It is important to note that the block SMHCCA works with two time periods. The first period T_S is the sampling time of the process temperature, and this period is equal to the period with which the block SMHCCA itself is executed. The other period $T_C = i_{pwmc} T_S$ is the control period with which the block SMHCCA generates the manipulated variable. This period T_C is equal to the cycle time of PWM block. At every instant when the manipulated variable mv is changed by SMHCCA the PWM algorithm recalculates the width of the output pulse and starts a new PWM cycle. The time resolution T_R of the PWM block is third time period involved in. This period is equal to the period with which the block PWM is executed and generally may be different from T_S. To achieve the high quality of control it is recommended to choose T_S as minimal as possible (i_{pwmc} as maximal as possible), the ratio T_C/T_S as maximal as possible but T_C should be sufficiently small with respect to the process dynamics. An example of reasonable values for an extruder temperature control is as follows:

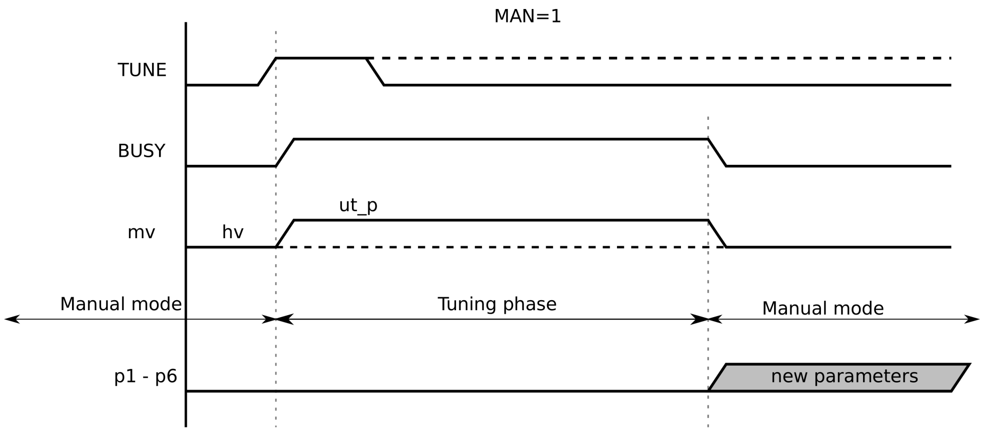
$$T_S = 0.1,\ i_{pwmc} = 50,\ T_C = 5s,\ T_R = 0.1s.$$

Notice however that for a faster controlled system the sampling periods T_S, T_C and T_R must be shortened! More precisely, the three minimal time constant of the process are important for selection of these time periods (all real thermal process has at least three time constants). For example, the sampling period $T_S = 0.1$ is sufficiently short for such processes that have at least three time constants, the minimal of them is greater than 10s and the maximal is greater than 100s. For the proper function of the controller it is necessary that these time parameters are suitably chosen by the user according to the actual dynamics of the process! If `SMHCCA` is implemented on a processor with floating point arithmetic then the accurate setting of the sampling periods T_S, T_C, T_R and the parameter `beta` is critical for correct function of the controller. Also, some other parameters with the clear meaning described below have to be chosen manually. All the remaining parameters (`xi`, `om`, `taup`, `taum`, `tauf`) can be set by the built-in autotuner automatically. The autotuner uses the two methods for this purpose.

- The first one is dedicated to situations where the asymmetry of the process is not enormous (approximately, it means that the gain ratio of heating/cooling or cooling/heating is less than 5).
- The second method provides the tuning support for the strong asymmetric processes and is not implemented yet (So far, this method has been developed and tested in Simulink only).

Despite the fact that the first method of the tuning is based only on the heating regime, the resulting parameters are usually satisfactory for both heating and cooling regimes because of the strong robustness of sliding mode control. The tuning procedure is very quick and can be accomplished during the normal rise time period of the process temperature from cold state to the setpoint usually without any temporization or degradation of control performance. Thus the tuning procedure can be included in every start up from cold state to the working point specified by the sufficiently high temperature setpoint. Now the implemented procedure will be described in detail. The tuning procedure starts in the tuning mode or in the manual mode. If the tuning mode (`TMODE` = `on`) is selected the manipulated variable `mv` is automatically set to zero and the output `TBSY` is set to 1 for indication of the tuning stage of the controller. The cold state of the process is preserved until the initialization pulse is applied to the input `TUNE` ($0 \rightarrow 1$). After some time (depending on `beta`), when the noise amplitude is estimated, the heating is switched on with the amplitude given by the parameter `ut_p`. The process temperature `pv` and its two derivatives (outputs `t_pv`, `t_dpv`, `t_d2pv`) are observed to obtain the optimal parameters of the controller. If the tuning procedure ends without errors, then `TBSY` is set to 0 and the controller begins to work in manual or automatic mode according to the input `MAN`. If `MAN` = `off` and affirmation input `TAFF` is set to 1, then the controller starts to work in automatic mode with the new parameter set provided by the tuner (if `TAFF` = `off`, then the new parameters are only displayed on the outputs `p1..p6`). If some error occurs during the tuning, then the tuning procedure stops immediately or stops after the condition `pv>sp` is fulfilled, the output `TE` is set to 1 and `ite` indicate the type of error. Also in this case, the controller starts to work in the mode determined by the input `MAN`. If `MAN` = `off` then works in automatic mode with the initial parameters before tuning! The tuning errors are usually caused either by an inappropriate setting of the parameter `beta` or by the too low value of `sp`. The suitable value of `beta` ranges in the interval (0.001,0.1). If a drift and noise in `pv` are large the small `beta` must be chosen especially for the tuning phase. The default value (`beta=0.01`) should work well for extruder applications. The correct value gives properly filtered signal of the second derivative of the process temperature `t_d2pv`. This well-filtered signal (corresponding to the low value of beta) is mainly necessary for proper tuning. For control, the parameter beta may be sometimes slightly increased. The tuning procedure may be also started from manual mode (`MAN` = `off`) with any constant value of the input `hv`. However, the steady state must be provided in this case. Again, the tuning is started by the initialization pulse at the input `TUNE` (`0` $\rightarrow$ `1`) and after the stop of tuning the controller continues in the manual mode. In both cases the resulting parameters appear on the outputs `p1,...,p6`.





The control law of the block SMHCCA in automatic mode (MAN = off) is based on the discrete dynamic sliding mode control technique and special 3rd order filters for estimation of the first and second derivatives of the control error.

The first control stage, after a setpoint change or upset, is the *reaching phase* when the dynamic sliding variable

$$s_k \stackrel{\triangle}{=} \ddot{e}_k + 2\xi\Omega\dot{e}_k + \Omega^2 e_k$$

is forced to zero. In the above definition of the sliding variable, $e_k, \dot{e}_k, \ddot{e}_k$ denote the filtered deviation error (pv − sp) and its first and second derivatives in the control period k, respectively, and ξ, Ω are the control parameters described below. In the second phase, s_k is hold at the zero value (*the sliding phase*) by the proper control "bangs". Here, the heating action is alternated by cooling action and *vice versa* rapidly. The amplitudes of control actions are adapted appropriately to guarantee $s_k = 0$ approximately. Thus, the hypothetical continuous dynamic sliding variable

$$s \stackrel{\triangle}{=} \ddot{e} + 2\xi\Omega\dot{e} + \Omega^2 e$$

is approximately equal to zero at any time. Therefore the control deviation behaves according to the second order differential equation

$$s \stackrel{\triangle}{=} \ddot{e} + 2\xi\Omega\dot{e} + \Omega^2 e = 0$$

describing so called *zero sliding dynamics*. From it follows that the evolution of e can be prescribed by the parameters ξ, Ω. For stable behavior, it must hold $\xi > 0, \Omega > 0$. A typical optimal value of ξ ranges in the interval $[4, 8]$ and ξ about 6 is often a satisfactory value. The optimal value of Ω strongly depends on the controlled process. The slower processes the lower optimal Ω. The recommended value of Ω for start of tuning is $\pi/(5T_C)$.

The manipulated variable mv usually ranges in the interval $[-1, 1]$. The positive (negative) value corresponds to heating (cooling). For example, mv $= 1$ means the full heating. The limits of mv can be reduced when needed by the controller parameters hilim_p and hilim_m. This reduction is probably necessary when the asymmetry between heating and cooling is significant. For example, if in the working zone the cooling is much more aggressive than heating, then these parameters should be set as hilim_p = 1 and hilim_m < 1. If we want to apply such limitation only in some time interval after a change of setpoint (during the transient response) then it is necessary to set initial value of the heating (cooling) action amplitude u0_p (u0_m) to the suitable value less than hilim_p (hilim_m). Otherwise set u0_p = hilim_p and u0_m = hilim_m.

The current amplitudes of heating and cooling uk_p, uk_m, respectively, are automatically adapted by the special algorithm to achieve so called *quasi sliding mode*, where the sign of s_k alternately changes its value. In such a case the controller output isv alternates the values 1 and −1. The rate of adaptation of the heating (cooling) amplitude is given by time constant taup (taum). Both of these time constants have to be sufficiently high to provide the proper function of adaptation but the fine tuning is not necessary. Note for completeness that the manipulated variable mv is determined from the action amplitudes uk_p, uk_m by the following expression

$$\text{if} \quad (s_k < 0.0) \quad \text{then} \quad \texttt{mv} = \texttt{uk\_p} \quad \text{else} \quad \texttt{mv} = -\texttt{uk\_m}.$$

Further, it is important to note that quasi sliding is seldom achievable because of a process dead time or disturbances. The suitable indicator of the quality of sliding is again the output isv. If the extraordinary fine tuning is required then it may be tried to find the better value for the bandwidth parameter beta of derivative filter, otherwise the default value 0.1 is preferred.

In the manual mode (MAN = on) the controller input hv is (after limitation to the range [−hilim_m, hilim_p]) copied to the manipulated variable mv. The controller output mve provides the equivalent amplitude-modulated value of the manipulated variable mv for informative purposes. The output mve is obtained by the first order filter with the time constant tauf applied to mv.

Inputs

sp	Setpoint variable	Double (F64)
pv	Process variable	Double (F64)
hv	Manual value	Double (F64)
MAN	Manual or automatic mode 0 ..... Automatic mode 1 ..... Manual mode	Bool
TMODE	Tuning mode	Bool
TUNE	Start the tuning experiment: TUNE off→on	Bool
TBRK	Stop the tuning experiment: TBRK off→on	Bool
TAFF	Affirmation of the parameter set provided by the tuning procedure: TAFF = on	Bool

ips	Meaning of the output signals p1,...,p6 0 ..... Controller parameters p1 ... recommended control period T_C p2 ... xi p3 ... om p4 ... taup p5 ... taum p6 ... tauf 1 ..... Auxiliary parameters p1 ... htp2 – time of the peak in the second derivative of pv p2 ... hpeak2 – peak value in the second derivative of pv p3 ... d2 – peak to peak amplitude of t_d2pv p4 ... tgain	Long (I32)

Outputs

mv	Manipulated variable (controller output)	Double (F64)
mve	Equivalent manipulated variable	Double (F64)
de	Deviation error	Double (F64)
SAT	Saturation flag 0 ..... Signal not limited 1 ..... Saturation limits active, mv $\geq$ hilim_p or mv $\leq$ -hilim_m	Bool
isv	Number of the positive (+) or negative (−) sliding variable steps	Long (I32)
t_ukp	Current amplitude of heating	Double (F64)
t_ukm	Current amplitude of cooling	Double (F64)
t_sk	Discrete dynamic sliding variable	Double (F64)
t_pv	Filtered process variable pv by 3rd order filter	Double (F64)
t_dpv	Filtered first derivative of pv by 3rd order filter	Double (F64)
t_d2pv	Filtered second derivative of pv by 3rd order filter	Double (F64)
TBSY	Tuner busy flag (TBSY = on)	Bool
TE	Tuning error off ... Autotuning successful on .... An error occured during the experiment	Bool

`ite`	Error code 0 ..... No error 1 ..... Noise level in `pv` too high, check the temperature input 2 ..... Incorrect parameter `ut_p` 3 ..... Setpoint `sp` too low 4 ..... The two minimal process time constants are probably too small with respect to the sampling period T_S OR too high level of noise in the second derivative of `pv` (try to decrease the `beta` parameter) 5 ..... Premature termination of the tuning procedure (`TBRK`)	`Long (I32)`
`p`i	Identified parameters with respect to `ips`, $i = 1, ..., 6$	`Double (F64)`

Parameters

`ipwmc`	PWM cycle (in sampling periods of the block, T_C/T_S) ⊙`100`	`Long (I32)`
`xi`	Relative damping of sliding zero dynamics ↓`0.5`↑`8.0`⊙`1.0`	`Double (F64)`
`om`	Natural frequency ω of sliding zero dynamics ↓`0.0`⊙`0.01`	`Double (F64)`
`taup`	Time constant for adaptation of heating action amplitude [s] ⊙`700.0`	`Double (F64)`
`taum`	Time constant for adaptation of cooling action amplitude [s] ⊙`400.0`	`Double (F64)`
`beta`	Bandwidth parameter of the derivative filter ⊙`0.01`	`Double (F64)`
`hilim_p`	Upper limit of the heating action amplitude ↓`0.0` ↑`1.0` ⊙`1.0`	`Double (F64)`
`hilim_m`	Upper limit of the cooling action amplitude ↓`0.0` ↑`1.0` ⊙`1.0`	`Double (F64)`
`u0_p`	Initial amplitude of the heating action ⊙`1.0`	`Double (F64)`
`u0_m`	Initial amplitude of the cooling action ⊙`1.0`	`Double (F64)`
`sp_dif`	Setpoint difference threshold for blocking of heating/cooling amplitudes reset ⊙`10.0`	`Double (F64)`
`tauf`	Time constant of the filter for obtaining the equivalent manipulated variable ⊙`400.0`	`Double (F64)`
`itm`	Tuning method ⊙`1` 1 ..... Restricted to symmetrical processes 2 ..... Asymmetrical processes (not implemented yet)	`Long (I32)`
`ut_p`	Amplitude of heating for tuning experiment ↓`0.0` ↑`1.0` ⊙`1.0`	`Double (F64)`
`ut_m`	Amplitude of cooling for tuning experiment ↓`0.0` ↑`1.0` ⊙`1.0`	`Double (F64)`

SWU – Switch unit

Block Symbol

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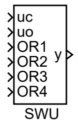

Function Description

The SWU block is used to select the appropriate signal which should be tracked by the inactive PIDU and MCU units in complex control structures. The input signal uc is copied to the output y when all the binary inputs OR1, . . . , OR4 are off, otherwise the output y takes over the uo input signal.

Inputs

uc	This input is copied to output y when all the binary inputs OR1, OR2, OR3 and OR4 are off	Double (F64)
uo	This input is copied to output y when any of the binary inputs OR1, OR2, OR3, OR4 is on	Double (F64)
OR1	First logical output of the block	Bool
OR2	Second logical output of the block	Bool
OR3	Third logical output of the block	Bool
OR4	Fourth logical output of the block	Bool

Output

y	Analog output of the block	Double (F64)

TSE – Three-state element

Block Symbol

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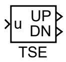
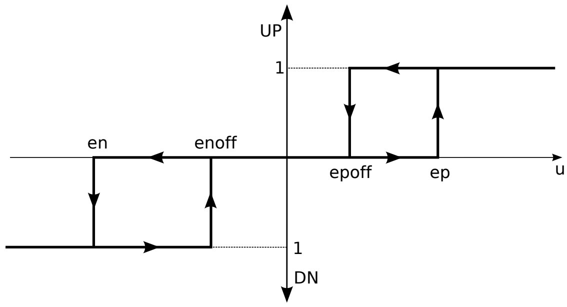


Function Description

The TSE block transforms the analog input u to a three-state signal ("up", "idle" and "down") according to the diagram below.



Input

u	Analog input of the block	Double (F64)

Outputs

UP	The "up" signal	Bool
DN	The "down" signal	Bool

Parameters

ep	The input value u > ep results in UP = on and DN = off	⊙1.0	Double (F64)
en	The input value u < en results in UP = off and DN = off	⊙-1.0	Double (F64)
epoff	UP switch off value; if UP = on and u < epoff then UP = off	⊙0.5	Double (F64)
enoff	DN switch off value; if DN = on and u > enoff then DN = off	⊙-0.5	Double (F64)

Chapter 8

LOGIC – Logic control

Contents

The LOGIC library encompasses a range of blocks for executing logical and sequential operations. It includes basic Boolean blocks like AND, OR, NOT for fundamental logical operations, and advanced blocks like ATMT for finite state machines. Blocks like COUNT and TIMER extend functionality to bidirectional pulse counting and time-based operations. Additional elements like BITOP, BMOCT, and BDOCT offer bitwise operations and multiplexing/demultiplexing capabilities, enhancing the library's versatility in handling combinational and sequential logic control.

AND – Logical product of two signals

Block Symbol

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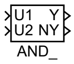

Function Description

The AND block computes the logical product of two input signals $Y = U1 \wedge U2$. If you need to work with more input signals, use the ANDQUAD, ANDOCT or ANDHEXD block.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

U1	First logical input of the block	Bool
U2	Second logical input of the block	Bool

Output

Y	Output signal, logical product	Bool
NY	Boolean complementation of Y	Bool

ANDQUAD, ANDOCT, ANDHEXD – Multi-input logical product

Block Symbols

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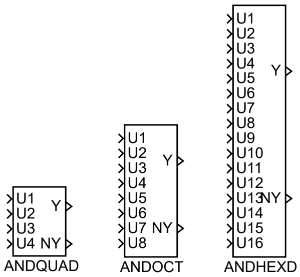

Function Description

The ANDQUAD, ANDOCT and ANDHEXD blocks compute the logical product of up to sixteen input signals U1, U2, ..., U16. The signals listed in the nl parameter are negated prior to computing the logical product.

For an empty nl parameter a simple logical product $\mathtt{Y} = \mathtt{U1} \wedge \mathtt{U2} \wedge \mathtt{U3} \wedge \mathtt{U4} \wedge \mathtt{U5} \wedge \mathtt{U6} \wedge \mathtt{U7} \wedge \mathtt{U8}$ is computed. For e.g. nl=1,3..5, the logical function is $\mathtt{Y} = \neg\mathtt{U1} \wedge \mathtt{U2} \wedge \neg\mathtt{U3} \wedge \neg\mathtt{U4} \wedge \neg\mathtt{U5} \wedge \mathtt{U6} \wedge \ldots \mathtt{U16}$.

If you have less than 4/8/16 signals, use the nl parameter to handle the unconnected inputs. If you have only two input signals, consider using the AND block.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

U1	Logical input of the block	Bool
U2	Logical input of the block	Bool
U3	Logical input of the block	Bool
U4	Logical input of the block	Bool
U5	Logical input of the block	Bool
U6	Logical input of the block	Bool
U7	Logical input of the block	Bool
U8	Logical input of the block	Bool
U9	Logical input of the block	Bool
U10	Logical input of the block	Bool
U11	Logical input of the block	Bool
U12	Logical input of the block	Bool
U13	Logical input of the block	Bool
U14	Logical input of the block	Bool

U15	Logical input of the block	Bool
U16	Logical input of the block	Bool

Parameter

nl	List of signals to negate	Long (I32)

Output

Y	Output signal, logical product	Bool
NY	Boolean complementation of Y	Bool

ATMT – Finite-state automaton

Block Symbol

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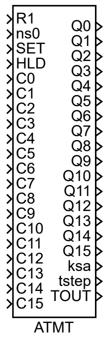

Function Description

The `ATMT` block implements a finite state machine with at most 16 states and 16 transition rules.

The current state of the machine i, $i = 0, 1, \ldots, 15$ is indicated by the binary outputs `Q0`, `Q1`, ..., `Q15`. If the state i is active, the corresponding output is set to `Q`i`=on`. The current state is also indicated by the `ksa` output (`ksa` $\in \{0, 1, \ldots, 15\}$).

The transition conditions C_k, $k = 0, 1, \ldots, 15$ are activated by the binary inputs `C0`, `C1`, ..., `C15`. If `C`k = `on` the `k`-th transition condition is fulfilled. The transition cannot happen when `C`k = `off`.

The automat function is defined by the following table of transitions:

$$\begin{array}{ccc} S1 & C1 & FS1 \\ S2 & C2 & FS2 \\ & & \ldots \\ Sn & Cn & FSn \end{array}$$

Each row of this table represents one transition rule. For example the first row

$$S1 \quad C1 \quad FS1$$

has the meaning

`If` ($S1$ is the current state `AND` transition condition $C1$ is fulfilled),
`then` proceed to the following state $FS1$.

The above mentioned table can be easily constructed from the automat state diagram or SFC description (Sequential Function Charts, formerly Grafcet).

The `R1` = `on` input resets the automat to the initial state $S0$. The `SET` input allows manual transition from the current state to the `ns0` state when rising edge occurs. The

R1 input overpowers the SET input. The HLD = on input freezes the automat activity, the automat stays in the current state regardless of the Ci input signals and the tstep timer is not incremented. The TOUT output indicates that the machine remains in the given state longer than expected. The time limits TOi for individual states are defined by the touts array. There is no time limit for the given state when TOi is set to zero. The TOUT output is set to off whenever the automat changes its state.

It is possible to allow more state transitions in one cycle by the morestps parameter. However, this option must be thoroughly considered and tested, namely when the TOUT output is used in transition conditions. In such a case it is strongly recommended to incorporate the ksa output in the transition conditions as well.

The development tools of the REXYGEN system include also the SFCEditor program. You can create SFC schemes graphically using this tool. Run this editor from REXYGEN Studio by clicking the *Configure* button in the parameter dialog of the ATMT block.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

R1	Block reset	Bool
ns0	Target state forced by the SET input	Long (I32)
SET	Forced transition to state ns0	Bool
HLD	Hold	Bool
C0	Transition condition	Bool
C1	Transition condition	Bool
C2	Transition condition	Bool
C3	Transition condition	Bool
C4	Transition condition	Bool
C5	Transition condition	Bool
C6	Transition condition	Bool
C7	Transition condition	Bool
C8	Transition condition	Bool
C9	Transition condition	Bool
C10	Transition condition	Bool
C11	Transition condition	Bool
C12	Transition condition	Bool
C13	Transition condition	Bool
C14	Transition condition	Bool
C15	Transition condition	Bool

Parameter

morestps	Allow multiple transitions in one cycle off . . . Disabled on . . . . Enabled	Bool

sfcname	Name of special editor data file		String
STT	State transition table	⊙[0 0 1; 1 1 2; 2 2 3; 3 3 0]	Byte (U8)
touts	Vector of timeouts	⊙[1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16]	Double (F64)

Output

Q0	Active state indicator	Bool
Q1	Active state indicator	Bool
Q2	Active state indicator	Bool
Q3	Active state indicator	Bool
Q4	Active state indicator	Bool
Q5	Active state indicator	Bool
Q6	Active state indicator	Bool
Q7	Active state indicator	Bool
Q8	Active state indicator	Bool
Q9	Active state indicator	Bool
Q10	Active state indicator	Bool
Q11	Active state indicator	Bool
Q12	Active state indicator	Bool
Q13	Active state indicator	Bool
Q14	Active state indicator	Bool
Q15	Active state indicator	Bool
ksa	Integer code of the active state	Long (I32)
tstep	Time elapsed since the last state transition	Double (F64)
TOUT	Timeout flag	Bool

BDOCT, BDHEXD – Bitwise demultiplexers

Block Symbols

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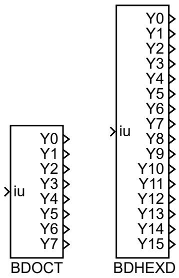


Function Description

Both BDOCT and BDHEXD are bitwise demultiplexers for easy decomposition of the input signal to individual bits. The only difference is the number of outputs, the BDOCT block has 8 Boolean outputs while the BDHEXD block offers 16-bit decomposition. The output signals Yi correspond with the individual bits of the input signal iu shifter by shift bits to the right. The Y0 output is the least significant bit.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

iu	Input signal to be decomposed		Long (I32)

Parameter

shift	Bit shift of the input signal	↓0 ↑31	Long (I32)
vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)

Output

Y0	Individual bit of the input signal	Bool
Y1	Individual bit of the input signal	Bool
Y2	Individual bit of the input signal	Bool

Y3	Individual bit of the input signal	Bool
Y4	Individual bit of the input signal	Bool
Y5	Individual bit of the input signal	Bool
Y6	Individual bit of the input signal	Bool
Y7	Individual bit of the input signal	Bool
Y8	Individual bit of the input signal	Bool
Y9	Individual bit of the input signal	Bool
Y10	Individual bit of the input signal	Bool
Y11	Individual bit of the input signal	Bool
Y12	Individual bit of the input signal	Bool
Y13	Individual bit of the input signal	Bool
Y14	Individual bit of the input signal	Bool
Y15	Individual bit of the input signal	Bool

BITOP – Bitwise operation

Block Symbol

Licence: STANDARD

Function Description

The BITOP block performs bitwise operation $i1 \circ i2$ on the signals i1 and i2, resulting in an integer output n. The type of operation is selected by the iop parameter described below. In case of logical negation or 2's complements the input i2 is ignored (i.e. the operation is unary).

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

i1	First integer input of the block	Long (I32)
i2	Second integer input of the block	Long (I32)

Parameter

iop   Bitwise operation   ⊙1   Long (I32)

- 1 ..... Bit NOT
- 2 ..... Bit OR
- 3 ..... Bit AND
- 4 ..... Bit XOR
- 5 ..... Shift Left
- 6 ..... Shift Right
- 7 ..... 2's Complement - Byte
- 8 ..... 2's Complement - Word
- 9 ..... 2's Complement - Long

vtype   Numeric type   ⊙4   Long (I32)

- 2 ..... Byte (U8)
- 3 ..... Short (I16)
- 4 ..... Long (I32)
- 5 ..... Word (U16)
- 6 ..... DWord (U32)
- 10 .... Large (I64)

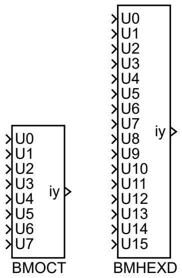
Output

n	Result of the bitwise operation	Long (I32)

BMOCT, BMHEXD – Bitwise multiplexers

Block Symbols

Licence: STANDARD



Function Description

Both `BMOCT` and `BMHEXD` are bitwise multiplexers for easy composition of the output signal from individual bits. The only difference is the number of inputs, the `BMOCT` block has 8 Boolean inputs while the `BMHEXD` block offers 16-bit composition. If the parameter `shift` = 0, the individual bits of the output signal `iy` are directly formed by the input signals Ui. The `U0` output is the least significant bit.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

U0	Individual bit of the output signal	Bool
U1	Individual bit of the output signal	Bool
U2	Individual bit of the output signal	Bool
U3	Individual bit of the output signal	Bool
U4	Individual bit of the output signal	Bool
U5	Individual bit of the output signal	Bool
U6	Individual bit of the output signal	Bool
U7	Individual bit of the output signal	Bool
U8	Individual bit of the output signal	Bool
U9	Individual bit of the output signal	Bool
U10	Individual bit of the output signal	Bool
U11	Individual bit of the output signal	Bool
U12	Individual bit of the output signal	Bool
U13	Individual bit of the output signal	Bool
U14	Individual bit of the output signal	Bool
U15	Individual bit of the output signal	Bool

Parameter

`shift`	Bit shift of the output signal	↓0 ↑31	`Long (I32)`
`vtype`	Numeric type `2` ..... Byte (U8) `3` ..... Short (I16) `4` ..... Long (I32) `5` ..... Word (U16) `6` ..... DWord (U32) `10` .... Large (I64)	⊙4	`Long (I32)`

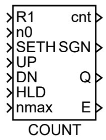
Output

`iy`	Composed output signal	`Long (I32)`

COUNT – Controlled counter

Block Symbol

Licence: STANDARD



Function Description

The COUNT block is designed for bidirectional pulse counting – more precisely, counting rising edges of the UP and DN input signals. When a rising edge occurs at the UP (DN) input, the cnt output is incremented (decremented) by 1. Simultaneous occurrence of rising edges at both inputs is indicated by the error output E set to on. The R1 input resets the counter to 0 and no addition or subtraction is performed unless the R1 input returns to off again. It is also possible to set the output cnt to the value n0 by the SETH input. Again, no addition or subtraction is performed unless the SETH input returns to off again. The R1 input has higher priority than the SETH input. The input HLD = on prevents both incrementing and decrementing. When the counter reaches the value cnt ≥ nmax, the Q output is set to on.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

R1	Block reset	Bool
n0	Value to set the counter to	Long (I32)
SETH	Set the counter value	Bool
UP	Incrementing input signal	Bool
DN	Decrementing input signal	Bool
HLD	Counter freeze off . . . Counter is running on . . . . Counter is locked	Bool
nmax	Counter target value	Long (I32)

Output

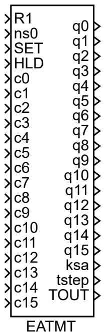
cnt	Total number of pulses	Long (I32)
SGN	Sign of the cnt output off . . . Less or equal to zero on . . . . Positive value	Bool

`Q`	Counter state `off` . . . Target value not reached `on` . . . . Target value reached	`Bool`
`E`	Error indicator `off` . . . No error `on` . . . . An error occurred	`Bool`

EATMT – Extended finite-state automaton

Block Symbol

Licence: ADVANCED



Function Description

The EATMT block implements a finite automat with at most 256 states and 256 transition rules, thus it extends the possibilities of the ATMT block.

The current state of the automat i, $i = 0, 1, \ldots, 255$ is indicated by individual bits of the integer outputs q0, q1, ..., q15. Only a single bit with index $i \,\mathrm{MOD}\, 16$ of the q($i \,\mathrm{DIV}\, 16$) output is set to 1. The remaining bits of that output and the other outputs are zero. The bits are numbered from zero, least significant bit first. Note that the DIV and MOD operators denote integer division and remainder after integer division respectively. The current state is also indicated by the ksa $\in \{0, 1, \ldots, 255\}$ output.

The transition conditions C_k, $k = 0, 1, \ldots, 255$) are activated by individual bits of the inputs c0, c1, ..., c15. The k-th transition condition is fulfilled when the ($k \,\mathrm{MOD}\, 16$)-th bit of the input c($k \,\mathrm{DIV}\, 16$) is equal to 1. The transition cannot happen otherwise.

The BMHEXD or BMOCT bitwise multiplexers can be used for composition of the input signals c0, c1, ..., c15 from individual Boolean signals. Similarly the output signals q0, q1, ..., q15 can be decomposed using the BDHEXD or BDOCT bitwise demultiplexers.

The automat function is defined by the following table of transitions:

$$\begin{array}{ccc} S1 & C1 & FS1 \\ S2 & C2 & FS2 \\ & & \ldots \\ Sn & Cn & FSn \end{array}$$

Each row of this table represents one transition rule. For example the first row

$$S1 \quad C1 \quad FS1$$

has the meaning

If ($S1$ is the current state AND transition condition $C1$ is fulfilled),
then proceed to the following state $FS1$.

The above described meaning of the table row holds for $C1 < 1000$. Negation of the $(C1 - 1000)$-th transition condition is assumed for $C1 \geq 1000$.

The above mentioned table can be easily constructed from the automat state diagram or SFC description (Sequential Function Charts, formerly Grafcet).

The R1 = on input resets the automat to the initial state $S0$. The SET input allows manual transition from the current state to the ns0 state when rising edge occurs. The R1 input overpowers the SET input. The HLD = on input freezes the automat activity, the automat stays in the current state regardless of the ci input signals and the tstep timer is not incremented. The TOUT output indicates that the machine remains in the given state longer than expected. The time limits TOi for individual states are defined by the touts array. There is no time limit for the given state when TOi is set to zero. The TOUT output is set to off whenever the automat changes its state.

It is possible to allow more state transitions in one cycle by the morestps parameter. However, this option must be thoroughly considered and tested, namely when the TOUT output is used in transition conditions. In such a case it is strongly recommended to incorporate the ksa output in the transition conditions as well.

The development tools of REXYGEN include also the SFCEditor program. You can create SFC schemes graphically using this tool. Run this editor from REXYGEN Studio by clicking the *Configure* button in the parameter dialog of the EATMT block.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

R1	Block reset	Bool
ns0	Target state forced by the SET input	Long (I32)
SET	Forced transition to state ns0	Bool
HLD	Hold	Bool
c0	Transition condition	Long (I32)
c1	Transition condition	Long (I32)
c2	Transition condition	Long (I32)
c3	Transition condition	Long (I32)
c4	Transition condition	Long (I32)
c5	Transition condition	Long (I32)
c6	Transition condition	Long (I32)
c7	Transition condition	Long (I32)
c8	Transition condition	Long (I32)
c9	Transition condition	Long (I32)
c10	Transition condition	Long (I32)
c11	Transition condition	Long (I32)
c12	Transition condition	Long (I32)
c13	Transition condition	Long (I32)
c14	Transition condition	Long (I32)
c15	Transition condition	Long (I32)

Parameter

`morestps`	Allow multiple transitions in one cycle `off` ... Disabled `on` .... Enabled	`Bool`
`sfcname`	Name of special editor data file	`String`
`STT`	State transition table ⊙`[0 0 1; 1 1 2; 2 2 3; 3 3 0]`	`Short (I16)`
`touts`	Vector of timeouts ⊙`[1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16]`	`Double (F64)`

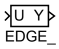
Output

`q0`	Active state indicator	`Long (I32)`
`q1`	Active state indicator	`Long (I32)`
`q2`	Active state indicator	`Long (I32)`
`q3`	Active state indicator	`Long (I32)`
`q4`	Active state indicator	`Long (I32)`
`q5`	Active state indicator	`Long (I32)`
`q6`	Active state indicator	`Long (I32)`
`q7`	Active state indicator	`Long (I32)`
`q8`	Active state indicator	`Long (I32)`
`q9`	Active state indicator	`Long (I32)`
`q10`	Active state indicator	`Long (I32)`
`q11`	Active state indicator	`Long (I32)`
`q12`	Active state indicator	`Long (I32)`
`q13`	Active state indicator	`Long (I32)`
`q14`	Active state indicator	`Long (I32)`
`q15`	Active state indicator	`Long (I32)`
`ksa`	Integer code of the active state	`Long (I32)`
`tstep`	Time elapsed since the last state transition	`Double (F64)`
`TOUT`	Timeout flag	`Bool`

EDGE – Falling/rising edge detection in a binary signal

Block Symbol

Licence: STANDARD



Function Description

The EDGE block detects rising (off→on), falling (on→off), or both edges on the input signal U, depending on the value of the iedge parameter. In case the desired edge (change in input signal) is found, the output Y is set to on for one step. As long as the value of the input signal remains unchanged, the output Y equals off. The output Y will also remain zero if the iedge parameter is set to detect a rising (falling) edge and a falling (rising) edge occurs in the signal.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

U	Logical input of the block		Bool

Parameter

iedge	Type of edges to detect 1 ..... Rising edge 2 ..... Falling edge 3 ..... Both edges	⊙1	Long (I32)

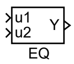
Output

Y	Logical output of the block		Bool

EQ – Equivalence two signals

Block Symbol

Licence: STANDARD



Function Description

The block compares two input signals and Y=on is set if both signals have the same value. Both signals must be either of a numeric type or strings. A conversion between numeric types is performed: for example 2.0 (double) and 2 (long) are evaluated as equivalent. Comparison of matrices or other complex types is not supported.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

u1	Block input signal	Any
u2	Block input signal	Any

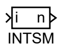
Output

Y	Logical output of the block	Bool
NY	Boolean complementation of Y	Bool

INTSM – Integer number bit shift and mask

Block Symbol

Licence: STANDARD



Function Description

The INTSM block performs bit shift of input value **i** by **shift** bits right (if **shift** is positive) or left (if **shift** is negative). Free space resulting from shifting is filled with zeros.

Output value **n** is calculated as bitwise AND of shifted input **i** and bit mask **mask**.

Typical application of this block is extraction of one or more adjacent bits from a given position in integer register which was read from some external system.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

i	Integer value to shift and mask	↓-9.22337E+18 ↑9.22337E+18	Large (I64)

Parameter

shift	Bit shift (negative=left, positive=right)	↓-63 ↑63	Long (I32)
mask	Bit mask (applied after bit shift)	↓0 ↑4294970000 ⊙4294967295	Large (I64)
vtype	Numeric type 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 10 .... Large (I64)	⊙4	Long (I32)

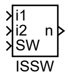
Output

n	Resulting integer value		Large (I64)

ISSW – Simple switch for integer signals

Block Symbol

Licence: STANDARD



Function Description

The ISSW block is a simple switch for integer input signals i1 and i2 whose decision variable is the binary input SW. If SW is off, then the output n is equal to the i1 signal. If SW is on, then the output n is equal to the i2 signal.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

i1	First integer input of the block	Long (I32)
i2	Second integer input of the block	Long (I32)
SW	Signal selector off . . . The i1 signal is selected on . . . . The i2 signal is selected	Bool

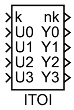
Output

n	Integer output of the block	Long (I32)

ITOI – Transformation of integer and binary numbers

Block Symbol

Licence: STANDARD



Function Description

The ITOI block transforms the input number k, or the binary number (U3 U2 U1 U0)$_2$, from the set $\{0, 1, 2, \ldots, 15\}$ to the output number nk and its binary representation (Y3 Y2 Y1 Y0)$_2$ from the same set. The transformation is described by the following table

k	0	1	2	...	15
nk	n0	n1	n2	...	n15

where n0, ..., n15 are given by the mapping table target vector fktab. If BINF = off, then the integer input k is active, while for BINF = on the input is defined by the binary inputs (U3 U2 U1 U0)$_2$.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

k	Integer input of the block	Long (I32)
U0	Binary input digit, weight of 1	Bool
U1	Binary input digit, weight of 2	Bool
U2	Binary input digit, weight of 4	Bool
U3	Binary input digit, weight of 8	Bool

Parameter

BINF	Enable the binary selectors off ... Disabled (analog selector) on .... Enabled (binary selectors)	⊙on	Bool
fktab	Mapping table	⊙[0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15]	Byte (U8)

Output

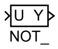
nk	Integer output of the block	Long (I32)
Y0	Binary output digit, weight of 1	Bool

Y1	Binary output digit, weight of 2	Bool
Y2	Binary output digit, weight of 4	Bool
Y3	Binary output digit, weight of 8	Bool

NOT – Boolean complementation

Block Symbol

Licence: STANDARD



Function Description

The NOT block negates the input signal $Y = \neg U$.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

U	Logical input of the block	Bool

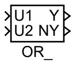
Output

Y	Logical output of the block	Bool

OR – Logical sum of two signals

Block Symbol

Licence: STANDARD



Function Description

The OR block computes the logical sum of two input signals Y = U1 ∨ U2. If you need to work with more input signals, use the ORQUAD, OROCT or ORHEXD block.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

U1	First logical input of the block	Bool
U2	Second logical input of the block	Bool

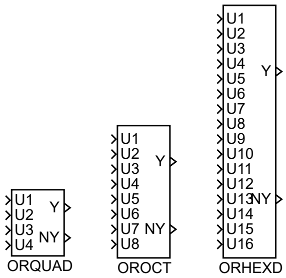
Output

Y	Output signal, logical sum	Bool
NY	Boolean complementation of Y	Bool

ORQUAD, OROCT, ORHEXD – Multi-input logical sum

Block Symbols

Licence: STANDARD



Function Description

The ORQUAD, OROCT and ORHEXD blocks compute the logical sum of up to sixteen input signals U1, U2, ..., U16. The signals listed in the nl parameter are negated prior to computing the logical sum.

For an empty nl parameter a simple logical sum Y = U1 ∨ U2 ∨ U3 ∨ U4 ∨ U5 ∨ U6 ∨ U7 ∨ ... ∨ U16 is computed. For e.g. nl=1,3..5, the logical function is Y = ¬U1 ∨ U2 ∨ ¬U3 ∨ ¬U4 ∨ ¬U5 ∨ U6 ∨ ... ∨ U16.

If you have only two input signals, consider using the OR block.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

U1	Logical input of the block	Bool
U2	Logical input of the block	Bool
U3	Logical input of the block	Bool
U4	Logical input of the block	Bool
U5	Logical input of the block	Bool
U6	Logical input of the block	Bool
U7	Logical input of the block	Bool
U8	Logical input of the block	Bool
U9	Logical input of the block	Bool
U10	Logical input of the block	Bool
U11	Logical input of the block	Bool
U12	Logical input of the block	Bool
U13	Logical input of the block	Bool
U14	Logical input of the block	Bool
U15	Logical input of the block	Bool
U16	Logical input of the block	Bool

Parameter

`nl`	List of signals to negate	`Long (I32)`

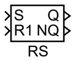
Output

`Y`	Output signal, logical sum	`Bool`
`NY`	Boolean complementation of Y	`Bool`

RS – Reset-set flip-flop circuit

Block Symbol

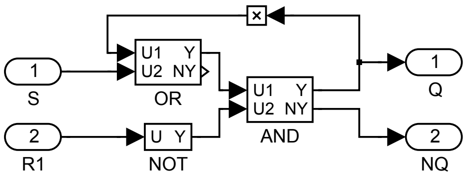
Licence: STANDARD



Function Description

The RS block is a flip-flop circuit, which sets its output permanently to on as soon as the input signal S is equal to on. The other input signal R1 resets the Q output to off even if the S input is on. The NQ output is simply the negation of the signal Q.

The block function is evident from the inner block structure depicted below.



This block propagates the signal quality. More information can be found in the 1.4 section.

Input

S	Flip-flop set	Bool
R1	Priority flip-flop reset	Bool

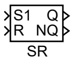
Output

Q	Flip-flop circuit state	Bool
NQ	Boolean complementation of Q	Bool

SR – Set-reset flip-flop circuit

Block Symbol

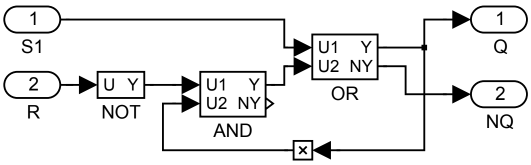
Licence: STANDARD



Function Description

The SR block is a flip-flop circuit, which sets its output permanently to on as soon as the input signal S1 is on. The other input signal R resets the Q output to off, but only if the S1 input is off. The NQ output is simply the negation of the signal Q.

The block function is evident from the inner block structure depicted below.



This block propagates the signal quality. More information can be found in the 1.4 section.

Input

S1	Priority flip-flop set	Bool
R	Flip-flop reset	Bool

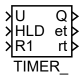
Output

Q	Flip-flop circuit state	Bool
NQ	Boolean complementation of Q	Bool

TIMER – Multipurpose timer

Block Symbol

Licence: STANDARD



Function Description

The TIMER block either generates an output pulse of the given width pt (in seconds) or filters narrow pulses in the U input signal whose width is less than pt seconds. The operation mode is determined by the mode parameter. Supported modes are:

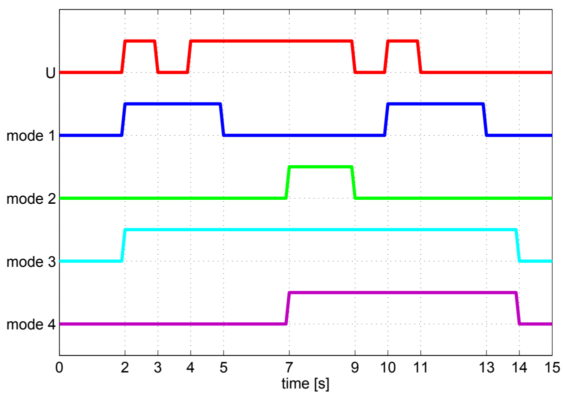
1: **Pulse**: An output pulse of the length pt is generated upon rising edge at the U input. All input pulses during the generation of the output pulse are ignored.

2: **Delayed ON**: The input signal U is copied to the Q output, but the start of the pulse is delayed by pt seconds. Any pulse shorter than pt is does not pass through the block.

3: **Delayed OFF**: The input signal U is copied to the Q output, but the end of the pulse is delayed by pt seconds. If the break between two pulses is shorter than pt, the output remains on for the whole time.

4: **Delayed change**: The Q output is set to the value of the U input no sooner than the input remains unchanged for pt seconds.

The graph illustrates the behaviour of the block in individual modes for pt $= 3$:



The timer can be paused by the HLD input. The R1 input resets the timer. The reset signal overpowers the U input, similarly to the RS block.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

U	Trigger of the timer		Bool
HLD	Timer hold		Bool
R1	Timer reset		Bool

Parameter

mode	Timer mode 1 ..... Pulse generator 2 ..... Delayed ON 3 ..... Delayed OFF 4 ..... Delayed change	⊙1	Long (I32)
pt	Timer interval [s]	⊙1.0	Double (F64)

Output

Q	Timer output		Bool
et	Elapsed time [s]		Double (F64)
rt	Remaining time [s]		Double (F64)

Chapter 9

TIME – Blocks for handling time

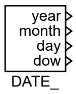
Contents

The TIME library is specialized for time-based operations and scheduling in REXYGEN system. It includes blocks like DATE, TIME and DATETIME for handling date and datetime, providing essential tools for working with temporal data. The library features TC for itnernal timer control. Additionally, WSCH is used for scheduling, enabling efficient management of time-dependent tasks. This library is particularly valuable for systems requiring precise time management and scheduling capabilities.

DATE – Current date

Block Symbol

Licence: STANDARD



Function Description

The outputs of the DATE function block correspond with the actual date of the operating system. Use the DATETIME block for advanced operations with date and time.

Outputs

year	Year	Long (I32)
month	Month	Long (I32)
day	Day	Long (I32)
dow	Day of week, first day of week is Sunday (1)	Long (I32)

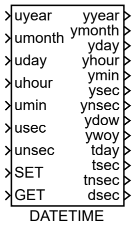
Parameter

tz	Timezone 1 ..... Local time 2 ..... UTC	⊙1	Long (I32)

DATETIME – Get, set and convert time

Block Symbol

Licence: STANDARD



Function Description

The DATETIME block is intended for advanced date/time operations in the REXYGEN system.

It allows synchronization of the operating system clock and the clock of the REXYGEN system. When the executive of the REXYGEN system is initialized, both clocks are the same. But during long-term operation the clocks may loose synchronization (e.g. due to daylight saving time). If re-synchronization is required, the rising edge (off→on) at the SET input adjusts the clock of the REXYGEN system according to the block inputs and parameters.

It is highly recommended not to adjust the REXYGEN system time when the controlled machine/process is in operation. Unexpected behavior might occur.

If date/time reading or conversion is required, the rising edge (off→on) at the GET input triggers the action and the block outputs are updated. The outputs starting with 't' denote the total number of respective units since January 1st, 2000 UTC.

Both reading and adjusting clock can be repeated periodically if set by getper and setper parameters.

If the difference of the two clocks is below the tolerance limit settol, the clock of the REXYGEN system is not adjusted at once, a gradual synchronization is used instead. In such a case, the timing of the REXYGEN system executive is negligibly altered and the clocks synchronization is achieved after some time. Afterwards the timing of the REXYGEN executive is reverted back to normal.

For simple date/time reading use the DATE_ and TIME function blocks.

Inputs

uyear	Input for setting year	Long (I32)
umonth	Input for setting month	Long (I32)
uday	Input for setting day	Long (I32)
uhour	Input for setting hours	Long (I32)
umin	Input for setting minutes	Long (I32)

usec	Input for setting seconds		Long (I32)
unsec	Input for setting nanoseconds	↓-9.22E+18 ↑9.22E+18	Large (I64)
SET	Trigger for setting time		Bool
GET	Trigger for getting time		Bool

Outputs

yyear	Year	Long (I32)
ymonth	Month	Long (I32)
yday	Day	Long (I32)
yhour	Hours	Long (I32)
ymin	Minutes	Long (I32)
ysec	Seconds	Long (I32)
ynsec	Nanoseconds	Long (I32)
ydow	Day of week	Long (I32)
ywoy	Week of year	Long (I32)
tday	Total number of days	Long (I32)
tsec	Total number of seconds	Long (I32)
tnsec	Total number of nanoseconds	Large (I64)
dsec	Number of seconds since midnight	Long (I32)

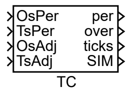
Parameters

isetmode	Source for setting time 1 ..... OS clock 2 ..... Block inputs 3 ..... The unsec input 4 ..... The usec input 5 ..... The unsec input, relative	⊙1	Long (I32)
igetmode	Source for getting or converting time 1 ..... OS clock 2 ..... Block inputs 3 ..... The unsec input 4 ..... The usec input 5 ..... The uday input 6 ..... REXYGEN clock	⊙6	Long (I32)
settol	Tolerance for setting the REXYGEN clock [s]	⊙1.0	Double (F64)
setper	Period for setting time [s] (0=not periodic)		Double (F64)
getper	Period for getting time [s] (0=not periodic)	⊙0.001	Double (F64)
FDOW	First day of week is Sunday off ... Week starts on Monday on .... Week starts on Sunday		Bool
tz	Timezone 1 ..... Local time 2 ..... UTC	⊙1	Long (I32)

TC – Timer control and status

Block Symbol

Licence: STANDARD



Function Description

The TC function block controls the internal timer of REXYGEN. It is possible to modify the actual basic tick period (e.g. the value set in the tick parameter of the EXEC block) or logical tick period (e.g. the time added to the timestamp of each tick if timer = CORETIMER is selected). By default, the logical and physical period is the same and is the EXEC:tick parameter. The discretization period of the blocks in the control algorithm is not affected by the TC block.

The actual period can be changed in two ways: set the desired value to the OsPer input or set OsAdj for one tick. OsAdj will temporarily increase or decrease the actual period until the total shift set on the OsAdj input is realized. How much the period increases is controlled by the OsMax parameter.

Example: Let's expect the tick period to be 0.1s and OsMax=0.2, so let's set OsAdj=1.0 to temporarily increase the real period to 0.12s (e.g. 20% defined in the OsMax parameter) until a total shift of 1s is realized, e.g. for 50 ticks.

Logical period control is the same using inputs/parameter TsPer, TsAdj, TsMax.

Note 1: The unconnected input or the input with a value of 0 is ignored.

Note 2: The actual period adjustment is not supported on Windows targets.

Note 3: The primary reason for this block is to synchronize with another controller in time-critical application, so the period should only be changed by a few percent. It is also possible to dramatically change the actual period to slow down or speed up the execution (for debugging and simulation reasons), but in this case some warning about missed tick or incorrect period could appear.

Inputs

OsPer	Physical tick period [s]	Double (F64)
TsPer	Logical (timestamp) tick period [s]	Double (F64)
OsAdj	Physical tick shift [s]	Double (F64)
TsAdj	Logical (timestamp) tick shift [s]	Double (F64)

Parameters

OsMax	Maximal relative quantum for physical adjustment ↓0.0 ↑1.0 ⊙0.1	Double (F64)

TsMax	Maximal relative quantum for logical adjustment ↓0.0 ↑1.0 ⊙0.1	Double (F64)

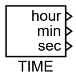
Outputs

per	Last physical tick period [s]	Double (F64)
over	Number of lost periods in the last tick	Long (I32)
ticks	Number of ticks since start	Large (I64)
SIM	Timer in simulation mode	Double (F64)

TIME – Current time

Block Symbol

Licence: STANDARD



Function Description

The outputs of the TIME function block correspond with the actual time of the operating system. Use the DATETIME block for advanced operations with date and time.

Outputs

hour	Hours	Long (I32)
min	Minutes	Long (I32)
sec	Seconds	Long (I32)

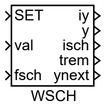
Parameter

tz	Timezone 1 ..... Local time 2 ..... UTC	⊙1	Long (I32)

WSCH – Weekly schedule

Block Symbol

Licence: STANDARD



Function Description

The WSCH function block is a weekly scheduler for e.g. heating (day, night, eco), ventilation (high, low, off), lighting, irrigation etc. Its outputs can be used for switching individual appliances on/off or adjusting the intensity or power of the connected devices.

During regular weekly schedule the outputs iy and y reflect the values from the wst table. This table contains triplets *day-hour-value*. E.g. the notation [2 6.5 21.5] states that on Tuesday, at 6:30 in the morning (24-hour format), the output y will be set to 21.5. The output iy will be set to 22 (rounding to nearest integer). The individual triplets are separated by semicolons.

The days in a week are numbered from 1 (Monday) to 7 (Sunday). Higher values can be used for special daily schedules, which can be forced using the fsch input or the specdays table. The active daily program is indicated by the isch output.

Alternatively it is possible to temporarily force a specific output value using the val input and a rising edge at the SET input (off→on). When a rising edge occurs at the SET input, the val input is copied to the y output and the isch output is set to 0. The forced value remains set until:

- the next interval as defined by the wst table, or
- another rising edge occurs at the SET input, or
- a different daily schedule is forced using the fsch input.

The list of special days (specdays) can be used for forcing a special daily schedule at given dates. E.g. you can force a Sunday daily schedule on holidays, Christmas, New Year, etc. The date is entered in the YYYYMMDD format. The notation [20160328 7] thus means that on March 28th, 2016, the Sunday daily schedule should be used. Individual pairs are separated by semicolons.

The trem and ynext outputs can be used for triggering specific actions in advance, before the y and iy are changed.

The iy output is meant for direct connection to function blocks with Boolean inputs (the conversion from type long to type bool is done automatically).

The nmax parameter defines memory allocation for the wst and specdays arrays. For nmax = 100 the wst list can contain up to 100 triplets *day-hour-value*. In typical applications there is no need to modify the nmax parameter.

Inputs

`SET`	Trigger for setting the `y` and `iy` outputs	`Bool`
`val`	Temporary value to set the `y` and `iy` outputs to	`Double (F64)`
`fsch`	Forced schedule `0` ..... standard weekly schedule `1` ..... Monday `2` ..... Tuesday .... `7` ..... Sunday `8 and above` additional daily programs as defined by the `wst` table	`Long (I32)`

Outputs

`iy`	Integer output value	`Long (I32)`
`y`	Output value	`Double (F64)`
`isch`	Daily schedule identifier	`Long (I32)`
`trem`	Time remaining in the current section (in seconds)	`Double (F64)`
`ynext`	Output in the next section	`Double (F64)`

Parameters

`tz`	Timezone `1` ..... Local time `2` ..... UTC	⊙1	`Long (I32)`
`nmax`	Allocated size of arrays	↓10 ↑1000000 ⊙100	`Long (I32)`
`wst`	Weekly schedule table (list of triplets *day-hour-value*) ⊙`[1 0.01 18.0; 2 6.0 22.0; 2 18.0 18.0; 3 6.0 22.0; 3 18.0 18.0; 4 6.0 22.0; 4 18.0 18.0`		`Double (F64)`
`specdays`	List of special days (list of pairs *date-daily program*) ⊙`[20150406 1; 20151224 1; 20151225 1; 20151226 1; 20160101 1; 20160328 1; 20170417 1; 20`		`Long (I32)`

Chapter 10

ARC – Data archiving

Contents

The RexCore executive of the REXYGEN system consists of various interconnected subsystems (real-time subsystem, diagnostic subsystem, drivers subsystem, etc.). One of these subsystems is the *archiving subsystem*.

The archiving subsystem takes care of recording the history of the control algorithm. The first chapter describes the functionality of the archiving subsystem while the subsequent chapters describe the function blocks of the REXYGEN system.

The function blocks can be divided into groups by their use:

- Blocks for generating alarms and events
- Blocks for recording trends
- Blocks for handling archives

10.1 Functionality of the archiving subsystem

The archive in the REXYGEN system stores the history of events, alarms and trends of selected signals. There can be up to 15 archives in each target device. The types or archives are listed below:

RAM memory archive – Suitable for short-term data storage. The data access rate is very high but the data is lost on reboot.

Archive in a backed-up memory – Similar to the RAM archive but the data is not lost on restart. Data can be accessed fast but the capacity is usually quite limited (depends on the target platform).

Disk archive The disk archives are files in a proprietary binary format. The files are easily transferrable among individual platforms and the main advantage is the size, which is limited only by the capacity of the storage medium. On the other hand, the drawback is the relatively slow data access.

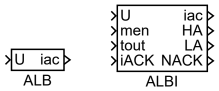
Not all hardware platforms support all types of archives. The individual types which are supported by the platform can be displayed in REXYGEN Studio in the Diagnostics tree view panel after clicking on the name of the target device (IP address). The supported types are listed in the lower left part of the `Target` tab.

10.2 Generating alarms and events

ALB, ALBI – Alarms for Boolean value

Block Symbols

Licence: STANDARD



Function Description

The ALB and ALBI blocks generate alarms or events when a Boolean input signal U changes. The men parameter selects whether the rising or falling or both edges in the input signal should be indicated. The iac output shows the current alarm (event) code.

The ALBI block is an extension of the ALB block as the alarms (events) are indicated also by Boolean output signals HA, LA and NACK. The type of edges to watch is selected by the men input signal and the alarms are acknowledged by the iACK input signal instead of parameters with the same name and meaning.

The events and alarms are differentiated by the lvl parameter in the REXYGEN system. The range $1 \leq$ lvl ≤ 127 is reserved for alarms. All starts, ends and acknowledgements of the alarms are stored in the archive. On the contrary, the range $128 \leq$ lvl ≤ 255 indicates events. Only the start (the time instant) of the event is stored in the archive.

Note: The input (parameter) iACK is set back to 0 immediately by the block algorithm. The funcionality is similar to the parameter BSTATE of the block MP.

Inputs

U	Logical input of the block whose changes are watched		Bool
men	Enable alarms 0 ..... All alarms disabled 1 ..... Low-alarm enabled (LA) (falling edge in the input signal U) 2 ..... High-alarm enabled (HA)(rising edge in the input signal U) 3 ..... All alarms enabled		Long (I32)
tout	Alarm activation delay time [s]	↓0.0	Double (F64)
iACK	Acknowledge alarm 1 ..... Low-alarm acknowledge 2 ..... High-alarm acknowledge 3 ..... Both alarms acknowledge Alarm is acknowledged on rising edge		Byte (U8)

Outputs

`iac`	Current alarm code `0` ..... All alarms inactive `1` ..... Low-alarm active (`LA`) `2` ..... High-alarm active (`HA`) `256` ... Low-alarm not acknowledged (`NACK`) `512` ... High-alarm not acknowledged (`NACK`)	`Long (I32)`
`HA`	High-alarm indicator	`Bool`
`LA`	Low-alarm indicator	`Bool`
`NACK`	Alarm-not-acknowledged indicator	`Bool`

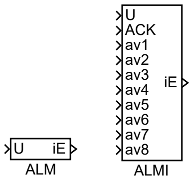
Parameters

`arc`	List of archives to store the events. The format of the list is e.g. `1,3..5,8`. The event will be stored in all listed archives (see the `ARC` block for details on archives numbering). Third-party programs (Simulink, OPC clients etc.) work with an integer number, which is a binary mask, i.e. `157` (binary `10011101`) in the mentioned case.	`Word (U16)`
`id`	Identification code of the alarm in the archive. This identifier must be unique in the whole target device with the REXYGEN control system (i.e. in all archiving blocks). Disabled for `id` = 0. ⊙1	`Word (U16)`
`lvl`	The level of the alarms (`HA` and `LA`) which differentiates alarms from events and defines the severity of the alarm/event ↓1 ⊙1	`Byte (U8)`
`Desc`	Extended description of the alarm which is displayed by the diagnostic tools of the REXYGEN system ⊙`Alarm Description`	`String`

ALM, ALMI – Alarm activation

Block Symbols

Licence: STANDARD



Function Description

The ALM and ALMI block is used to generate an alarm. The alarm is active when the input U=on. The alarm must be defined by the ALARMS block and is uniquely identified using the id parameter. Active alarms can be displayed by special component in HMI. Status change of the alarm and its acknowledgment is also stored in the archive (if defined in configuration in the ALARMS block). The alarm can be acknowledged by setting the parameter ACK=on.

Remark: The system displays the acknowledgment status, allows the user to acknowledge the ongoing alarm and can display the acknowledgment status in the HMI and in the archive. Acknowledging alarms has no further meaning for REXYGEN itself and nothing depends on it. Whether alarms will be acknowledged depends on the filter settings in the visualization and the design of the entire system.

Inputs

U	Alarm is active when U = on	Bool

Outputs

iE	Error code	Error

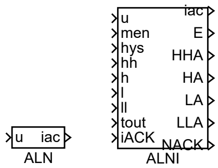
Parameters

id	Unique identification number of the alarm. Alarm is disabled for id = 0. Value id = −1 means that alarm is identified by name (e.g. name of the block without ALM(I) prefix) not by id. ↓-1 ↑65535 ⊙-1	Long (I32)
ACK	Set ACK = on acknowledge alarm. The algorithm immediately reverts the parameter to ACK = off.	Bool
av1..av8	Value associated with alarm. See description of the ALARMS block to clarify how this value is propagate into alarm description. ↓1.79769e+308 ⊙-1.79769e+308	Double (F64)

ALN, ALNI – Alarms for numerical value

Block Symbols

Licence: STANDARD



Function Description

The ALN and ALNI blocks generate two-level alarms or events when a limit value is exceeded (or not reached). There are four limit values the input signal u is compared to, namely high-limits h and hh and low-limits l and ll. The iac output shows the current alarm (event) code.

The ALNI block is an extension of the ALN block as the alarms (events) are indicated also by Boolean output signals HHA, HA, LA and LLA and the variables of the alarm algorithm are given by the input signals hys, hh, h, l and ll instead of parameters with the same name and meaning.

The events and alarms are differentiated by the lvl parameter in the REXYGEN system. The range $1 \leq$ lvl ≤ 127 is reserved for alarms. All starts, ends and acknowledgements of the alarms are stored in the archive. On the contrary, the range $128 \leq$ lvl ≤ 255 indicates events. Only the start (the time instant) of the event is stored in the archive.

Note 1: The input (parameter) iACK is set back to 0 immediately by the block algorithm. The functionality is similar to the parameter BSTATE of the block MP.

Note2: The parameter Desc can include formatting characters (multilingual texts, associated variables). Formatting rules are described in the ALARMS block.

Inputs

u	Analog input of the block which is checked to remain within the given limits		Double (F64)
hys	Alarm hysteresis for switching the alarm off	↓1e-10 ↑1e+10	Double (F64)
hh	The second high-alarm limit, must be greater than h		Double (F64)
h	High-alarm limit, must be greater than l		Double (F64)
l	Low-alarm limit, must be greater than ll		Double (F64)
ll	The second low-alarm limit		Double (F64)
tout	Alarm activation delay time [s]	↓0.0	Double (F64)
iACK	Alarm is acknowledged on rising edge of the individual bits of this input/parameter. E.g. value 15 acknowledges all alarms.		

`Byte (U8)`
- `1` ..... Second low-alarm acknowledge
- `2` ..... Low-alarm acknowledge
- `4` ..... High-alarm acknowledge
- `8` ..... Second high-alarm acknowledge

In case a one-level alarm is required, it is sufficient to set `lvl2=0` or set the `hh` and `ll` limits to extreme values which can never be reached by the input signal.

Outputs

`iac`	Current alarm code. Additional bitwise combinations of the codes may appear. E.g. `12` means both high alarms. `0` ..... Signal within limits `1` ..... Low-alarm active `2` ..... High-alarm active `4` ..... Second low-alarm active `8` ..... Second high-alarm active `256` ... Low-alarm not acknowledged `512` ... High-alarm not acknowledged `1024` .. Second low-alarm not acknowledged `2048` .. Second high-alarm not acknowledged `-1` .... Invalid alarm limits	`Long (I32)`
`E`	Error flag `off` ... No error `on` .... An error occurred, alarm limits disordered	`Bool`
`HHA`	The second high-alarm indicator	`Bool`
`HA`	High-alarm indicator	`Bool`
`LA`	Low-alarm indicator	`Bool`
`LLA`	The second low-alarm indicator	`Bool`
`NACK`	Alarm-not-acknowledged indicator	`Bool`

Parameters

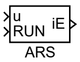
`acls`	Alarm class (data type to store) `1` ..... Bool `2` ..... Byte (U8) `3` ..... Short (I16) `4` ..... Long (I32) `5` ..... Word (U16) `6` ..... DWord (U32) `7` ..... Float (F32) `8` ..... Double (F64) `10` .... Large (I64)	⊙8	`Byte (U8)`
`arc`	List of archives to store the events. The format of the list is e.g. `1,3..5,8`. The event will be stored in all listed archives (see the `ARC` block for details on archives numbering). Third-party programs (Simulink, OPC clients etc.) work with an integer number, which is a binary mask, i.e. `157` (binary `10011101`) in the mentioned case.		`Word (U16)`

`id`	Identification code of the alarm in the archive. This identifier must be unique in the whole target device with the REXYGEN control system (i.e. in all archiving blocks). Disabled for `id` = 0. ⊙1	`Word (U16)`
`lvl1`	The level of first high- and low-alarms (`HA` and `LA`) which differentiates alarms from events and defines the severity of the alarm/event ↓1 ⊙1	`Byte (U8)`
`lvl2`	The level of second high- and low-alarms (`HHA` and `LLA`) which differentiates alarms from events and defines the severity of the alarm/event ↓1 ⊙10	`Byte (U8)`
`Desc`	Extended description of the alarm which is displayed by the diagnostic tools of the REXYGEN system ⊙`Alarm Description`	`String`

ARS – Archive store value

Block Symbol

Licence: STANDARD



Function Description

The block allow to store value into archive subsystem. Written value must be connected to the `u` input. Value could be simple like bool, int or float, string or matrix/vector. Type of value must be set by the `type` parameter. The the parameter codetype=13:Reference must be set for vector or matrix. There is one archive item for each column of the matrix. Data are stored only if the input `RUN=on` is set. The parameter `subtype` allow write alarm type that write other alarm blocks (for example `L->H` for bool alarm, `HiHi` for numeric alarm). the value of this parameter is in range 0 to 7 and is not used in vector/matrix items. This parameter is usualy not needed.

Note 1: The archive subsystem is limited for 255 values, but no more then 512 bytes in one archive item (e.g. 128 values of type Short, 64 values of type Long, 32 values of type Double). Vector (matrix's column) is truncated to this size and stored into archive and no error nor warning is indicated, if the input array is bigger.

Note 2: The string value is limited to 65535 byte (i.e. characters if only characters from english keyboard is used; UTF-8 encoding is used). String is truncated to this size and stored into archive and no error nor warning is indicated, if the input string is bigger. It is recomended to not overcome 4000 bytes, because some reading functions has limited buffer and could failed for long strings.

Note 3: The parameter `id` is intended as bind source block (and also source signal) with item in archive (and with alarm subsystem in same cases). So REXYGENcheck unique this binding. The `ARS` block is intend to be low-level-function writing into archive, therefore parameters are not checked (mainly unique of `id` is not checked).

Inputs

`u`	Value to store into archive	`Any`
`RUN`	Enable execution	`Bool`

Parameters

`type`	Type of all trend buffers 1 ..... Bool 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 7 ..... Float (F32) 8 ..... Double (F64) 9 ..... Time 10 .... Large (I64) 11 .... Error 12 .... String 13 .... Reference	⊙12	`Byte (U8)`
`arc`	List of archives to write the events to		`Word (U16)`
`id`	Archive item ID. The block not check if `id` is unique in whole configuration.	⊙1	`Word (U16)`
`lvl`	Alarm level	⊙1	`Word (U16)`
`Desc`	Event description string	⊙`Value Description`	`String`
`subtype`	alarm subtype (for special ussage only)		

Output

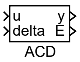
`iE`	Error code	`Error`

10.3 Trends recording

ACD – Archive compression using Delta criterion

Block Symbol

Licence: STANDARD



Function Description

The ACD block is meant for storing compressed analog signals to archives using archive events.

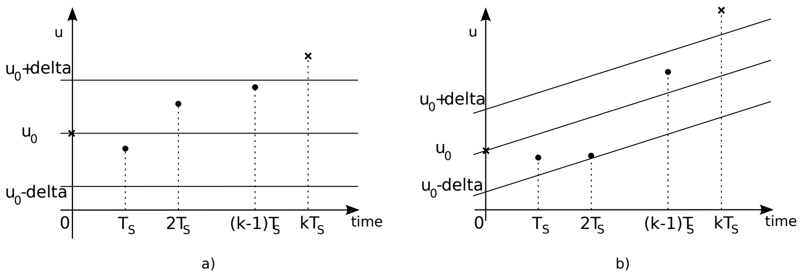
The main idea is to store the input signal u only when it changes significantly. The interval between two samples is in the range ⟨tmin,tmax⟩ seconds (rounded to the nearest multiple of the sampling period). A constant input signal is stored every tmax seconds while rapidly changing signal is stored every tmin seconds.

When the execution of the block is started, the first input value is stored. This value will be referred to as u0 in the latter. The rules for storing the following samples are given by the delta and TR input signals.

For TR = off the condition $|\mathtt{u}-\mathtt{u0}| > \mathtt{delta}$ is checked. If it holds and the last stored sample occurred more than tmin seconds ago, the value of input u is stored and u0=u is set. If the condition is fulfilled sooner than tmin seconds after the last stored value, the error output E is set to 1 and the first value following the tmin interval is stored. At that time the output E is set back to 0 and the whole procedure is repeated.

For TR = on the input signal values are compared to a signal with compensated trend. The condition for storing the signal is the same as in the previous case.

The following figure shows the archiving process for both cases: a) TR = off, b) TR = on. The stored samples are marked by the symbol ×.



Inputs

u	Signal to compress and store		Double (F64)
delta	Threshold for storing the signal	↓0.0 ↑1e+10	Double (F64)

Outputs

`y`	The last value stored in the archive	`Double (F64)`
`E`	Error flag – indicates that a significant change in the input signal occurred sooner than the `tmin` interval passes `off` ... No error `on` .... An error occurred	`Bool`

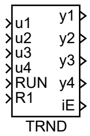
Parameters

`acls`	Archive class determining the variable type to store ⊙8 `1` ..... Bool `2` ..... Byte (U8) `3` ..... Short (I16) `4` ..... Long (I32) `5` ..... Word (U16) `6` ..... DWord (U32) `7` ..... Float (F32) `8` ..... Double (F64) `10` ... Large (I64)	`Byte (U8)`
`arc`	List of archives to store the events. The format of the list is e.g. `1,3..5,8`. The event will be stored in all listed archives (see the `ARC` block for details on archives numbering). Third-party programs (Simulink, OPC clients etc.) work with an integer number, which is a binary mask, i.e. `157` (binary `10011101`) in the mentioned case.	`Word (U16)`
`id`	Identification code of the event in the archive. This identifier must be unique in the whole target device with the REXYGEN control system (i.e. in all archiving blocks). Disabled for `id` = 0. ⊙1	`Word (U16)`
`tmin`	The shortest interval between two samples of the `u` input signal stored in the archive [s] ↓0.001 ↑1000000.0 ⊙1.0	`Double (F64)`
`tmax`	The longest interval between two samples of the `u` input signal stored in the archive [s] ↓1.0 ↑1000000.0 ⊙1000.0	`Double (F64)`
`TR`	Trend evaluation flag ⊙on `off` ... The deviation of the input signal from the last stored value is evaluated `on` .... The deviation of the input signal from the last value's trend is evaluated	`Bool`
`Desc`	Extended description of the event which is displayed by the diagnostic tools of the REXYGEN system ⊙`Value Description`	`String`

TRND – Real-time trend recording

Block Symbol

Licence: STANDARD



Function Description

The TRND block is designed for storing of up to 4 input signals (u1 to u4) in cyclic buffers in the memory of the target device. The main advantage of the TRND block is the synchronization with the real-time executive, which allows trending of even very fast signals (i.e. with very high sampling frequency). In contrary to asynchronous data storing in the higher level operator machine (host), there are no lost or multiply stored samples.

The number of stored signals is determined by the parameter n. In case the trend buffer of length l samples gets full, the oldest samples are overwritten. Data can be stored once in pfac executions of the block (decimation) and the data can be further processed according to the ptype1 to ptype4 parameters. The other decimation factor afac can be used for storing data in archives.

The type of trend buffers can be specified in order to conserve memory of the target device. The memory requirements of the trend buffers are defined by the formula $s \cdot \mathtt{n} \cdot \mathtt{l}$, where s is the size of the corresponding variable in bytes. The default type Double consumes 8 bytes per sample, thus for storing $\mathtt{n} = 4$ trends of this type and length $\mathtt{l} = 1000$, $8 \cdot 4 \cdot 1000 = 32000$ bytes are required. In case the input signals come from 16-bit A/D converter the Word type can be used and memory requirements drop to one quarter. Memory requirements and allowed ranges of individual types are summarized in table 1.1 on page 22 of this reference guide.

It can happen that the processed input value exceeds the representable limits when using different type of buffer than Double. In such a case the highest (lowest) representable number of the corresponding type is stored in the buffer and an error is binary encoded to the iE output according to the following table (the unused bits are omitted):

Error	Range underflow				Range overflow			
Input	u4	u3	u2	u1	u4	u3	u2	u1
Bit number	11	10	9	8	3	2	1	0
Bit weight	2048	1024	512	256	8	4	2	1

In case of simultaneous errors the resulting error code is given by the sum of the weights of individual errors. Note that underflow and overflow cannot happen simultaneously on a single input.

It is possible to read, display and export the stored data by the REXYGEN Studio in the `Watch` mode. After double-clicking on the corresponding `TRND` block, a new card with the prefix Trend will open.

WARNING: set any of the parameters `arc`, `afac`, `id` to 0/empty disable writing data into archive. The data are available in diagnostic tools only in this case.

Inputs

`u1..u4`	Analog inputs to be processed and stored in the trend	`Double (F64)`
`RUN`	Enable execution. The data are processed and stored if and only if `RUN` = `on`.	`Bool`
`R1`	Input for clearing the trend contents. The buffers are cleared when `R1` = `on`. This flag overpowers the `RUN` input.	`Bool`

Outputs

`y1..y4`	Analog outputs of the block set once in `pfac` executions of the block to the last values stored in the trend buffers	`Double (F64)`
`iE`	Error code, see the table above	`Long (I32)`

Parameters

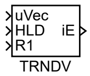
`n`	Number of signals to process and store in the trend buffers ↓1 ↑4 ⊙4	`Long (I32)`
`l`	Number of samples reserved in memory for each trend buffer ↓0 ↑268435000 ⊙1000	`Long (I32)`
`btype`	Type of all `n` trend buffers ⊙8 1 ..... Bool 4 ..... Long 7 ..... Float 2 ..... Byte 5 ..... Word 8 ..... Double 3 ..... Short 6 ..... DWord 10 .... Large	`Long (I32)`
`ptype`i	The way the signal `u`i, $i = 1 \ldots 4$, is processed. The last `pfac` samples are processed as selected and the result is stored in the i-th trend buffer. ⊙1 1 ..... No processing, just storing data 2 ..... Minimum from the last `pfac` samples 3 ..... Maximum from the last `pfac` samples 4 ..... Sum of the last `pfac` samples 5 ..... Simple average of the last `pfac` samples 6 ..... Root mean square of the last `pfac` samples 7 ..... Variance of the last `pfac` samples	`Long (I32)`
`pfac`	Multiple of the block execution period defining the period for storing the data in the trend buffers. Data are stored with the period of `pfac` $\cdot T_S$ unless `RUN` = `off`, where T_S is the block execution period in seconds. ↓1 ↑1000000 ⊙1	`Long (I32)`

afac	Every afac-th sample stored in the trend buffer is also stored in the archives specified by the arc parameter. There are no data stored in the archives for afac = 0. Data are stored with the period of afac·pfac·T_S, where T_S is the block execution period in seconds. ↓0 ↑1000000	Long (I32)
arc	List of archives to store the trend data. The format of the list is e.g. 1,3..5,8. The data will be stored in all listed archives (see the ARC block for details on archives numbering). Third-party programs (Simulink, OPC clients etc.) work with an integer number, which is a binary mask, i.e. 157 (binary 10011101) in the mentioned case.	Word (U16)
id	Identification code of the trend block. This identifier must be unique in the whole target device with the REXYGEN system (i.e. in all archiving blocks). Disabled for id = 0. ⊙1	Word (U16)
Title	Title of the trend to be displayed in the diagnostic tools of the REXYGEN system, e.g. in the Watch mode in the REXYGEN Studio program. ⊙Trend Title	String
timesrc	Source of timestamps. Each data sample in the trend buffer is stored with a timestamp. For fast or short-term trends where you are interested in sample-by-sample timing more than in absolute time, choose CORETIMER – REXYGEN internal technological time, which is incremented by the nominal period each base tick. For long-running trends where you are mostly interested in absolute time shared with the operating system (and possibly synchronized by NTP), choose SYSCLOCK. Other values are intended for debugging or special purposes. ⊙1 1 ..... CORETIMER – Time maintained by the Core Timer (at the current tick) 2 ..... CORETIMER-PRECISE – Time maintained by the Core Timer (at block execution) 3 ..... SYSCLOCK – Time maintained by the System (at the current tick) 4 ..... SYSCLOCK-PRECISE – Time maintained by the System (at block execution) 5 ..... PFC – Performance Counter Time	Long (I32)
SigNames	Names of the signals to be displayed in the diagnostic tools of the REXYGEN system, e.g. in the Watch mode in the REXYGEN Studio program. Each line is name of one signal respectively.	String

TRNDV – Real-time trend recording with vector input

Block Symbol

Licence: STANDARD



Function Description

The TRNDV block is designed for storing input signals which arrive at the uVec input in vector form. On the contrary to the TRND block it allows storing more than 4 signals. The signals are stored in cyclic buffers in the memory of the target device. The main advantage of the TRNDV block is the synchronization with the real-time executive, which allows trending of even very fast signals (i.e. with very high sampling frequency). In contrary to asynchronous data storing in the higher level operator machine (host), there are no samples lost or multiply stored.

The number of stored signals is determined by the parameter n. In case the trend buffer of length l samples gets full, the oldest samples are overwritten. Data can be stored once in pfac executions of the block (decimation). The other decimation factor afac can be used for storing data in archives.

The type of trend buffers can be specified in order to conserve memory of the target device. The memory requirements of the trend buffers are defined by the formula $s \cdot \mathtt{n} \cdot \mathtt{l}$, where s is the size of the corresponding variable in bytes. The default type Double consumes 8 bytes per sample, thus for storing e.g. $\mathtt{n} = 4$ trends of this type and length $\mathtt{l} = 1000$, $8 \cdot 4 \cdot 1000 = 32000$ bytes are required. In case the input signals come from 16-bit A/D converter the Word type can be used and memory requirements drop to one quarter. Memory requirements and allowed ranges of individual types are summarized in table 1.1 on page 22 of this reference guide.

It is possible to read, display and export the stored data by the REXYGEN Studio in the Watch mode. After double-clicking on the corresponding TRNDLF block, a new card with the prefix Trend will open.

WARNING: set any of the parameters arc, afac, id to 0/empty disable writing data into archive. The data are available in diagnostic tools only in this case.

Inputs

uVec	Vector signal to record	Reference
HLD	Input for freezing the cyclic buffers, no data is appended when HLD = on	Bool
R1	Input for clearing the trend contents. The buffers are cleared when R1 = on. This flag overpowers the HLD input.	Bool

Output

`iE`	Error code `i` ..... REXYGEN general error	`Error`

Parameters

`n`	Number of signals (trend buffers) ↓1 ↑64 ⊙8	`Long (I32)`
`l`	Number of samples per trend buffer ↓2 ↑268435000 ⊙1000	`Long (I32)`
`btype`	Type of all trend buffers ⊙8 `1` ..... Bool `4` ..... Long `7` ..... Float `2` ..... Byte `5` ..... Word `8` ..... Double `3` ..... Short `6` ..... DWord `10` .... Large	`Long (I32)`
`pfac`	Multiple of the block execution period defining the period for storing the data in the trend buffers. Data are stored with the period of `pfac` $\cdot T_S$ unless `RUN` = `off`, where T_S is the block execution period in seconds. ↓1 ↑1000000 ⊙1	`Long (I32)`
`afac`	Every `afac`-th sample stored in the trend buffer is also stored in the archives specified by the `arc` parameter. There are no data stored in the archives for `afac` = 0. Data are stored with the period of `afac`$\cdot$`pfac`$\cdot T_S$, where T_S is the block execution period in seconds. ↓0 ↑1000000	`Long (I32)`
`arc`	List of archives to store the trend data. The format of the list is e.g. `1,3..5,8`. The data will be stored in all listed archives (see the `ARC` block for details on archives numbering). Third-party programs (Simulink, OPC clients etc.) work with an integer number, which is a binary mask, i.e. `157` (binary `10011101`) in the mentioned case.	`Word (U16)`
`id`	Identification code of the trend block. This identifier must be unique in the whole target device with the REXYGEN system (i.e. in all archiving blocks). Disabled for `id` = 0. ⊙1	`Word (U16)`
`Title`	Title of the trend to be displayed in the diagnostic tools of the REXYGEN system, e.g. in the `Watch` mode in the REXYGEN Studio program. ⊙`Trend Title`	`String`

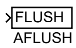
`timesrc`	Source of timestamps. Each data sample in the trend buffer is stored with a timestamp. For fast or short-term trends where you are interested in sample-by-sample timing more than in absolute time, choose `CORETIMER` – REXYGEN internal technological time, which is incremented by the nominal period each base tick. For long-running trends where you are mostly interested in absolute time shared with the operating system (and possibly synchronized by NTP), choose `SYSCLOCK`. Other values are intended for debugging or special purposes. ⊙1 1 ..... `CORETIMER` – Time maintained by the Core Timer (at the current tick) 2 ..... `CORETIMER-PRECISE` – Time maintained by the Core Timer (at block execution) 3 ..... `SYSCLOCK` – Time maintained by the System (at the current tick) 4 ..... `SYSCLOCK-PRECISE` – Time maintained by the System (at block execution) 5 ..... `PFC` – Performance Counter Time	`Long (I32)`
`SigNames`	Names of the signals to be displayed in the diagnostic tools of the REXYGEN system, e.g. in the `Watch` mode in the REXYGEN Studio program. Each line is name of one signal respectively.	`String`

10.4 Archive management

`AFLUSH` – Forced archive flushing

Block Symbol

Licence: STANDARD



Function Description

The `AFLUSH` block is intended for immediate storing of archive data to permanent memory (hard drive, flash disk, etc.). It is useful when power loss can be anticipated, e.g. emergency shutdown of the system following some failure. It forces the archive subsystem to write all archive data to avoid data loss. The write operation is initiated by a rising edge (`off`→`on`) at the `FLUSH` input regardless of the `period` parameter of the `ARC` block.

Input

`FLUSH`	Force archive flushing	`Bool`

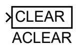
Parameter

arc	List of archives to store the events. The format of the list is e.g. 1,3..5,8. The event will be stored in all listed archives (see the ARC block for details on archives numbering). Third-party programs (Simulink, OPC clients etc.) work with an integer number, which is a binary mask, i.e. 157 (binary 10011101) in the mentioned case.	Word (U16)

ACLEAR – * Forced archive purge

Block Symbol

Licence: STANDARD



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

CLEAR	Archive purge on rising edge	Bool

Parameter

arc	List of archives to write the events to	Word (U16)

Chapter 11

STRING – Blocks for string operations

Contents

The STRING library is dedicated to string manipulation and analysis in REXYGEN system. It includes blocks like CONCAT for concatenating strings, FIND for searching within strings, and REPLACE for replacing string segments. The library offers LEN and MID for determining string length and extracting substrings, respectively. Advanced pattern matching is provided by REGEXP. Conversion blocks such as ITOS, STOR and RTOS convert integers and real numbers to strings, while a simple CNS block defines a string constant. Additionally, the library features blocks like PJROCT for JSON parsing. This collection of blocks is essential for handling and processing string data in various applications.

CNS – String constant

Block Symbol

Licence: STANDARD

Function Description

The CNS block is a simple string constant with maximal available size. A value of scv is always truncated to nmax.

Parameters

scv	String (constant) value		String
nmax	Allocated size of string [bytes]	↓0 ↑65520	Long (I32)

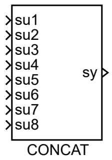
Output

sy	String output value	String

CONCAT – Concat string by pattern

Block Symbol

Licence: STANDARD



Function Description

Concatenates up to 8 input strings **su1** to **su8** by pattern specified in **ptrn** parameter.

Inputs

su1..8	String input value		String

Parameters

ptrn	Concatenation pattern	⊙%1%2%3%4	String
nmax	Allocated size of string [bytes]	↓0 ↑65520	Long (I32)

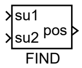
Output

sy	String output value		String

FIND – Find a Substring

Block Symbol

Licence: STANDARD



Function Description

The FIND block searches for the string su2 in the string su1 and returns a one-based index into su1 if a su2 is found or zero otherwise. Both su1 and su2 are truncated to nmax.

Inputs

su1	String input value	String
su2	String input value	String

Parameter

nmax	Allocated size of string [bytes]	↓0 ↑65520	Long (I32)

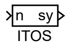
Output

pos	Position of substring	Long (I32)
iE	Error code	Error

ITOS – Integer number to string conversion

Block Symbol

Licence: STANDARD



Function Description

The ITOS block is used for converting an integer into text. The len parameter specifies the minimum length of the output string. If the number has a smaller number of digits, zeroes or spaces will be added according to the mode parameter. The radix parameter specifies the numerical system in which the conversion is to be performed. The output string does not contain any identification of the numerical system used (e.g. the 0x prefix for the hexadecimal system).

Input

n	Integer input of the block	Long (I32)

Output

sy	String output value	String

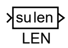
Parameters

len	Minimum length of output string	↓0 ↑30	Long (I32)
mode	Output string format 1 ..... Align right, fill with spaces 2 ..... Align right, fill with zeroes 3 ..... Align left, fill with spaces	⊙1	Long (I32)
radix	Radix 2 ..... Binary 8 ..... Octal 10 .... Decimal 16 .... Hexadecimal	⊙10	Long (I32)

LEN – String length

Block Symbol

Licence: STANDARD



Function Description

The LEN block returns the actual length of the string in su in UTF-8 characters.

Input

su	String input value		String

Parameter

nmax	Allocated size of string [bytes]	↓0 ↑65520	Long (I32)

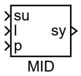
Output

len	Length of input string		Long (I32)

MID – Substring Extraction

Block Symbol

Licence: STANDARD



Function Description

The MID block extracts a substring sy from su. The parameters l and p specify position and length of the string being extracted in UTF-8 characters. The parameter p is one-based.

Inputs

su	String input value	String
l	Length of output string	Long (I32)
p	Position of output string (one-based)	Long (I32)

Parameter

nmax	Allocated size of string [bytes]	↓0 ↑65520	Long (I32)

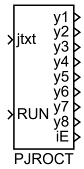
Output

sy	String output value	String
iE	Error code	Error

PJROCT – Parse JSON string (real output)

Block Symbol

Licence: STANDARD



Function Description

Parses input JSON string `jtxt` according to specified `name*` parameters when the input `RUN` is `on`. Output signals are `real` type. Value of the `yerr` parameter is put on the `y*` output when error occured (e.g. specified object is not exist or value is not a number).

This block expects text in JSON format on the `jtxt` input. The outputs of `y1` to `y7` then have the values (string) of the objects identified by the parameters `name1` to `name7`. If one of the parameters `name1` to `name7` is empty, the corresponding output will be empty and this is not considered as an error. The input string evaluates only if `RUN = on`. An error is indicated on the output `iE`. The following cases may occur:

- 0 - no error
- -1 - one of the parameters `name1` to `name7` refers to an object that does not appear in the input text (at the input `jtxt`)
- -103 - the text on the input `jtxt` does not correspond to the JSON format
- -106 - all of the parameters `name1` to `name7` refer to an object that does not appear in the input text (on the input `jtxt`)

Example: Let

```
jtxt = "{"id": 12345, "params": {"temperature": 23, "pressure": 2.34 },
"description": "reactor1", "values" :[12, 34.5 , 45.0, 30.2]}"
name1 = "params.temperature",
name2 = "values[0]",
name3 = "pressure",
name4 = "description",
```

then the output `y1` will be the `"23"` string, the output `y2` will be the `"12"` string, output `y3` will remain empty and an error will be signaled, the output `y4` will remain empty and an error will be signaled.

Inputs

`jtxt`	JSON formated string	`String`

RUN	Enable execution		Bool

Parameters

name1..8	Property name of JSON element		String
nmax	Allocated size of string [bytes]	↓0 ↑65520	Long (I32)
yerr	Substitute value for an error case		Double (F64)

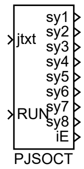
Outputs

y1..8	Block output signal	Double (F64)
iE	Error code	Error

PJSOCT – Parse JSON string (string output)

Block Symbol

Licence: STANDARD



Function Description

Parses input JSON string `jtxt` according to specified `name*` parameters when the input `RUN` is `on`. Output signals are `string` type.

This block expects text in JSON format on the `jtxt` input. The outputs of `sy1` to `sy7` then have the values of the objects identified by the parameters `name1` to `name7`. If one of the parameters `name1` to `name7` is empty, the corresponding output will be empty and this is not considered as an error. The input string evaluates only if `RUN = on`. An error is indicated on the output `iE`. The following cases may occur:

- 0 - no error
- -1 - one of the parameters `name1` to `name7` refers to an object that does not appear in the input text (at the input `jtxt`)
- -103 - the text on the input `jtxt` does not correspond to the JSON format
- -106 - all of the parameters `name1` to `name7` refer to an object that does not appear in the input text (on the input `jtxt`)

Example: Let

```
jtxt = "{"id": 12345, "params": {"temperature": 23, "pressure": 2.34 },
"description": "reactor1", "values" :[12, 34.5 , 45.0, 30.2]}"
name1 = "params.temperature",
name2 = "values[0]",
name3 = "pressure",
name4 = "description",
```

then the output `sy1` will be the `"23"` string, the output `sy2` will be the `"12"` string, output `sy3` will remain empty and an error will be signaled, the output `sy4` will be the `"reactor1"` string.

Inputs

`jtxt`	JSON formated string	`String`
`RUN`	Enable execution	`Bool`

Parameters

`name1..8`	Name of JSON object		`String`
`nmax`	Allocated size of string [bytes]	↓0 ↑65520	`Long (I32)`

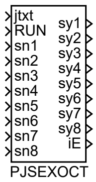
Outputs

`sy1..8`	String output value	`String`
`iE`	Error code	`Error`

PJSEXOCT – Parse JSON string (string output)

Block Symbol

Licence: STANDARD



Function Description

The block is almost the same as PJSOCT block, except `name*` parameters can contain control sequence `% + number` that is substituted by `sn + number` input.

Example: Let
`sn1 = "2"`,
`sn2 = "rpm"`,
`name1 = "motor[%1].temp"`,
`name2 = "motor[%1].%2"`,
then `name1` is expand to `motor[2].temp`, `name2` is expand to `motor[2].rpm`.

Inputs

jtxt	JSON formated string		String
RUN	Enable execution		Bool
sn1..8	Part of name of JSON object		String

Parameters

name1..8	Name of JSON object		String
nmax	Allocated size of string [bytes]	↓0 ↑65520	Long (I32)

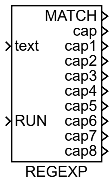
Outputs

sy1..8	String output value		Error
iE	Error code		Error

REGEXP – Regular expresion parser

Block Symbol

Licence: ADVANCED



Function Description

This block implements a subset of Perl or `C#` or Unix command `grep` regular expression syntax.

Supported syntax is :

- `(?i)` ... Must be at the beginning of the regex. Makes match case-insensitive
- `^` ... Match beginning of a buffer
- `$` ... Match end of a buffer
- `()` ... Grouping and substring capturing
- `\s` ... Match whitespace
- `\S` ... Match non-whitespace
- `\d` ... Match decimal digit
- `\n` ... Match new line character
- `\r` ... Match line feed character
- `\f` ... Match form feed character
- `\v` ... Match vertical tab character
- `\t` ... Match horizontal tab character
- `\b` ... Match backspace character
- `+` ... Match one or more times (greedy)
- `+?` ... Match one or more times (non-greedy)
- `*` ... Match zero or more times (greedy)

- `*?` ... Match zero or more times (non-greedy)
- `?` ... Match zero or once (non-greedy)
- `x|y` ... Match x or y (alternation operator)
- `\meta` ... Match one of the meta characters: ^$().[ ]*+?|\
- `\xHH` ... Match byte with hex value 0xHH, e.g. \x4a
- `[...]` ... Match any character from set. Ranges like [a-z] are supported.
- `[^...]` ... Match any character except the ones in set. Ranges like [a-z] are supported.

Examples

- `[0-9]+` ... Find first integer in input string (and put it into `cap` output)
- `[-+]?[0-9]*\.[0-9]+([eE][-+]?[0-9]+)?` ... Find first real number in input string (and put it into `cap` output)
- `^\s*(.*?)\s*$` ... Put trimmed input string into `cap1` output
- `num\s*:\s*([0-9]*\.[0-9]*)` ... Expect input string in JSON format; find integer parameter `num`, and put its value into `cap1`

Inputs

`text`	String to parse	`String`
`RUN`	Enable execution	`Bool`

Parameters

`expr`	Regular expresion pattern		`String`
`nmax`	Allocated size of string	↓0 ↑65534	`Long (I32)`
`bufmax`	Parser internal buffer size (0 = autodetect)	↓0 ↑10000000	`Long (I32)`

Outputs

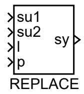
`MATCH`	Pattern match flag	`Bool`
`cap`	Whole matching string	`String`
`cap1`	Captured string (string matched to 1st bracket)	`String`
`cap2`	Captured string (string matched to 2nd bracket)	`String`
`cap3`	Captured string (string matched to 3rd bracket)	`String`
`cap4`	Captured string (string matched to 4th bracket)	`String`

`cap5`	Captured string (string matched to 5th bracket)	`String`
`cap6`	Captured string (string matched to 6th bracket)	`String`
`cap7`	Captured string (string matched to 7th bracket)	`String`
`cap8`	Captured string (string matched to 8th bracket)	`String`

`REPLACE` – Replace substring

Block Symbol

Licence: STANDARD



Function Description

The `REPLACE` block replaces a substring from `su1` by the string `su2` and puts the result in `sy`. The parameters `l` and `p` specify position and length of the string being replaced in UTF-8 characters. The parameter `p` is one-based.

Inputs

`su1`	String input value	`String`
`su2`	String input value	`String`
`l`	Length of origin text	`Long (I32)`
`p`	Position of origin text (one-based)	`Long (I32)`

Parameter

`nmax`	Allocated size of string [bytes]	↓0 ↑65520	`Long (I32)`

Output

`sy`	String output value	`String`
`iE`	Error code	`Error`

RTOS – Real Number to String Conversion

Block Symbol

Licence: STANDARD

Function Description

The RTOS converts a real number in u into a string value in su. Precision and format are specified by the prec and mode parameters.

Input

u	Analog input of the block	Double (F64)

Output

sy	String output value	String

Parameters

prec	Precision (number of digits)	↓0 ↑20	Long (I32)
mode	Output string format	⊙1	Long (I32)

1 ..... Best fit – fixed point, but for extremly small or big numbers exponential format; parameter prec is total maximum number of characters in output (mantisa for exponential format)

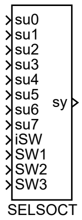
2 ..... Normal – fixed point format; parameter prec is number of places after the decimal point

3 ..... Exponential – scientific format; parameter prec is number of places after the decimal pointe

SELSOCT – Selector switch for string signals

Block Symbol

Licence: STANDARD



Function Description

The SELSOCT block selects one of the input strings and copy it to the output string sy. The selection of the active signal u0. . . u15 is based on the iSW input or the binary inputs SW1. . . SW3. These two modes are distinguished by the BINF binary flag. The signal is selected according to the following table:

iSW	SW1	SW2	SW3	y
0	off	off	off	u0
1	on	off	off	u1
2	off	on	off	u2
3	on	on	off	u3
4	off	off	on	u4
5	on	off	on	u5
6	off	on	on	u6
7	on	on	on	u7

Inputs

su0..7	String input value		String
iSW	Active signal selector		Long (I32)
SW1..3	Binary signal selector		Bool

Parameters

BINF	Enable the binary selectors		Bool
nmax	Allocated size of string [bytes]	↓0 ↑65520	Long (I32)

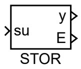
Output

sy	The selected input signal		String

STOR – String to real number conversion

Block Symbol

Licence: STANDARD



Function Description

The STOR converts a string in su into a real number in y. An error is signaled in E if unsuccessful.

Input

su	String input value	String

Parameter

yerr	Substitute value for an error case	Double (F64)

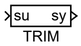
Outputs

y	Analog output of the block	Double (F64)
E	Error indicator	Bool

TRIM – * Remove leading and trailing whitechar

Block Symbol

Licence: STANDARD



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block propagates the signal quality. More information can be found in the 1.4 section.

Input

su	String input value		String

Parameter

nmax	Allocated size of string	↓0 ↑65520	Long (I32)

Output

sy	String output value		String

Chapter 12

PARAM – Blocks for parameter handling

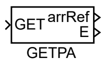
Contents

The PARAM library is designed for parameter management and signal processing in the REXYGEN system. It includes blocks like PARR and its variants for defining and modifying various types of parameters. Search blocks like GETPA and GETPS enable the extraction of these parameters for further processing. Conversely, SETPA, SETPR, and SETPS are used for dynamically setting parameter values. Additionally, the library contains SILO and SILOS for exporting and importing values from a file. This library is crucial for systems requiring dynamic parameter manipulation and the ability to read/save values to a file.

GETPA – Block for remote array parameter acquirement

Block Symbol

Licence: STANDARD



Function Description

The GETPA block is used for acquiring the array parameters of other blocks in the model remotely . The block operates in two modes, which are switched by the GETF parameter. For GETF = off the output arrRef is set to the value of the remote parameter at the start and every time when the remote parameter changes. If the GETF parameter is set to on, then the block works in single-shot read mode. In that case the remote parameter is read only when rising edge (off→on) occurs at the GET input.

The name of the remote parameter is determined by the string parameter sc (string connection), which has the form <block_path:parameter_name>. The path to the block whose parameter should be read can contain hierarchic levels separated by dots followed by the block name. The path can be either relative or absolute:

- Relative – starts at the level where the GETPA block is located. The string has to be prefixed with '.' in this case. Examples of relative paths: ".CNDR:yp", ".Lights.ATMT:touts".
- Relative to task – starts at the root level of the task where the SETPA block is located. The string has to be prefixed with '%' in this case. Examples of paths: "%CNDR:yp", "%Lights.ATMT:touts".
- Absolute – complete sequence of hierarchic levels down to the block. For referring to blocks located in the driver task (see the IOTASK block for details on configuration) the '&' followed by the driver's name is used at the beginning of the absolute path. Examples of absolute paths: "task1.inputs.ATMT:touts", "&EfaDrv.measurements.CNDR:yp".

The order and names of individual hierarchic levels are presented in a tree-like structure within the Diagnostics section of the REXYGEN Studio program.

Warning 1: If the remote parameter is in a task other than the GETPA block, block execution is delayed until the remote task is completed. It is necessary to avoid the so-called race conditions and guarantee the correct value reading. Therefore, it is recommended to include the GETPA block in a slower task (longer period/execution time) and read parameter in a faster task (shorter period/execution time). In the opposite situation (e.g. the GETPA block in a faster task), the SETPA block should be used in a slower task.

Note 1: If parameter GETF = off and source array is in same task as the GETPA block, data are not copy into intermediate array, but output is direct reference to original array.

It save resources (cpu time and memory). The `nmax, etype` parameters are ignored in this case.

Note 2: When using multiple `GETPA` blocks, it is not guaranteed to read all data from a remote task in the same tick. It is only guaranteed that the previous block will receive a value in the same or previous period as the next block (the order of blocks execution can be checked in REXYGEN Diagnostics).

Note 3: The remote parameter must be a primary array (for example `CNA:acn`, `RTOV:xVec`, `MX_MAT:ay`). The array reference (like `CNA:vec`, `RTOV:yVec`, `SUBSYSTEM:Outport`) is not supported.

Input

`GET`	Input for initiating one-shot parameter read. Array is read on rising edge of this input.	`Bool`

Outputs

`arrRef`	Array reference	`Reference`
`E`	Error flag	`Bool`

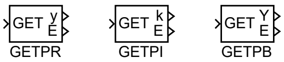
Parameters

`sc`	String connection to the parameter	`String`
`GETF`	Get parameter only when forced to. `off` ... Remote parameter is continuously read `on` .... One-shot mode, the remote parameter is read only when forced to by the `GET` input (rising edge)	`Bool`
`nmax`	Maximum size of array ↓10 ⊙256	`Long (I32)`
`etype`	Type of members of the acquired array. This is type of the intermediate (state) array where is copy of acquired data. The conversion is performed if original and intermediate array has different type. ⊙8 `2` ..... Byte `5` ..... Word `8` ..... Double `3` ..... Short `6` ..... DWord `10` .... Large `4` ..... Long `7` ..... Float	`Long (I32)`

GETPR, GETPI, GETPB – Blocks for remote parameter acquirement

Block Symbols

Licence: STANDARD



Function Description

The GETPR, GETPI and GETPB blocks are used for acquiring the parameters of other blocks in the model remotely . The only difference among the three blocks is the type of parameter which they are acquiring. The GETPR block is used for obtaining real parameters, the GETPI block for integer parameters and the GETPB block for Boolean parameters.

The blocks operate in two modes, which are switched by the GETF parameter. For GETF = off the output y (or k, Y) is set to the value of the remote parameter at the start and every time when the remote parameter changes. If the GETF parameter is set to on, then the blocks work in single-shot read mode. In that case the remote parameter is read only when rising edge (off→on) occurs at the GET input.

The name of the remote parameter is determined by the string parameter sc (string connection), which has the form <block_path:parameter_name>. It is also possible to access individual items of array-type parameters (e.g. the tout parameter of the ATMT block). This can be achieved using the square brackets and item number, e.g. .ATMT:touts[2]. The items are numbered from zero, thus the string connection stated above refers to the third element of the array.

The path to the block whose parameter should be read can contain hierarchic levels separated by dots followed by the block name. The path can be either relative or absolute:

- Relative – starts at the level where the GETPR block (or GETPI, GETPB) is located. The string has to be prefixed with '.' in this case. Examples of relative paths: ".GAIN:k", ".Motor1.Position:ycn".
- Relative to task – starts at the root level of the task where the GETPR block (or GETPI, GETPB, GETPS) is located. The string has to be prefixed with '%' in this case. Examples of paths: "%GAIN:k", "%Motor1.Position:ycn".
- Absolute – complete sequence of hierarchic levels down to the block. For referring to blocks located in the driver task (see the IOTASK block for details on configuration) the '&' followed by the driver's name is used at the beginning of the absolute path. Examples of absolute paths: "task1.inputs.lin1:u2", "&EfaDrv.measurements.DER1:n".

The order and names of individual hierarchic levels are presented in a tree-like structure within the Diagnostics section of the REXYGEN Studio program.

Warning: If the remote parameter is in a task other than the GETPx block, block execution is delayed until the remote task is completed. It is necessary to avoid the so-called race conditions and guarantee the correct value reading. Therefore, it is recommended to include the GETPx block in a slower task (longer period/execution time) and read parameter in a faster task (shorter period/execution time). In the opposite situation (e.g. the GETPx block in a faster task), the SETPx block should be used in a slower task.

Note: When using multiple GETPx blocks, it is not guaranteed to read all data from a remote task in the same tick. It is only guaranteed that the previous block will receive a value in the same or previous period as the next block (the order of blocks execution can be checked in REXYGEN Diagnostics). To obtain multiple values in the same period, it is needed to use the Inport and Outport blocks or the GETPA block.

Input

GET	Input for initiating one-shot parameter read (off→on)	Bool

Outputs

y	Parameter value, output of the GETPR block	Double (F64)
k	Parameter value, output of the GETPI block	Long (I32)
Y	Parameter value, output of the GETPB block	Bool
E	Error flag off ... No error on .... An error occurred	Bool

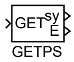
Parameters

sc	String connection to the remote parameter respecting the above mentioned notation	String
GETF	Continuous or one-shot mode off ... Remote parameter is continuously read on .... One-shot mode, the remote parameter is read only when forced to by the GET input (rising edge)	Bool

GETPS – * Block for remote string parameter acquirement

Block Symbol

Licence: STANDARD



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Input

GET	Input for initiating one-shot parameter read	Bool

Parameters

sc	String connection to the parameter	String
GETF	Get parameter only when forced to off . . . Remote parameter is continuously read on . . . . One-shot mode	Bool
nmax	Allocated size of string	Long (I32)

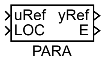
Outputs

sy	Parameter value	String
E	Error indicator off . . . No error on . . . . An error occurred	Bool

PARA – Block with input-defined array parameter

Block Symbol

Licence: STANDARD



Function Description

The PARA block allows, additionally to the standard way of parameter setting, changing one of its parameters by the input signal. The input-parameter pair is uRef and apar.

The Boolean input LOC (LOCal) determines whether the value of the apar parameter is read from the input uRef or is input-independent (LOC = on). In the local mode LOC = on the parameter apar contains the last value of input uRef entering the block right before LOC was set to on.

The output value is equivalent to the value of the parameter (yRef = apar).

Inputs

uRef	Array reference	Reference
LOC	Activation of local mode off ... The parameter follows the input on .... Local mode active	Bool

Output

yRef	Array reference	Reference

Parameters

SETS	Set array size flag. Use this flag to adjust the size of array when setting the parameter.	Bool
nmax	Allocated size of the apar array ↓10 ⊙100	Long (I32)
etype	Type of members of the apar array ⊙8 2 ..... Byte 5 ..... Word 8 ..... Double 3 ..... Short 6 ..... DWord 10 .... Large 4 ..... Long 7 ..... Float	Long (I32)
apar	Internal value of the parameter ⊙[0.0 1.0 2.0 3.0 4.0 5.0]	Double (F64)

PARE – Block with input-defined enumeration parameter

Block Symbol

Licence: STANDARD

Function Description

The block is similar to the the PARI block with the additional option to assign texts to numeric values. The corresponding text is set on the output sy. The block has two modes and the active mode is selected by the LIST parameter. If LIST=off a corresponding text for the input value is set on the output sy. If LIST=on the input number is considered as a bitfield, texts are defined for each bit and the output sy is composed of the texts that correspond to bits which are set. The behavior for undefined values is determined by the SATF parameter. If SATF=off, undefined values are set to output iy and the output sy is set to empty text. Undefined values are ignored if SAT=on. The pupstr parameter has the same format as in the CNE block: <number1>: <description1>|<number2>: <description2>|<number3>: <description3> ...

Inputs

ip	Parameter value	Long (I32)
LOC	Activation of local mode off ... The parameter follows the input on .... Local mode active	Bool

Parameters

ipar	Internal value of parameter	⊙1	Long (I32)
pupstr	Popup list definition ⊙1: option A|2: option B|3: option C		String
NUM	Number in string outut		Bool
LIST	Bitfield mode		Bool
SATF	Saturation flag (if undefined values are passed to output)		Bool

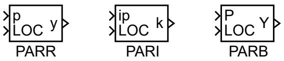
Outputs

iy	Integer output of the block	Long (I32)
sy	String output value	String

PARR, PARI, PARB – Blocks with input-defined parameter

Block Symbols

Licence: STANDARD



Function Description

The PARR, PARI and PARB blocks allow, additionally to the standard way of parameters setting, changing one of their parameters by the input signal. The input-parameter pairs are p and par for the PARR block, ip and ipar for the PARI block and finally P and PAR for the PARB block.

The Boolean input LOC (LOCal) determines whether the value of the par (or ipar, PAR) parameter is read from the input p (or ip, P) or is input-independent (LOC = on). In the local mode LOC = on the parameter par (or ipar, PAR) contains the last value of input p (or ip, P) entering the block right before LOC was set to on. Afterwards it is possible to modify the value manually.

The output value is equivalent to the value of the parameter y = par, (or k = ipar, Y = PAR). The output of the PARR and PARI blocks can be additionally constrained by the saturation limits ⟨lolim, hilim⟩. The saturation is active only when SATF = on.

See also the SHLD block, which can be used for storing a numeric value, similarly as in the PARR block.

Inputs

p	Parameter value (the PARR block)	Double (F64)
ip	Parameter value (the PARI block)	Long (I32)
P	Parameter value (the PARB block)	Bool
LOC	Activation of local mode off . . . The parameter follows the input on . . . . Local mode active	Bool

Output

y	Logical output of the PARR block	Double (F64)
k	Logical output of the PARI block	Long (I32)
Y	Logical output of the PARB block	Bool

Parameter

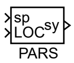
par	Initial value of the parameter (the PARR block)	⊙1.0	Double (F64)
ipar	Initial value of the parameter (the PARI block)	⊙1	Long (I32)
PAR	Initial value of the parameter (the PARB block)	⊙on	Bool

`SATF`	Activation of the saturation limits for the `PARR` and `PARI` blocks `off` ... Signal not limited `on` .... Saturation limits active	`Bool`
`hilim`	Upper limit of the output signal (the `PARR` and `PARI` blocks) ⊙`1.0`	`Double (F64)`
`lolim`	Lower limit of the output signal (the `PARR` and `PARI` blocks) ⊙`-1.0`	`Double (F64)`

PARS – * Block with input-defined string parameter

Block Symbol

Licence: STANDARD



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

`sp`	Parameter value	`String`
`LOC`	Activation of local mode	`Bool`

Parameters

`spar`	Internal value of the parameter	`String`
`nmax`	Allocated size of string	`Long (I32)`

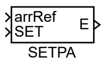
Output

`sy`	String output of the block	`String`

SETPA – Block for remote array parameter setting

Block Symbol

Licence: STANDARD



Function Description

The SETPA block is used for setting the array parameters of other blocks in the model remotely . The block operates in two modes, which are switched by the SETF parameter. For SETF = off the remote parameter cs is set to the value of the input vector signal arrRef at the start and every time when the input signal changes. If the SETF parameter is set to on, then the block works in one-shot write mode. In that case the remote parameter is set only when rising edge (off→on) occurs at the SET input.

The name of the remote parameter is determined by the string parameter sc (string connection), which has the form <block_path:parameter_name>. The path to the block whose parameter should be read can contain hierarchic levels separated by dots followed by the block name. The path can be either relative or absolute:

- Relative – starts at the level where the GETPA block is located. The string has to be prefixed with '.' in this case. Examples of relative paths: ".CNDR:yp", ".Lights.ATMT:touts".
- Relative to task – starts at the root level of the task where the SETPA block is located. The string has to be prefixed with '%' in this case. Examples of paths: "%GAIN:k", "%Motor1.Position:ycn".
- Absolute – complete sequence of hierarchic levels down to the block. For referring to blocks located in the driver task (see the IOTASK block for details on configuration) the '&' followed by the driver's name is used at the beginning of the absolute path. Examples of absolute paths: "task1.inputs.ATMT:touts", "&EfaDrv.measurements.CNDR:yp".

The order and names of individual hierarchic levels are presented in a tree-like structure within the Diagnostics section of the REXYGEN Studio program.

Warning: If the remote parameter is in a task other than the SETPA block, block execution is delayed until the remote task is completed. It is necessary to avoid the so-called race conditions and guarantee the correct value setting. Therefore, it is recommended to include the SETPA block in a slower task (longer period/execution time) and set parameter in a faster task (shorter period/execution time). In the opposite situation (e.g. the SETPA block in a faster task), the GETPA block should be used in a slower task.

Note 1: When using multiple SETPA blocks, it is not guaranteed that all data will be written to the remote task in the same tick. It is only guaranteed that the previous block will set a value in the same or previous period as the next block (the order of blocks execution can be checked in REXYGEN Diagnostics).

Note 2: The remote parameter must be a primary array (for example `CNA:acn`, `RTOV:xVec`, `MX_MAT:ay`). The array reference (like `CNA:vec`, `RTOV:yVec`, `SUBSYSTEM:Outport`) is not supported.

Inputs

`arrRef`	Array reference	`Reference`
`SET`	Input for initiating one-shot parameter write	`Bool`

Output

`E`	Error flag	`Bool`

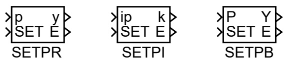
Parameters

`sc`	String connection to the parameter	`String`
`SETF`	Continuous or one-shot mode `off` ... Remote parameter is continuously updated `on` .... One-shot mode, the remote parameter is updated only when forced to by the `SET` input (rising edge)	`Bool`
`SETS`	Set array size flag. Use this flag to adjust the size of array when setting the parameter.	`Bool`

SETPR, SETPI, SETPB – Blocks for remote parameter setting

Block Symbols

Licence: STANDARD



Function Description

The SETPR, SETPI, SETPB and SETPS blocks are used for setting the parameters of other blocks in the model remotely. The only difference among the three blocks is the type of parameter which they are setting. The SETPR block is used for setting real parameters, the SETPI block for integer parameters, the SETPB block for Boolean parameters and the SETPS block for string parameters.

The blocks operate in two modes, which are switched by the SETF parameter. For SETF = off the remote parameter sc is set to the value of the input signal p (or ip, P) at the start and every time when the input changes. If the SETF parameter is set to on, then the blocks work in one-shot write mode. In that case the remote parameter is set only when rising edge (off→on) occurs at the SET input. Successful modification of the remote parameter is indicated by zero error output E = off and the output y (or k, Y) is set to the value of the modified parameter. The error output is set to E = on in case of write error.

The name of the remote parameter is determined by the string parameter sc (string connection), which has the form <block_path:parameter_name>. It is also possible to access individual items of array-type parameters (e.g. the tout parameter of the ATMT block). This can be achieved using the square brackets and item number, e.g. .ATMT:touts[2]. The items are numbered from zero, thus the string connection stated above refers to the third element of the array.

The path to the block whose parameter should be set can contain hierarchic levels separated by dots followed by the block name. The path can be either relative or absolute:

- Relative – starts at the level where the SETPR block (or SETPI, SETPB, SETPS) is located. The string has to be prefixed with '.' in this case. Examples of relative paths: ".GAIN:k", ".Motor1.Position:ycn".
- Relative to task – starts at the root level of the task where the SETPR block (or SETPI, SETPB, SETPS) is located. The string has to be prefixed with '%' in this case. Examples of paths: "%GAIN:k", "%Motor1.Position:ycn".
- Absolute – complete sequence of hierarchic levels down to the block. For referring to blocks located in the driver task (see the IOTASK block for details on configuration) the '&' followed by the driver's name is used at the beginning of the absolute path. Examples of absolute paths: "task1.inputs.lin1:u2", "&EfaDrv.measurements.DER1:n".

The order and names of individual hierarchic levels are displayed in a tree structure in the REXYGEN Diagnostics program.

Warning: If the remote parameter is in a task other than the SETPx block, block execution is delayed until the remote task is completed. It is necessary to avoid the so-called race conditions and guarantee the correct value setting. Therefore, it is recommended to include the SETPx block in a slower task (longer period/execution time) and set parameter in a faster task (shorter period/execution time). In the opposite situation (e.g. the SETPx block in a faster task), the GETPx block should be used in a slower task.

Note: When using multiple SETPx blocks, it is not guaranteed that all data will be written to the remote task in the same tick. It is only guaranteed that the previous block will set a value in the same or previous period as the next block (the order of blocks execution can be checked in REXYGEN Diagnostics). To send multiple values in the same period, it is needed to use the Inport and Outport blocks or the SETPA block.

Inputs

p	Desired parameter value at the SETPR block input	Double (F64)
ip	Desired parameter value at the SETPI block input	Long (I32)
P	Desired parameter value at the SETPB block input	Bool
SET	Input for initiating one-shot parameter write (off→on)	Bool

Outputs

y	Parameter value (the SETPR block)	Double (F64)
k	Parameter value (the SETPI block)	Long (I32)
Y	Parameter value (the SETPB block)	Bool
E	Error flag off ... No error on .... An error occurred	Bool

Parameters

sc	String connection to the remote parameter respecting the above mentioned notation	String
SETF	Continuous or one-shot mode off ... Remote parameter is continuously updated on .... One-shot mode, the remote parameter is updated only when forced to by the SET input (rising edge)	Bool

SETPS – * Block for remote string parameter setting

Block Symbol

Licence: STANDARD

Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

sp	Desired parameter value	String
SET	Input for initiating one-shot parameter write	Bool

Parameters

sc	String connection to the parameter	String
SETF	Set parameter only when forced to	Bool
nmax	Allocated size of string	Long (I32)

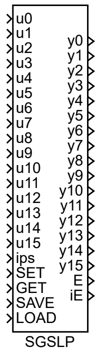
Outputs

sy	Parameter value	String
E	Error indicator	Bool

SGSLP – Set, get, save and load parameters

Block Symbol

Licence: ADVANCED



Function Description

The SGSLP block is a special function block for manipulation with parameters of other function blocks in the REXYGEN system configuration. It works also in the Matlab-Simulink system but its scope is limited to the .mdl file it is included in.

The block can manage up to 16 parameter sets, which are numbered from 0 to 15. The number of parameter sets is given by the nps parameter and the active set is defined by the ips input. If the ips input remains unconnected, the active parameter set is ips $= 0$. Each set contains up to 16 different parameters defined by the string parameters sc0 to sc15. Thus the SGSLP block can work with a maximum of 256 parameters of the REXYGEN system. An empty sc$i$ string means that no parameter is specified, otherwise one of the following syntaxes is used:

1. <block>:<param> – Specifies one function block named block and its parameter param. The same block and parameter are used for all nps parameter sets in this case.

2. <block>:<param><sep>...<block>:<param> – This syntax allows the parameters to differ among the parameter sets. In general, each sc$i$ string can contain up to 16 items in the form <blok>:<param> separated by comma or semi-colon. E.g. the third item of these is active for ips $= 2$. There should be exactly nps items in each non-empty sc$i$ string. If there is less items than nps none of the below described operations can be executed on the incomplete parameter set.

It is recommended not to use both syntaxes in one SGSLP block, all 16 sc$i$ strings should have the same form. The first syntax is for example used when producing nps types of goods, where many parameters must be changed for each type of production. The second syntax is usually used for saving user-defined parameters to disk (see the

SAVE operation below). In that case it is desirable to arrange automated switching of the ips input (e.g. using the ATMT block from the LOGIC library).

The broot parameter is suitable when all blocks whose parameters are to be controlled by the SGSLP block reside in the same subsystem or deeper in the hierarchy. It is inserted in front of each <block> substring in the sc$i$ parameters. The '.' character stands for the subsystem where the SGSLP block is located. No quotation marks are used to define the parameter, they are used here solely to highlight a single character. If the broot parameter is an empty string, all <block> items must contain full path. For example, to create a connection to the CNR block and its parameter ycn located in the same subsystem as the SGSLP block, broot = . and sc0 = CNR:ycn must be set. Or it is possible to leave the broot parameter empty and put the '.' character to the sc0 string. See the GETPR or SETPR blocks description for more details about full paths in the REXYGEN system.

The SGSLP block executes one of the below described operations when a rising edge (off→on) occurs at the input of the same name. The operations are:

SET – Sets the parameters of the corresponding parameter set ips to the values of the input signals ui. In case the parameter is successfully set, the same value is also sent to the yi output.

GET – Gets the parameters of the corresponding parameter set ips. In case the parameter is successfully read, its value is sent to the yi output.

SAVE – Saves the parameters of the corresponding parameter set ips to a file on the target platform. The parameters of the procedure and the format of the resulting file are described below.

LOAD – Loads the parameters of the corresponding parameter set ips from a file on the target platform. This operation is executed also during the initialization of the block but only when $0 \leq \text{ips0} \leq \text{nps} - 1$. The parameters of the procedure and the format of the file are described below.

The LOAD and SAVE operations work with a file on the target platform. The name of the file is given by the fname parameter and the following rules:

- If no extension is specified in the fname parameter, the .rxs (ReX Status file) extension is added.

- A backup file is created when overwriting the file. The file name is preserved, only the extension is modified by adding the ' ' character right after the '.' (e.g. when no extension is specified, the backup file has a . rxs extension.

- The path is relative to the folder where the archives of the REXYGEN system are stored. The file should be located on a media which is not erased by system restart (flash drive or hard drive, not RAM).

The SAVE operation stores the data in a text file. Two lines are added for each parameter sc$i$, $i = 0, \ldots, m$, where $m < 16$ defines the nonempty sc$m$ string with the highest number. The lines have the form:

"<block>:<param>", ..., "<block>:<param>"

<value>, ..., <value>

There are nps individual items "<block>:<param>" which are separated by commas. The second line contains the same number of <value> items which contain the value of the parameter at the same position in the line above. Note that the format of the file remains the same even for sc$i$ containing only one <block>:<param> item (see the syntax no. 1 above). The "<block>:<param>" item is always listed nps-times in the file, which allows seamless switching of the sc$i$ parameters syntax without modifying the file.

Consider using the SILO block if working with only a few values.

Inputs

ui	i-th analog input signal, $i = 0, \ldots, 15$	Double (F64)
ips	Parameter set index (numbered from zero)	Long (I32)
SET	Set the parameters of the ips parameter set according to the values of the ui inputs. The values can be found at the yi outputs after a successful operation.	Bool
GET	Get the parameters of the ips parameter set. The values can be found at the yi outputs after a successful operation.	Bool
SAVE	Save the ips parameter set to a file on the target device	Bool
LOAD	Load the ips parameter set from a file on the target device	Bool

Outputs

yi	i-th analog output signal, $i = 0, \ldots, 15$	Double (F64)
E	Error flag off ... No error on .... An error occurred (see iE)	Bool

iE	Error or warning code of the last operation 0 ..... Operation successful 1 ..... Fatal error of the Matlab system (only in Simulink), the block is no longer executed 2 ..... Error opening the file for reading (LOAD operation) 3 ..... Error opening the file for writing (SAVE operation) 4 ..... Incorrect file format 5 ..... The ips parameter set not found in the file 6 ..... Parameter not found in the configuration, name mismatch (LOAD operation) 7 ..... Unexpected end of file 8 ..... Error writing to file (disk full?) 9 ..... Parameter syntax error (the ':' character not found) 10 .... Only whitespace in the parameter name 11 .... Error creating the backup file 12 .... Error obtaining the parameter value by the GET operation (non-existing parameter?) 13 .... Error setting the parameter value by the SET operation (non-existing parameter?) 14 .... Timeout during obtaining/setting the parameter 15 .... The specified parameter is read-only 16 .... The ips parameter is out of range	Long (I32)

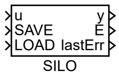
Parameters

nps	Number of parameter sets ↓1 ↑16 ⊙1	Long (I32)
ips0	Index of parameter set to load and set during the block initialization. No set is read for ips0 <0 or ips0 $\geq$ nps ↓-1 ↑15	Long (I32)
iprec	Precision (number of digits) for storing the values of double type in a file ↓2 ↑15 ⊙12	Long (I32)
icolw	Requested column width in the status file. Spaces are appended to the parameter value when necessary. ↓0 ↑22	Long (I32)
fname	Name of the file the SAVE and LOAD operations work with ⊙status	String
broot	Root block in hierarchy, inserted at the beginning of all sc$i$ parameters, see the description above ⊙.	String
sc$i$	Strings defining the connection of ui inputs and yi outputs to the parameters, $i = 0, \ldots, 15$, see details above	String

SILO – Save input value, load output value

Block Symbol

Licence: STANDARD



Function Description

The SILO block can be used to export or import a single value to/from a file. The value is saved when a rising edge (off→on) occurs at the SAVE input and the value is also set to the y output. The value is loaded at startup and when a rising edge (off→on) occurs at the LOAD input.

The outputs E and lastErr indicate an error during disk operation. The E indicator is reset on falling edge at the SAVE or LOAD input while the lastErr output holds the value until another disk operation is invoked. If the error occurs during the LOAD operation, a substitute value yerr is set to the y output.

Alternatively it is possible to write or read the value continuously if the corresponding flag (CSF, CLF) is set to on. The disk operation is then performed when the corresponding input is set to on. Beware, in that case the disk operation is executed in each cycle, which can cause excessive use of the storage medium. Thus it is necessary to use this feature with caution.

The fname parameter defines the location of the file on the target platform. The path is relative to the data folder of the RexCore runtime module.

Use the SGSLP function block for advanced and complex operations.

Inputs

u	Input signal	Double (F64)
SAVE	Save value to file	Bool
LOAD	Load value from file	Bool

Parameters

fname	Name of persistent storage file	String
CSF	Flag for continuous saving	Bool
CLF	Flag for continuous loading	Bool
yerr	Substitute value for an error case	Double (F64)

Outputs

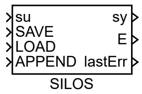
y	Output signal	Double (F64)
E	Error flag	Bool

`lastErr`	Result of last operation	`Long (I32)`

SILOS – Save input string, load output string

Block Symbol

Licence: STANDARD



Function Description

The SILOS block can be used to export or import a string to/from a file. The string is saved when a rising edge (off→on) occurs at the SAVE input and the string is also set to the sy output. The string is loaded at startup and when a rising edge (off→on) occurs at the LOAD input.

If a logical true (on) is brought to the APPEND input, the input string is added to the end of the file when it is saved. This mode is useful for logging events into text files. This input signal has no effect on loading from the file.

The LLO parameter is intended for choosing whether to load the entire file (off) or its last line only (on).

The outputs E and lastErr indicate an error during disk operation. The E indicator is reset on falling edge at the SAVE or LOAD input while the lastErr output holds the value until another disk operation is invoked.

Alternatively it is possible to write or read the string continuously if the corresponding flag (CSF, CLF) is set to on. The disk operation is then performed when the corresponding input is set to on. Beware, in that case the disk operation is executed in each cycle, which can cause excessive use of the storage medium. Thus it is necessary to use this feature with caution.

The fname parameter defines the location of the file on the target platform. The path is relative to the data folder of the RexCore runtime module.

Inputs

su	String input of the block	⊙0	String
SAVE	Save string to file		Bool
LOAD	Load string from file		Bool
APPEND	Append saved string to file		Bool

Outputs

sy	String output of the block	String
E	Error indicator off . . . No error on . . . . An error occurred	Bool
lastErr	Result of last operation	Long (I32)

Parameters

fname	Name of persistent storage file		String
CSF	Continuous saving		Bool
CLF	Continuous loading		Bool
LLO	Last line only loading		Bool
nmax	Allocated size of string	↓0 ↑65520	Long (I32)

Chapter 13

MODEL – Dynamic systems simulation

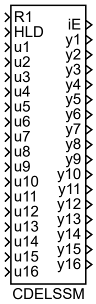
Contents

The MODEL library is centered around system modeling and simulation. It includes blocks like CSSM and DSSM for continuous and discrete state-space models, and DFIR for digital finite impulse response filters. The library offers EKF for Extended Kalman Filter implementations, and FOPDT, SOPDT for first and second order process time delay models. Additionally, it provides FMUCS and FMUINFO for interfacing with Functional Mock-up Units, and MDL, MDLI for generic model interfaces. Advanced functionalities are covered by blocks like CDELSSM, DDELSSM for continuous and discrete state space models of a linear system with time delay, and MVD for model variable delays, catering to a wide range of modeling requirements in REXYGEN system.

CDELSSM – Continuous state space model of a linear system with time delay

Block Symbol

Licence: ADVANCED



Function Description

The CDELSSM block (Continuous State Space Model with time DELay) simulates behavior of a linear system with time delay *del*

$$\begin{aligned}\frac{dx(t)}{dt} &= A_c x(t) + B_c u(t - del),\ x(0) = x0 \\ y(t) &= C_c x(t) + D_c u(t),\end{aligned}$$

where $x(t) \in \mathbb{R}^n$ is the state vector, $x0 \in \mathbb{R}^n$ is the initial value of the state vector, $u(t) \in \mathbb{R}^m$ is the input vector, $y(t) \in \mathbb{R}^p$ is the output vector. The matrix $A_c \in \mathbb{R}^{n\times n}$ is the system dynamics matrix, $B_c \in \mathbb{R}^{n\times m}$ is the input matrix, $C_c \in \mathbb{R}^{p\times n}$ is the output matrix and $D_c \in \mathbb{R}^{p\times m}$ is the direct transmission (feedthrough) matrix.

All matrices are specified in the same format as in Matlab, i.e. the whole matrix is placed in brackets, elements are entered by rows, elements of a row are separated by spaces (blanks), rows are separated by semicolons. The $x0$ vector is a column, therefore the elements are separated by semicolons (each element is in a separate row).

The simulated system is first converted to the discrete (discretized) state space model

$$\begin{aligned}x((k+1)T) &= A_d x(kT) + B_{d1} u((k-d)T) + B_{d2} u((k-d+1)T),\ x(0) = x0 \\ y(kT) &= C_c x(kT) + D_c u(kT),\end{aligned}$$

where $k \in \{1, 2, \ldots\}$ is the simulation step, T is the execution period of the block in seconds and d is a delay in simulation step such that $(d-1)T < del \leq d.T$. The period T is not entered in the block, it is determined automatically as a period of the task (TASK, QTASK nebo IOTASK) containing the block.

If the input $u(t)$ is changed only in the moments of sampling and between two consecutive sampling instants is constant, i.e. $u(t) = u(kT)$ for $t \in [kT, (k+1)T)$, then the matrices A_d, B_{d1} and B_{d2} are determined by

$$\begin{aligned} A_d &= e^{A_c T} \\ B_{d1} &= e^{A_c(T-\Delta)} \int_0^{\Delta} e^{A_c \tau} B_c d\tau \\ B_{d2} &= \int_0^{T-\Delta} e^{A_c \tau} B_c d\tau, \end{aligned}$$

where $\Delta = del - (d-1)T$.

Computation of discrete matrices A_d, B_{d1} and B_{d2} is based on a method described in [5], which uses Padé approximations of matrix exponential and its integral and scaling technique.

During the real-time simulation, single simulation step of the above discrete state space model is computed in each execution time instant.

Inputs

`R1`	Reset signal. When `R1` = `on`, the state vector `x` is set to its initial value `x0`. The simulation continues on the falling edge of `R1` (`on`→`off`).	`Bool`
`HLD`	Simulation output holds its value if `HLD`=`on`.	`Bool`
`u1..u16`	Simulated system inputs. First m simulation inputs are used where m is the number of columns of the matrix `Bc`.	`Double (F64)`

Outputs

`iE`	Block error code `0` ..... O.K., the simulation runs correctly `-213` .. incompatibility of the state space model matrices dimensions `-510` .. the model is badly conditioned (some working matrix is singular or nearly singular) `xxx` ... error code `xxx` of REXYGEN, see appendix C for details	`Error`
`y1..y16`	Simulated system outputs. First p simulation outputs are used where p is the number of rows of the matrix `Cc`.	`Double (F64)`

Parameters

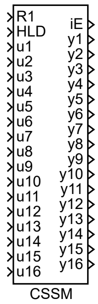
`UD`	Matrix `Dc` usage flag. If `UD`=`off`then the `Dc` matrix is not used for simulation (simulation behaves as if the `Dc` matrix is zero).	`Bool`
`del`	Model time delay [s]. ↓0.0	`Double (F64)`
`is`	Order of the Padé approximation of the matrix exponential for the computation of the discretized system matrices. ↓0 ↑4 ⊙2	`Long (I32)`
`eps`	Required accuracy of the Padé approximation. ↓0.0 ↑1.0 ⊙1e-15	`Double (F64)`
`Ac`	Matrix $(n \times n)$ of the continuous linear system dynamics.	`Double (F64)`

Bc	Input matrix ($n \times m$) of the continuous linear system.	Double (F64)
Cc	Output matrix ($p \times n$) of the continuous linear system.	Double (F64)
Dc	Direct transmission (feedthrough) matrix ($p \times m$) of the continuous linear system. The matrix is used only if the parameter UD=on. If UD=off, the dimensions of the Dc matrix are not checked.	Double (F64)
x0	Initial value of the state vector (of dimension n) of the continuous linear system.	Double (F64)

CSSM – Continuous state space model of a linear system

Block Symbol

Licence: ADVANCED



Function Description

The CSSM block (Continuous State Space Model) simulates behavior of a linear system

$$\begin{aligned} \frac{dx(t)}{dt} &= A_c x(t) + B_c u(t), \; x(0) = x0 \\ y(t) &= C_c x(t) + D_c u(t), \end{aligned}$$

where $x(t) \in \mathbb{R}^n$ is the state vector, $x0 \in \mathbb{R}^n$ is the initial value of the state vector, $u(t) \in \mathbb{R}^m$ is the input vector, $y(t) \in \mathbb{R}^p$ is the output vector. The matrix $A_c \in \mathbb{R}^{n \times n}$ is the system dynamics matrix, $B_c \in \mathbb{R}^{n \times m}$ is the input matrix, $C_c \in \mathbb{R}^{p \times n}$ is the output matrix and $D_c \in \mathbb{R}^{p \times m}$ is the direct transmission (feedthrough) matrix.

All matrices are specified in the same format as in Matlab, i.e. the whole matrix is placed in brackets, elements are entered by rows, elements of a row are separated by spaces (blanks), rows are separated by semicolons. The $x0$ vector is a column, therefore the elements are separated by semicolons (each element is in a separate row).

The simulated system is first converted to the discrete (discretized) state space model

$$\begin{aligned} x((k+1)T) &= A_d x(kT) + B_d u(kT), \; x(0) = x0 \\ y(kT) &= C_c x(kT) + D_c u(kT), \end{aligned}$$

where $k \in \{1, 2, \ldots\}$ is the simulation step, T is the execution period of the block in seconds. The period T is not entered in the block, it is determined automatically as a period of the task (TASK, QTASK nebo IOTASK) containing the block.

If the input $u(t)$ is changed only in the moments of sampling and between two consecutive sampling instants is constant, i.e. $u(t) = u(kT)$ for $t \in [kT, (k+1)T)$, then the matrices A_d and B_d are determined by

$$\begin{aligned} A_d &= e^{A_c T} \\ B_d &= \int_0^T e^{A_c \tau} B_c d\tau \end{aligned}$$

Computation of discrete matrices A_d and B_d is based on a method described in [5], which uses Padé approximations of matrix exponential and its integral and scaling technique.

During the real-time simulation, single simulation step of the above discrete state space model is computed in each execution time instant.

Inputs

`R1`	Reset signal. When `R1` = `on`, the state vector `x` is set to its initial value `x0`. The simulation continues on the falling edge of `R1` (`on`→`off`).	`Bool`
`HLD`	Simulation output holds its value if `HLD`=`on`.	`Bool`
`u1..u16`	Simulated system inputs. First m simulation inputs are used where m is the number of columns of the matrix `Bc`.	`Double (F64)`

Outputs

`iE`	Block error code `0` ..... O.K., the simulation runs correctly `-213` .. incompatibility of the state space model matrices dimensions `-510` .. the model is badly conditioned (some working matrix is singular or nearly singular) `xxx` ... error code `xxx` of REXYGEN, see appendix C for details	`Error`
`y1..y16`	Simulated system outputs. First p simulation outputs are used where p is the number of rows of the matrix `Cc`.	`Double (F64)`

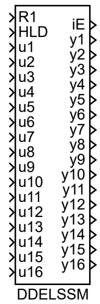
Parameters

`UD`	Matrix `Dc` usage flag. If `UD`=`off`then the `Dc` matrix is not used for simulation (simulation behaves as if the `Dc` matrix is zero).	`Bool`
`is`	Order of the Padé approximation of the matrix exponential for the computation of the discretized system matrices. ↓0 ↑4 ⊙2	`Long (I32)`
`eps`	Required accuracy of the Padé approximation. ↓0.0 ↑1.0 ⊙1e-15	`Double (F64)`
`Ac`	Matrix $(n \times n)$ of the continuous linear system dynamics.	`Double (F64)`
`Bc`	Input matrix $(n \times m)$ of the continuous linear system.	`Double (F64)`
`Cc`	Output matrix $(p \times n)$ of the continuous linear system.	`Double (F64)`
`Dc`	Direct transmission (feedthrough) matrix $(p \times m)$ of the continuous linear system. The matrix is used only if the parameter `UD`=`on`. If `UD`=`off`, the dimensions of the `Dc` matrix are not checked.	`Double (F64)`
`x0`	Initial value of the state vector (of dimension n) of the continuous linear system.	`Double (F64)`

DDELSSM – Discrete state space model of a linear system with time delay

Block Symbol

Licence: ADVANCED



Function Description

The DDELSSM block (Discrete State Space Model with time DELay) simulates behavior of a linear system with time delay *del*

$$
\begin{aligned}
x(k+1) &= A_d x(k) + B_d u(k-d),\ x(0) = x0 \\
y(k) &= C_d x(k) + D_d u(k),
\end{aligned}
$$

where k is the simulation step, $x(k) \in \mathbb{R}^n$ is the state vector, $x0 \in \mathbb{R}^n$ is the initial value of the state vector, $u(k) \in \mathbb{R}^m$ is the input vector, $y(k) \in \mathbb{R}^p$ is the output vector. The matrix $A_d \in \mathbb{R}^{n\times n}$ is the system dynamics matrix, $B_d \in \mathbb{R}^{n\times m}$ is the input matrix, $C_d \in \mathbb{R}^{p\times n}$ is the output matrix and $D_d \in \mathbb{R}^{p\times m}$ is the direct transmission (feedthrough) matrix. Number of steps of the delay d is the largest integer such that $d.T \leq del$, where T is the block execution period.

All matrices are specified in the same format as in Matlab, i.e. the whole matrix is placed in brackets, elements are entered by rows, elements of a row are separated by spaces (blanks), rows are separated by semicolons. The $x0$ vector is a column, therefore the elements are separated by semicolons (each element is in a separate row).

During the real-time simulation, single simulation step of the above discrete state space model is computed in each execution time instant.

Inputs

R1	Reset signal. When R1 = on, the state vector x is set to its initial value x0. The simulation continues on the falling edge of R1 (on→off).	Bool
HLD	Simulation output holds its value if HLD=on.	Bool
u1..u16	Simulated system inputs. First m simulation inputs are used where m is the number of columns of the matrix Bd.	Double (F64)

Outputs

`iE`	Block error code `0` ..... O.K., the simulation runs correctly `-213` .. incompatibility of the state space model matrices dimensions `xxx` ... error code `xxx` of REXYGEN, see appendix C for details	`Error`
`y1..y16`	Simulated system outputs. First p simulation outputs are used where p is the number of rows of the matrix `Cd`.	`Double (F64)`

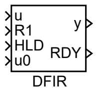
Parameters

`UD`	Matrix `Dd` usage flag. If `UD`=`off`then the `Dd` matrix is not used for simulation (simulation behaves as if the `Dd` matrix is zero).	`Bool`
`del`	Model time delay [s]. ↓`0.0`	`Double (F64)`
`Ad`	Matrix $(n \times n)$ of the discrete linear system dynamics.	`Double (F64)`
`Bd`	Input matrix $(n \times m)$ of the discrete linear system.	`Double (F64)`
`Cd`	Output matrix $(p \times n)$ of the discrete linear system.	`Double (F64)`
`Dd`	Direct transmission (feedthrough) matrix $(p \times m)$ of the discrete linear system. The matrix is used only if the parameter `UD`=`on`. If `UD`=`off`, the dimensions of the `Dd` matrix are not checked.	`Double (F64)`
`x0`	Initial value of the state vector (of dimension n) of the discrete linear system.	`Double (F64)`

DFIR – Discrete finite input response filter

Block Symbol

Licence: ADVANCED



Function Description

The DFIR block is a filter whose impulse response (or response to any finite length input) is of finite duration, because it settles to zero in finite time. The calculation takes place in the form of a convolutional integral (sum) - the impulse characteristic is entered in the hk field already in discretized form for the correct period.

Input

u	Analog input of the block	Double (F64)
R1	Block reset	Bool
HLD	Hold – the block code is not executed if the input is set to on	Bool
u0	Initial input value (fill buffer)	Double (F64)

Output

y	Analog output of the block	Double (F64)
RDY	Ready flag	Bool

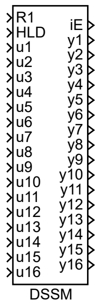
Parameters

nmax	Allocated size of array	↓10 ↑10000000 ⊙100	Long (I32)
hk	hk	⊙[0.6 0.3 0.1]	Double (F64)

DSSM – Discrete state space model of a linear system

Block Symbol

Licence: ADVANCED



Function Description

The DSSM block (Discrete State Space Model) simulates behavior of a linear system

$$\begin{aligned} x(k+1) &= A_d x(k) + B_d u(k), \ x(0) = x0 \\ y(k) &= C_d x(k) + D_d u(k), \end{aligned}$$

where k is the simulation step, $x(k) \in \mathbb{R}^n$ is the state vector, $x0 \in \mathbb{R}^n$ is the initial value of the state vector, $u(k) \in \mathbb{R}^m$ is the input vector, $y(k) \in \mathbb{R}^p$ is the output vector. The matrix $A_d \in \mathbb{R}^{n \times n}$ is the system dynamics matrix, $B_d \in \mathbb{R}^{n \times m}$ is the input matrix, $C_d \in \mathbb{R}^{p \times n}$ is the output matrix and $D_d \in \mathbb{R}^{p \times m}$ is the direct transmission (feedthrough) matrix.

All matrices are specified in the same format as in Matlab, i.e. the whole matrix is placed in brackets, elements are entered by rows, elements of a row are separated by spaces (blanks), rows are separated by semicolons. The $x0$ vector is a column, therefore the elements are separated by semicolons (each element is in a separate row).

During the real-time simulation, single simulation step of the above discrete state space model is computed in each execution time instant.

Inputs

R1	Reset signal. When R1 = on, the state vector x is set to its initial value x0. The simulation continues on the falling edge of R1 (on→off).	Bool
HLD	Simulation output holds its value if HLD=on.	Bool
u1..u16	Simulated system inputs. First m simulation inputs are used where m is the number of columns of the matrix Bd.	Double (F64)

Outputs

`iE`	Block error code `0` ..... O.K., the simulation runs correctly `-213` .. incompatibility of the state space model matrices dimensions `xxx` ... error code `xxx` of REXYGEN, see appendix C for details	`Error`
`y1..y16`	Simulated system outputs. First p simulation outputs are used where p is the number of rows of the matrix `Cd`.	`Double (F64)`

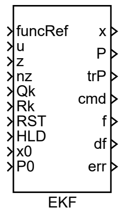
Parameters

`UD`	Matrix `Dd` usage flag. If `UD`=`off`then the `Dd` matrix is not used for simulation (simulation behaves as if the `Dd` matrix is zero).	`Bool`
`Ad`	Matrix $(n \times n)$ of the discrete linear system dynamics.	`Double (F64)`
`Bd`	Input matrix $(n \times m)$ of the discrete linear system.	`Double (F64)`
`Cd`	Output matrix $(p \times n)$ of the discrete linear system.	`Double (F64)`
`Dd`	Direct transmission (feedthrough) matrix $(p \times m)$ of the discrete linear system. The matrix is used only if the parameter `UD`=`on`. If `UD`=`off`, the dimensions of the `Dd` matrix are not checked.	`Double (F64)`
`x0`	Initial value of the state vector (of dimension n) of the discrete linear system.	`Double (F64)`

EKF – Extended (nonlinear) Kalman filter

Block Symbol

Licence: MODEL



Function Description

The block implements a nonlinear state estimator known as Extended Kalman filter. The goal is to provide estimates of unmeasurable state quantities of a nonlinear dynamic system described by a state space model $\mathrm{d}x/\mathrm{d}t = f(x,u) + w(t), y = h(x,u) + v(t)$ for a continuous-time case and $x(k+1) = f(x(k),u(k)) + w(k), y(k) = h(x(k),u(k)) + v(k)$ for the case of a discrete-time system. The variables w, v are the process and observation noises which are both assumed to be zero mean multivariate Gaussian processes with covariance Q and R specified in the block parameters. The Extended Kalman filter is the nonlinear version of the Kalman filter which linearizes the state and output equations about the current working point. It is a predictor-corrector type algorithm which switches between open-loop prediction using the state equation and correction of the estimates by directly measured output quantities. The measurements can be supplied to the filter non-equidistantly in an arbitrary execution period of the block.

The prediction step is run in each execution period and solves the state equation by numerical integration, starting from an initial value $x0$ and initial covariance $P0$. Various numerical methods, chosen by the user specified parameter *solver*, are available to perform the integration of the vector state differential equation. A special choice of $solver = 1$ signalizes the discrete-time system case for which the numerical integration reduces to simple evaluation of the recursive formula given by the first-order difference equation in $x(k+1) = f(x(k),u(k))$. Apart from the state vector, also its covariance matrix P is propagated in time, capturing the uncertainty of the estimates in the form of their (co)variances. Please refer to the documentation of the NSSM block for more details about the available numerical integration algorithms.

The filtering correction step takes place whenever the input of the block is set to $nz > 0$. This signalizes that new vector of measurements is available at the z input and it is used to correct the state and its covariance estimates from the prediction step. Multiple right sides of the output equation can be implemented in the cooperating REXLANG block. This may be useful e.g. for systems equipped with various sensors providing their data asynchronously to each other (and with respect to the block execution times) with different sampling periods. For the setting $nz = 0$, the user algorithm signalizes no output data available in the current execution period, forcing the filter to extrapolate the state estimates by performing the prediction step only.

The Extended Kalman filter is generally not an optimal filter in the sense of minimization of the mean-squared error of the obtained state estimates. However, it provides modest performance for sufficiently smooth nonlinear systems and is considered to be a de facto standard solution for nonlinear estimation. A special case is obtained by setting linear state and output equations in the cooperating `REXLANG` block. This case leads to standard linear Kalman filter which is stochastically optimal for the formulated state estimation problem.

Inputs

`funcRef`	Cooperating REXLANG block reference		`Reference`
`u`	Input vector of the model		`Reference`
`z`	Output (mesurement) vector of the model		`Reference`
`nz`	Index of the actual output vector set	↓1	`Long (I32)`
`Qk`	State noise covariance matrix		`Reference`
`Rk`	Output noise covariance matrix		`Reference`
`RST`	Block reset		`Bool`
`HLD`	Hold		`Bool`
`x0`	Initial state vector		`Reference`
`P0`	Initial covariance matrix		`Reference`

Parameters

`nmax` Allocated size of output matrix (total number of items) ↓5 ↑10000 ⊙20 `Long (I32)`

`solver` Numeric integration method ⊙2 `Long (I32)`

1 ..... Discrete equation
2 ..... Euler (1st order)
3 ..... 2nd order Adams-Bashforth
4 ..... 3rd order Adams-Bashforth
5 ..... 4th order Adams-Bashforth
6 ..... 5th order Adams-Bashforth
7 ..... 4th order Runge-Kutha
8 ..... Implicit Euler
9 ..... Implicit Euler(more iteration)
10 .... 2nd order Adams-Moulton implicit
11 .... 2nd order Adams-Moulton implicit (more iterations)
12 .... 3rd order Adams-Moulton implicit
13 .... 3nd order Adams-Moulton implicit (more iterations)
14 .... 2nd order RadauIIA implicit
15 .... 2nd order RadauIIA implicit (more iterations)
16 .... 3rd order RadauIIA implicit
17 .... 3rd order RadauIIA implicit (more iterations)

Outputs

`x`	Model state vector	`Reference`
`P`	Model state covariance matrix	`Reference`
`trP`	Trace of model state covariance matrix	`Reference`
`cmd`	Cooperating REXLANG block requested function	`Long (I32)`
`f`	Vector reference set by cooperating REXLANG block	`Reference`
`df`	Matrix reference set by cooperating REXLANG block	`Reference`
`err`	Error code (0 is OK, see SystemLog for details)	`Long (I32)`

FOPDT – First order plus dead-time model

Block Symbol

Licence: STANDARD

Function Description

The FOPDT block is a discrete simulator of a first order continuous-time system with time delay, which can be described by the transfer function below:

$$P(s) = \frac{\mathtt{k0}}{(\mathtt{tau} \cdot s + 1)} \cdot e^{-\mathtt{del} \cdot s}$$

The exact discretization at the sampling instants is used for discretization of the $P(s)$ transfer function. The sampling period used for discretization is equivalent to the execution period of the FOPDT block.

Input

u	Analog input of the block	Double (F64)

Output

y	Analog output of the block	Double (F64)

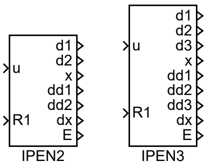
Parameters

k0	Static gain	⊙1.0	Double (F64)
del	Dead time [s]		Double (F64)
tau	Time constant	⊙1.0	Double (F64)
nmax	Size of delay buffer (number of samples) for the time delay del. Used for internal memory allocation.	↓10 ↑10000000 ⊙1000	Long (I32)

IPEN2, IPEN3 – N-link inverted pendulum on cart - Physical parameters

Block Symbols

Licence: MODEL



Function Description

The IPEN2 and IPEN3 blocks simulate the dynamics of double and triple inverted pendulums on a cart, respectively. These models enable users to conduct experiments with various control strategies, making them suitable for both educational and research purposes.

The primary input to the models is an analog signal u, interpreted based on the IACC parameter setting:

- for IACC=on, the input u is assumed to be a force acting on the cart [N],
- for IACC=off, the models assume the input represents speed [m/s].

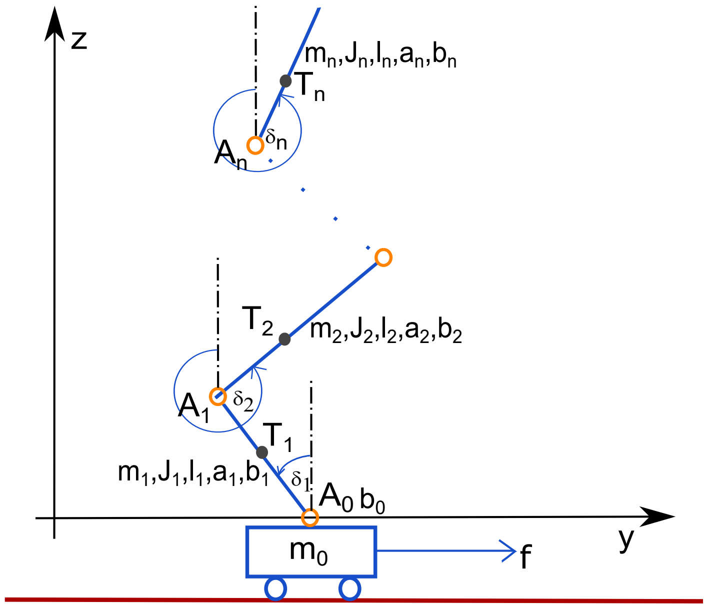
The R1 signal is used to reset each model to its initial configuration.

Both models can be precisely configured with a series of parameters that reflect the system's physical characteristics. These include the relative center of gravity positions a, moments of inertia J, lengths l, and masses of the pendulums m, as well as damping coefficients b and the initial state of the system (positions d_0, velocities dd_0). A schematic representation of the system with parameters is shown below. The parameters are intuitively defined. The relative position of the center of gravity for the i-th pendulum, a_i, is determined by the equation

$$|A_{i-1}T_i| = a_i l_i,$$

where A_{i-1} is the position of the previous joint, T_i is the position of the pendulum's center of gravity, and l_i is the length of the pendulum.

The computation of the models adheres to the mathematical model and physical parameters detailed in the literature [6]. The IPEN2pu and IPEN3pu blocks are used for simulating the inverted pendulum models with dynamic parameters.



This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

u	Analog input of the block	Double (F64)
R1	Block reset	Bool

Parameter

a1	Relative position of center of gravity	⊙1.0	Double (F64)
a2	Relative position of center of gravity	⊙1.0	Double (F64)
a3	Relative position of center of gravity	⊙1.0	Double (F64)
J1	Moment of inertia of pendulum	⊙1.0	Double (F64)
J2	Moment of inertia of pendulum	⊙1.0	Double (F64)
J3	Moment of inertia of pendulum	⊙1.0	Double (F64)
l1	Length of pendulum [m]	⊙1.0	Double (F64)
l2	Length of pendulum [m]	⊙1.0	Double (F64)
l3	Length of pendulum [m]	⊙1.0	Double (F64)
m1	Mass of pendulum [kg]	⊙1.0	Double (F64)
m2	Mass of pendulum [kg]	⊙1.0	Double (F64)
m3	Mass of pendulum [kg]	⊙1.0	Double (F64)
m0	Mass of cart [kg]	⊙1.0	Double (F64)
b1	Damping coefficient of pendulum	⊙1.0	Double (F64)
b2	Damping coefficient of pendulum	⊙1.0	Double (F64)
b3	Damping coefficient of pendulum	⊙1.0	Double (F64)
b0	Damping coefficient of cart	⊙1.0	Double (F64)

d1_0	Initial angle of pendulum [rad]	⊙1.0	Double (F64)
d2_0	Initial angle of pendulum [rad]	⊙1.0	Double (F64)
d3_0	Initial angle of pendulum [rad]	⊙1.0	Double (F64)
x_0	Initial position of cart [m]	⊙1.0	Double (F64)
dd1_0	Initial angular velocity of pendulum [rad/s]	⊙1.0	Double (F64)
dd2_0	Initial angular velocity of pendulum [rad/s]	⊙1.0	Double (F64)
dd3_0	Initial angular velocity of pendulum [rad/s]	⊙1.0	Double (F64)
dx_0	Initial velocity of cart [m/s]	⊙1.0	Double (F64)
IACC	on=Input u is velocity, off=Input u is force		Bool

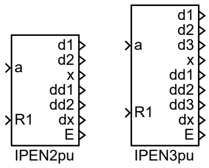
Output

d1	Angle of pendulum [rad]	Double (F64)
d2	Angle of pendulum [rad]	Double (F64)
d3	Angle of pendulum [rad]	Double (F64)
x	Position of cart [m]	Double (F64)
dd1	Angular velocity of pendulum [rad/s]	Double (F64)
dd2	Angular velocity of pendulum [rad/s]	Double (F64)
dd3	Angular velocity of pendulum [rad/s]	Double (F64)
dx	Velocity of cart [m/s]	Double (F64)
E	Error indicator	Bool

IPEN2pu, IPEN3pu – N-link inverted pendulum on cart - Dynamic parameters

Block Symbols

Licence: MODEL



Function Description

The IPEN2pu and IPEN3pu blocks simulate the dynamics of double and triple inverted pendulums on a cart, respectively. These models enable users to conduct experiments with various control strategies, making them suitable for both educational and research purposes.

For both models, the primary input is an analog signal a, which denotes the acceleration of the cart $[m/s^2]$. The R1 signal is used to reset each model to its initial configuration.

Both models can be precisely configured with using the system's dynamic parameters p1 - p11 and the initial state of the system (positions d_0, velocities dd_0). The dynamic parameters can be determined using the physical parameters defined in the IPEN2 and IPEN3 blocks and the equations listed below. The model details are thoroughly described in the literature [6].

For the IPEN2pu model, the dynamic parameters are defined as follows:

$$p_1 = \frac{\left(m_1 {a_1}^2 + m_2\right) {l_1}^2 + J_1}{m_2 a_2 l_2 l_1}, \quad p_2 = \frac{{a_2}^2 {l_2}^2 m_2 + J_2}{m_2 a_2 l_2 l_1}, \quad p_3 = \frac{m_1 a_1 + m_2}{m_2 a_2 l_2},$$

$$p_4 = \frac{1}{l_1}, \quad p_5 = \frac{b_1}{m_2 a_2 l_2 l_1}, \quad p_6 = \frac{b_2}{m_2 a_2 l_2 l_1}.$$

For the IPEN3pu model, the dynamic parameters are defined as follows:

$$p_1 = \frac{l_1(m_2 a_2 + m_3)}{a_3 l_3 m_3}, \quad p_2 = \frac{l_1}{l_2}, \quad p_3 = \frac{\left(m_1 {a_1}^2 + m_2 + m_3\right) {l_1}^2 + J_1}{a_3 l_3 m_3 l_2},$$

$$p_4 = \frac{(m_2 {a_2}^2 + m_3) {l_2}^2 + J_2}{a_3 l_3 m_3 l_2}, \quad p_5 = \frac{{a_3}^2 {l_3}^2 m_3 + J_3}{a_3 l_3 m_3 l_2}, \quad p_6 = \frac{l_1(m_1 a_1 + m_2 + m_3)}{a_3 l_3 m_3 l_2},$$

$$p_7 = \frac{a_2 m_2 + m_3}{a_3 l_3 m_3}, \quad p_8 = \frac{1}{l_2}, \quad p_9 = \frac{b_1}{a_3 l_3 m_3 l_2}, \quad p_{10} = \frac{b_2}{a_3 l_3 m_3 l_2}, \quad p_{11} = \frac{b_3}{a_3 l_3 m_3 l_2}.$$

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

a	Acceleration of cart [m/s^2]		Double (F64)
R1	Block reset		Bool

Parameter

p1	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p2	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p3	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p4	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p5	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p6	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p7	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p8	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p9	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p10	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
p11	Dynamic model parameter (see model equation)	⊙1.0	Double (F64)
d1_0	Initial angle of pendulum [rad]	⊙1.0	Double (F64)
d2_0	Initial angle of pendulum [rad]	⊙1.0	Double (F64)
d3_0	Initial angle of pendulum [rad]	⊙1.0	Double (F64)
x_0	Initial position of cart [m]	⊙1.0	Double (F64)
dd1_0	Initial angular velocity of pendulum [rad/s]	⊙1.0	Double (F64)
dd2_0	Initial angular velocity of pendulum [rad/s]	⊙1.0	Double (F64)
dd3_0	Initial angular velocity of pendulum [rad/s]	⊙1.0	Double (F64)
dx_0	Initial velocity of cart [m/s]	⊙1.0	Double (F64)

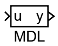
Output

d1	Angle of pendulum [rad]		Double (F64)
d2	Angle of pendulum [rad]		Double (F64)
d3	Angle of pendulum [rad]		Double (F64)
x	Position of cart [m]		Double (F64)
dd1	Angular velocity of pendulum [rad/s]		Double (F64)
dd2	Angular velocity of pendulum [rad/s]		Double (F64)
dd3	Angular velocity of pendulum [rad/s]		Double (F64)
dx	Velocity of cart [m/s]		Double (F64)
E	Error indicator		Bool

MDL – Process model

Block Symbol

Licence: STANDARD



Function Description

The MDL block is a discrete simulator of continuous-time system with transfer function

$$F(s) = \frac{K_0 e^{-Ds}}{(\tau_1 s + 1)(\tau_2 s + 1)},$$

where $K_0 > 0$ is the static gain k0, $D \geq 0$ is the time-delay del and $\tau_1, \tau_2 > 0$ are the system time-constants tau1 and tau2.

Input

u	Analog input of the block	Double (F64)

Output

y	Analog output of the block	Double (F64)

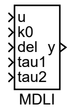
Parameters

k0	Static gain	⊙1.0	Double (F64)
del	Dead time [s]		Double (F64)
tau1	The first time constant	⊙1.0	Double (F64)
tau2	The second time constant	⊙2.0	Double (F64)
nmax	Size of delay buffer (number of samples) for the time delay del. Used for internal memory allocation.	↓10 ↑10000000 ⊙1000	Long (I32)

MDLI – Process model with input-defined parameters

Block Symbol

Licence: STANDARD



Function Description

The MDLI block is a discrete simulator of continuous-time system with transfer function

$$F(s) = \frac{K_0 e^{-Ds}}{(\tau_1 s + 1)(\tau_2 s + 1)},$$

where $K_0 > 0$ is the static gain k0, $D \geq 0$ is the time-delay del and $\tau_1, \tau_2 > 0$ are the system time-constants tau1 and tau2. In contrary to the MDL block the system is time variant. The system parameters are determined by the input signals.

Inputs

u	Analog input of the block	Double (F64)
k0	Static gain	Double (F64)
del	Dead time [s]	Double (F64)
tau1	The first time constant	Double (F64)
tau2	The second time constant	Double (F64)

Output

y	Analog output of the block	Double (F64)

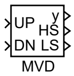
Parameters

nmax	Size of delay buffer (number of samples) for the time delay del. Used for internal memory allocation. ↓10 ↑10000000 ⊙1000	Long (I32)

MVD – Motorized valve drive

Block Symbol

Licence: STANDARD



Function Description

The MVD block simulates a servo valve. The UP (DN) input is a binary command for opening (closing) the valve at a constant speed 1/tv, where tv is a parameter of the block. The opening (closing) continues for UP = on (DN = on) until the full open y = hilim (full closed y = lolim) position is reached. The full open (full closed) position is signalized by the end switch HS (LS). The initial position at start-up is y = y0. If UP = DN = on or UP = DN = off, then the position of the valve remains unchanged (neither opening nor closing).

Inputs

UP	Open	Bool
DN	Close	Bool

Outputs

y	Valve position	Double (F64)
HS	Upper end switch	Bool
LS	Lower end switch	Bool

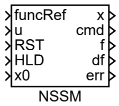
Parameters

y0	Initial valve position		Double (F64)
tv	Time required for transition between y = 0 and y = 1 [s]	⊙10.0	Double (F64)
hilim	Upper limit position (open)	⊙1.0	Double (F64)
lolim	Lower limit position (closed)		Double (F64)

NSSM – Nonlinear State-Space Model

Block Symbol

Licence: MODEL



Function Description

The block provides a solution to a nonlinear continuous-time state-space model in the form of $\mathrm{d}x/\mathrm{d}t = f(x,u), y = h(x,u)$ or its discrete-time counterpart defined as $x(k+1) = f(x(k),u(k)), y(k) = h(x(k),u(k))$. The equation is discretized into a form $x(t) = F(x(t-T),u(t))$, where T is sampling period of the NSSM block. The method used for discretization (i.e. a method to numerically solve the vector differential equation) depends on the `solver` parameter . Various methods for numerical integration are implemented including one step methods (like Runge-Kutta, Euler), multistep methods (Adams-Bashforth), and also implicit methods (Adams-Moulton). It is possible to choose different method order for each kind to find a suitable precision vs computational time trade-off. The block does not support variable step algorithms (the time-step for the solver is always the same as the execution period of the task where the block is inserted).

The non-linear-vector function $f(x,u)$ must be implemented in the REXLANG block that is connected to the NSSM block in a special way. The input `funcRef` of the NSSM block must be connected to the output `y0` of the REXLANG block and the output `y0` can not be used internally in the code/script of the REXLANG block. The outputs `x`, `f` and `df` of the NSSM block must be connected to the inputs of the REXLANG block. These inputs must be processed in the REXLANG code as an input array. The main function of the REXLANG block must set the value of $f(x,u)$ into the `f` vector (e.g. into the input array, where f is connected) and the matrix $\mathrm{d}f(x,u)/\mathrm{d}x$ into the `af` matrix.

The NSSM block calls the main-function of the REXLANG block when needed for numerical integration of the differential equation system (for example the Runge-Kutta method performs 4 calls in each execution period with different x-vector values). The REXLANG block should be disabled in the schematics of the algorithm to prevent its execution REXYGEN system itself. If the REXLANG must be executed by REXYGEN (e.g. for compute output function $y = h(x,u)$), it is recommended to connect the output `cmd` of the NSSM block into input of the REXLANG block to distinguish between calling by the NSSM block (`cmd` $= 0$) and calling by REXYGEN system (`cmd` $= -1$).

Notes:

- computation of the $\mathrm{d}f(x,u)/\mathrm{d}x$ is necessary for implicit methods only (explicit methods do not use it).

- size of the vector `x` (and also `f`, `df`) is defined by the size of the vector `x0`. The size should be changed by reset only (the `RST` input).
- **`solver=1: discrete`** signalizes a discrete-time state space model with the functions `f` and `h` designating the right side of the corresponding difference equation. This mode does not require numerical integration and the algorithm reduces to the execution of the code in the connecnted REXLANG block; the mode is used mainly for symmetry with the `EKF` block.
- for `NSSM` connecting the output **`cmd`** is necessary, because **`cmd`**`>0` indicate number of measurement and REXLANG must return $f = h(x, u)$, $\mathrm{d}f = \mathrm{d}h(x, u)/\mathrm{d}x$.

Inputs

`funcRef`	Cooperating REXLANG block reference	`Reference`
`u`	Input vector of the model	`Reference`
`RST`	Block reset	`Bool`
`HLD`	Hold	`Bool`
`x0`	Initial state vector	`Reference`

Parameters

`nmax`	Allocated size of output matrix (total number of items) ↓5 ↑10000 ⊙20	`Long (I32)`
`solver`	Numeric integration method ⊙2 1 ..... Discrete equation 2 ..... Euler (1st order) 3 ..... 2nd order Adams-Bashforth 4 ..... 3rd order Adams-Bashforth 5 ..... 4th order Adams-Bashforth 6 ..... 5th order Adams-Bashforth 7 ..... 4th order Runge-Kutta 8 ..... Implicit Euler 9 ..... Implicit Euler(more iteration) 10 .... 2nd order Adams-Moulton implicit 11 .... 2nd order Adams-Moulton implicit (more iterations) 12 .... 3rd order Adams-Moulton implicit 13 .... 3nd order Adams-Moulton implicit (more iterations) 14 .... 2nd order RadauIIA implicit 15 .... 2nd order RadauIIA implicit (more iterations) 16 .... 3rd order RadauIIA implicit 17 .... 3rd order RadauIIA implicit (more iterations)	`Long (I32)`

Outputs

`x`	Model state vector	`Reference`
`y`	Model output vector	`Reference`

`cmd`	Cooperating REXLANG block requested function	`Long (I32)`
`f`	Vector reference set by cooperating REXLANG block	`Reference`
`df`	Matrix reference set by cooperating REXLANG block	`Reference`
`err`	Error code (0 is OK, see SystemLog for details)	`Long (I32)`

SOPDT – Second order plus dead-time model

Block Symbol

Licence: STANDARD

Function Description

The SOPDT block is a discrete simulator of a second order continuous-time system with time delay, which can be described by one of the transfer functions below. The type of the model is selected by the itf parameter.

$$\begin{aligned}
\texttt{itf} = 1: \quad P(s) &= \frac{\texttt{pb1} \cdot s + \texttt{pb0}}{s^2 + \texttt{pa1} \cdot s + \texttt{pa0}} \cdot e^{-\texttt{del} \cdot s} \\
\texttt{itf} = 2: \quad P(s) &= \frac{\texttt{k0}\,(\texttt{tau} \cdot s + 1)}{(\texttt{tau1} \cdot s + 1)\,(\texttt{tau2} \cdot s + 1)} \cdot e^{-\texttt{del} \cdot s} \\
\texttt{itf} = 3: \quad P(s) &= \frac{\texttt{k0} \cdot \texttt{om}^2 \cdot (\texttt{tau}/\texttt{om} \cdot s + 1)}{(s^2 + 2 \cdot \texttt{xi} \cdot \texttt{om} \cdot s + \texttt{om}^2)} \cdot e^{-\texttt{del} \cdot s} \\
\texttt{itf} = 4: \quad P(s) &= \frac{\texttt{k0}\,(\texttt{tau} \cdot s + 1)}{(\texttt{tau1} \cdot s + 1)\, s} \cdot e^{-\texttt{del} \cdot s}
\end{aligned}$$

For simulation of first order plus dead time systems (FOPDT) use the LLC block with parameter a set to zero.

The exact discretization at the sampling instants is used for discretization of the $P(s)$ transfer function. The sampling period used for discretization is equivalent to the execution period of the SOPDT block.

Input

u	Analog input of the block	Double (F64)

Output

y	Analog output of the block	Double (F64)

Parameters

itf	Transfer function form 1 ..... A general form 2 ..... A form with real poles 3 ..... A form with complex poles 4 ..... A form with integrator	⊙1	Long (I32)

k0	Static gain	⊙1.0	Double (F64)
tau	Numerator time constant		Double (F64)
tau1	The first time constant	⊙1.0	Double (F64)
tau2	The second time constant	⊙1.0	Double (F64)
om	Natural frequency	⊙1.0	Double (F64)
xi	Relative damping coefficient	⊙1.0	Double (F64)
pb0	Numerator coefficient: s^0	⊙1.0	Double (F64)
pb1	Numerator coefficient: s^1	⊙1.0	Double (F64)
pa0	Denominator coefficient: s^0	⊙1.0	Double (F64)
pa1	Denominator coefficient: s^1	⊙1.0	Double (F64)
del	Dead time [s]		Double (F64)
nmax	Size of delay buffer (number of samples) for the time delay del. Used for internal memory allocation.	↓10 ↑10000000 ⊙1000	Long (I32)

Chapter 14

MATRIX – Blocks for matrix and vector operations

Contents

The MATRIX library is designed for advanced matrix computations and manipulations. It encompasses a wide range of blocks such as MB_DGEMM, MB_DTRMM, and MB_DGER for matrix-matrix and matrix-vector operations. The library includes functions for matrix decomposition (ML_DGEBRD, ML_DGEQRF), eigenvalue problems (ML_DGEEV, ML_DGEES), and singular value decomposition (ML_DGESDD). Additionally, it offers utility blocks like MX_MAT, MX_VEC, and MX_FILL for matrix creation and manipulation, as well as specialized blocks such as MX_DTRNSP for matrix transposition and MX_RAND for generating random matrices. This library is essential for complex mathematical operations involving matrices in various applications.

14.1 Implementation notice:

First element of a matrix has index (0,0), first element of a vector has index (0).

The vector is one-column-matrix, not separate object. One-row-matrix is called a row vector, but that object should not be used as vector in REXYGEN.

The matrix inputs and outputs are references. It means one block (the `MX_MAT` block or the `MX_VEC` block most often) reserve memory for the matrix and other block (using same reference) write/read same space. The `MB_DCOPY` block (and second the `MX_MAT` block) must be used to create copy of the matrix.

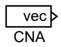
Some blocks using vector (`MB_DCPY`, `RTOV`, `VTOR`) not check exact dimensions (for example a 10x10 matrix is regard as 100-elements vector). Matrix is linearize into vector column by column, because a matrix is stored this way in memory (e.g. for a 10x10 matrix: element (1,0) has index 1 in vector, element (2,0) has index 2 in vector, element (0,1) has index 10 in vector, element (0,2) has index 11 in vector, etc.) These type of blocks could not be used with submatrix returned by the `MX_DSAREF` block. Behavior is undefined in this case.

The most matrix blocks has input and output matrix reference. Both are equal, but connecting input reference to output reference of previous block define execution order (the blocks are executed according signal flow in REXYGEN) and therefore computed matrix equation.

CNA – Array (vector/matrix) constant

Block Symbol

Licence: STANDARD



Function Description

The block `CNA` allocates memory for `nmax` elements of the type `etype` of the vector/matrix referenced by the output `vec` and initializes all elements to data stored in the parameter `acn`.

If the string parameter `filename` is not empty then it loads initalization data from the `filename` file on the host computer in CSV format. Column separator can be comma or semicolon or space (but the same in the whole file), decimal separator have to be dot, row separator is new line. Empty lines are skipped.

If the parameter `TRN` = `on` then the output reference `vec` contains transposed data.

Note: In case of `etype = Large (I64)`, values loaded from parameter `acn` are converted to double-precision float due to implementation reasons, so you can loose precision for very large values. If this could be a problem, use external file for initialization which does not have this issue.

Parameters

`filename`	CSV data file		`String`
`TRN`	Transpose loaded matrix		`Bool`
`nmax`	Allocated size of output matrix (total number of items)	↓2 ↑10000000 ⊙100	`Long (I32)`
`etype`	Type of elements 1 ..... Bool 2 ..... Byte (U8) 3 ..... Short (I16) 4 ..... Long (I32) 5 ..... Word (U16) 6 ..... DWord (U32) 7 ..... Float (F32) 8 ..... Double (F64) -- .... 10 .... Large (I64)	⊙8	`Long (I32)`
`acn`	Initial array value	⊙`[0 1 2 3]`	`Double (F64)`

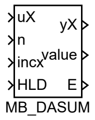
Output

`vec`	Reference to vector/matrix data	`Reference`

MB_DASUM – Sum of the absolute values

Block Symbol

Licence: STANDARD



Function Description

The output reference yX is always set to the input reference uX. If HLD = on then nothing is computed otherwise the BLAS function DASUM is called internally:

```
value = DASUM(N, uX, INCX);
```

where the values N and INCX are set in the following way:

- If the input n > 0 then N is set to n else N is set to the current number of the vector or matrix elements CNT referenced by uX.
- If the input incx > 0 then INCX is set to incx else INCX is set to 1.

The error flag E is set to on if:

- the reference uX is not defined (i.e. input uX is not connected),
- n < 0 or incx < 0,
- $(\mathtt{N} - 1) * \mathtt{INCX} + 1 > \mathtt{CNT}$.

See BLAS documentation [7] for more details.

Inputs

uX	Input reference to vector x	Reference
n	Number of processed vector elements	Long (I32)
incx	Index increment of vector x	Long (I32)
HLD	Hold	Bool

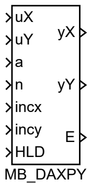
Outputs

yX	Output reference to vector x	Reference
value	Return value of the function	Double (F64)
E	Error flag	Bool

MB_DAXPY – Performs y := a*x + y for vectors x,y

Block Symbol

Licence: STANDARD



Function Description

The output references yX and yY are always set to the corresponding input references uX and uY. If HLD = on then nothing is computed otherwise the BLAS function DAXPY is called internally:

```
DAXPY(N, a, uX, INCX, uY, INCY);
```

where the values N, INCX and INCY are set in the following way:

- If the input n > 0 then N is set to n else N is set to the current number of the vector or matrix elements CNTY referenced by uY.
- If the input incx $\neq 0$ then INCX is set to incx else INCX is set to 1.
- If the input incy $\neq 0$ then INCY is set to incy else INCY is set to 1.

The error flag E is set to on if:

- the reference uX or uY is not defined (i.e. input uX or uY is not connected),
- n < 0,
- $(N - 1) * |INCX| + 1 > CNTX$, where CNTX is a number of the vector or matrix elements referenced by uX,
- $(N - 1) * |INCY| + 1 > CNTY$.

See BLAS documentation [7] for more details.

Inputs

uX	Input reference to vector x	Reference
uY	Input reference to vector y	Reference
a	Scalar coefficient a	Double (F64)
n	Number of processed vector elements	Long (I32)

`incx`	Index increment of vector x	`Long (I32)`
`incy`	Index increment of vector y	`Long (I32)`
`HLD`	Hold	`Bool`

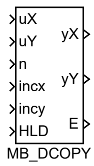
Outputs

`yX`	Output reference to vector x	`Reference`
`yY`	Output reference to vector y	`Reference`
`E`	Error indicator	`Bool`

MB_DCOPY – Copies vector x to vector y

Block Symbol

Licence: STANDARD



Function Description

The output references yX and yY are always set to the corresponding input references uX and uY. If HLD = on then nothing is computed otherwise the BLAS function DCOPY is called internally:

```
DCOPY(N, uX, INCX, uY, INCY);
```

where the values N, INCX and INCY are set in the following way:

- If the input n > 0 then N is set to n else N is set to the current number of the vector or matrix elements CNTX referenced by uX.
- If the input incx $\neq 0$ then INCX is set to incx else INCX is set to 1.
- If the input incy $\neq 0$ then INCY is set to incy else INCY is set to 1.

The error flag E is set to on if:

- the reference uX or uY is not defined (i.e. input uX or uY is not connected),
- n < 0,
- $(\mathtt{N} - 1) * |\mathtt{INCX}| + 1 > \mathtt{CNTX}$,
- $(\mathtt{N} - 1) * |\mathtt{INCY}| + 1 > \mathtt{CNTY}$, where CNTY is a number of the vector or matrix elements referenced by uY.

See BLAS documentation [7] for more details.

Inputs

uX	Input reference to vector x	Reference
uY	Input reference to vector y	Reference
n	Number of processed vector elements	Long (I32)
incx	Index increment of vector x	Long (I32)
incy	Index increment of vector y	Long (I32)
HLD	Hold	Bool

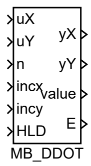
Outputs

`yX`	Output reference to vector x	`Reference`
`yY`	Output reference to vector y	`Reference`
`E`	Error indicator	`Bool`

MB_DDOT – Dot product of two vectors

Block Symbol

Licence: STANDARD



Function Description

The output references `yX` and `yY` are always set to the corresponding input references `uX` and `uY`. If `HLD = on` then nothing is computed otherwise the BLAS function `DDOT` is called internally:

```
DDOT(N, uX, INCX, uY, INCY);
```

where the values `N`, `INCX` and `INCY` are set in the following way:

- If the input `n` > 0 then `N` is set to `n` else `N` is set to the current number of the vector or matrix elements `CNTX` referenced by `uX`.
- If the input `incx` $\neq 0$ then `INCX` is set to `incx` else `INCX` is set to 1.
- If the input `incy` $\neq 0$ then `INCY` is set to `incy` else `INCY` is set to 1.

The error flag `E` is set to `on` if:

- the reference `uX` or `uY` is not defined (i.e. input `uX` or `uY` is not connected),
- `n` < 0,
- $(\mathtt{N} - 1) * |\mathtt{INCX}| + 1 > \mathtt{CNTX}$,
- $(\mathtt{N} - 1) * |\mathtt{INCY}| + 1 > \mathtt{CNTY}$, where `CNTY` is a number of the vector or matrix elements referenced by `uY`.

See BLAS documentation [7] for more details.

Inputs

`uX`	Input reference to vector x	`Reference`
`uY`	Input reference to vector y	`Reference`
`n`	Number of processed vector elements	`Long (I32)`
`incx`	Index increment of vector x	`Long (I32)`
`incy`	Index increment of vector y	`Long (I32)`
`HLD`	Hold	`Bool`

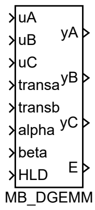
Outputs

yX	Output reference to vector x	Reference
yY	Output reference to vector y	Reference
value	Return value of the function	Double (F64)
E	Error indicator	Bool

MB_DGEMM – Performs C := alpha*op(A)*op(B) + beta*C, where op(X) = X or op(X) = X^T

Block Symbol

Licence: STANDARD



Function Description

The output references yA, yB and yC are always set to the corresponding input references uA, uB and uC. If HLD = on then nothing is computed otherwise the BLAS function DGEMM is called internally:

```
DGEMM(sTRANSA, sTRANSB, M, N, KA, alpha, uA, LDA, uB, LDB, beta, uC, LDC);
```

where parameters of DGEMM are set in the following way:

- Integer inputs transa and transb are mapped to strings sTRANSA and sTRANSB: $\{0, 1\} \rightarrow$ "N", $\{2\} \rightarrow$ "T" and $\{3\} \rightarrow$ "C".
- M is number of rows of the matrix referenced by uC.
- N is number of columns of the matrix referenced by uC.
- If the input transa is equal to 0 or 1 then KA is number of columns else KA is number rows of the matrix referenced by uA.
- LDA, LDB and LDC are leading dimensions of matrices referenced by uA, uB and uC.

The error flag E is set to on if:

- the reference uA or uB or uC is not defined (i.e. input uA or uB or uC is not connected),
- transa or transb is less than 0 or greater than 3
- KA $\neq$ KB; if the input transb is equal to 0 or 1 then KB is number of rows else KB is number of columns of the matrix referenced by uB (i.e. matrices $op(A)$ and $op(B)$ have to be multipliable).
- the call of the function DGEMM returns error using the function XERBLA, see the system log.

See BLAS documentation [7] for more details.

Inputs

uA	Input reference to matrix A		Reference
uB	Input reference to matrix B		Reference
uC	Input reference to matrix C		Reference
transa	Transposition of matrix A	↓0 ↑3	Long (I32)
transb	Transposition of matrix B	↓0 ↑3	Long (I32)
alpha	Scalar coefficient alpha		Double (F64)
beta	Scalar coefficient beta		Double (F64)
HLD	Hold		Bool

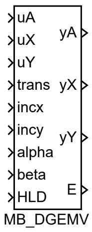
Outputs

yA	Output reference to matrix A	Reference
yB	Output reference to matrix B	Reference
yC	Output reference to matrix C	Reference
E	Error indicator	Bool

MB_DGEMV – Performs y := alpha*A*x + beta*y or y := alpha*A^T*x + beta*y

Block Symbol

Licence: STANDARD



Function Description

The output references yA, yX and yY are always set to the corresponding input references uA, uX and uY. If HLD = on then nothing is computed otherwise the BLAS function DGEMV is called internally:

```
DGEMV(sTRANS, M, N, alpha, uA, LDA, uX, INCX, beta, uY, INCY);
```

where parameters of DGEMV are set in the following way:

- Integer input trans is mapped to the string sTRANS: $\{0, 1\} \rightarrow$ "N", $\{2\} \rightarrow$ "T" and $\{3\} \rightarrow$ "C".
- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- LDA is the leading dimension of matrix referenced by uA.
- If the input incx $\neq 0$ then INCX is set to incx else INCX is set to 1.
- If the input incy $\neq 0$ then INCY is set to incy else INCY is set to 1.

The error flag E is set to on if:

- the reference uA or uX or uY is not defined (i.e. input uA or uX or uY is not connected),
- trans is less than 0 or greater than 3
- the call of the function DGEMV returns error using the function XERBLA, see the system log.

See BLAS documentation [7] for more details.

Inputs

uA	Input reference to matrix A		Reference
uX	Input reference to vector x		Reference
uY	Input reference to vector y		Reference
trans	Transposition of the input matrix	↓0 ↑3	Long (I32)
incx	Index increment of vector x		Long (I32)
incy	Index increment of vector y		Long (I32)
alpha	Scalar coefficient alpha		Double (F64)
beta	Scalar coefficient beta		Double (F64)
HLD	Hold		Bool

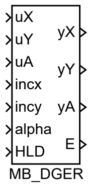
Outputs

yA	Output reference to matrix A	Reference
yX	Output reference to vector x	Reference
yY	Output reference to vector y	Reference
E	Error indicator	Bool

MB_DGER – Performs A := alpha*x*y^T + A

Block Symbol

Licence: STANDARD



Function Description

The output references `yX`, `yY` and `yA` are always set to the corresponding input references `uX`, `uY` and `uA`. If `HLD = on` then nothing is computed otherwise the BLAS function `DGER` is called internally:

```
DGER(M, N, alpha, uX, INCX, uY, INCY, uA, LDA);
```

where parameters of `DGER` are set in the following way:

- `M` is number of rows of the matrix referenced by `uA`.
- `N` is number of columns of the matrix referenced by `uA`.
- If the input `incx` $\neq 0$ then `INCX` is set to `incx` else `INCX` is set to 1.
- If the input `incy` $\neq 0$ then `INCY` is set to `incy` else `INCY` is set to 1.
- `LDA` is the leading dimension of matrix referenced by `uA`.

The error flag `E` is set to `on` if:

- the reference `uX` or `uY` or `uA` is not defined (i.e. input `uX` or `uY` or `uA` is not connected),
- the call of the function `DGER` returns error using the function `XERBLA`, see the system log.

See BLAS documentation [7] for more details.

Inputs

uX	Input reference to vector x	Reference
uY	Input reference to vector y	Reference
uA	Input reference to matrix A	Reference
incx	Index increment of vector x	Long (I32)
incy	Index increment of vector y	Long (I32)
alpha	Scalar coefficient alpha	Double (F64)
HLD	Hold	Bool

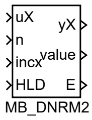
Outputs

yX	Output reference to vector x	Reference
yY	Output reference to vector y	Reference
yA	Output reference to matrix A	Reference
E	Error indicator	Bool

MB_DNRM2 – Euclidean norm of a vector

Block Symbol

Licence: STANDARD



Function Description

The output reference yX is always set to the input reference uX. If HLD = on then nothing is computed otherwise the BLAS function DNRM2 is called internally:

```
value = DNRM2(N, uX, INCX);
```

where the values N and INCX are set in the following way:

- If the input n > 0 then N is set to n else N is set to the current number of the vector or matrix elements CNT referenced by uX.
- If the input incx > 0 then INCX is set to incx else INCX is set to 1.

The error flag E is set to on if:

- the reference uX is not defined (i.e. input uX is not connected),
- n < 0 or incx < 0,
- $(\mathtt{N} - 1) * |\mathtt{INCX}| + 1 > \mathtt{CNT}$.

See BLAS documentation [7] for more details.

Use the block ML_DLANGE for computation of various norms of a matrix.

Inputs

uX	Input reference to vector x	Reference
n	Number of processed vector elements	Long (I32)
incx	Index increment of vector x	Long (I32)
HLD	Hold	Bool

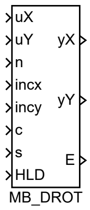
Outputs

yX	Output reference to vector x	Reference
value	Return value of the function	Double (F64)
E	Error indicator	Bool

MB_DROT – Plain rotation of a vector

Block Symbol

Licence: STANDARD



Function Description

The output references yX and yY are always set to the corresponding input references uX and uY. If HLD = on then nothing is computed otherwise the BLAS function DROT is called internally:

```
DROT(N, uX, INCX, uY, INCY, c, s);
```

where parameters of DROT are set in the following way:

- If the input n > 0 then N is set to n else N is set to the current number of the vector or matrix elements CNTX referenced by uX.
- If the input incx $\neq 0$ then INCX is set to incx else INCX is set to 1.
- If the input incy $\neq 0$ then INCY is set to incy else INCY is set to 1.

The error flag E is set to on if:

- the reference uX or uY is not defined (i.e. input uX or uY is not connected),
- n < 0,
- $(\mathtt{N} - 1) * |\mathtt{INCX}| + 1 > \mathtt{CNTX}$,
- $(\mathtt{N} - 1) * |\mathtt{INCY}| + 1 > \mathtt{CNTY}$, where CNTY is a number of the vector or matrix elements referenced by uY.

See BLAS documentation [7] for more details.

Inputs

uX	Input reference to vector x	Reference
uY	Input reference to vector y	Reference
n	Number of processed vector elements	Long (I32)
incx	Index increment of vector x	Long (I32)

`incy`	Index increment of vector y	`Long (I32)`
`c`	Scalar coefficient c	`Double (F64)`
`s`	Scalar coefficient s	`Double (F64)`
`HLD`	Hold	`Bool`

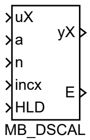
Outputs

`yX`	Output reference to vector x	`Reference`
`yY`	Output reference to vector y	`Reference`
`E`	Error indicator	`Bool`

MB_DSCAL – Scales a vector by a constant

Block Symbol

Licence: STANDARD



Function Description

The output references yX is always set to the corresponding input reference uX. If HLD = on then nothing is computed otherwise the BLAS function DSCAL is called internally:

```
DSCAL(N, a, uX, INCX);
```

where parameters of DSCAL are set in the following way:

- If the input n > 0 then N is set to n else N is set to the current number of the vector or matrix elements CNT referenced by uX.
- If the input incx $\neq 0$ then INCX is set to incx else INCX is set to 1.

The error flag E is set to on if:

- the reference uX is not defined (i.e. input uX is not connected),
- n < 0 or incx < 0,
- $(\mathtt{N} - 1) * \mathtt{INCX} + 1 > \mathtt{CNT}$.

See BLAS documentation [7] for more details.

Inputs

uX	Input reference to vector x	Reference
a	Scalar coefficient a	Double (F64)
n	Number of processed vector elements	Long (I32)
incx	Index increment of vector x	Long (I32)
HLD	Hold	Bool

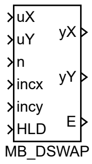
Outputs

yX	Output reference to vector x	Reference
E	Error indicator	Bool

MB_DSWAP – Interchanges two vectors

Block Symbol

Licence: STANDARD



Function Description

The output references yX and yY are always set to the corresponding input references uX and uY. If HLD = on then nothing is computed otherwise the BLAS function DSWAP is called internally:

```
DSWAP(N, uX, INCX, uY, INCY);
```

where the values N, INCX and INCY are set in the following way:

- If the input n > 0 then N is set to n else N is set to the current number of the vector or matrix elements CNTX referenced by uX.
- If the input incx $\neq 0$ then INCX is set to incx else INCX is set to 1.
- If the input incy $\neq 0$ then INCY is set to incy else INCY is set to 1.

The error flag E is set to on if:

- the reference uX or uY is not defined (i.e. input uX or uY is not connected),
- n < 0,
- $(N - 1) * |INCX| + 1 > CNTX$,
- $(N - 1) * |INCY| + 1 > CNTY$, where CNTY is a number of the vector or matrix elements referenced by uY.

See BLAS documentation [7] for more details.

Inputs

uX	Input reference to vector x	Reference
uY	Input reference to vector y	Reference
n	Number of processed vector elements	Long (I32)
incx	Index increment of vector x	Long (I32)
incy	Index increment of vector y	Long (I32)
HLD	Hold	Bool

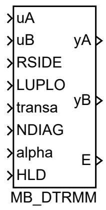
Outputs

yX	Output reference to vector x	Reference
yY	Output reference to vector y	Reference
E	Error indicator	Bool

MB_DTRMM – Performs B := alpha*op(A)*B or B := alpha*B*op(A), where op(X) = X or op(X) = X^T for triangular matrix A

Block Symbol

Licence: STANDARD



Function Description

The output references `yA` and `yB` are always set to the corresponding input references `uA` and `uB`. If `HLD = on` then nothing is computed otherwise the BLAS function `DTRMM` is called internally:

```
DTRMM(sRSIDE, sLUPLO, sTRANSA, sNDIAG, M, N, alpha, uA, LDA, uB, LDB);
```

where parameters of `DTRMM` are set in the following way:

- If `RSIDE` = `on` then the string `sRSIDE` is set to `"R"` else it is set to `"L"`.
- If `LUPLO` = `on` then the string `sLUPLO` is set to `"L"` else it is set to `"U"`.
- Integer input `transa` is mapped to the string `sTRANSA`: $\{0, 1\} \rightarrow$ `"N"`, $\{2\} \rightarrow$ `"T"` and $\{3\} \rightarrow$ `"C"`.
- If `NDIAG` = `on` then the string `sNDIAG` is set to `"N"` else it is set to `"U"`.
- `M` is number of rows of the matrix referenced by `uB`.
- `N` is number of columns of the matrix referenced by `uB`.
- `LDA` and `LDB` are leading dimensions of matrices referenced by `uA` and `uB`.

The error flag `E` is set to `on` if:

- the reference `uA` or `uB` is not defined (i.e. input `uA` or `uB` is not connected),
- `transa` is less than 0 or greater than 3,
- matrix referenced by `uA` is not square or is not compatible with the matrix referenced by `uB`,
- the call of the function `DTRMM` returns error using the function `XERBLA`, see the system log.

See BLAS documentation [7] for more details.

Inputs

uA	Input reference to matrix A		Reference
uB	Input reference to matrix B		Reference
RSIDE	Operation is applied from right side		Bool
LUPLO	Matrix A is a lower triangular matrix		Bool
transa	Transposition of matrix A	↓0 ↑3	Long (I32)
NDIAG	Matrix A is not assumed to be unit triangular		Bool
alpha	Scalar coefficient alpha		Double (F64)
HLD	Hold		Bool

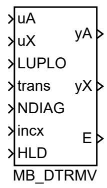
Outputs

yA	Output reference to matrix A	Reference
yB	Output reference to matrix B	Reference
E	Error indicator	Bool

MB_DTRMV – Performs x := A*x or x := A^T*x for triangular matrix A

Block Symbol

Licence: STANDARD



Function Description

The output references yA and yX are always set to the corresponding input references uA and uX. If HLD = on then nothing is computed otherwise the BLAS function DTRMV is called internally:

```
DTRMV(sLUPLO, sTRANS, sNDIAG, N, uA, LDA, uX, INCX);
```

where parameters of DTRMV are set in the following way:

- If LUPLO = on then the string sLUPLO is set to "L" else it is set to "U".
- Integer input trans is mapped to the string sTRANS: $\{0, 1\} \rightarrow$ "N", $\{2\} \rightarrow$ "T" and $\{3\} \rightarrow$ "C".
- If NDIAG = on then the string sNDIAG is set to "N" else it is set to "U".
- N is number of rows and columns of the square matrix referenced by uA.
- LDA is the leading dimension of matrix referenced by uA.
- If the input incx $\neq 0$ then INCX is set to incx else INCX is set to 1.

The error flag E is set to on if:

- the reference uA or uX is not defined (i.e. input uA or uX is not connected),
- trans is less than 0 or greater than 3,
- matrix referenced by uA is not square,
- $(\mathtt{N} - 1) * |\mathtt{INCX}| + 1 > \mathtt{CNTX}$, where CNTX is a number of the vector or matrix elements referenced by uX.
- the call of the function DTRMV returns error using the function XERBLA, see the system log.

See BLAS documentation [7] for more details.

Inputs

uA	Input reference to matrix A		Reference
uX	Input reference to vector x		Reference
LUPLO	Matrix A is a lower triangular matrix		Bool
trans	Transposition of the input matrix	↓0 ↑3	Long (I32)
NDIAG	Matrix A is not assumed to be unit triangular		Bool
incx	Index increment of vector x		Long (I32)
HLD	Hold		Bool

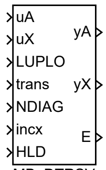
Outputs

yA	Output reference to matrix A	Reference
yX	Output reference to vector x	Reference
E	Error indicator	Bool

MB_DTRSV – Solves one of the system of equations A*x = b or A^T*x = b for triangular matrix A

Block Symbol

Licence: STANDARD



MB_DTRSV

Function Description

The output references `yA` and `yX` are always set to the corresponding input references `uA` and `uX`. If `HLD = on` then nothing is computed otherwise the BLAS function `DTRSV` is called internally:

```
DTRSV(sLUPLO, sTRANS, sNDIAG, N, uA, LDA, uX, INCX);
```

where parameters of `DTRSV` are set in the following way:

- If `LUPLO` = `on` then the string `sLUPLO` is set to `"L"` else it is set to `"U"`.
- Integer input `trans` is mapped to the string `sTRANS`: $\{0,1\} \rightarrow$ `"N"`, $\{2\} \rightarrow$ `"T"` and $\{3\} \rightarrow$ `"C"`.
- If `NDIAG` = `on` then the string `sNDIAG` is set to `"N"` else it is set to `"U"`.
- `N` is number of rows and columns of the square matrix referenced by `uA`.
- `LDA` is the leading dimension of matrix referenced by `uA`.
- If the input `incx` $\neq 0$ then `INCX` is set to `incx` else `INCX` is set to 1.

The error flag `E` is set to `on` if:

- the reference `uA` or `uX` is not defined (i.e. input `uA` or `uX` is not connected),
- `trans` is less than 0 or greater than 3,
- matrix referenced by `uA` is not square,
- $(\mathtt{N} - 1) * |\mathtt{INCX}| + 1 > \mathtt{CNTX}$, where `CNTX` is a number of the vector or matrix elements referenced by `uX`.
- the call of the function `DTRMV` returns error using the function `XERBLA`, see the system log.

See BLAS documentation [7] for more details.

Inputs

uA	Input reference to matrix A		Reference
uX	Input reference to vector x		Reference
LUPLO	Matrix A is a lower triangular matrix		Bool
trans	Transposition of the input matrix	↓0 ↑3	Long (I32)
NDIAG	Matrix A is not assumed to be unit triangular		Bool
incx	Index increment of vector x		Long (I32)
HLD	Hold		Bool

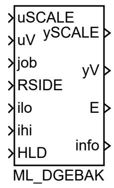
Outputs

yA	Output reference to matrix A	Reference
yX	Output reference to vector x	Reference
E	Error indicator	Bool

ML_DGEBAK – Backward transformation to ML_DGEBAL of left or right eigenvectors

Block Symbol

Licence: MATRIX



Function Description

The output references ySCALE and yV are always set to the corresponding input references uSCALE and uV. If HLD = on then nothing is computed otherwise the LAPACK function DGEBAK is called internally:

```
DGEBAK(sJOB, sRSIDE, N, ilo, IHI, uSCALE, M, uV, LDV, info);
```

where parameters of DGEBAK are set in the following way:

- Integer input job is mapped to the string sJOB: $\{0,1\} \rightarrow$ "N", $\{2\} \rightarrow$ "P", $\{3\} \rightarrow$ "S" and $\{4\} \rightarrow$ "B".
- If RSIDE = on then the string sRSIDE is set to "R" else it is set to "L".
- N is number of elements of the vector referenced by uSCALE.
- If the input ihi $\neq 0$ then IHI is set to ihi else IHI is set to N $- 1$.
- M is number of columns of the matrix referenced by uV.
- LDV is the leading dimension of the matrix referenced by uV.
- info is return code from the function DGEBAK.

The error flag E is set to on if:

- the reference uSCALE or uV is not defined (i.e. input uSCALE or uV is not connected),
- the call of the function DGEBAK returns error using the function XERBLA, see the return code info and system log.

Emphasize that the indices ilo and ihi start from zero unlike FORTRAN version where they start from one. See LAPACK documentation [8] for more details.

Inputs

uSCALE	Input reference to vector SCALE		Reference
uV	Reference to matrix of right or left eigenvectors to be transformed		Reference
job	Type of backward transformation required	↓0 ↑4	Long (I32)
RSIDE	Operation is applied from right side		Bool
ilo	Zero based low row and column index of working submatrix		Long (I32)
ihi	Zero based high row and column index of working submatrix		Long (I32)
HLD	Hold		Bool

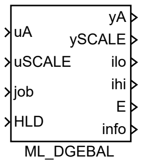
Outputs

ySCALE	Output reference to vector SCALE	Reference
yV	Reference to matrix of transformed right or left eigenvectors	Reference
E	Error indicator	Bool
info	LAPACK function result info. If info = -i, the i=th argument had an illegal value	Long (I32)

ML_DGEBAL – Balancing of a general real matrix

Block Symbol

Licence: MATRIX



Function Description

The output references yA and ySCALE are always set to the corresponding input references uA and uSCALE. If HLD = on then nothing is computed otherwise the LAPACK function DGEBAL is called internally:

```
DGEBAL(sJOB, N, uA, LDA, ilo, ihi, uSCALE, info);
```

where parameters of DGEBAL are set in the following way:

- Integer input job is mapped to the string sJOB: $\{0, 1\} \rightarrow$ "N", $\{2\} \rightarrow$ "P", $\{3\} \rightarrow$ "S" and $\{4\} \rightarrow$ "B".
- N is number of columns of the square matrix referenced by uA.
- LDA is the leading dimension of the matrix referenced by uA.
- ilo and ihi are returned low and high row and column indices of the balanced submatrix of the matrix referenced by uA.
- info is return code from the function DGEBAL.

The error flag E is set to on if:

- the reference uA or uSCALE is not defined (i.e. input uA or uSCALE is not connected),
- matrix referenced by uA is not square,
- number of elements of the vector referenced by uSCALE is less than N.
- the call of the function DGEBAL returns error using the function XERBLA, see the return code info and system log.

Emphasize that the indices ilo and ihi start from zero unlike FORTRAN version where they start from one. See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A		Reference
uSCALE	Input reference to vector SCALE		Reference
job	Specifies the operations to be performed on matrix A	↓0 ↑4	Long (I32)
HLD	Hold		Bool

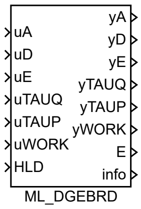
Outputs

yA	Output reference to matrix A	Reference
ySCALE	Output reference to vector SCALE	Reference
ilo	Zero based low row and column index of working submatrix	Long (I32)
ihi	Zero based high row and column index of working submatrix	Long (I32)
E	Error indicator	Bool
info	LAPACK function result info. If info = -i, the i=th argument had an illegal value	Long (I32)

ML_DGEBRD – Reduces a general real matrix to bidiagonal form by an orthogonal transformation

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yD, yE, yTAUQ, yTAUP and yWORK are always set to the corresponding input references uA, uD, uE, uTAUQ, uTAUP and uWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGEBRD is called internally:

```
DGEBRD(M, N, uA, LDA, uD, uE, uTAUQ, uTAUP, uWORK, info);
```

where parameters of DGEBRD are set in the following way:

- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- LDA is the leading dimension of the matrix referenced by uA.
- info is return code from the function DGEBRD.

The error flag E is set to on if:

- the reference uA or uD or uE or uTAUQ or uTAUP or uWORK is not defined (i.e. input uA or uD or uE or uTAUQ or uTAUP or uWORK is not connected),
- number of elements of any vector referenced by uD, uTAUQ and uTAUP is less than MINMN, where MINMN is minimum from M and N,
- number of elements of the vector referenced by uE is less than MINMN − 1,
- the call of the function DGEBRD returns error using the function XERBLA, see the return code info and system log.

See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A	Reference
uD	Diagonal elements of the bidiagonal matrix B	Reference
uE	Off-diagonal elements of the bidiagonal matrix B	Reference
uTAUQ	Reference to a vector of scalar factors of the elementary reflectors which represent the orthogonal matrix Q	Reference
uTAUP	Reference to a vector of scalar factors of the elementary reflectors which represent the orthogonal matrix P	Reference
uWORK	Input reference to working vector WORK	Reference
HLD	Hold	Bool

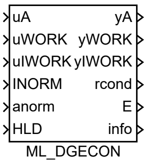
Outputs

yA	Output reference to matrix A	Reference
yD	Output reference to D	Reference
yE	Output reference to E	Reference
yTAUQ	Output reference to TAUQ	Reference
yTAUP	Output reference to TAUP	Reference
yWORK	Output reference to working vector WORK	Reference
E	Error indicator	Bool
info	LAPACK function result info. If info = -i, the i=th argument had an illegal value	Long (I32)

ML_DGECON – Estimates the reciprocal of the condition number of a general real matrix

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yWORK and yIWORK are always set to the corresponding input references uA, uWORK and uIWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGECON is called internally:

```
DGECON(sINORM, N, uA, LDA, anorm, rcond, uWORK, uIWORK, info);
```

where parameters of DGECON are set in the following way:

- If INORM = on then the string sINORM is set to "I" else it is set to "1".
- N is number of columns of the matrix referenced by uA.
- LDA is the leading dimension of the matrix referenced by uA.
- rcond is returned reciprocal value of the condition number of the matrix referenced by uA.
- info is return code from the function DGECON.

The error flag E is set to on if:

- the reference uA or uWORK or uIWORK is not defined (i.e. input uA or uWORK or uIWORK is not connected),
- the matrix referenced by uA is not square,
- number of elements of the vector referenced by uWORK is less than $4 * N$,
- number of elements of the integer vector referenced by uIWORK is less than N,
- the call of the function DGECON returns error using the function XERBLA, see the return code info and system log.

See LAPACK documentation [8] for more details.

Inputs

`uA`	Input reference to matrix A	`Reference`
`uWORK`	Input reference to working vector WORK	`Reference`
`uIWORK`	Input reference to integer working vector WORK	`Reference`
`INORM`	Use Infinity-norm	`Bool`
`anorm`	Norm of the original matrix A	`Double (F64)`
`HLD`	Hold	`Bool`

Outputs

`yA`	Output reference to matrix A	`Reference`
`yWORK`	Output reference to working vector WORK	`Reference`
`yIWORK`	Output reference to integer working vector WORK	`Reference`
`rcond`	The reciprocal of the condition number of the matrix A	`Double (F64)`
`E`	Error indicator	`Bool`
`info`	LAPACK function result info. If info = -i, the i=th argument had an illegal value	`Long (I32)`

ML_DGEES – Computes the eigenvalues, the Schur form, and, optionally, the matrix of Schur vectors

Block Symbol

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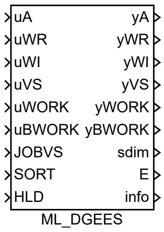


Function Description

The output references yA, yWR, yWI, yVS, yWORK and yBWORK are always set to the corresponding input references uA, uWR, uWI, uVS, uWORK and uBWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGEES is called internally:

```
DGEES(sJOBVS, sSORT, SELECT, N, uA, LDA, sdim, uWR, uWI, uVS, LDVS,uWORK,
    LWORK, uBWORK, info);
```

where parameters of DGEES are set in the following way:

- If JOBVS = on then the string sJOBVS is set to "V" else it is set to "N".
- If SORT = on then the string sSORT is set to "S" else it is set to "N".
- SELECT is the reference to Boolean eigenvalues sorting function which in this function block returns always true (i.e. on).
- N is number of columns of the matrix referenced by uA.
- LDA is the leading dimension of the matrix referenced by uA.
- sdim is returned number of eigenvalues for which the function SELECT is true.
- LDVS is the leading dimension of the matrix referenced by uVS.
- LWORK is number of elements in the vector referenced by uWORK.
- info is return code from the function DGEES.

The error flag E is set to on if:

- the reference uA or uWR or uWI or uVS or uWORK or uBWORK is not defined (i.e. input uA or uWR or uWI or uVS or uWORK or uBWORK is not connected),

- the matrix referenced by `uA` is not square,
- number of elements of any vector referenced by `uWR`, `uWI` and `uBWORK` is less than `N`,
- number of columns of the matrix referenced by `uVS` is not equal to `N`,
- the call of the function `DGEES` returns error using the function `XERBLA`, see the return code `info` and system log.

See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A	Reference
uWR	Input reference to vector of real parts of eigenvalues	Reference
uWI	Input reference to vector of imaginary parts of eigenvalues	Reference
uVS	Input reference to orthogonal matrix of Schur vectors	Reference
uWORK	Input reference to working vector WORK	Reference
uBWORK	Input reference to Boolean working vector WORK	Reference
JOBVS	If true then Schur vectors are computed	Bool
SORT	If true then eigenvalues are sorted	Bool
HLD	Hold	Bool

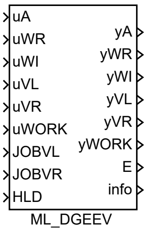
Outputs

yA	Output reference to matrix A	Reference
yWR	Output reference to vector of real parts of eigenvalues	Reference
yWI	Output reference to vector of imaginary parts of eigenvalues	Reference
yVS	Output reference to VS	Reference
yWORK	Output reference to working vector WORK	Reference
yBWORK	Output reference to Boolean working vector WORK	Reference
sdim	If SORT then number of eigenvalues for which SELECT is true else 0	Long (I32)
E	Error indicator	Bool
info	LAPACK function result info. If info = -i, the i=th argument had an illegal value	Long (I32)

ML_DGEEV – Computes the eigenvalues and, optionally, the left and/or right eigenvectors

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yWR, yWI, yVL, yVR and yWORK are always set to the corresponding input references uA, uWR, uWI, uVL, uVR and uWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGEEV is called internally:

```
DGEEV(sJOBVL, sJOBVR, N, uA, LDA, uWR, uWI, uVL, LDVL, uVR, LDVR,
    uWORK, LWORK, info);
```

where parameters of DGEEV are set in the following way:

- If JOBVL = on then the string sJOBVL is set to "V" else it is set to "N".
- If JOBVR = on then the string sJOBVR is set to "V" else it is set to "N".
- N is number of columns of the matrix referenced by uA.
- LDA, LDVL and LDVR are leading dimensions of the matrices referenced by uA, uVL and uVR.
- LWORK is number of elements of the vector referenced by uWORK.
- info is return code from the function DGEEV.

The error flag E is set to on if:

- the reference uA or uWR or uWI or uVL or uVR or uWORK is not defined (i.e. input uA or uWR or uWI or uVL or uVR or uWORK is not connected),
- the matrix referenced by uA is not square,
- number of elements of vectors referenced by uWR or uWI is less than N,
- number of columns of matrices referenced by uVL or uVR is not equal to N,

- the call of the function DGEEV returns error using the function XERBLA, see the return code info and system log.

See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A	Reference
uWR	Input reference to vector of real parts of eigenvalues	Reference
uWI	Input reference to vector of imaginary parts of eigenvalues	Reference
uVL	Input reference to matrix of left eigenvectors	Reference
uVR	Input reference to matrix of right eigenvectors	Reference
uWORK	Input reference to working vector WORK	Reference
JOBVL	If true then left eigenvectors are computed	Bool
JOBVR	If true then right eigenvectors are computed	Bool
HLD	Hold	Bool

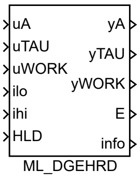
Outputs

yA	Output reference to matrix A	Reference
yWR	Output reference to vector of real parts of eigenvalues	Reference
yWI	Output reference to vector of imaginary parts of eigenvalues	Reference
yVL	Output reference to VL	Reference
yVR	Output reference to VR	Reference
yWORK	Output reference to working vector WORK	Reference
E	Error indicator	Bool
info	LAPACK function result info. If info = -i, the i=th argument had an illegal value	Long (I32)

ML_DGEHRD – Reduces a real general matrix A to upper Hessenberg form

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yTAU and yWORK are always set to the corresponding input references uA, uTAU and uWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGEHRD is called internally:

```
DGEHRD(N, ilo, IHI, uA, LDA, uTAU, uWORK, LWORK, info);
```

where parameters of DGEHRD are set in the following way:

- N is number of columns of the square matrix referenced by uA.
- If the input ihi $\neq 0$ then IHI is set to ihi else IHI is set to $\mathtt{N} - 1$.
- LDA is the leading dimension of the matrix referenced by uA.
- LWORK is number of elements of the vector referenced by uWORK.
- info is return code from the function DGEHRD.

The error flag E is set to on if:

- the reference uA or uTAU or uWORK is not defined (i.e. input uA or uTAU or uWORK is not connected),
- matrix referenced by uA is not square,
- number of elements of the vector referenced by uTAU is less than $\mathtt{N} - 1$.
- the call of the function DGEHRD returns error using the function XERBLA, see the return code info and system log.

Emphasize that the indices ilo and ihi start from zero unlike FORTRAN version where they start from one. See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A	Reference
uTAU	Input reference to vector of scalar factors of the elementary reflectors	Reference
uWORK	Input reference to working vector WORK	Reference
ilo	Zero based low row and column index of working submatrix	Long (I32)
ihi	Zero based high row and column index of working submatrix	Long (I32)
HLD	Hold	Bool

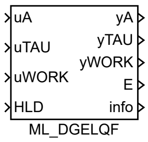
Outputs

yA	Output reference to matrix A	Reference
yTAU	Output reference to vector of scalar factors of the elementary reflectors	Reference
yWORK	Output reference to working vector WORK	Reference
E	Error indicator	Bool
info	LAPACK function result info. If info = -i, the i=th argument had an illegal value	Long (I32)

ML_DGELQF – Computes an LQ factorization of a real M-by-N matrix A

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yTAU and yWORK are always set to the corresponding input references uA, uTAU and uWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGELQF is called internally:

```
DGELQF(M, N, uA, LDA, uTAU, uWORK, LWORK, info);
```

where parameters of DGELQF are set in the following way:

- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- LDA is the leading dimension of the matrix referenced by uA.
- LWORK is number of elements of the vector referenced by uWORK.
- info is return code from the function DGELQF.

The error flag E is set to on if:

- the reference uA or uTAU or uWORK is not defined (i.e. input uA or uTAU or uWORK is not connected),
- number of elements of the vector referenced by uTAU is less than the minimum of number of rows and number of columns of the matrix referenced by uA.
- the call of the function DGELQF returns error using the function XERBLA, see the return code info and system log.

See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A	Reference

uTAU	Input reference to vector of scalar factors of the elementary reflectors	Reference
uWORK	Input reference to working vector WORK	Reference
HLD	Hold	Bool

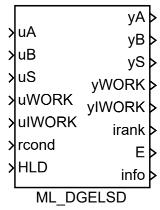
Outputs

yA	Output reference to matrix A	Reference
yTAU	Output reference to vector of scalar factors of the elementary reflectors	Reference
yWORK	Output reference to working vector WORK	Reference
E	Error indicator	Bool
info	LAPACK function result info. If info = -i, the i=th argument had an illegal value	Long (I32)

ML_DGELSD – Computes the minimum-norm solution to a real linear least squares problem

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yB, yS, yWORK and yIWORK are always set to the corresponding input references uA, uB, uS, uWORK and uIWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGELSD is called internally:

```
DGELSD(M, N, NRHS, uA, LDA, uB, LDB, uS, rcond, irank,uWORK,
    LWORK, uIWORK, info);
```

where parameters of DGELSD are set in the following way:

- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- NRHS is number of columns of the matrix referenced by uB.
- LDA and LDB are leading dimensions of the matrices referenced by uA and uB.
- irank is returned effective rank of the matrix referenced by uA.
- LWORK is number of elements in the vector referenced by uWORK.
- info is return code from the function DGELSD.

The error flag E is set to on if:

- the reference uA or uB or uS or uWORK or uIWORK is not defined (i.e. input uA or uB or uS or uWORK or uIWORK is not connected),
- the number of rows of the matrix referenced by uB is not equal to M,
- number of elements of any vector referenced by uS is less than the minimum of M and N,

- number of elements of the integer vector referenced by `uIWORK` is not sufficient (see details in the LAPACK documentation of the function `DGELSD`),
- the call of the function `DGELSD` returns error using the function `XERBLA`, see the return code `info` and system log.

See LAPACK documentation [8] for more details.

Inputs

`uA`	Input reference to matrix A	`Reference`
`uB`	Input reference to matrix B	`Reference`
`uS`	Input reference to vector of singular values	`Reference`
`uWORK`	Input reference to working vector WORK	`Reference`
`uIWORK`	Input reference to integer working vector WORK	`Reference`
`rcond`	Used to determine the effective rank of A	`Double (F64)`
`HLD`	Hold	`Bool`

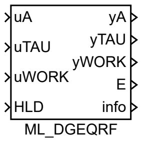
Outputs

`yA`	Output reference to matrix A	`Reference`
`yB`	Output reference to matrix B	`Reference`
`yS`	Output reference to vector of singular values	`Reference`
`yWORK`	Output reference to working vector WORK	`Reference`
`yIWORK`	Output reference to integer working vector WORK	`Reference`
`irank`	Effective rank of A	`Long (I32)`
`E`	Error indicator	`Bool`
`info`	LAPACK function result info. If info = -i, the i=th argument had an illegal value	`Long (I32)`

ML_DGEQRF – Computes an QR factorization of a real M-by-N matrix A

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yTAU and yWORK are always set to the corresponding input references uA, uTAU and uWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGEQRF is called internally:

```
DGEQRF(M, N, uA, LDA, uTAU, uWORK, LWORK, info);
```

where parameters of DGEQRF are set in the following way:

- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- LDA is the leading dimension of the matrix referenced by uA.
- LWORK is number of elements of the vector referenced by uWORK.
- info is return code from the function DGEQRF.

The error flag E is set to on if:

- the reference uA or uTAU or uWORK is not defined (i.e. input uA or uTAU or uWORK is not connected),
- number of elements of the vector referenced by uTAU is less than the minimum of number of rows and number of columns of the matrix referenced by uA.
- the call of the function DGEQRF returns error using the function XERBLA, see the return code info and system log.

See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A	Reference

uTAU	Input reference to vector of scalar factors of the elementary reflectors	Reference
uWORK	Input reference to working vector WORK	Reference
HLD	Hold	Bool

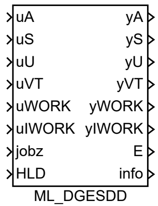
Outputs

yA	Output reference to matrix A	Reference
yTAU	Output reference to vector of scalar factors of the elementary reflectors	Reference
yWORK	Output reference to working vector WORK	Reference
E	Error indicator	Bool
info	LAPACK function result info. If info = -i, the i=th argument had an illegal value	Long (I32)

ML_DGESDD – Computes the singular value decomposition (SVD) of a real M-by-N matrix A

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yS, yU, yVT, yWORK and yIWORK are always set to the corresponding input references uA, uS, uU, uVT, uWORK and uIWORK. If HLD = on then nothing is computed otherwise the LAPACK function DGESDD is called internally:

```
DGESDD(sJOBZ, M, N, uA, LDA, uS, uU, LDU, uVT, LDVT, uWORK, LWORK,
    uIWORK, info);
```

where parameters of DGESDD are set in the following way:

- Integer input jobz is mapped to the string sJOBZ: $\{0, 1\} \rightarrow$ "A", $\{2\} \rightarrow$ "S", $\{3\} \rightarrow$ "O" and $\{4\} \rightarrow$ "N".
- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- LDA, LDU and LDVT are leading dimensions of the matrices referenced by uA, uU and uVT.
- LWORK is number of elements of the vector referenced by uWORK.
- info is return code from the function DGESDD.

The error flag E is set to on if:

- the reference uA or uS or uU or uVT or uWORK or uIWORK is not defined (i.e. input uA or uS or uU or uVT or uWORK or uIWORK is not connected),
- number of elements of the vector referenced by uS is less than MINMN, the minimum of number of rows and number of columns of the matrix referenced by uA,
- number of elements of the integer vector referenced by uIWORK is less than 8∗MINMN,

- the call of the function `DGESDD` returns error using the function `XERBLA`, see the return code `info` and system log.

See LAPACK documentation [8] for more details.

Inputs

`uA`	Input reference to matrix A	`Reference`
`uS`	Input reference to vector of singular values	`Reference`
`uU`	Input reference to matrix containing left singular vectors of A	`Reference`
`uVT`	Input reference to matrix containing right singular vectors of A	`Reference`
`uWORK`	Input reference to working vector WORK	`Reference`
`uIWORK`	Input reference to integer working vector WORK	`Reference`
`jobz`	Specifies options for computing	`Long (I32)`
`HLD`	Hold	`Bool`

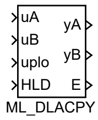
Outputs

`yA`	Output reference to matrix A	`Reference`
`yS`	Output reference to vector of singular values	`Reference`
`yU`	Output reference to matrix containing left singular vectors of A	`Reference`
`yVT`	Output reference to matrix containing right singular vectors of A	`Reference`
`yWORK`	Output reference to working vector WORK	`Reference`
`yIWORK`	Output reference to integer working vector WORK	`Reference`
`E`	Error indicator	`Bool`
`info`	LAPACK function result info. If info = -i, the i=th argument had an illegal value	`Long (I32)`

ML_DLACPY – Copies all or part of one matrix to another matrix

Block Symbol

Licence: STANDARD



Function Description

The output references yA and yB are always set to the corresponding input references uA and uB. If HLD = on then nothing is computed otherwise the LAPACK function DLACPY is called internally:

```
DLACPY(sUPLO, M, N, uA, LDA, uB, LDA);
```

where parameters of DLACPY are set in the following way:

- Integer input uplo is mapped to the string sUPLO: $\{0, 1\} \rightarrow$ "A", $\{2\} \rightarrow$ "U" and $\{3\} \rightarrow$ "L".
- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- LDA is the leading dimension of the matrix referenced by uA.

The number of rows of the matrix referenced by uB is set to M and the leading dimension of the matrix referenced by uB is set to LDA
The error flag E is set to on if:

- the reference uA or uB is not defined (i.e. input uA or uB is not connected),
- the allocated number of elements of the matrix referenced by uA is different from the allocated number of elements of the matrix referenced by uB.

See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A	Reference
uB	Input reference to matrix B	Reference
uplo	Part of the matrix to be copied 0 ..... All 1 ..... All 2 ..... Upper 3 ..... Lower	Long (I32)
HLD	Hold	Bool

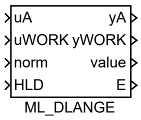
Outputs

`yA`	Output reference to matrix A	`Reference`
`yB`	Output reference to matrix B	`Reference`
`E`	Error indicator	`Bool`

ML_DLANGE – Computes one of the matrix norms of a general matrix

Block Symbol

Licence: STANDARD



Function Description

The output references yA and yWORK are always set to the corresponding input references uA and uWORK. If HLD = on then nothing is computed otherwise the LAPACK function DLANGE is called internally:

```
value = DLANGE(sNORM, M, N, uA, LDA, uWORK;
```

where parameters of DLACPY are set in the following way:

- Integer input norm is mapped to the string sNORM: $\{0, 1\} \rightarrow$ "F" (Frobenius norm), $\{2\} \rightarrow$ "M" (max(abs(A(i,j)))), $\{3\} \rightarrow$ "1" (one norm) and $\{4\} \rightarrow$ "I" (infinity norm).
- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- LDA is the leading dimension of the matrix referenced by uA.
- uWORK is the working vector of dimension LWORK $\geq$ M. uWORK is used only for infinity norm, otherwise it is not referenced.

The error flag E is set to on if:

- the reference uA is not defined (i.e. input uA is not connected),
- the reference uWORK is not defined for norm $= 4$ (i.e. input uWORK is not connected).

See LAPACK documentation [8] for more details.

Use the block MB_DNRM2 for computation of Frobenius norm of a vector.

Inputs

uA	Input reference to matrix A		Reference
uWORK	Input reference to working vector WORK		Reference
norm	The selected matrix norm	↓0 ↑4	Long (I32)
HLD	Hold		Bool

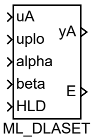
Outputs

`yA`	Output reference to matrix A	`Reference`
`yWORK`	Output reference to working vector WORK	`Reference`
`value`	Return value of the function	`Double (F64)`
`E`	Error indicator	`Bool`

ML_DLASET – Initilizes the off-diagonal elements and the diagonal elements of a matrix to given values

Block Symbol

Licence: STANDARD



Function Description

The output reference **yA** is always set to the corresponding input references **uA**. If HLD = on then nothing is computed otherwise the LAPACK function DLASET is called internally:

```
DLASET(sUPLO, M, N, alpha, beta,uA, LDA);
```

where parameters of DLACPY are set in the following way:

- Integer input uplo is mapped to the string sUPLO: $\{0, 1\} \rightarrow$ "A", $\{2\} \rightarrow$ "U" and $\{3\} \rightarrow$ "L".
- M is number of rows of the matrix referenced by **uA**.
- N is number of columns of the matrix referenced by **uA**.
- LDA is the leading dimension of the matrix referenced by **uA**.

The error flag E is set to on if:

- the reference **uA** is not defined (i.e. input **uA** is not connected),

See LAPACK documentation [8] for more details.

Inputs

uA	Input reference to matrix A	Reference
uplo	Part of the matrix to be set 0 ..... All 1 ..... All 2 ..... Upper 3 ..... Lower	Long (I32)
alpha	Scalar coefficient alpha	Double (F64)
beta	Scalar coefficient beta	Double (F64)
HLD	Hold	Bool

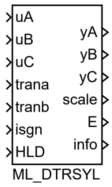
Outputs

`yA`	Output reference to matrix A	`Reference`
`E`	Error indicator	`Bool`

ML_DTRSYL – Solves the real Sylvester matrix equation for quasi-triangular matrices A and B

Block Symbol

Licence: MATRIX



Function Description

The output references yA, yB and yC are always set to the corresponding input references uA, uB and uC. If HLD = on then nothing is computed otherwise the LAPACK function DTRSYL is called internally:

```
DTRSYL(sTRANA, sTRANB, M, N, uA, LDA, uB, LDB, uC, LDC, scale, info);
```

where parameters of DTRSYL are set in the following way:

- Integer inputs trana and tranb are mapped to strings sTRANA and sTRANB: $\{0, 1\} \rightarrow$ "N", $\{2\} \rightarrow$ "T" and $\{3\} \rightarrow$ "C".
- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uB.
- LDA, LDB and LDC are leading dimensions of matrices referenced by uA, uB and uC.
- scale is returned scaling factor to avoid overflow.
- info is return code from the function DTRSYL.

The error flag E is set to on if:

- the reference uA or uB or uC is not defined (i.e. input uA or uB or uC is not connected),
- trana or tranb is less than 0 or greater than 3
- number of columns of the matrix referenced by uA is not equal to M
- number of rows of the matrix referenced by uB is not equal to N
- number of rows of the matrix referenced by uC is not equal to N or number of columns of this matrix is not equal to M,

- the call of the function `DTRSYL` returns error using the function `XERBLA`, see the system log.

See LAPACK documentation [8] for more details.

Inputs

`uA`	Input reference to matrix A		`Reference`
`uB`	Input reference to matrix B		`Reference`
`uC`	Input reference to matrix C		`Reference`
`trana`	Transposition of matrix A	↓0 ↑3	`Long (I32)`
`tranb`	Transposition of matrix B	↓0 ↑3	`Long (I32)`
`isgn`	Sign in the equation (1 or -1)	↓-1 ↑1	`Long (I32)`
`HLD`	Hold		`Bool`

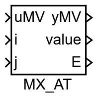
Outputs

`yA`	Output reference to matrix A	`Reference`
`yB`	Output reference to matrix B	`Reference`
`yC`	Output reference to matrix C	`Reference`
`scale`	Scale	`Double (F64)`
`E`	Error indicator	`Bool`
`info`	LAPACK function result info. If info = -i, the i=th argument had an illegal value	`Long (I32)`

MX_AT – Get Matrix/Vector element

Block Symbol

Licence: STANDARD



Function Description

The function block MX_AT returns the value (output value) of the matrix element at the i-th row and j-th column or the i-th vector element.

The output reference yMV is always set to the corresponding input reference uMV to the connected matrix/vector.

The error flag E is set to on if:

- the reference uMV is not defined (i.e. input uMV is not connected),
- the zero based row index $i < 0$ or $i \geq m$, where m is the number of rows,
- the zero based column index $j < 0$ or $j \geq n$, where n is the number of columns. Note that j must be 0 for a vector.

Inputs

uMV	Input reference to a matrix or vector		Reference
i	Row index of the element	↓0	Long (I32)
j	Column index of the element	↓0	Long (I32)

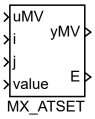
Outputs

yMV	Output reference to a matrix or vector	Reference
value	Value of element at position (i,j)	Long (I32)
E	Error indicator	Bool

MX_ATSET – Set Matrix/Vector element

Block Symbol

Licence: STANDARD



Function Description

The function block MX_ATSET sets the value (input value) to the matrix element at the i-th row and j-th column or to the i-th vector element.

The output reference yMV is always set to the corresponding input reference uMV to the connected matrix/vector.

The error flag E is set to on if:

- the reference uMV is not defined (i.e. input uMV is not connected),
- the zero based row index $i < 0$ or $i \geq m$, where m is the number of rows,
- the zero based column index $j < 0$ or $j \geq n$, where n is the number of columns. Note that j must be 0 for a vector.

Inputs

uMV	Input reference to a matrix or vector		Reference
i	Row index of the element	↓0	Long (I32)
j	Column index of the element	↓0	Long (I32)
value	Value which should be set to the element at position (i,j)		Long (I32)

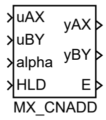
Outputs

yMV	Output reference to a matrix or vector	Reference
E	Error indicator	Bool

MX_CNADD – Add scalar to each Matrix/Vector element

Block Symbol

Licence: STANDARD



Function Description

The function block MX_CNADD adds the value of the input alpha to each matrix/vector element referenced by uAX and the result is stored to the matrix/vector referenced by uBY. If HLD = on then nothing is computed.

The output references yAX and yBY are always set to the corresponding input references uAX and uBY. The dimensions of the matrix/vector referenced by uBY are set to the dimensions of the matrix/vector referenced by uAX if they are different.
The error flag E is set to on if:

- the reference uAX of uBY is not defined (i.e. input uAX or uBY is not connected),
- the count of allocated elements of the matrix/vector referenced by uAX is different from the count of allocated elements of the matrix/vector referenced by uBY.

Inputs

uAX	Input reference to the matrix A or vector X	Reference
uBY	Input reference to the matrix B or vector Y	Reference
alpha	Scalar coefficient alpha	Double (F64)
HLD	Hold	Bool

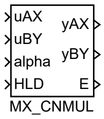
Outputs

yAX	Output reference to the matrix A or vector X	Reference
yBY	Output reference to the matrix B or vector Y	Reference
E	Error indicator	Bool

MX_CNMUL – Multiply a Matrix/Vector by a scalar

Block Symbol

Licence: STANDARD



Function Description

The function block MX_CNADD multiplies each matrix/vector element referenced by uAX by the value of the input alpha and the result is stored to the matrix/vector referenced by uBY. If HLD = on then nothing is computed.

The output references yAX and yBY are always set to the corresponding input references uAX and uBY. The dimensions of the matrix/vector referenced by uBY are set to the dimensions of the matrix/vector referenced by uAX if they are different.
The error flag E is set to on if:

- the reference uAX of uBY is not defined (i.e. input uAX or uBY is not connected),
- the count of allocated elements of the matrix/vector referenced by uAX is different from the count of allocated elements of the matrix/vector referenced by uBY.

Inputs

uAX	Input reference to the matrix A or vector X	Reference
uBY	Input reference to the matrix B or vector Y	Reference
alpha	Scalar coefficient alpha	Double (F64)
HLD	Hold	Bool

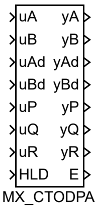
Outputs

yAX	Output reference to the matrix A or vector X	Reference
yBY	Output reference to the matrix B or vector Y	Reference
E	Error indicator	Bool

MX_CTODPA – Discretizes continuous model given by (A,B) to (Ad,Bd) using Pade approximations

Block Symbol

Licence: STANDARD



Function Description

This function block discretizes a continuous state space model using Padé approximations of matrix exponential and its integral and scaling technique ([5]). The used technique is similar to method 3 Scaling and squaring described in [9].

The output references `yA`, `yB`, `yAd`, `yBd`, `yP` , `yQ` and `yR` are always set to the corresponding input references `uA`, `uB`, `uAd`, `uBd`, `uP`, `uQ` and `uR`. If `HLD = on` then nothing is computed otherwise the function `mCtoD` is called internally:

```
mCtoD(nRes, uAd, uBd, uA, uB, N, M, is, Ts, eps, uP, uQ, uR);
```

where parameters of `mCtoD` are set in the following way:

- `nRes` is return code from the function `mCtoD`.
- `N` is number of rows of the square system matrix referenced by `uA`.
- `M` is number of columns of the input matrix referenced by `uB`.
- `Ts` is sampling period for the discretization, which is equal to sampling period of the task containing this function block.

The error flag `E` is set to `on` if:

- the reference `uA` or `uB` or `uAd` or `uBd` or `uP` or `uQ` or `uR` is not defined (i.e. input `uA` or `uB` or `uAd` or `uBd` or `uP` or `uQ` or `uR` is not connected),
- number of columns of the matrix referenced by `uA` is not equal to `N`,
- number of rows of the matrix referenced by `uB` is not equal to `N`,
- number of elements of any matrix referenced by `uAd`, `uP`, `uQ` or `uR` is less than $\mathtt{N}*\mathtt{N}$,
- number of elements of the matrix referenced by `uBd` is less than $\mathtt{N}*\mathtt{M}$,

- the return code `nRes` of the function `mCtoD` is not equal to zero.

Inputs

`uA`	Input reference to matrix A		`Reference`
`uB`	Input reference to matrix B		`Reference`
`uAd`	Input reference to discretized matrix A		`Reference`
`uBd`	Input reference to discretized matrix B		`Reference`
`uP`	Input reference to a helper matrix		`Reference`
`uQ`	Input reference to a helper matrix		`Reference`
`uR`	Input reference to a helper matrix		`Reference`
`HLD`	Hold		`Bool`

Parameters

`is`	Pade approximation order	↓0 ↑4 ⊙2	`Long (I32)`
`eps`	Approximation accuracy	↓1e-20 ↑0.001 ⊙1e-15	`Double (F64)`

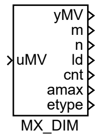
Outputs

`yA`	Output reference to matrix A		`Reference`
`yB`	Output reference to matrix B		`Reference`
`yAd`	Output reference to discretized matrix A		`Reference`
`yBd`	Output reference to discretized matrix B		`Reference`
`yP`	Output reference to a helper matrix		`Reference`
`yQ`	Output reference to a helper matrix		`Reference`
`yR`	Output reference to a helper matrix		`Reference`
`E`	Error indicator		`Bool`

MX_DIM – Matrix/Vector dimensions

Block Symbol

Licence: STANDARD



Function Description

The function block MX_DIM sets its outputs to the dimensions of the matrix or vector referenced by uMV.

The output reference yMV is always set to the corresponding input reference uMV. The error flag E is set to on if the reference uMV is not defined (i.e. input uMV is not connected).

Input

uMV	Input reference to a matrix or vector	Reference

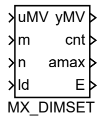
Outputs

yMV	Output reference to a matrix or vector	Reference
m	Number of matrix rows	Long (I32)
n	Number of matrix columns	Long (I32)
ld	Leading dimension (>= number of rows)	Long (I32)
cnt	Count of used matrix/vector elements	Long (I32)
amax	Count of reserved/allocated matrix/vector elements	Long (I32)
etype	Matrix/vector element type (double, long, byte etc.)	Long (I32)

MX_DIMSET – Set Matrix/Vector dimensions

Block Symbol

Licence: STANDARD



Function Description

The function block MX_DIMSET sets number rows m of the vector or number of rows m, number of columns n and the leading dimension ld of the matrix referenced by uMV. If any of the inputs m, n, ld is not connected, its original value is retained.

The output cnt contains the actual number of occupied elements of the matrix/vector and is determined by the formula

$$\mathtt{cnt} = \mathtt{ld} * (\mathtt{n} - 1) + \mathtt{m} \leq \mathtt{amax} \ ,$$

where the output amax is the allocated count of matrix/vector elements. If this inequality is fulfilled the output cnt is set to the matrix/vector structure and can be retrieved by the MX_DIM block, otherwise the value of cnt shows the minimum necessary number of elements of the matrix/vector.

The output reference yMV is always set to the corresponding input reference uMV. The error flag E is set to on if:

- the reference uMV is not defined (i.e. input uMV is not connected),
- the number of rows $\mathtt{m} < 1$ or $\mathtt{m} > \mathtt{ld}$,
- the number of columns $\mathtt{n} < 1$,
- the required number of elements $\mathtt{cnt} > \mathtt{amax}$.

Inputs

uMV	Input reference to a matrix or vector	Reference
m	Number of matrix rows	Long (I32)
ld	Leading dimension (>= number of rows)	Long (I32)

Outputs

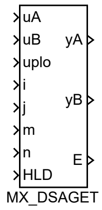
yMV	Output reference to a matrix or vector	Reference
cnt	Count of used matrix/vector elements	Long (I32)
amax	Number of allocated matrix/vector elements	Long (I32)

`E`	Error indicator	`Bool`

MX_DSAGET – Set subarray of A into B

Block Symbol

Licence: STANDARD



Function Description

Generally, the function block MX_DSAGET copies the subarray (submatrix) of matrix referenced by uA into the matrix referenced by uB.

The output references yA and yB are always set to the corresponding input references uA and uB. If HLD = on then nothing is copied otherwise the submatrix of matrix referenced by uA starting the row with zero based index I and the column with zero based index J containing M rows and N columns is copied (with respect to the value of the input uplo) to the matrix referenced by uB. The mentioned variables have the following meanings:

- If the input $i \leq 0$ then I is set to 0 else if $i \geq MA$ then I is set to $MA - 1$ else I is set to i, where MA is the number of rows of the matrix referenced by uA.
- If the input $j \leq 0$ then J is set to 0 else if $j \geq NA$ then J is set to $NA - 1$ else J is set to j, where NA is the number of columns of the matrix referenced by uA.
- Number of copied rows M is set in two stages. First, M is set to minimum of $MA - I$ and number of rows of the matrix referenced by uB. Second, if $m > 0$ then M is set to the minimum of m and M.
- Number of copied columns N is set in two stages. First, N is set to minimum of $NA - J$ and number of columns of the matrix referenced by uB. Second, if $n > 0$ then N is set to the minimum of n and N.

The error flag E is set to on if:

- the reference uA or uB is not defined (i.e. input uA or uB is not connected),
- uplo is less than 0 or greater than 3,
- the number of elements of the matrix referenced by uB is less than $M * N$.

Inputs

`uA`	Input reference to matrix A	`Reference`
`uB`	Input reference to matrix B	`Reference`
`uplo`	Part of the matrix to be copied `0` ..... All `2` ..... Upper `1` ..... All `3` ..... Lower	`Long (I32)`
`i`	Index of the subarray first row	`Long (I32)`
`j`	Index of the subarray first column	`Long (I32)`
`m`	Number of matrix rows	`Long (I32)`
`n`	Number of matrix columns	`Long (I32)`
`HLD`	Hold	`Bool`

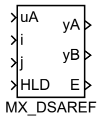
Outputs

`yA`	Output reference to matrix A	`Reference`
`yB`	Output reference to matrix B	`Reference`
`E`	Error indicator	`Bool`

MX_DSAREF – Set reference to subarray of A into B

Block Symbol

Licence: STANDARD



Function Description

The function block MX_DSAREF creates a reference yB to the subarray (submatrix) of matrix referenced by uA. This operation is very fast because no matrix element is copied.

The output reference yA is always set to the corresponding input reference uA, the output reference yB is created inside each instance of this function block. If HLD = on then no other operation is performed otherwise the reference to the matrix yB is created with the following properties:

- Number of rows of the submatrix is set to $\mathtt{M} - \mathtt{i}$, where M is number of rows of the matrix referenced by uA.
- Number of columns of the submatrix is set to $\mathtt{N} - \mathtt{j}$, where N is number of columns of the matrix referenced by uA.
- The first element in position $(0, 0)$ of the submatrix is the element of the matrix referenced by uA in position $(\mathtt{i}, \mathtt{j})$, all indices are zero based.
- The matrix referenced by yB has the same leading dimension as the matrix referenced by uA.

The error flag E is set to on if:

- the reference uA is not defined (i.e. input uA is not connected),
- $0 > \mathtt{i} \geq \mathtt{M}$.
- $0 > \mathtt{j} \geq \mathtt{N}$.

Inputs

uA	Input reference to matrix A	Reference
i	Index of the subarray first row	Long (I32)
j	Index of the subarray first column	Long (I32)
HLD	Hold	Bool

Parameter

ay	Output reference of the subarray	⊙[0 0]	Double (F64)

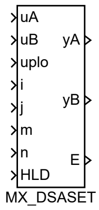
Outputs

yA	Output reference to matrix A	Reference
yB	Output reference to matrix B	Reference
E	Error indicator	Bool

MX_DSASET – Set A into subarray of B

Block Symbol

Licence: STANDARD



Function Description

Generally, the function block MX_DSASET copies the matrix referenced by uA into the subarray (submatrix) of the matrix referenced by uB.

The output references yA and yB are always set to the corresponding input references uA and uB. If HLD = on then nothing is copied otherwise the matrix referenced by uA is copied (with respect to the value of the input uplo) to the submatrix of the matrix referenced by uB to the row with zero based index I and the column with zero based index J containing M rows and N columns. The mentioned variables have the following meanings:

- If the input i ≤ 0 then I is set to 0 else if i $\geq$ MB then I is set to MB -1 else I is set to i, where MB is the number of rows of the matrix referenced by uB.
- If the input j ≤ 0 then J is set to 0 else if j $\geq$ NB then J is set to NB -1 else J is set to j, where NB is the number of columns of the matrix referenced by uB.
- Number of copied rows M is set in two stages. First, M is set to minimum of MB $-$ I and number of rows of the matrix referenced by uA. Second, if m > 0 then M is set to the minimum of m and M.
- Number of copied columns N is set in two stages. First, N is set to minimum of NB $-$ J and number of columns of the matrix referenced by uA. Second, if n > 0 then N is set to the minimum of n and N.

The error flag E is set to on if:

- the reference uA or uB is not defined (i.e. input uA or uB is not connected),
- uplo is less than 0 or greater than 3,
- the number of elements of the matrix referenced by uB is less than M $*$ N.

Inputs

`uA`	Input reference to matrix A	`Reference`
`uB`	Input reference to matrix B	`Reference`
`uplo`	Part of the matrix to be copied `0` ..... All `2` ..... Upper `1` ..... All `3` ..... Lower	`Long (I32)`
`i`	Index of the subarray first row	`Long (I32)`
`j`	Index of the subarray first column	`Long (I32)`
`m`	Number of matrix rows	`Long (I32)`
`n`	Number of matrix columns	`Long (I32)`
`HLD`	Hold	`Bool`

Outputs

`yA`	Output reference to matrix A	`Reference`
`yB`	Output reference to matrix B	`Reference`
`E`	Error indicator	`Bool`

MX_DTRNSP – General matrix transposition: B := alpha*A^T

Block Symbol

Licence: STANDARD

Function Description

The function block MX_DTRNSP stores the scalar multiple of the general (i.e. rectangular) matrix referenced by uA into the matrix referenced by uB.

The output references yA and yB are always set to the corresponding input references uA and uB. If HLD = on then nothing else is done otherwise the BLAS-like function X_DTRNSP is called internally:

```
X_DTRNSP(M, N, ALPHA, uA, LDA, uB, LDB);
```

where parameters of X_DTRNSP are set in the following way:

- M is number of rows of the matrix referenced by uA.
- N is number of columns of the matrix referenced by uA.
- If the input alpha is equal to 0 then ALPHA is set to 1 else ALPHA is set to alpha.
- LDA and LDB are leading dimensions of matrices referenced by uA and uB.

The error flag E is set to on if:

- the reference uA or uB is not defined (i.e. input uA or uB is not connected),
- the call of the function X_DTRNSP returns error using the function XERBLA, see the system log.

Inputs

uA	Input reference to matrix A	Reference
uB	Input reference to matrix B	Reference
alpha	Scalar coefficient alpha	Double (F64)
HLD	Hold	Bool

Outputs

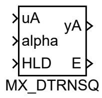
yA	Output reference to matrix A	Reference

`yB`	Output reference to matrix B	`Reference`
`E`	Error indicator	`Bool`

MX_DTRNSQ – Square matrix in-place transposition: A := alpha*A^T

Block Symbol

Licence: STANDARD



Function Description

The function block `MX_DTRNSQ` transpose the scalar multiple of the square matrix referenced by `uA` in-place.

The output reference `yA` is always set to the corresponding input references `uA`. If `HLD = on` then nothing else is done otherwise the BLAS-like function `X_DTRNSQ` is called internally:

```
X_DTRNSQ(N, ALPHA, uA, LDA);
```

where parameters of `X_DTRNSQ` are set in the following way:

- `N` is number of rows and columns of the matrix referenced by `uA`.
- If the input `alpha` is equal to 0 then `ALPHA` is set to 1 else `ALPHA` is set to `alpha`.
- `LDA` is the leading dimension of the matrix referenced by `uA`.

The error flag `E` is set to `on` if:

- the reference `uA` is not defined (i.e. input `uA` is not connected),
- the matrix referenced by `uA` is not square,
- the call of the function `X_DTRNSQ` returns error using the function `XERBLA`, see the system log.

Inputs

uA	Input reference to matrix A	Reference
alpha	Scalar coefficient alpha	Double (F64)
HLD	Hold	Bool

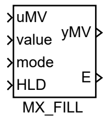
Outputs

yA	Output reference to matrix A	Reference
E	Error indicator	Bool

MX_FILL – Fill real matrix or vector

Block Symbol

Licence: STANDARD



Function Description

The function block MX_FILL fills elements of the matrix or vector referenced by uMV according to the input mode.

The output reference yMV is always set to the corresponding input references uMV. If HLD = on then nothing else is done.
The error flag E is set to on if:

- the reference uMV is not defined (i.e. input uMV is not connected),
- $0 >$ mode > 4.

Inputs

uMV	Input reference to a matrix or vector	Reference
value	Fill value of matrix/vector	Double (F64)
mode	Fill mode 0,1 ... Value – All elements are set to value 2 ..... Ones – All elements are set to 1 3 ..... Diagonal value – Diagonal is set to value, the other elements to 0 4 ..... Diagonal ones – Initializes identity matrix (eye)	Long (I32)
HLD	Hold	Bool

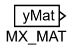
Outputs

yMV	Output reference to a matrix or vector	Reference
E	Error indicator	Bool

MX_MAT – Matrix data storage block

Block Symbol

Licence: STANDARD



Function Description

The function block MX_MAT allocates memory (during the block initialization) for $m * n$ elements of the type determined by the parameter etype of the matrix referenced by the output yMat. Also matrix leading dimension can be set by the parameter ld. If $ld < m$ then the leading dimension is set to m.

Note that the present version of the MATRIX function block set supports only matrices with the etype equal to 8: Double.

Parameters

m	Number of matrix rows	↓1 ↑1000000000 ⊙10	Long (I32)
n	Number of matrix columns	↓1 ↑1000000000 ⊙10	Long (I32)
ld	Leading dimension (>= number of rows)	↓0 ↑1000000000	Long (I32)
etype	Type of elements	⊙8	Long (I32)

1	Bool	6	DWord (U32)
2	Byte (U8)	7	Float (F32)
3	Short (I16)	8	Double (F64)
4	Long (I32)	--	
5	Word (U16)	10	Large (I64)

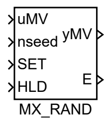
Output

yMat	Output reference to a matrix	Reference

MX_RAND – Randomly generated matrix or vector

Block Symbol

Licence: STANDARD



Function Description

The function block MX_RAND generates random elements of the matrix or vector referenced by uMV.

The output reference yMV is always set to the corresponding input references uMV. If HLD = on then nothing is generated otherwise pseudo-random values of the matrix or vector elements referenced by uMV are generated using these rules:

- If the parameter BIP is on then the generated elements are inside the interval [−scale; scale] else they are inside the interval [0; scale].
- Elements are internally generated using the standard C language function rand() which generates pseudo-random numbers in the range from 0 to RAND_MAX. Note, that the value of RAND_MAX can be platform dependent (and it should be at least 32767).
- The rising edge on the input SET causes that the standard C language function srand(nseed) (initailizes the pseudo-random generator with the value of nseed) is called before the generation of random elements. The same sequences of pseudo-random numbers are generated after calls of srand(nseed) for the same values of nseed.

The error flag E is set to on if the reference uMV is not defined (i.e. input uMV is not connected).

Inputs

uMV	Input reference to a matrix or vector	Reference
nseed	Random number seed	Long (I32)
SET	Set initial value of random number generator to nseed on rising edge	Bool
HLD	Hold	Bool

Parameters

BIP	Bipolar random values flag	Bool

`scale`	Random values multiplication factor	⊙1.0	`Double (F64)`

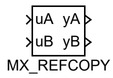
Outputs

`yMV`	Output reference to a matrix or vector	`Reference`
`E`	Error indicator	`Bool`

MX_REFCOPY – Copies input references of matrices A and B to their output references

Block Symbol

Licence: STANDARD



Function Description

The function block MX_REFCOPY is an administrative block of the MATRIX blockset. It does nothing else than copying the input references uA and uB to the corresponding output references yA and yB.

But suitable insertion of this block to the function block scheme can substantially influence (change) the execution order of blocks which can be very advantageous especially in combination with such blocks as e.g. MX_DSAREF.

Inputs

uA	Input reference to matrix A	Reference
uB	Input reference to matrix B	Reference

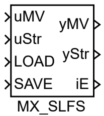
Outputs

yA	Output reference to matrix A	Reference
yB	Output reference to matrix B	Reference

MX_SLFS – Save or load a Matrix/Vector into file or string

Block Symbol

Licence: STANDARD



Function Description

The block allows to convert a matrix or vector into text form and vice versa. The matrix is supplied as a reference to the `uMV` input. The `yMV` output refers to the same matrix as the `uMV` input, and is intended to chain matrix blocks in the correct order, as is common with all MATRIX blocks. The text can be either in the input `uStr` (or output `yStr` for the opposite direction of conversion) or in the file. If the text is in a file, its name is the string connected to the `uStr` input. The usual REXYGENsystem file name rules applies , ie it is relative to datadir and `../` is not allowed to leave the directory. If the `uStr` input is unattached (or empty string), the path name of the file is used with the full path (that is, including the task name and all subsystems) with the `.dat` extension.

The format of a matrix in a text file or in text input and output is determined by the `format` parameter. Supported English and Czech CSV (i.e., columns separated by comma or semicolon), JSON format (created by Google and often used in web applications) and the format used by MATLAB (for entering a matrix in MATLAB scripts).

Conversion from text to matrix/vector or vice versa can be performed at each step of the algorithm or is triggered by the `LOAD` and `SAVE` inputs. The exact method is determined by the `mode` parameter and is explained in detail in the description of this parameter. If an error occurs, it is signaled to the `iE` output and in the log. After a fatal error, the conversion from/to the matrix stops. Error reset for `mode = 1 .. 4` is done by setting `LOAD = SAVE = off`, resetting fatal error cannot be performed for `mode = 5 .. 8` (must switch to `mode = 1 .. 4` and then back).

The `nmax` parameter is used to alocate the output string. If `nmax> 0`, it is allocated specified number of chars during initialization. If this amount is insufficient, the block reports an error. If `nmax = 0`, the block increases the length of the output string as needed. If user don't specify the `nmax` parameter it can lead to full RAM memory in extreme situations and unpredictable behaviour of entire system.

Inputs

`uMV`	Input reference to a matrix or vector	`Reference`
`uStr`	Input string (to convert into matrix) or filename	`String`
`LOAD`	Trigger to move data to matrix/vector	`Bool`
`SAVE`	Trigger to move data from matrix/vector	`Bool`

Parameters

`mode`	Triggering mode 1 ..... level-triggered file 2 ..... edge-triggered file 3 ..... level-triggered string 4 ..... edge-triggered string 5 ..... continuous string to matrix 6 ..... continuous matrix to string 7 ..... continuous file to matrix 8 ..... continuous matrix to file	⊙2	`Long (I32)`
`format`	String/file format 1 ..... CSV 2 ..... CSV(semicolon) 3 ..... JSON 4 ..... MATLAB	⊙1	`Long (I32)`
`prec`	Number of digits for single value	↓0 ↑20 ⊙6	`Long (I32)`
`TRN`	Transposition flag		`Bool`
`nmax`	Allocated size of string	↓0	`Long (I32)`

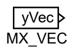
Outputs

`yMV`	Output reference to a matrix or vector	`Reference`
`yStr`	String representation of the matrix/vector	`String`
`iE`	Error code	`Error`

MX_VEC – Vector data storage block

Block Symbol

Licence: STANDARD



Function Description

The function block MX_VEC allocates memory (during the block initialization) for n elements of the type determined by the parameter etype of the vector referenced by the output yVec.

Note that the present version of the MATRIX function block set supports only vectors with the etype equal to 8: Double.

Parameters

n	Number of vector elements	↓1 ↑1000000000 ⊙10	Long (I32)
etype	Type of elements	⊙8	Long (I32)

1 ..... Bool
2 ..... Byte (U8)
3 ..... Short (I16)
4 ..... Long (I32)
5 ..... Word (U16)
6 ..... DWord (U32)
7 ..... Float (F32)
8 ..... Double (F64)
-- ....
10 .... Large (I64)

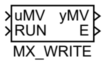
Output

yVec	Output reference to a vector	Reference

MX_WRITE – Write a Matrix/Vector to the console/system log

Block Symbol

Licence: STANDARD



Function Description

This function block can write a vector or matrix to the console or the system log. The severity of the console/system log output is set by the parameter `mode` in combination with settings of system log from REXYGEN Studio, menu `Target/Configure System Log`. Written data can be viewed in REXYGEN Studio, after opening the system log window by the command `Target/Show System Log`. The function block is very useful for debugging purposes of matrix/vector algorithms.

The output references `yMV` is always set to the input reference `uMV`. If `RUN = off` then nothing else is done otherwise matrix or vector is written to the system log if the configured target logging level for function blocks contains the configured `mode`. Format of each matrix/vector element is determined by parameters `mchars` and `mdec`.
The error flag `E` is set to `on` if:

- the reference `uMV` is not defined (i.e. input `uMV` is not connected),
- $3 >$ `mchars` > 25,
- $0 >$ `mdec` $>$ `mchars` $- 2$.

Inputs

`uMV`	Input reference to a matrix or vector	`Reference`
`RUN`	Enable execution	`Bool`

Parameters

`Symbol`	Matrix/vector symbolic name for console or log output	⊙A	`String`
`mchars`	Number of characters per single element	↓3 ↑25 ⊙8	`Long (I32)`
`mdec`	Number of decimal digits per single element	↓0 ↑23 ⊙4	`Long (I32)`
`mode`	Severity mode of writing 1 ..... None 2 ..... Verbose 3 ..... Information 4 ..... Warning 5 ..... Error	⊙3	`Long (I32)`

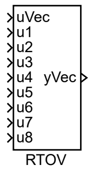
Outputs

`yMV`	Output reference to a matrix or vector	`Reference`
`E`	Error indicator	`Bool`

RTOV – Vector multiplexer

Block Symbol

Licence: STANDARD



Function Description

The RTOV block can be used to create vector signals in the REXYGEN system. It combines the scalar input signals into one vector output signal.

It is also possible to chain the RTOV blocks to create signals with more than 8 items.

The nmax parameter defines the maximal number of items in the vector (in other words, the size of memory allocated for the signal). The offset parameter defines the position of the first input signal u1 in the resulting signal. Only the first n input signals are combined into the resulting yVec vector signal.

ATTENTION: Up to version 2.50.10.x output vector is one-row-matrix. Later version (2.51.0.9525 and later) use one-column-matrix. This change was necessary for consistance in matrix operation.

Inputs

uVec	Vector signal	Reference
u1	Analog input of the block	Double (F64)
u2	Analog input of the block	Double (F64)
u3	Analog input of the block	Double (F64)
u4	Analog input of the block	Double (F64)
u5	Analog input of the block	Double (F64)
u6	Analog input of the block	Double (F64)
u7	Analog input of the block	Double (F64)
u8	Analog input of the block	Double (F64)

Parameters

nmax	Allocated size of vector	↓0 ⊙8	Long (I32)
offset	Index of the first input in vector	↓0	Long (I32)
n	Number of valid inputs	↓0 ↑8 ⊙8	Long (I32)

Output

`yVec`	Vector signal	`Reference`

SWVMR – Vector/matrix/reference signal switch

Block Symbol

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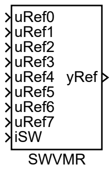

Function Description

The SWVMR allows switching of vector or matrix signals. It also allow switching of motion axes in motion control algorithms (see the RM_Axis block).

Use the SSW block or its alternatives SWR and SELU for switching simple signals.

Inputs

uRef0	Vector signal	Reference
uRef1	Vector signal	Reference
uRef2	Vector signal	Reference
uRef3	Vector signal	Reference
uRef4	Vector signal	Reference
uRef5	Vector signal	Reference
uRef6	Vector signal	Reference
uRef7	Vector signal	Reference
iSW	Active signal selector	Long (I32)

Output

yRef	Vector signal	Reference

VTOR – Vector demultiplexer

Block Symbol

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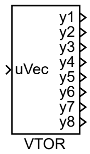

Function Description

The VTOR block splits the input vector signal into individual signals. The user defines the starting item and the number of items to feed to the output signals using the offset and N parameter respectively.

Input

uVec	Vector signal		Reference

Parameters

n	Number of valid outputs	↓0 ↑8 ⊙8	Long (I32)
offset	Index of the first output	↓0	Long (I32)

Outputs

y1	Analog output of the block	Double (F64)
y2	Analog output of the block	Double (F64)
y3	Analog output of the block	Double (F64)
y4	Analog output of the block	Double (F64)
y5	Analog output of the block	Double (F64)
y6	Analog output of the block	Double (F64)
y7	Analog output of the block	Double (F64)
y8	Analog output of the block	Double (F64)

Chapter 15

OPTIM – Optimization blocks

Contents

The OPTIM library is tailored for optimization algorithms and processes. It includes QCEDPOPT for Quadratic Cost Economic Dispatch Problem optimization, providing advanced tools for handling complex optimization problems. The library also features blocks like QP_MPC2QP and QP_OASES for Quadratic Programming, essential in Model Predictive Control (MPC) scenarios. Additionally, QP_UPDATE is available for updating quadratic program parameters. This library is particularly useful in systems requiring high-level optimization solutions, such as in advanced control and decision-making algorithms.

QCEDPOPT – * Quadratic Cost Economic Dispatch Problem optimization block

Block Symbol

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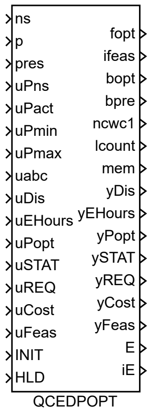


Function Description

The economic dispatch problem (EDP) with quadratic cost functions can be formulated as an optimization problem. Let's have n power sources (generators) with powers $P_1, P_2, \ldots, P_n$ satisfying the constraints $P_{i,\min} \leq P_i \leq P_{i,\max}$, $i = 1, \ldots, n$. Let the cost of the P_i generation is given by the quadratic function $F_i = a_i P_i^2 + b_i P_i + c_i, i = 1, \ldots, n$. Produce the given total power $P = P_1 + P_2 + \ldots + P_n$ at the lowest possible price $F = F_1 + F_2 + \ldots + F_n$. The economic dispatch problem can be rewritten as

$$\min F(P) = \min \sum_{i=1}^{n} (a_i P_i^2 + b_i P_i + c_i) \tag{15.1}$$

with respect to the equality constraint

$$P = \sum_{i=1}^{n} P_i \tag{15.2}$$

and inequality constraints

$$P_{i,\min} \leq P_i \leq P_{i,\max}, i = 1, \ldots, n. \tag{15.3}$$

The **QCEDPOPT** function block solves not only the economic dispatch problem (15.1) – (15.3) but much more complex problem. Let's describe the extensions of this problem.

Very often it is not necessary to run all generators to achieve the power P (connected to the input **p** of the block). If the i-th generator is not running, it is assumed that the price of its zero power is zero. A given combination of running generators is feasible for the given power P if P is greater than or equal to the smallest of the minimum powers of the running generators and at the same time P is less than or equal to the sum of the maximum powers of the running generators. Unfortunately, such combinations can be up to 2^n (e.g. if all minimum power of the generators is zero and P is less than or equal to the smallest maximum power of all generators). In real applications, it is required that the given combination of generators be able to supply not only P with a certain reserve (connected to the input `pres`), i.e. the sum of the powers of running generators must be at least `p + pres`. Minimum and maximum powers in (15.3) are elements of vectors referenced by inputs `uPmin` and `uPmax`.

This block calculates the price of all feasible combinations of generators, where the price coefficients in (15.1) are passed in the n rows matrix referenced by `uabc`. Coefficients a_i are in the first, b_i in the second and c_i in the third column of this matrix ($i = 1, \ldots, n$). If the i-th generator is not running and should be started then this start can be evaluated by the starting costs (the generator is cold, some fuel is consumed for the start, etc.). Similarly, stopping a running generator can also be evaluated by stopping costs. Starting and stopping costs are optional and can be passed to the function block as fourth and fifth columns of the matrix referenced by `uabc`.

Quite often, in the short term, a higher total delivered power is required. This can lead to the start-up of other generators for only one or a few periods. Operating the generator for only a short time and then turning it off shortens the life of the generator. A similar situation occurs during a short-term decrease in the required power, when some generator is switched off for a short time. To eliminate these phenomenons, the so-called start horizon n_s (input `ns`) is introduced in the `QCEDPOPT` block. The optimal EDP solution is not only sought for a given period, but over successive n_s periods. In this case, the prediction of the required power is stored in a vector with at least n_s elements which is referenced by the input `uPns`.

This problem is solved by the following algorithm:

1. For each step k from 1 to n_s, calculate the optimal EDP solutions for all feasible combinations of generators (the number of these combinations can be up to 2^n). This creates a state space with n_s layers and a maximum number of elements $n_s \times 2^n$.

2. Search the state space in depth. Start with a layer with index $i_{\text{ns}} = 0$, which corresponds to the power prediction for the next period.

3. Go through the given layer from the index $i = 0$ (no generator runs) to $i = 2^n - 1$ (all n generators run).

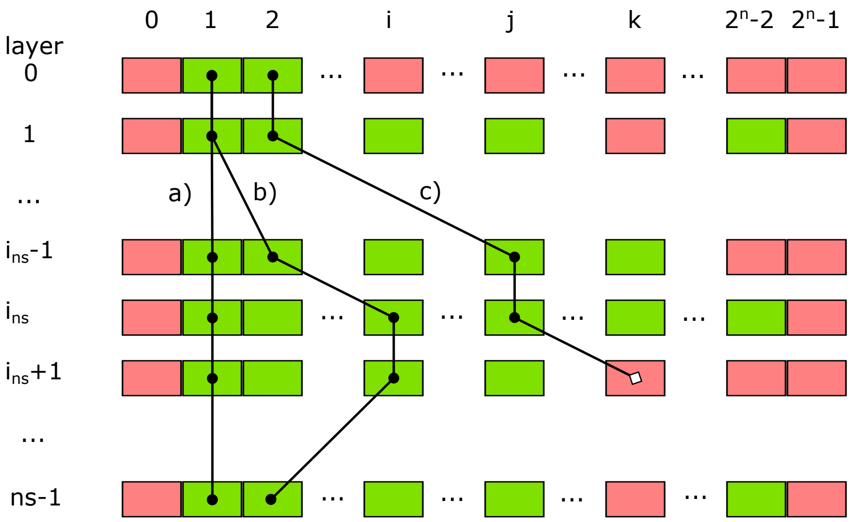
4. If the variant with index i is feasible, save the value i and go to the next step. If not, increment i. If $i < 2^n$ then repeat this step, else go to step 7.

5. If $i_{\text{ns}} = n_s - 1$, goto next step, otherwise increment i_{ns} and go to step **??** (look for a feasible solution one layer deeper).

6. Here, we have a sequence of feasible solutions going through all n_s layers. Calculate and store the cost function of this feasible sequence as sum of stored cost functions of particular solutions in each layer plus sum of (optional) starting and (optional) stopping costs between neighboring layers. Increment i. If $i < 2^n$ then goto step 4

7. The end of the current layer $i_{\rm ns}$ has been reached. Repeat: go one layer up ($i_{\rm ns} = i_{\rm ns} - 1$) and restore the stored index i for this layer until $i \geq 2^n - 1$ or $i_{\rm ns} = 0$. If $i_{\rm ns} > 0$, increment i and go to step 4, otherwise the state space search is complete.

The following figure demonstrates the state space search in depth. Green rectangles corresponds to feasible state, red rectangles to infeasible states. Variants a) and b) represents feasible paths, path in variant c) is not feasible.



The number of all states of this algorithm in the state space grows exponentially. Ideally, the number of all feasible states is equal to

$$C_{\rm full} = (2^n)^{n_s}\,. \tag{15.4}$$

Therefore, this algorithm is computable only for a low number of generators n, (e.g. $n \leq 10$) and a short start horizon n_s (e.g. $n_s \leq 10$). For a larger number of generators and/or a longer horizon n_s, it is necessary to reduce the number of states in the state space. One option is to limit the maximum number of generator state changes (i.e. start a stopped generator or stop a started generator) at each step.

Assume that the state of just m generators can be changed between two consecutive steps, which corresponds to the number of m combinations of n generators, i.e. $\binom{n}{m}$. If we allow a maximum of m changes in each step, the number of variants for horizon n_s is reduced to:

$$C_{\rm r1} = \left[\sum_{i=0}^{m}\binom{n}{i}\right]^{n_s}\,. \tag{15.5}$$

For small values of m, which is very common in real cases, there is a significant reduction in the number of variants. The efficient implementation of this block's algorithm is based on the calculation of internal fields for all combinations in one step. For the reduction just proposed, such a recalculation would have to occur each time the state of any generator changed, i.e. even during the search for an feasible path.

Therefore, it was finally decided to implement an even greater reduction in the number of states so that the maximum number of changes m is not considered for adjacent steps, but over the entire horizon n_s. In this case, a maximum of n changes can occur in each of the n_s steps. Of all such possibilities, we are only interested in those where $n \cdot n_s$ values change just m times. For the maximum number of m changes we receive

$$C_{\mathrm{r}2} = \sum_{i=0}^{m} \binom{n \cdot n_s}{i}. \tag{15.6}$$

The maximum number of changes is specified in the parameter `mchng`. The above algorithm remains basically the same, only a reduced number of variants is tested. The original algorithm is used for the special value `mchng = 0`.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`ns`	Starting horizon of power sources	↓1 ↑10	`Long (I32)`
`p`	Power to be distributed among sources	↓0.0 ↑1000000.0	`Double (F64)`
`pres`	Power reserve	↓0.0 ↑1000000.0	`Double (F64)`
`uPns`	Input reference to vector of distributed power prediction		`Reference`
`uPact`	Input reference to vector of powers of active (running) sources		`Reference`
`uPmin`	Input reference to vector of minimum powers of sources		`Reference`
`uPmax`	Input reference to vector of maximum powers of sources		`Reference`
`uabc`	Input reference to matrix of price coefficients		`Reference`
`uDis`	Input reference to integer vector of disabled reasons of sources		`Reference`
`uEHours`	Input reference to vector of engineering hours		`Reference`
`uPopt`	Input reference to allocated vector for optimum power distribution		`Reference`
`uSTAT`	Input reference to bool vector indicating running states		`Reference`
`uREQ`	Input reference to allocated bool vector for running requests		`Reference`
`uCost`	Input reference to optional vector for cost function values		`Reference`
`uFeas`	Input reference to optional byte vector for feasibility types		`Reference`
`INIT`	If TRUE then reinit optimization else optimize in real-time		`Bool`
`HLD`	Hold		`Bool`

Parameter

`modesh`	Starting heuristics mode	↓0 ↑3	`Long (I32)`

mchng	Maximum allowed number of run changes m per period ↓0 ↑10 ⊙3	Long (I32)
nmax	Maximum value of n, nmax <= 10 ↓0 ↑10 ⊙10	Long (I32)
nsmax	Maximum value of ns, nsmax <= 10 ↓0 ↑10 ⊙10	Long (I32)
logflags	System log output flags ↓0 ↑63 ⊙3	Long (I32)
ts	Sampling period. For ts = 0 the containing task sampling period is used ↓0.0 ↑1000000.0	Double (F64)
tspre	Time of power source prestart in seconds ↓0.0 ↑1000000.0	Double (F64)
svNF1	Substitute value in yCost for not feasible solution in the first step ⊙-1.0	Double (F64)
svNFns	Substitute value in yCost for not feasible solution in the whole horizon ns ⊙-1.0	Double (F64)

Output

fopt	Optimum value of cost function for horizon ns	Double (F64)
ifeas	Type of feasibility of the solution	Long (I32)
bopt	Bit combination of power sources to run for fopt	Long (I32)
bpre	Bit combination of power sources to be prestarted	Long (I32)
ncwc1	Worst case number of combinations depending on n power sources and parameter mchng	Long (I32)
lcount	Number of states traversed when searching the state space	Large (I64)
mem	Memory in bytes occupied by internally allocated working arrays	Long (I32)
yDis	Output reference to integer vector of disabled reasons of sources	Reference
yEHours	Output reference to vector of engineering hours	Reference
yPopt	Output reference to allocated vector for optimum power distribution	Reference
ySTAT	Output reference to bool vector indicating running states	Reference
yREQ	Output reference to allocated bool vector for running requests	Reference
yCost	Output reference to optional vector for cost function values	Reference
yFeas	Output reference to optional byte vector for feasibility types	Reference
E	Error indicator	Bool
iE	Error code	Long (I32)

QP_MPC2QP – Conversion of MPC problem to quadratic programming

Block Symbol

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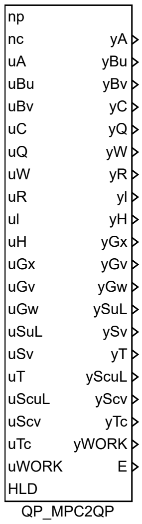

Function Description

Quadratic Programming (QP) is a standard technique which suites very well to solve model based predictive control (MPC) problems [10]. Quadratic Programming is an optimization technique that minimizes the sum of quadratic form and linear form.

The QP_MPC2QP block converts a linear MPC problem with quadratic optimization criterion to a quadratic programming problem. The block is compatible with the block QP_UPDATE and the QP solver QP_OASES.

MPC problem formulation

The MPC problem consists of a discrete linear time invariant state space model

$$\begin{aligned} x_{k+1} &= Ax_k + B_u u_k + B_v v_k\,, \\ y_k &= Cx_k\,, \end{aligned} \tag{15.7}$$

where $x \in \mathbb{R}^n$ is the state vector, $u \in \mathbb{R}^{m_u}$ is the input vector, $v \in \mathbb{R}^{m_v}$ is the disturbance vector and $y \in \mathbb{R}^p$ is the output vector. Matrices $A \in \mathbb{R}^{n\times n}$, $B_u \in \mathbb{R}^{n\times m_u}$, $B_v \in \mathbb{R}^{n\times m_v}$ and $C \in \mathbb{R}^{p\times n}$ are referenced by inputs uA, uBu, uBv and uC. The model based predictive control problem is formulated as an optimization problem – minimization of the quadratic optimality criterion (cost function) in the form

$$J = \sum_{k=1}^{n_p} \left\{ \hat{x}_k^T Q \hat{x}_k + \hat{x}_k^T W + \hat{u}_{k-1}^T R \hat{u}_{k-1} \right\} , \tag{15.8}$$

where symmetric and positive (semi-)definite matrices $Q \in \mathbb{R}^{n \times n}$ and $R \in \mathbb{R}^{m_u \times m_u}$ and the vector $W \in \mathbb{R}^n$ are referenced by inputs `uQ`, `uR` and `uW`, and n_p is the prediction horizon (input `np`).

Additional constraints on the state x and the output y may be required for the minimization process:

$$x_{\min} \leq x_k \leq x_{\max} \tag{15.9}$$

$$y_{\min} \leq y_k \leq y_{\max} \tag{15.10}$$

Predictor

From the state equation with the initial condition x_0 it holds

$$\begin{aligned}
x_1 &= Ax_0 + B_u u_0 + B_v v_0 \\
x_2 &= Ax_1 + B_u u_1 + B_v v_1 \\
&= A^2 x_0 + AB_u u_0 + B_u u_1 + AB_v v_0 + B_v v_1 \\
&\vdots \\
x_k &= A^k x_0 + \begin{bmatrix} A^{k-1}B_u & \dots & AB_u & B_u \end{bmatrix} \begin{bmatrix} u_0 \\ \vdots \\ u_{k-1} \end{bmatrix} \\
&+ \begin{bmatrix} A^{k-1}B_v & \dots & AB_v & B_v \end{bmatrix} \begin{bmatrix} v_0 \\ \vdots \\ v_{k-1} \end{bmatrix}
\end{aligned}$$

Thus, for the prediction horizon n_p we have

$$\underbrace{\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_{n_p} \end{bmatrix}}_{X} = \underbrace{\begin{bmatrix} B_u & 0 & \dots & 0 \\ AB_u & B_u & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ A^{n_p-1}B_u & A^{n_p-2}B_u & \dots & B_u \end{bmatrix}}_{S_u} \underbrace{\begin{bmatrix} u_0 \\ u_1 \\ \vdots \\ u_{n_p-1} \end{bmatrix}}_{U}$$

$$+ \underbrace{\begin{bmatrix} B_v & 0 & \dots & 0 \\ AB_v & B_v & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ A^{n_p-1}B_v & A^{n_p-2}B_v & \dots & B_v \end{bmatrix}}_{S_v} \underbrace{\begin{bmatrix} v_0 \\ v_1 \\ \vdots \\ v_{n_p-1} \end{bmatrix}}_{V} + \underbrace{\begin{bmatrix} A \\ A^2 \\ \vdots \\ A^{n_p} \end{bmatrix}}_{T} x_0$$

i.e.

$$X = S_u U + S_v V + T x_0 \tag{15.11}$$

Similarly, for the output equation we can get

$$\underbrace{\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_{n_p} \end{bmatrix}}_{Y} = \begin{bmatrix} Cx_1 \\ Cx_2 \\ \vdots \\ Cx_{n_p} \end{bmatrix} = \underbrace{\begin{bmatrix} CB_u & 0 & \dots & 0 \\ CAB_u & CB_u & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ CA^{n_p-1}B_u & CA^{n_p-2}B_u & \dots & CB_u \end{bmatrix}}_{S_{cu}} \begin{bmatrix} u_0 \\ u_1 \\ \vdots \\ u_{n_p-1} \end{bmatrix}$$

$$+ \underbrace{\begin{bmatrix} CB_v & 0 & \dots & 0 \\ CAB_v & CB_v & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ CA^{n_p-1}B_v & CA^{n_p-2}B_v & \dots & CB_v \end{bmatrix}}_{S_{cv}} \begin{bmatrix} v_0 \\ v_1 \\ \vdots \\ v_{n_p-1} \end{bmatrix} + \underbrace{\begin{bmatrix} CA \\ CA^2 \\ \vdots \\ CA^{n_p} \end{bmatrix}}_{T_c} x_0$$

i.e.

$$Y = S_{cu} U + S_{cv} V + T_c x_0 \tag{15.12}$$

and standard QP matrices A_{eq} and b_{eq}

$$A_{eq} = S_{cu} L, \quad b_{eq} = -S_{cv} V - T_c x_0 \tag{15.13}$$

Predictor for control horizon less than prediction horizon

Until now, it was assumed that optimal control would be sought over the entire prediction horizon n_p. For a long prediction horizon, this leads to time-consuming optimization, which can be accelerated by choosing a control horizon n_c (input `nc`) smaller than the prediction horizon n_p. Then U can be written as

$$U = \left.\begin{bmatrix} u_0 \\ u_1 \\ \vdots \\ u_{n_c-1} \\ u_{n_c-1} \\ \vdots \\ u_{n_c-1} \end{bmatrix} \begin{matrix} \left.\begin{matrix} \\ \\ \\ \\ \end{matrix}\right\} n_c \\ \left.\begin{matrix} \\ \\ \\ \end{matrix}\right\} n_p - n_c \end{matrix} \right\} n_p$$

Note that the input u_k is the difference of the state and for control horizon n_c it holds $u_{k+n_c-1} = u_{k+n_c} = u_{k+n_c+1} = \dots = u_{k+n_p-1} = 0$ (for the step k). Then it can be written as

$$U = \begin{matrix} n_c \left\{ \vphantom{\begin{matrix} a \\ b \\ c \end{matrix}} \right. \\ n_p - n_c \left\{ \vphantom{\begin{matrix} a \\ b \end{matrix}} \right. \end{matrix} \underbrace{\begin{bmatrix} I_{m_u} & & \mathbf{0} \\ & \ddots & \\ \mathbf{0} & & I_{m_u} \\ & \mathbf{0} & \end{bmatrix}}_{L} \begin{bmatrix} u_0 \\ \vdots \\ u_{n_c-1} \end{bmatrix} \triangleq LU_{n_c} \tag{15.14}$$

where $U \in \mathbb{R}^{n_p \cdot m_u}$, $U_{n_c} \in \mathbb{R}^{n_c \cdot m_u}$ and $I_{m_u} \in \mathbb{R}^{m_u \times m_u}$ is identity matrix.

The equations (15.11) and (15.12) are modified for U_{n_c} to

$$X = S_u L U_{n_c} + S_v V + T x_0 \tag{15.15}$$
$$Y = S_{cu} L U_{n_c} + S_{cv} V + T_c x_0 \tag{15.16}$$

Matrices $S_u L \in \mathbb{R}^{n_p \cdot n \times n_c \cdot m_u}$, $S_v \in \mathbb{R}^{n_p \cdot n \times n_p \cdot m_v}$, $T \in \mathbb{R}^{n_p \cdot n \times n}$, $S_{cu} L \in \mathbb{R}^{n_p \cdot p \times n_c \cdot m_u}$, $S_{cv} \in \mathbb{R}^{n_p \cdot p \times n_p \cdot m_v}$ and $T_c \in \mathbb{R}^{n_p \cdot p \times n}$ are computed by this block, must be allocated e.g. by the `MX_MAT` blocks and references to the preallocated matrices must be connected to the block inputs `uSuL`, `uSv`, `uT`, `uScuL`, `uScv` and `uTc`.

The default value of the matrix $L \in \mathbb{R}^{n_p \cdot m_u \times n_c \cdot m_u}$ in equation 15.14 selects the first n_c subvectors $u_i, i = 0, \ldots, n_c - 1$ from U. The block also allows to select n_c subvectors u_i with arbitrary indices from $0, \ldots, n_p$, which are contained in the integer vector of dimension n_c referenced by the input `ul`. The elements of this vector must form an increasing sequence. If the input `ul` is not connected, the default value of L is used (the same value of L is obtained if the vector referenced by `ul` is equal to $[0,\ 1, \ldots, n_c{-}1]^T$).

Conversion of MPC with the same prediction and control horizons to QP

The standard form of cost function for QP is

$$J_{QP} = hU^T H U + U^T G \tag{15.17}$$

where U a vector of optimal control sequence, H is a symmetric and positive (semi-) definite Hessian matrix, G is a gradient vector and h is a scalar constant which is usually equal to 1 or 1/2.

The cost function (15.8) can be modified to the form

$$
\begin{aligned}
J &= \sum_{k=1}^{n_p} \left\{ x_k^T Q x_k + x_k^T W + u_{k-1}^T R u_{k-1} \right\} \\
&= \begin{bmatrix} x_1 & x_2 & \dots & x_{n_p} \end{bmatrix} \underbrace{\begin{bmatrix} Q & & & \\ & Q & & \\ & & \ddots & \\ & & & Q \end{bmatrix}}_{\bar{Q} = \bar{Q}^T} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_{n_p} \end{bmatrix} + \begin{bmatrix} x_1 & x_2 & \dots & x_{n_p} \end{bmatrix} \underbrace{\begin{bmatrix} W \\ W \\ \vdots \\ W \end{bmatrix}}_{\bar{W}} \\
&+ \begin{bmatrix} u_0 & u_1 & \dots & u_{n_p-1} \end{bmatrix} \underbrace{\begin{bmatrix} R & & & \\ & R & & \\ & & \ddots & \\ & & & R \end{bmatrix}}_{\bar{R} = \bar{R}^T} \begin{bmatrix} u_0 \\ u_1 \\ \vdots \\ u_{n_p-1} \end{bmatrix} \\
&= X^T \bar{Q} X + X^T \bar{W} + U^T \bar{R} U \\
&= (U^T S_u^T + V^T S_v^T + x_0^T T^T) \bar{Q} (S_u U + S_v V + T x_0) \\
&+ (U^T S_u^T + V^T S_v^T + x_0^T T^T) \bar{W} + U^T \bar{R} U \\
&= U^T S_u^T \bar{Q} S_u U + U^T S_u^T \bar{Q} S_v V + U^T S_u^T \bar{Q} T x_0 \\
&+ V^T S_v^T \bar{Q} S_u U + V^T S_v^T \bar{Q} S_v V + V^T S_v^T \bar{Q} T x_0 \\
&+ x_0^T T^T \bar{Q} S_u U + x_0^T T^T \bar{Q} S_v V + x_0^T T^T \bar{Q} T x_0 \\
&+ U^T S_u^T \bar{W} + V^T S_v^T \bar{W} + x_0^T T^T \bar{W} + U^T \bar{R} U \\
&= U^T (S_u^T \bar{Q} S_u + \bar{R}) U + U^T S_u^T (2\bar{Q} S_v V + 2\bar{Q} T x_0 + \bar{W}) \\
&+ \underbrace{V^T S_v^T (\bar{Q} S_v V + 2\bar{Q} T x_0 + \bar{W}) + x_0^T T^T (\bar{Q} T x_0 + \bar{W})}_{J_{\text{dif}}} \triangleq J_{QP} + J_{\text{dif}}
\end{aligned}
\tag{15.18}
$$

where J_{dif} is a constant independent of U. From here follows

$$
J_{QP} = U^T (S_u^T \bar{Q} S_u + \bar{R}) U + U^T S_u^T (2\bar{Q} S_v V + 2\bar{Q} T x_0 + \bar{W}) \tag{15.19}
$$

Comparing this equation with (15.17), it is obvious that

$$
\begin{aligned}
H &= \frac{1}{h} (S_u^T \bar{Q} S_u + \bar{R}) \\
G &= S_u^T (2\bar{Q} S_v V + 2\bar{Q} T x_0 + \bar{W})
\end{aligned}
\tag{15.20}
$$

Conversion of MPC with control horizon less than prediction horizon

Similarly as in previous subsection we can get for $n_c < n_p$

$$\begin{aligned} H &= \frac{1}{h} L^T (S_u^T \bar{Q} S_u + \bar{R}) L \\ G &= (S_u L)^T (2\bar{Q} S_v V + 2\bar{Q} T x_0 + \bar{W}) \triangleq G_v V + G_x x_0 + G_w \end{aligned} \tag{15.21}$$

where matrix L is defined by (15.14). The Hessian matrix H is a constant matrix for all steps k of the MPC. But gradient vector G is generally changing in each step k because vectors V and x_0 are changing. Therefore, G is composed of parts G_v, G_x and G_w, which are already constant vectors. The matrix H and vectors G_v, G_x and G_w are computed by this function block and are referenced by inputs `uH`, `uGv`, `uGx` and `uGw` which must be preallocated. The scalar constant h is the function block parameter.

Inputs

`np`	Prediction horizon	↓1 ↑1000000	`Long (I32)`
`nc`	Control horizon	↓1 ↑1000000	`Long (I32)`
`uA`	Input reference to system matrix A		`Reference`
`uBu`	Input reference to input matrix Bu of control vector u		`Reference`
`uBv`	Input reference to input matrix Bv of disturbance vector v		`Reference`
`uC`	Input reference to output matrix C		`Reference`
`uQ`	Input reference to symmetric matrix Q in cost function		`Reference`
`uW`	Input reference to vector W in cost function		`Reference`
`uR`	Input reference to symmetric matrix R in cost function		`Reference`
`ul`	Input reference to integer index vector l		`Reference`
`uH`	Input reference to Hessian matrix H		`Reference`
`uGx`	Input reference to part of gradient vector G corresponding to state vector x		`Reference`
`uGv`	Input reference to part of gradient vector G corresponding to disturbance vector v		`Reference`
`uGw`	Intput reference to part of gradient vector G corresponding to vector W		`Reference`
`uSuL`	Input reference to work matrix Su*L		`Reference`
`uSv`	Input reference to work matrix Sv		`Reference`
`uT`	Input reference to work matrix T		`Reference`
`uScuL`	Input reference to work matrix Scu*L		`Reference`
`uScv`	Input reference to work matrix Scv		`Reference`
`uTc`	Input reference to work matrix Tc		`Reference`
`uWORK`	Input reference to matrix WORK		`Reference`
`HLD`	Hold		`Bool`

Outputs

`yA`	Output reference to system matrix A	`Reference`

yBu	Output reference to input matrix Bu of control vector u	Reference
yBv	Output reference to input matrix Bv of disturbance vector v	Reference
yC	Output reference to output matrix C	Reference
yQ	Output reference to symmetric matrix Q in cost function	Reference
yW	Output reference to vector W in cost function	Reference
yR	Output reference to symmetric matrix R in cost function	Reference
yl	Output reference to integer index vector l	Reference
yH	Output reference to Hessian matrix H	Reference
yGx	Output reference to part of gradient vector G corresponding to state vector x	Reference
yGv	Output reference to part of gradient vector G corresponding to disturbance vector v	Reference
yGw	Output reference to part of gradient vector G corresponding to vector W	Reference
ySuL	Output reference to work matrix Su*L	Reference
ySv	Output reference to work matrix Sv	Reference
yT	Output reference to work matrix T	Reference
yScuL	Output reference to work matrix Scu*L	Reference
yScv	Output reference to work matrix Scv	Reference
yTc	Output reference to work matrix Tc	Reference
yWORK	Output reference to matrix WORK	Reference
E	Error indicator	Bool

QP_OASES – Quadratic programming using active set method

Block Symbol

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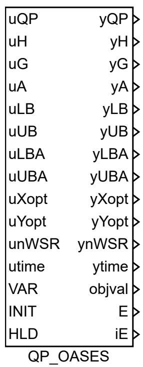

Function Description

The QP_OASES block solves a quadratic programming problem using active set method [11]

$$
\begin{aligned}
\min_{x \in \mathbb{R}^{\mathrm{nV}}} \quad & \tfrac{1}{2} x^T H x + x^T G \,, \\
\text{s. t.} \quad & \mathrm{lb}A \leq Ax \leq \mathrm{ub}A \,, \\
& \mathrm{lb} \leq x \leq \mathrm{ub} \,,
\end{aligned}
$$

where nV is number of variables, nC is number of constraints, the Hessian matrix $H \in \mathbb{R}^{\mathrm{nV} \times \mathrm{nV}}$ is symmetric and positive (semi-)definite, the gradient vector $G \in \mathbb{R}^{\mathrm{nV}}$, the constraint matrix $A \in \mathbb{R}^{\mathrm{nC} \times \mathrm{nV}}$, bound vectors $\mathrm{lb}, \mathrm{ub} \in \mathbb{R}^{\mathrm{nV}}$ and constraint vectors $\mathrm{lb}A, \mathrm{ub}A \in \mathrm{R}^{\mathrm{nC}}$.

The block wraps the qpOASES library[1], the use of which is described in the manual [12].

The output references yH, yG, yA, yLB, yUB, yLBA, yUBA, yXopt and yYopt are always set to the corresponding input uH, uG, uA, uLB, uUB, uLBA, uUBA, uXopt and uYopt. If the input uQP is not connected, the particular quadratic problem (QP) is allocated in the first execution of the function block (see below) and the output yQP is set to the reference of the allocated QP. If uQP is connected (to the yQP output of the previous QP_OASES block), the yQP output is set to uQP and the block works with an already allocated QP.

The block uses internal variables nV and nC. The value of nV is set to the number of rows of the vector G referenced by uG, the value of nV is set to the number of rows of

[1] qpOASES is distributed under the GNU Lesser General Public License, see Appendix A of [12].

the matrix A referenced by `uA`. If the reference `uA` is not defined (the matrix A is not connected), the value `nC = 0`.

To solve the QP problem, a `QProblem` object is created in the generic case (see Chapter 3 of [12]). However, the block can also solve the following special cases depending on the input references and the `hessianType` parameter:

`uH` not connected. In this case, it is assumed that Hessian matrix has a trivial value of the identity or zero matrix. The `hessianType` parameter must be equal to `HST_ZERO` or `HST_IDENTITY`, see Section 4.5 of the manual [12].

`uA` not connected. In this case, the constraint matrix A is not used (`nC = 0`, the `QProblemB` object is created, see Section 4.3 of the manual [12]. The `hessianType` parameter can be any allowed value.

`VAR = on`. If the input `VAR = on` during the first time the block is executed, an object of class `SQProblem` is created, see Section 4.2 of the manual [12]. In this case, all input matrices and vectors can change in each execution step in which `VAR = on`.

To obtain the solution of the QP problem, at least one of the input references `uXopt` and `uYopt` must be defined (connected to a vector). If connected to `uXopt`, the `yXopt` output will refer to the primal solution $\mathrm{Xopt} \in \mathbb{R}^{\mathrm{nV}}$, if connected to `uYopt`, the `yYopt` output will refer to the dual solution $\mathrm{Yopt} \in \mathbb{R}^{\mathrm{nV+nC}}$ of the QP problem. If both inputs are connected, both solutions will be obtained in each step. The optimal objective function value is indicated on the output `objval`.

The integer input `unWSR` specifies the maximum number of working set recalculations to be performed during the initial homotopy, see Section 3.2 of the manual [12]. Output `ynWSR` contains the number of working set recalculations actually performed. If the double input `utime` is connected and has a positive value, it contains the maximum allowed CPU time in seconds for the whole initialisation. The actually required CPU time for the initialization is indicated on the output `ytime`.

At least one vector must be connected from the `uXopt` and `uYopt` pair must be connected to obtain the solution of the QP problem. If uXopt is connected, the yXopt output will refer to the primary Xopt solution, if uYopt is connected, the yYopt output will refer to the dual Yopt solution of the QP task. If both inputs are connected, both solutions will be obtained in each step.

If the input `INIT = on` then the particular allocated QP problem is re-initialized. The `INIT` should be `on` for only a single period (edge) because no solution is computed during the QP initialisation. If `HLD = on` then nothing is computed.
The error flag `E` is set to `on` and the error code `iE` is set to zero if:

- the reference `uG` or `uLB` or `uUB` is not defined (i.e. input `uG` or `uLB` or `uUB` is not connected),
- the reference `uA` is defined and `uLBA` or `uUBA` is not defined (i.e. input `uA` is connected and `uLBA` or `uUBA` is not connected),

- both references uXopt and uYopt are not defined (i.e. neither of the inputs uXopt and uYopt is connected),
- the Hessian matrix H referenced by uH has a different number of rows and columns than nV,
- the number of rows of vectors referenced by uLB and uUB is not equal to nV (or the number of their columns is not equal to 1),
- the number of rows of vectors referenced by uLBA and uUBA is not equal to nC (or the number of their columns is not equal to 1) if the matrix A referenced by uA is connected,
- the number of rows of the vector referenced by uXopt is not equal to nV or the number of rows of the vector referenced by yOpt is not equal to nV+nC (or the number of their columns is not equal to 1),
- the internal space for transposed copies of matrices H or A is too small.

If the flag E is set to on and the error code iE is not zero then iE indicates the qpOASES error code, see the include file MessageHandling.hpp from qpOASES library.

Inputs

uQP	Input reference to quadratic programming problem	Reference
uH	Input reference to Hessian matrix H	Reference
uG	Input reference to gradient vector G	Reference
uA	Input reference to constraint matrix A	Reference
uLB	Input reference to lower bound vector LB	Reference
uUB	Input reference to upper bound vector LB	Reference
uLBA	Input reference to lower constraints' bound vector LB	Reference
uUBA	Input reference to upper constraints' bound vector LB	Reference
uXopt	Input reference to primal optimal solution	Reference
uYopt	Input reference to dual optimal solution	Reference
unWSR	Maximum number of initial working set recalculations	Long (I32)
utime	Maximum allowed CPU time in seconds for the whole initialisation	Double (F64)
VAR	Indiates that matrices H and A are time varying	Bool
INIT	Calls init() function instead of hotstart() in each block execution	Bool
HLD	If HLD = on then nothing is computed	Bool

Parameters

nVmax	Maximum number of optimization variables nV	Long (I32)
nCmax	Maximum number of optimization constraints nC	Long (I32)

`hessianType`	Hessian matrix type	`Long (I32)`
`printLevel`	Print level	`Long (I32)`
`enableRamping`	Enable ramping	`Bool`
`enableFarBounds`	Enable use of far bounds	`Bool`
`enableFlippingBounds`	Enable use of flipping bounds	`Bool`
`enableRegularisation`	Enable regularisation of semidefinite Hessian matrix	`Bool`
`enableFullLITests`	Enable use of condition-hardened linear independence tests	`Bool`
`enableNZCTests`	Enable nonzero curvature tests	`Bool`
`enableDriftCorrection`	Frequency of drift corrections (0 = off)	`Long (I32)`
`enableCholeskyRefact`	Frequency of full refactorisation of projected Hessian (0 = off)	`Long (I32)`
`enableEqualities`	Equalities shall be always treated as active constraints	`Bool`
`terminationTolerance`	Termination tolerance	`Double (F64)`
`boundTolerance`	If upper and lower limits differ less than this tolerance, they are regarded equal, i.e. as equality constraint	`Double (F64)`
`boundRelaxation`	Initial relaxation of bounds to start homotopy and initial value for far bounds.	`Double (F64)`
`epsNum`	Numerator tolerance for ratio tests	`Double (F64)`
`epsDen`	Denominator tolerance for ratio tests	`Double (F64)`
`maxPrimalJump`	Maximum allowed jump in primal variables in nonzero curvature tests	`Double (F64)`
`maxDualJump`	Maximum allowed jump in dual variables in linear independence tests	`Double (F64)`
`initialRamping`	Start value for ramping strategy	`Double (F64)`
`finalRamping`	Final value for ramping strategy	`Double (F64)`
`initialFarBounds`	Initial size of Far Bounds	`Double (F64)`
`growFarBounds`	Factor to grow Far Bounds	`Double (F64)`
`initialStatusBounds`	Initial status of bounds at first iteration	`Long (I32)`
`epsFlipping`	Tolerance of squared entry of Cholesky diagonal which triggers flipping bounds	`Double (F64)`
`numRegularisationSteps`	Maximum number of successive regularisation steps	`Long (I32)`
`epsRegularisation`	Scaling factor of identity matrix used for Hessian regularisation	`Double (F64)`
`numRefinementSteps`	Maximum number of iterative refinement steps	`Long (I32)`
`epsIterRef`	Early termination tolerance for iterative refinement	`Double (F64)`
`epsLITests`	Tolerance for linear independence tests	`Double (F64)`
`epsNZCTests`	Tolerance for nonzero curvature tests	`Double (F64)`

Outputs

yQP	Output reference to quadratic programming problem	Reference
yH	Output reference to Hessian matrix H	Reference
yG	Output reference to gradient vector G	Reference
yA	Output reference to constraint matrix A	Reference
yLB	Output reference to lower bound vector LB	Reference
yUB	Output reference to upper bound vector LB	Reference
yLBA	Output reference to lower constraints'bound vector LB	Reference
yUBA	Output reference to upper constraints' bound vector LB	Reference
yXopt	Output reference to primal optimal solution	Reference
yYopt	Output reference to dual optimal solution	Reference
ynWSR	Number of performed initial working set recalculations	Long (I32)
ytime	Elapsed CPU time in seconds for the whole initialisation	Double (F64)
objval	Optimal objective function value	Double (F64)
E	Error indicator	Bool
iE	Error code	Long (I32)

QP_UPDATE – Update matrices/vectors of quadratic programming

Block Symbol

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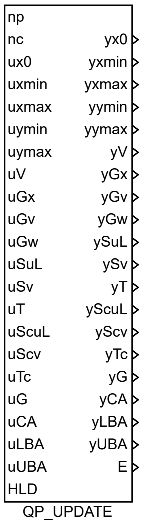

Function Description

The **QP_UPDATE** function block cooperates with the QP_MPC2QP block which converts the MPC problem described by equations (15.7)–(15.10) with prediction horizon n_p and control horizon n_c (inputs **np** and **nc**), to quadratic programming and pre-computes the Hessian matrix H, parts of the gradient vector G_x, G_v, G_w, matrices determining state constraints $S_u L$, S_v, T, and matrices determining output constraints $S_{cu} L$, S_{cv}, T_c. Besides the constant Hessian matrix H, the other vectors and matrices are connected to input references **uGx**, **uGv**, **uGw**, **uSuL**, **uSv**, **uT**, **uScuL**, **uScv** and **uTc**.

This block updates the QP problem for the given time instant with current values of state vector initial condition x_0, state vector bounds $x_{\min}$ and $x_{\max}$, output vector bounds $y_{\min}$ and $y_{\max}$, vector V (see eq. (15.11)) of disturbance prediction vectors $v_k, k = 0, \ldots, n_p - 1$. These vectors are referenced by inputs **ux0**, **uxmin**, **uxmax**, **uymin**, **uymax** and **uV**.

First, the gradient vector G referenced by the input **uG** is updated according to the equation (15.21):

$$G = G_x x_0 + G_v V + G_w.$$

The state constraints (15.9) can be rewritten using (15.15) for the prediction horizon n_p to

$$X_{\min} - S_v V - T x_0 \le S_u L U_{n_c} \le X_{\max} - S_v V - T x_0,$$

where $X_{\min}$ resp. $X_{\max}$ is a vector composed of n_p copies of the $x_{\min}$ resp. $x_{\max}$ vector. Similarly, the output constraints (15.10) can be rewritten using (15.16) to

$$Y_{\min} - S_{cv}V - T_c x_0 \leq S_{cu} L U_{n_c} \leq Y_{\max} - S_{cv}V - T_c x_0, .$$

where $Y_{\min}$ resp. $Y_{\max}$ is a vector composed of n_p copies of the $y_{\min}$ resp. $y_{\max}$ vector. The more compact form of these two equations is

$$\underbrace{\begin{bmatrix} X_{\min} - S_v V - T x_0 \\ Y_{\min} - S_{cv} V - T_c x_0 \end{bmatrix}}_{\mathrm{lb}A} \leq \underbrace{\begin{bmatrix} S_u L \\ S_{cu} L \end{bmatrix}}_{\mathrm{C}A} U_{n_c} \leq \underbrace{\begin{bmatrix} X_{\max} - S_v V - T x_0 \\ Y_{\max} - S_{cv} V - T_c x_0 \end{bmatrix}}_{\mathrm{ub}A}, \tag{15.22}$$

where the matrix CA and vectors lb$A$, ub$A$ are computed by this block, must be allocated e.g. by the `MX_MAT` blocks and references to the preallocated matrices must be connected to the block inputs `uCA`, `uLBA` and `uUBA`.

The last equation 15.22 is a general form of QP constraints. It covers both equality or inequality constraints for states and outputs.

If no state constraints are required, leave the `uxmin`, `uxmax`, `uSuL`, `uSv` and `uT` inputs disconnected. Then equation 15.22 gets the form

$$\underbrace{\begin{bmatrix} X_{\min} - S_v V - T x_0 \end{bmatrix}}_{\mathrm{lb}A} \leq \underbrace{\begin{bmatrix} S_u L \end{bmatrix}}_{\mathrm{C}A} U_{n_c} \leq \underbrace{\begin{bmatrix} X_{\max} - S_v V - T x_0 \end{bmatrix}}_{\mathrm{ub}A}. \tag{15.23}$$

Similarly, if no output constraints are required, leave the `uymin`, `uymax`, `uScuL`, `uScv` and `uTc` inputs disconnected. Then equation 15.22 gets the form

$$\underbrace{\begin{bmatrix} Y_{\min} - S_{cv} V - T_c x_0 \end{bmatrix}}_{\mathrm{lb}A} \leq \underbrace{\begin{bmatrix} S_{cu} L \end{bmatrix}}_{\mathrm{C}A} U_{n_c} \leq \underbrace{\begin{bmatrix} Y_{\max} - S_{cv} V - T_c x_0 \end{bmatrix}}_{\mathrm{ub}A}. \tag{15.24}$$

The output references `yx0`, `yxmin`, `yxmax`, `yymin`, `yymax`,`yV`, `yGx`, `yGv`, `yGw`, `ySuL`, `ySv`, `yT`, `yScuL`, `yScv`, `yTc`, `yG`, `yCA`, `yLBA` and `yUBA` are always set to the corresponding input `ux0`, `uxmin`, `uxmax`, `uymin`, `uymax`,`uV`, `uGx`, `uGv`, `uGw`, `uSuL`, `uSv`, `uT`, `uScuL`, `uScv`, `uTc`, `uG`, `uCA`, `uLBA` and `yUBA`.

If `HLD = on` then nothing is computed.

The error flag `E` is set to `on` if:

- the prediction horizon `np < 1` or control horizon `nc < 1`, or `nc > np`,
- the reference `ux0` is not defined or the element type of the array it references is not `Double (F64)`,
- the internal variable `bStateConstr = on` and at least one of the references `uxmin`, `uxmax` is not defined, or the element type of at least one of the arrays they reference is not `Double (F64)`,

- the internal variable `bOutputConstr = on` and the reference `uymin` is defined and the element type of the array it references is not `Double (F64)`,
- the internal variable `bOutputConstr = on` and the reference `uymax` is defined and the element type of the array it references is not `Double (F64)`,
- the reference `uV` is defined and the element type of the array it references is not `Double (F64)`,
- the reference `uG` is defined and at least one of the references `uGx`, `uGv`, `uSuL`, `uSv` or `uT` is not defined,
- the reference `uG` is defined and the element type of the array it references is not `Double (F64)`, or the reference `uGx` is defined and the element type of the array it references is not `Double (F64)`, or the reference `uGv` is defined and the element type of the array it references is not `Double (F64)`, or the reference `uGw` is defined and the element type of the array it references is not `Double (F64)`,
- the reference `uSuL` is defined and the element type of the array it references is not `Double (F64)`, or the reference `uSv` is defined and the element type of the array it references is not `Double (F64)`, or the reference `uT` is defined and the element type of the array it references is not `Double (F64)`,
- the reference `uScuL` is defined and the element type of the array it references is not `Double (F64)`, or the reference `uScv` is defined and the element type of the array it references is not `Double (F64)`, or the reference `uTc` is defined and the element type of the array it references is not `Double (F64)`,
- the reference `uCA` or `uLBA` or `uUBA` or the element type of at least one of the arrays they reference is not `Double (F64)`,
- the arrays referenced by defined references are too small or have incompatible dimensions.

If `E = on`, see the system log for details.

Inputs

`np`	Prediction horizon	↓1 ↑1000000	`Long (I32)`
`nc`	Control horizon	↓1 ↑1000000	`Long (I32)`
`ux0`	Input reference to initial condition vector x0 of the state vector x		`Reference`
`uxmin`	Input reference to vector of low limits of the state vector elements		`Reference`
`uxmax`	Input reference to vector of high limits of the state vector elements		`Reference`
`uymin`	Input reference to vector of low limits of the output inequalities		`Reference`

uymax	Input reference to vector of high limits of the output inequalities	Reference
uV	Input reference to vector predicted disturbancies	Reference
uGx	Input reference to part of gradient vector G corresponding to state vector x	Reference
uGv	Input reference to part of gradient vector G corresponding to disturbance vector v	Reference
uGw	Intput reference to part of gradient vector G corresponding to vector W	Reference
uSuL	Input reference to work matrix Su*L	Reference
uSv	Input reference to work matrix Sv	Reference
uT	Input reference to work matrix T	Reference
uScuL	Input reference to work matrix Scu*L	Reference
uScv	Input reference to work matrix Scv	Reference
uTc	Input reference to work matrix Tc	Reference
uG	Input reference to gradient vector G	Reference
uCA	Input reference to QP constraints matrix CA	Reference
uLBA	Input reference to lower constraints' bound vector LB	Reference
uUBA	Input reference to upper constraints' bound vector LB	Reference
HLD	Hold	Bool

Outputs

yx0	Output reference to initial condition vector x0 of the state vector x	Reference
yxmin	Output reference to vector of low limits of the state vector elements	Reference
yxmax	Output reference to vector of high limits of the state vector elements	Reference
yymin	Output reference to vector of low limits of the output inequalities	Reference
yymax	Output reference to vector of high limits of the output inequalities	Reference
yV	Output reference to vector predicted disturbancies	Reference
yGx	Output reference to part of gradient vector G corresponding to state vector x	Reference
yGv	Output reference to part of gradient vector G corresponding to disturbance vector v	Reference
yGw	Output reference to part of gradient vector G corresponding to vector W	Reference
ySuL	Output reference to work matrix Su*L	Reference
ySv	Output reference to work matrix Sv	Reference
yT	Output reference to work matrix T	Reference
yScuL	Output reference to work matrix Scu*L	Reference
yScv	Output reference to work matrix Scv	Reference

yTc	Output reference to work matrix Tc	Reference
yG	Output reference to gradient vector G	Reference
yCA	Output reference to QP constraints matrix CA	Reference
yLBA	Output reference to lower constraints' bound vector LB	Reference
yUBA	Output reference to upper constraints' bound vector LB	Reference
E	Error indicator	Bool

Chapter 16

SPEC – Special blocks

Contents

The SPEC library encompasses a diverse set of functional blocks designed to integrate a wide range of functionalities into automation, control systems, and communication protocols. From facilitating precise thermodynamic calculations with the STEAM block to enabling seamless data communication through UART and SMTP, the library serves as a comprehensive toolkit for engineers and developers. It includes specialized blocks for executing external programs (EPC), handling web-based requests (HTTP2). Additionally, it offers unique input-output solutions (RDC) and a versatile programming environment with REXLANG.

EPC – External program call

Block Symbol

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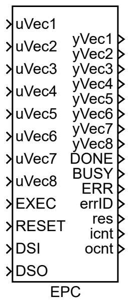


Function Description

The EPC block executes an external program upon a rising edge (off→on) occurring at the EXEC input. The name and options of the program are defined by the cmd parameter. The format is the same as if the program was executed from the command line of the operating system.

It is possible to pass data from the REXYGEN system to the external program via files. The formatting of the files is defined by the format parameter. All the currently supported formats are textual and simple, which allows straightforward processing of the data in arbitrary program. Use e.g.
`values=load('-ASCII', 'epc_inputVec1');`
for loading the data in MATLAB or
`values=read('epc_inputVec1',-1,32);`
in SCILAB. The filename and number of columns must be adjusted for the given project. Data exchange in the opposite direction is naturally also supported, the REXYGEN system can read the files in the same format.

The block works in two modes. In *basic mode*, the rising edge on the EXEC input triggers reading the data on inputs and storing them in the ifns file. The values of the i-th input vector uVec<i> are stored in the i-th file from the ifns list. In *sampling mode*, the data from the input vectors are stored in each period of the control algorithm. In both cases the values from one time instant form one line in the file.

Analogically, the data from output files are copied to the outputs of the block (one line from the i-th file in the ofns list to the i-th output vector yVec<i>).

The inputs working in the *sampling mode* are defined by the sl list (comma-separated numbers). The outputs work always in the *sampling mode* – the last values are kept when the end of file is reached. The copying of data to input files can be blocked by the DSI input, the same holds for output data and the DSO input.

Use the RTOV block to combine individual signals into a vector one for the uVec input.

The RTOV blocks can be chained, therefore it is possible to create a vector of arbitrary dimension. Similarly, use the VTOR block to demultiplex a vector signal to individual signals.

Inputs

uVec1..uVec8	Input vector signal	Reference
EXEC	External program is called on rising edge	Bool
RESET	Block reset (deletes the input and output files and terminates the external program)	Bool
DSI	Disable inputs sampling	Bool
DSO	Disable outputs sampling	Bool

Outputs

yVec1..yVec8	Output vector signal	Reference
DONE	External program finished	Bool
BUSY	External program running	Bool
ERR	Error flag	Bool
errID	Error code i ..... REXYGEN general error	Error
res	External program return code	Long (I32)
icnt	Current input sample	Long (I32)
ocnt	Current output sample	Long (I32)

Parameters

cmd	Operating system command to execute	String
ifns	Input filenames (separated by semicolon) ⊙epc_uVec1;epc_uVec2	String
ofns	Output filenames (separated by semicolon) ⊙epc_yVec1;epc_yVec2	String
sl	List of inputs working in the *sampling mode*. The format of the list is e.g. 1,3..5,8. Third-party programs (Simulink, OPC clients etc.) work with an integer number, which is a binary mask, i.e. 157 (binary 10011101) in the mentioned case. ↓0 ↑255 ⊙85	Long (I32)
ifm	Maximum number of input samples ⊙10000	Long (I32)
format	Format of input and output files ⊙1 1 ..... Space-delimited values 2 ..... CSV (decimal point and commas) 3 ..... CSV (decimal comma and semicolons)	Long (I32)
nmax	Maximum output vectors length ↓2 ↑1000000 ⊙100	Long (I32)

Notes

- The called external program has the same priority as the calling task. This priority is high, in some cases higher than operating-system-kernel tasks. On Linux based systems, it is possible to lower the priority by using the `chrt` command:
  `chrt -o 0 extprg.sh`,
  where `extprg.sh` is the original external program.

- The size of signals is limited by parameter `nmax`. Bigger parameter means bigger memory consumption, so choose this parameter as small as possible.

- The filenames must respect the naming conventions of the target platform operating system. It is recommended to use only alphanumeric characters and an underscore to avoid problems. Also respect the capitalization, e.g. Linux is case-sensitive.

- The block also creates copies of the `ifns` and `ofns` files for implementation reasons. The names of these files are extended by the underscore character.

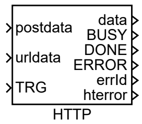
- The `ifns` and `ofns` paths are relative to the folder where the archives of the REXYGEN system are stored. It is recommended to define a symbolic link to a RAM-drive inside this folder for improved performance. On the other hand, for long series of data it is better to store the data on a permanent storage medium because the data can be appended e.g. after a power-failure recovery.

- The `OSCALL` block can be used for execution of some operating system functions.

HTTP – HTTP GET or POST request (obsolete)

Block Symbol

Licence: ADVANCED



Function Description

The HTTP block performs a single HTTP GET or POST request. Target address (URL) is defined by url parameter and urldata input. A final URL is formed in the way so that urldata input is simply added to url parameter.

HTTP request is started by the TRG parameter. Then the BUSY output is set until a request is finished, which is signaled by the DONE output. In case of an error, the ERROR output is set. The errId output carries last error identified by REXYGEN system error code. The hterror carries a HTTP status code. All data sent back by server to client is stored in the data output.

The block may be run in blocking or non-blocking mode which is specified by the BLOCKING parameter. In blocking mode, execution of a task is suspended until a request is finished. In non-blocking mode, the block performs only single operation depending on available data and execution of a task is not blocked. It is advised to always run HTTP block in non-blocking mode. It is however necessary to mention that on various operating systems some operations can not be performed in the non-blocking mode, so be careful and do not use this block in quick tasks or in tasks with short execution period. The non-blocking operation is best supported on GNU/Linux operating system. The maximal duration of a request performed by the HTTP block is specified by the timeout parameter.

The block supports user authentication using basic HTTP authentication method. User name and password may be specified by user and password parameters. The block also supports secure HTTP (HTTPS). It is also possible to let the block verify server's certificate by setting the VERIFY parameter. SSL certificate of a server or server's trusted certificate authority must be stored in the certificate parameter in a PEM format. The block does not support any certificate storage.

Parameters postmime and acceptmime specify MIME encoding of data being sent to server or expected encoding of a HTTP response.

Parameters nmax, postmax, and datamax specify maximum sizes of buffers allocated by the block. The nmax parameter is maximal size of any string parameter. The postmax parameter specifies a maximal size of postdata. The datamax parameter specifies a maximal size of data.

Inputs

`postdata`	Data to put in HTTP POST request		`String`
`urldata`	Data to append to URL address		`String`
`TRG`	Trigger of the selected action		`Bool`

Parameters

`url`	URL address to send the HTTP request to		`String`
`method`	HTTP request type 1 ..... GET 2 ..... POST	⊙1	`Long (I32)`
`user`	User name		`String`
`password`	Password		`String`
`certificate`	Authentication certificate		`String`
`VERIFY`	Enable server verification (valid certificate)		`Bool`
`postmime`	MIME encoding for POST request	⊙`application/json`	`String`
`acceptmime`	MIME encoding of HTTP response	⊙`application/json`	`String`
`timeout`	Timeout interval	⊙5.0	`Double (F64)`
`BLOCKING`	Wait for the operation to finish		`Bool`
`nmax`	Allocated size of string	↓0 ↑65520	`Long (I32)`
`postmax`	Allocated memory for POST request data	↓128 ↑65520 ⊙256	`Long (I32)`
`datamax`	Allocated memory for HTTP response	↓128 ↑10000000 ⊙1024	`Long (I32)`

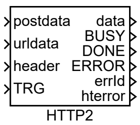
Outputs

`data`	Response data		`String`
`BUSY`	Sending HTTP request		`Bool`
`DONE`	HTTP request processed		`Bool`
`ERROR`	Error indicator		`Bool`
`errId`	Error code		`Error`
`hterror`	HTTP response		`Long (I32)`

HTTP2 – Block for generating HTTP GET or POST requests

Block Symbol

Licence: ADVANCED



Function Description

The HTTP block performs a single shot HTTP request. Target address (URL) is defined by url parameter and urldata input. A final URL is formed in the way so that urldata input is appended to the url parameter. The header input can be used for declaration of additional header fields.

A HTTP request is started by the TRG input. Then the BUSY output is set until the request is finished, which is signaled by a pulse at the DONE output. In case of an error, the pulse is generated at the ERROR output. The errId output carries information about the last error identified by REXYGEN system error code. The hterror carries a HTTP status code. All data received from server is published via the data output. All error outputs are reset when a new HTTP request is triggered by the TRG input.

The block may be run in blocking or non-blocking mode which is specified by the BLOCKING parameter. In blocking mode, execution of a task is suspended until the request is finished. In non-blocking mode, the block performs only single operation depending on available data and execution of a task is not blocked. It is advised to always run HTTP block in non-blocking mode. It is however necessary to mention that on various operating systems some operations cannot be performed in the non-blocking mode, so be careful and do not use this block in quick tasks (QTASK) or in tasks with short execution period. The non-blocking operation is best supported on GNU/Linux operating system. The maximal duration of a request performed by the HTTP block is specified by the timeout parameter.

The block supports user authentication using basic HTTP authentication method. User name and password may be specified by user and password parameters. The block also supports secure HTTP (HTTPS). It is also possible to let the block verify server's certificate by setting the VERIFY parameter. SSL certificate of a server or server's trusted certificate authority must be stored in the certificate parameter in a PEM format. The block does not support any certificate storage.

Parameters postmime and acceptmime specify MIME encoding of data being sent to server and expected encoding of the HTTP response.

Parameters nmax, postmax, and datamax specify maximum sizes of buffers allocated by the block. The nmax parameter is maximal size of any string parameter. The postmax parameter specifies a maximal size of postdata. The datamax parameter specifies a maximal size of `data`.

Inputs

`postdata`	Data to put in HTTP POST request		`String`
`urldata`	Data to append to URL address		`String`
`header`	Additional header fields		`String`
`TRG`	Trigger of the selected action		`Bool`

Parameters

`url`	URL address to send the HTTP request to		`String`
`method`	HTTP request type 1 ..... GET 2 ..... POST 3 ..... PUT 4 ..... DELETE 5 ..... HEAD 6 ..... TRACE 7 ..... PATCH 8 ..... OPTIONS 9 ..... CONNECT	⊙1	`Long (I32)`
`user`	User name		`String`
`password`	Password		`String`
`certificate`	Authentication certificate		`String`
`VERIFY`	Enable server verification (valid certificate)		`Bool`
`postmime`	MIME encoding for POST request	⊙`application/json`	`String`
`acceptmime`	MIME encoding for GET request	⊙`application/json`	`String`
`timeout`	Timeout interval	⊙5.0	`Double (F64)`
`BLOCKING`	Wait for the operation to finish		`Bool`
`nmax`	Allocated size of string	↓0 ↑65520	`Long (I32)`
`postmax`	Allocated memory for POST request data	↓128 ↑65520 ⊙4096	`Long (I32)`
`datamax`	Allocated memory for HTTP response	↓128 ↑10000000 ⊙64000	`Long (I32)`

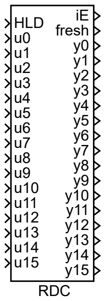
Outputs

`data`	Response data		`String`
`BUSY`	Sending HTTP request		`Bool`
`DONE`	HTTP request processed		`Bool`
`ERROR`	Error indicator		`Bool`
`errId`	Error code		`Error`
`hterror`	HTTP response		`Long (I32)`

RDC – Remote data connection

Block Symbol

Licence: ADVANCED



Function Description

The RDC block is a special input-output block. The values are transferred between two blocks on different computers, eventually two different Simulinks on the same computer or Simulink and the REXYGEN system on the same computer. In order to communicate, the two RDC blocks must have the same id number. The communication is based on UDP/IP protocol. This protocol is used as commonly as the more known TCP/IP, i.e. it works over all LAN networks and the Internet. The algorithm performs the following operations in each step:

- If HLD = on, the block execution is terminated.
- If the period parameter is a positive number, the difference between the system timer and the time of the last packet sending is evaluated. The block execution is stopped if the difference does not exceed the period parameter. If the period parameter is zero or negative, the time difference is not checked.
- A data packet is created. The packet includes block number, the so-called invoke number (serial number of the packet) and the values u0 to u15. All values are stored in the commonly used so-called network byte order, therefore the application is computer and/or processor independent.
- The packet is sent to the specified IP address and port.
- The invoke number is increased by 1.
- It is checked whether any incoming packets have been received.
- If so, the packet validity is checked (size, id number, invoke number).

- If the data is valid, all outputs `y0` to `y15` are set to the values contained in the packet received.
- The `fresh` output is updated. In case of error, the error code is displayed by the `err` output.

There are 16 values transmitted in each direction periodically between two blocks with the same `id` number. The `u(i)` input of the first block is transmitted the `y(i)` output of the other block. Unlike the TCP/IP protocol, the UDP/IP protocol does not have any mechanism for dealing with lost or duplicate packets, so it must be handled by the algorithm itself. The `invoke` number is used for this purpose. This state variable is increased by 1 each time a packet is sent. The block stores also the `invoke` number of the last received packet. It is possible to distinguish between various events by comparing these two invoke numbers. The packets with invoke numbers lower than the invoke number of the last received packet are denied unless the difference is grater than 10. This solves the situation when one of the `RDC` blocks is restarted and its `invoke` number is reset.

All `RDC` blocks in the same application must have the same `local port` number and the number of `RDC` blocks is limited to 64 for implementation reasons. If there are two applications using the `RDC` block running on the same machine, then each of them must use a different `local port` number.

Inputs

`HLD`	Input for disabling the execution of the block. No packets are received nor transmitted when `HLD` = `on`.	`Bool`
`u0..u15`	Values which are sent/written to the output values `y0` to `y15` of the paired block	`Double (F64)`

Outputs

`iE`	Displays the code of the last error. The error codes are listed below: `0` ..... No error	`Long (I32)`

	Persistent errors originating in the initialization phase (< 0). Cannot be fixed automatically. `-1` .... Maximum number of blocks exceeded (> 64) `-2` .... Local ports mismatch; the `lport` parameter must be the same for all `RDC` blocks within one application `-3` .... Error opening socket (the UDP/IP protocol is not available) `-4` .... Error assigning local port (port already occupied by another service or application) `-5` .... Error setting the so-called non-blocking socket mode (the `RDC` block requires this mode) `-10` ... Error initializing the socket library `-11` ... Error initializing the socket library `-12` ... Error initializing the socket library *Temporary errors originating in any cycle of the code (> 0). Can be fixed automatically.* `1` ..... Initialization successful, yet no data packet has been received `2` ..... Packet consistency error (incorrect length – transmission error or conflicting service/application is running) `4` ..... Error receiving packet (socket library error) `8` ..... Error sending packet (socket library error)	
`fresh`	Elapsed time (in seconds) since the last received packet. Can be used for detection of an error in the paired block.	`Double (F64)`
`y0..y15`	Values transmitted from the input ports `u0` to `u15` of the paired `RDC` block – data from the last packet received	`Double (F64)`

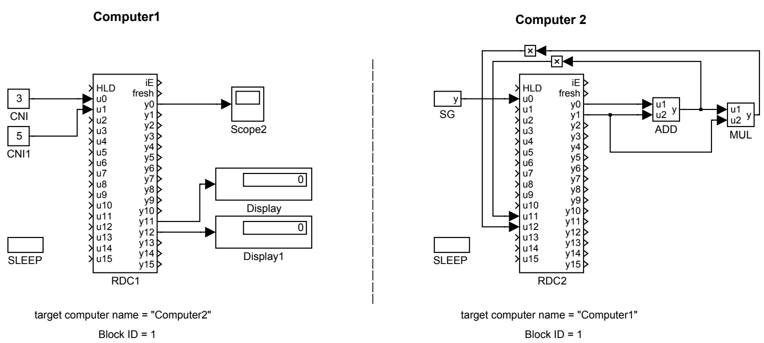
Parameters

`target`	Name or IP address running the paired `RDC` block. Broadcast address is allowed.	`String`
`rport`	Remote port – address of the UDP/IP protocol service, it is recommended to keep the default value unless necessary (service/application conflict) ⊙1288	`Word (U16)`
`lport`	Local port – similar meaning as the `rport` parameter; remote port applies to the receiving machine, local port applies to the machine sending the packet ⊙1288	`Word (U16)`
`id`	Block ID – this number is contained within the data packet in order to reach the proper target block (all blocks on the target receive the packet but only the one with the corresponding `id` decomposes it and uses the data contained to update its outputs) ↓1 ↑32767 ⊙1	`Long (I32)`

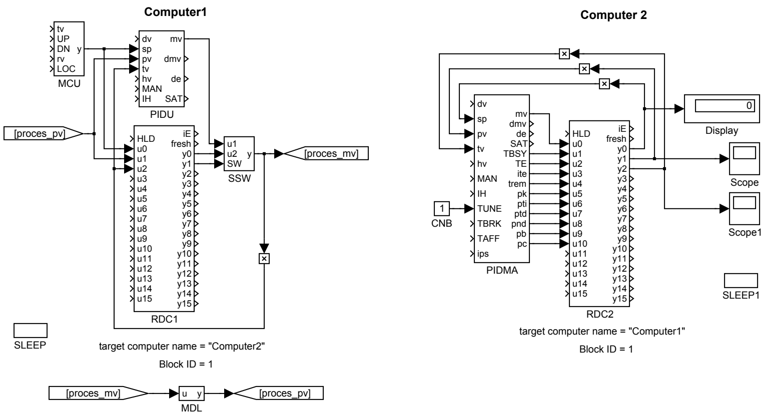
`period`	The shortest time interval between transmitting/receiving packets (in seconds). The packets are transmitted/received during each execution of the block for `period`≤`0` while the positive values of this parameter are extremely useful when sending data out of the Simulink continuous models based on a `Variable step` solver.	`Double (F64)`

Example

The following example explains the function of the `RDC` block. The constants 3 and 5 are sent from `Computer1` to `Computer2`, where they appear at the `y0` and `y1` outputs of the `RDC2` block. The constants are then summed and multiplied and sent back to `Computer1` via the `u11` and `u12` outputs of the `RDC2` block. The displays connected to the `y11` and `y12` outputs of the `RDC1` block show the results of mathematical operations $3+5$ and $(3+5)*5$. The signal from the `SG` generator running on `Computer2` is transmitted to the `y0` output of the `RDC1` block, where it can be easily displayed. Note that `Display` and `Scope` are Matlab/Simulink blocks – to visualize data within the REXYGEN system, the `TRND` block or similar must be utilized.



The simplicity of the example is intentional. The goal is to demonstrate the functionality of the block, not the complexity of the system. In reality, the `RDC` block is used in more complex tasks, e.g. for remote tuning of the PID controller as shown below. The PID control algorithm is running on `Computer1` while the tuning algorithm is executed by `Computer2`. See the `PIDU`, `PIDMA` and `SSW` blocks for more details.



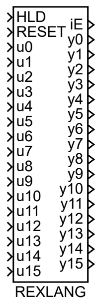
OPC server of the RDC block

There is also an OPC server embedded in the RDC block. Detailed description will be available soon.

REXLANG – User Programmable Block

Block Symbol

Licence: REXLANG



Function Description

The REXYGEN system's standard function blocks address most typical control application requirements. However, there are scenarios where a user-defined function is necessary or more efficient. The `REXLANG` block is designed for these situations. It allows the implementation of a user-defined algorithm using a scripting language that closely resembles C (or Java).

Scripting Language

The scripting language employed in `REXLANG` is akin to C, but there are notable differences and limitations:

- Supported data types include `double`, `long` and `string`. Types like `int`, `short`, and `bool` are internally converted to `long`. The `float` type is converted to `double`. The `typedef` type is not available.
- Pointers and structures are not implemented. Arrays can be defined and indexing is possible using the `[ ]` operator. Inputs, outputs, and parameters of the block cannot be arrays.
- The '`,`' operator is not implemented.
- The preprocessor supports commands like `#include`, `#define`, `#ifdef` .. [`#else` ..] `#endif`, and `#ifndef` .. [`#else` ..] `#endif`. However, `#pragma` and `#if` .. [`#else` ..] `#endif` are not supported.
- While standard ANSI C libraries are not implemented, many mathematical functions from `math.h` and other functions are available (detailed below).

- Keywords input, output, and parameter are used to reference the REXLANG block's inputs, outputs, and parameters. System functions for execution control and diagnostics are implemented.
- The main() function is executed periodically during runtime. Other functions like init() (executed once at startup), exit() (executed upon control algorithm stop), and parchange() (executed upon parameter changes) are also available.
- Functions and procedures without parameters must declare void explicitly.
- Overloading of identifiers is not allowed, i.e., keywords and built-in functions cannot share names with identifiers. Local and global variables must have distinct names.
- Array initializers are not supported for both local and global arrays.
- User-defined return values from main(), init(), and exit() are written to the iE output. Values < -99 will stop algorithm execution (requiring a RESET input for further execution). Return values are categorized as follows:

iE >= 0	indicates no errors.
0 > iE >= -99	signifies a warning, without affecting function block execution.
iE < -99	implies an error, halting the function block execution.

Scripting Language Syntax

The syntax of the scripting language is rooted in C, but with some modifications:

- <type> input(<input number>) <variable name>; for input variables.
- <type> output(<output number>) <variable name>; for output variables.
- <type> parameter(<parameter number>) <variable name>; for parameter variables.

The input and parameter variables are read-only, whereas output variables are write-only.

Example:

```
double input(1) input_signal; /* declaration of a variable of type
                                 double, which corresponds with the
                                 u1 input of the block */
long output(2) output_signal; /* declaration of a variable of type
                                 long, which corresponds with the y2
                                 output of the block */

input_signal = 3;               //not allowed, inputs are read-only
sum = output_signal + 1;        //not allowed, outputs are write-only
if (input_signal>1) output_signal = 3 + input_signal;  //correct
```

Available Functions

The scripting language encompasses a broad spectrum of functions, including those for mathematical calculations, vector operations, string handling, and system-level commands. The functions are categorized and described in detail as follows:

- **Mathematical Functions** (aligned with ANSI C's `math.h` library):
  This category includes functions like `atan`, `sin`, `cos`, `exp`, `log`, `sqrt`, `tan`, `asin`, `acos`, `fabs`, `fmod`, `sinh`, `cosh`, `tanh`, `pow`, `atan2`, `ceil`, `floor`, and `abs`. Note that `abs` is specifically designed for integer values, while the rest operate with `double` type variables. The `fabs` function is used to calculate the absolute value of a decimal number.

- **Vector Functions** (not part of ANSI C):
  This set includes specialized functions for vector manipulation:

  `double max([n,] val1, ..., valn)`
  : Returns the maximum value among the provided elements. The first parameter, indicating the number of items, is optional.

  `double max(n, vec)`
  : Finds the maximum value in the `vec` vector.

  `double min([n,] val1, ..., valn)`
  : Similar to `max`, but returns the minimum value.

  `double min(n, vec)`
  : Finds the minimum value in the `vec` vector.

  `double poly([n,] x, an, ..., a1, a0)`
  : Calculates the value of a polynomial $\mathtt{y} = \mathtt{an} * \mathtt{x}^{\mathtt{n}} + \ldots + \mathtt{a1} * \mathtt{x} + \mathtt{a0}$. The first parameter is optional.

  `double poly(n, x, vec)`
  : Computes the polynomial value $\mathtt{y} = \mathtt{vec[n]} * \mathtt{x}^{\mathtt{n}} + \ldots + \mathtt{vec[1]} * \mathtt{x} + \mathtt{vec[0]}$.

  `double scal(n, vec1, vec2)`
  : Calculates the scalar product of two vectors: $\mathtt{y} = \mathtt{vec1[0]} * \mathtt{vec2[0]} + \ldots + \mathtt{vec1[n-1]} * \mathtt{vec2[n-1]}$.

  `double scal(n, vec1, vec2, skip1, skip2)`
  : A variant of `scal` that allows skipping elements: $\mathtt{y} = \mathtt{vec1[0]} * \mathtt{vec2[0]} + \mathtt{vec1[skip1]} * \mathtt{vec2[skip2]} + \ldots + \mathtt{vec1[(n-1)*skip1]} * \mathtt{vec2[(n-1)*skip2]}$. This is well suited for multiplication of matrices, which are stored as vectors (line by line or column by column).

  `double conv(n, vec1, vec2)`
  : Computes the convolution of two vectors: $\mathtt{y} = \mathtt{vec1[0]} * \mathtt{vec2[n-1]} + \mathtt{vec1[1]} * \mathtt{vec2[n-2]} + \ldots + \mathtt{vec1[n-1]} * \mathtt{vec2[0]}$.

  `double sum(n, vec)`
  : Sums the elements of a vector: $\mathtt{y} = \mathtt{vec[0]} + \mathtt{vec[1]} + \ldots + \mathtt{vec[n-1]}$.

  `double sum([n,] val1, ..., valn)`
  : Sums the provided values. The count parameter is optional.

`[]array([n,] an-1, ..., a1, a0)`
: Creates an array/vector with specified elements. The count parameter `n` is optional. The type of the returned value is chosen automatically to fit the type of parameters (all must be of the same type).

`[]subarray(idx, vec)`
: Returns a subarray of `vec` starting from index `idx`. The type of the returned value is chosen automatically according to the `vec` array.

`copyarray(count, vecSource, idxSource, vecTarget, idxTarget)`
: Copies `count` items of the `vecSource` array, starting at `idxSource` index, to the `vecTarget` array, starting at `idxTarget` index. Both arrays must be of the same type.

`void fillarray(vector, value, count)`
: Copies `value` to `count` items of the `vector` array (always starting from index 0).

Note: The functions `max`, `min`, `poly`, `scal`, `conv`, and `sum` are overloaded, meaning they have multiple variants based on the parameters. Parameters are strictly type-checked, requiring casting for non-double types. For instance:
`double res = max(dVal, (double)iVal, 1.0, (double)2);`
casts `iVal` to double. If a parameter is not a double, an error stating "no function of this prototype was found" is reported.

- **String Functions** (This section covers functions analogous to those found in ANSI C's `string.h` library, providing a range of operations for string manipulation and analysis:)

`string strsub(str, idx, len)`
: Extracts a substring from `str`, starting at index `idx` and spanning `len` characters.

`long strlen(str)`
: Returns the length of the string `str`, measured in characters.

`long strfind(str, substr[, offset])`
: Finds the first occurrence of `substr` within `str` and returns its position. The search starts from the character with index `offset` (if not specified, then from the beginning). The parameter `substr` can also be a character.

`long strrfind(str, substr)`
: Identifies the last occurrence of `substr` within `str` and provides its index.

`strreplace(str, pattern, substr)`
: Replaces all instances of `pattern` in `str` with `substr`. This modification is done in-place, directly altering `str`.

`strupr(str)`
: Converts all characters in `str` to uppercase.

`strlwr(str)`
: Transforms `str` to all lowercase characters.

`strtrim(str)`
: Removes leading and trailing whitespace from `str`.

`long str2long(str[, default])`
: Converts `str` to an integer. If conversion fails, the optional second parameter (default value) is returned, or 0 if not provided.

`double str2double(str[, default])`
: Turns `str` into a decimal number. Similar to `str2long`, it returns an optional default value or 0 on failure.

`string long2str(num[, radix])`
: Converts an integer `num` to a string, with an optional `radix` parameter specifying the base (default is 10). The output string does not indicate the numeral system (no prefixes like 0x for hexadecimal).

`string double2str(num)`
: Converts a decimal number `num` to a string representation.

`strcpy(dest, src)`
: Copies the content of `src` into `dest`. For ANSI C compatibility, `dest = src` achieves the same result.

`strcat(dest, src)`
: Appends `src` to the end of `dest`. As in ANSI C, `dest = dest + src` performs the same operation.

`strcmp(str1, str2)`
: Compares two strings `str1` and `str2`. The construction `str1 == str2` can be used for the same purpose, providing ANSI C compatibility.

`float2buf(buf, x[,endian])`
: Converts the real number `x` into an array `buf` of four elements, each representing an octet of the number in IEEE 754 single precision format (known as float). The function is useful for filling communication buffers. Optional 3rd parameter has the following meaning:
  - `0` processor native endian (default),
  - `1` little endian,
  - `2` big endian.

`double2buf(buf, x[,endian])`
: Similar to `float2buf`, but for double precision, storing eight elements (double type).

`double buf2float(buf[, endian])`
: The inverse of `float2buf`.

`double buf2double(buf[, endian])`
: The inverse of `double2buf`.

`long RegExp(str, regexp, capture[])`
: Matches `str` against the regular expression `regexp`, storing captured groups in `capture`. Returns the number of captures or a negative error code. The regular expression syntax includes standard constructs like:

- (?i) — Must be at the beginning of the regular expression. Makes the matching case-insensitive.
- ^ — Match beginning of a string
- $ — Match end of a string
- () — Grouping and substring capturing
- \s — Match whitespace
- \S — Match non-whitespace
- \d — Match decimal digit
- \n — Match new line character
- \r — Match line feed character
- \f — Match vertical tab character
- \v — Match horizontal tab character
- \t — Match horizontal tab character
- \b — Match backspace character
- + — Match one or more times (greedy)
- +? — Match one or more times (non-greedy)
- * — Match zero or more times (greedy)
- *? — Match zero or more times (non-greedy)
- ? — Match zero or once (non-greedy)
- x|y — Match x or y (alternation operator)
- \meta — Match one of the meta characters: ^$().[]*+?|\
- \xHH — Match byte with hex value 0xHH, e.g. \x4a.
- [...] — Match any character from the set. Ranges like [a-z] are supported.
- [^...] — Match any character but the ones from the set.

Example:

```
RegExp("48,string1,string2","^(\\d+),([^,]+),",capture);
```

Result: capture=["48,string1","48","string1"]

long ParseJson(json, cnt, names[], values[])

This function processes a json string, extracting the values of specified objects. The names array should list the properties of interest (access subitems with . and array indices with [], for instance, "cars[1].model"). Corresponding values are then populated in the values array. The cnt parameter determines the number of objects to be parsed, which should match the length of both the names and values arrays. This function returns the total number of successfully parsed values, or a negative value if an error occurs during parsing.

Note: String variables are declared as in ANSI C (char <variable name>[<max chars>];). For function arguments, use char <variable name>[] or string <variable name>.

- **System functions** (not part of ANSI C)

Archive(arc, type, id, lvl_cnt, value)

This function archives a value into the system's archival subsystem. arc serves as a bitmask to specify the target archives (e.g., for archives 3 and 5, set `arc` = 20, which is 10100 in binary or 20 in decimal). Archive numbering starts from 1, with a maximum of 15 archives (archive 0 is reserved for internal system logs). The `type` parameter defines the data type, with options:

1	Bool
2	Byte (U8)
3	Short (I16)
4	Long (I32)
5	Word (U16)
6	DWord (U32)
7	Float (F32)
8	Double (F64)
9	Time
10	Large (I64)
11	Error
12	String
17	Bool Group
18	Byte Group (U8)
19	Short Group (I16)
20	Long Group (I32)
21	Word Group (U16)
22	DWord Group (U32)
23	Float Group (F32)
24	Double Group (F64)
25	Time Group
26	Large Group (I64)
27	Error Group

`id` represents a unique archive item ID, `lvl_cnt` denotes an alarm level or the number of elements for Group types, and `value` is the data to be archived.

`Trace(id, val)`

Displays both the `id` and `val` values, mainly used for debugging purposes. `id` is a user-defined constant ranging from 0 to 9999 for easy message identification. `val` can be any data type, including strings. Output appears in the system log of REXYGEN.. In order to view these debugging messages in System log it is necessary to enable them. Go to the menu *Target→Diagnostic messages* and tick the *Information* checkbox in the *Function block messages* box. Logging has to be also enabled for the particular block by ticking the *Enable logging* checkbox in the *Runtime* tab of the block parameters dialog. By default, this is enabled after placing a new block from library. Only then are the messages displayed in the *System log*.

`TraceError(id, val) TraceWarning(id, val) TraceVerbose(id, val)`
: Similar to `Trace`, these commands categorize the output into Error, Warning, or Verbose logging groups. *Error* messages are always logged. For *Warning* and *Verbose* messages, enable the respective message groups in the *Diagnostic messages* menu.

`Suspend(sec)`
: Suspends script execution if it exceeds the specified time in `sec` during a sampling period. The script resumes from the suspension point upon the next block execution. Use `Suspend(0)` to pause the script immediately.

`double GetPeriod()`
: Returns the block's sampling period in seconds.

`double CurrentTime()`
: Function provides the current time in an internal format, often used with `ElapsedTime()`.

`double ElapsedTime(new_time, old_time)`
: Calculates elapsed time between `new_time` and `old_time` in seconds. Function `CurrentTime()` is typically used for `new_time`.

`double Random()`
: Generates a pseudo-random number from the $\langle 0, 1)$ interval. The generator is initialized before the `init()` function, ensuring a consistent sequence.

`long QGet(var)`
: Returns the quality of the `var` variable (see the `QFC`, `QFD`, `VIN`, `VOUT` blocks). The function is intended for use with the inputs, outputs and parameters. It always returns 0 for internal variables.

`void QSet(var, value)`
: Sets the quality of the `var` variable (see the `QFC`, `QFD`, `VIN`, `VOUT` blocks). The function is intended for use with the inputs, outputs and parameters. It has no meaning for internal variables.

`long QPropag([n, ]val1, ..., valn)`
: Returns the quality resulting from merging of qualities of `val1,...,valn`. The basic rule for merging is that the resulting quality correspond with the worst quality of `val1,...,valn`. To obtain the same behavior as in other blocks of the REXYGEN system, use this function to set the quality of output, use all the signals influencing the output as parameters.

`double LoadValue(fileid, idx)`
: Reads a value from a file. Supports both binary files (with `double` values) and text files (values on separate lines). The file is identified by `fileid`, and `idx` indicates the index (for binary files) or line number (for text files). At present the following values are supported:

- `0` file on a disk identified by the `p0` parameter,
- `1` file on disk identified by name of the `REXLANG` block and extension `.dat`,
- `2` file on a disk identified by the `srcname` parameter, but the extension is changed to `.dat`,
- `3` `rexlang.dat` file in the current directory,
- `4-7` same like `0-3`, but format is text file. Each line contains one number. The index `idx` is the line number and starts at zero. Value `idx=-1` means next line (e.g. sequential writing).

`void SaveValue(fileid, idx, value)`
: Stores a value in a file, with parameters functioning similarly to `LoadValue`.

`void GetSystemTime(time)`
: Returns the system time in UTC (modifiable via OS settings). The `time` parameter must be an array of at least 8 `long` items. The function fills the array with the following values in the given order: year, month, day (in the month), day of week, hours, minutes, seconds, milliseconds. On some platforms the milliseconds value has a limited precision or is not available at all (the function returns 0 ms).

`void Sleep(seconds)`
: Halts the block's algorithm (and whole task) for the defined time. Use this block with extreme caution and only if there is no other possibility to achieve the desired behaviour of your algorithm. The sleep interval should not exceed 900 milliseconds. The shortest interval is about 0.01s, the precise value depends on the target platform.

`long GetExtInt(ItemID)`
: Returns the value of input/output/parameter of arbitrary block in REXYGEN algorithm. Such an external data item is referenced by the `ItemID` parameter. The structure of the string parameter `ItemID` is the same as in e.g. the `sc` parameter of the `GETPI` function block. If the value cannot be obtained (e.g. invalid or non-existing `ItemID`, data type conflict, etc.), the `REXLANG` block issues an error and must be reset.

`long GetExtLong(ItemID)`
: See `GetExtInt(ItemID)`.

`double GetExtReal(ItemID)`
: Similar to `GetExtInt(ItemID)` but for decimal numbers.

`double GetExtDouble(ItemID)`
: See `GetExtReal(ItemID)`.

`string GetExtString(ItemID)`
: Similar to `GetExtInt(ItemID)` but for strings.

`void SetExt(ItemID, value)`
: Sets the input/output/parameter of arbitrary block in REXYGEN algorithm to `value`. Such an external data item is referenced by the `ItemID` parameter. The structure of the string parameter `ItemID` is the same as in

e.g. the `sc` parameter of the SETPI function block. The type of the external data item (long/double/string) must correspond with the type of the `value` parameter. If the value cannot be set (e.g. invalid or non-existing `ItemID`, data type conflict, etc.), the `REXLANG` block issues an error and must be reset.

`int BrowseExt(ItemID, first_subitem_index, max_count, subitems, kinds)`
: Function browses task address space. If `ItemID` is a block identifier (block path), `subitems` string array will contain names of all inputs, outputs, parameters and internal states. Function returns number of subitems or negative error code. `kinds` values: executive = 0, module = 1, driver = 2, archive = 3, level = 4, task = 5, quicktask = 6, subsystem = 7, block = 8, input = 9, output = 10, internal state = 11, parameter or state array = 12, special = 13.

`long CallExt(ItemID)`
: Executes a single step of any block within the REXYGEN algorithm, identified by `ItemID`. The structure of the string parameter `ItemID` is the same as in e.g. the `sc` parameter of the GETPI function block. It's recommended to call only halted blocks[1], which should be in the same task as the REXLANG block. The function returns result code of the calling block (see REXYGEN error codes).

`long GetInArrRows(input)`
: Returns the number of rows of the array that is attached to the input with index `input` of the REXLANG block.

`long GetInArrCols(input)`
: Returns the number of columns of the array that is attached to the input with index `input` of the REXLANG block.

`long GetInArrMax(input)`
: Returns the maximum (allocated) size of the array that is attached to the input with index `input` of the REXLANG block.

`double GetInArrDouble(input, row, col)`
: Returns the member of the array that is attached to the input with index `input` of the REXLANG block.

`long GetInArrLong(input, row, col)`
: Similar to `GetInArrDouble(...)`, but the value is of type long.

`Void SetInArrValue(input, row, col, value)`
: Sets the member of the array that is attached to the input with index `input` of the REXLANG block.

`Void SetInArrDim(input, row, col)`
: Sets the dimension of the array that is attached to the input with index `input` of the REXLANG block.

`long memrd32(hMem, offset)`
: Reading physical memory. Get the handle by
`Open(72,"/dev/mem",<physical address>,<area size>)`.

[1] set checkbox `Halt` on the property page `Runtime` in the parameters dialog of the block

`long memwr32(hMem, offset, value)`
: Writing to physical memory. Get the handle by `OpenMemory("/dev/mem",<physical address>,<area size>)`.

- **Communication Functions** (not part of ANSI C)

  This suite of functions facilitates communication over various channels including TCP/IP, UDP/IP, serial lines (RS-232 or RS-485), SPI bus, and I2C bus. Below is a concise list of these functions. For comprehensive details, refer to the example projects in the REXYGEN system.

  `long OpenFile(string filename)`
  : This function opens a file and returns an identification number (handle) of the file. If the function returns a negative value, the file opening was unsuccessful.

  `long OpenCom(string comname, long baudrate, long parity)`
  : Opens a serial line and returns its handle. From REXYGEN version 3.0 onwards, virtual ports can be specified as `comname`. For detailed information about virtual ports, see the `UART` block description. If a negative value is returned, the opening failed. The parity setting options are 0 for none, 1 for odd, and 2 for even.

  `long OpenUDP(string localname, long lclPort, string remotename, long remPort)`
  : Opens a UDP socket and returns its handle. If the function returns a negative value, the socket opening was unsuccessful. The function can open either an IPv4 or IPv6 socket based on the `remotename`, `localname`, or operating system settings if a DNS name is used. Optional settings include an empty `localname` (any interface), an empty `remotename` or 0 for `remPort` (unused), and 0 for `lclPort` (assigned by the UDP/IP stack).

  `long OpenTCPsvr(string localname, long lclPort)`
  : This function opens a TCP socket in server (listening) mode. It returns a handle for the socket, and a negative return value indicates an unsuccessful opening. The function can open either IPv4 or IPv6 sockets depending on `remotename`, `localname`, or operating system settings if a DNS name is used. You can set an empty `localname` to mean any interface.

  `long OpenTCPcli(string remotename, long remPort)`
  : Opens a TCP socket in client mode and returns its handle. A negative return value indicates failure to open the socket. The function opens either an IPv4 or IPv6 socket based on `remotename`, `localname`, or operating system settings if a DNS name is used. Note that this function does not wait for the connection to be established, which might take a few milliseconds on a local network or a few seconds for remote locations. If `Write()` or `Read()` are called before the connection is established, an error code -307 (file open error) is returned.

  `long OpenI2C(string devicename)`
  : Opens the I2C bus and returns its handle. If the function returns a negative value, the opening was not successful.

`long OpenSPI(string devicename)`
: Opens the SPI bus and returns its handle. A negative return value indicates an unsuccessful opening.

`long OpenDevice(string filename)`
: Similar to `OpenFile()`, but the functions `Write()` and `Read()` are non-blocking. If data cannot be read or written, the function immediately returns a -1 error code.

`long OpenMemory(string devicename, long baseaddr, long size)`
: Maps physical memory and returns the associated handle. If a negative value is returned, the operation was unsuccessful.

`long OpenSHM(string devicename, long deviceid, long size, long flags)`
: Maps shared memory (Linux only, using `ftok()` and `shmget()`) and returns the associated handle. The first and second parameters serve to identify the memory area (they must be the same for all cooperating entities). The `size` parameter specifies the size of the shared memory area in bytes. The `flags` parameter represents standard Linux flags and permissions (if set to 0, which is the default value, the following rights are set: create the area if it does not exist, and allow everyone to read and write).

`void Close(long handle)`
: Closes a socket, serial line, file, or any device opened with the `Open...` functions.

`void SetOptions(long handle, long params[])`
: Configures the parameters of a socket or serial line. The array size must be at least:

- `22` for serial line (on Windows parameters for SetCommState() and SetCommTimeouts() in following order: BaudRate, fParity, Parity, StopBits, ByteSize, fDtrControl, fRtsControl, fAbortOnError, fBinary, fErrorChar, fNull, fDsrSensitivity, fInX, fOutX, fOutxCtsFlow, fOutxDsrFlow, fTXContinueOnXoff, ReadIntervalTimeout, ReadTotalTimeoutConstant, ReadTotalTimeoutMultiplier, WriteTotalTimeoutConstant, WriteTotalTimeoutMultiplier; linux use different function, but meaning of the parameters is as same as possible),
- `2` for file (1st item is mode: 1=seek begin, 2=seek current, 3=seek end, 4=set file end, 2nd item is offset for seek),
- `3` for SPI (1st item is SPI mode, 2nd item is bits per word, 3rd item is max speed in Hz),
- `5` for I2C (1st item is slave address, 2nd item is 10-bit address flag, 3rd item is Packet Error Checking flag, 4th item is number of retries, 5th item is timeout),
- `other` handle types are not supported

`void GetOptions(long handle, long params[])`
: Reads the parameters of a socket or serial line and stores them in the

`params` array. The array size must accommodate the specific device requirements (see `SetOptions`).

`long Accept(long hListen)`

Accepts a connection on a listening socket, returning a communication socket handle or an error code.

`long Read(long handle, long buffer[], long count[, offset])`

Receives data from a serial line or socket, returning the number of bytes read or an error code. The `count` parameter defines the maximum number of bytes to read. Each byte of incoming data is put to the `buffer` array of type `long` in the corresponding order. The function has one more (optional) `offset` parameter that can be used when reading data from memory when the handle is created using the `OpenSHM()` or `OpenMemory()`.

It is also possible to use the form
`long Read(long handle, string data[], long count)` (i.e. a string is used instead of a data array; one byte in the input file corresponds to one character; not applicable to binary files).

The error codes are:

`-1`	it is necessary to wait for the operation to finish (the function is "non-blocking")
`-309`	reading failed; the operating system error code appears in the log (when function block logging is enabled)
`-307`	file/socket is not open

`long Write(long handle, long buffer[], long count[, offset])`

Sends data over a serial line or socket. The `count` parameter defines the number of bytes to send. The count of bytes or en error code sent is returned. Each byte of outgoing data is read from the `buffer` array of type `long` in the corresponding order. The function has one more (optional) `offset` parameter that can be used to write data to memory when the handle is created using the `OpenSHM()` or `OpenMemory()`.

It is also possible to use the form
`long Write(long handle, string data)` (i.e. a string is used instead of a data array; one byte in the output file corresponds to one character; not applicable to binary files).

The error codes are:

`-1`	it is necessary to wait for the operation to finish (the function is "non-blocking")
`-310`	write failed; the operating system error code appears in the log (when function block logging is enabled)
`-307`	file/socket is not open

`long ReadLine(long handle, string data)`

Reads a line from a (text) file, serial line, or socket, storing the characters in `data` up to its allocated size. The function returns the actual size of the line or an error code.

`long DeleteFile(string filename)`
: Deletes a file, returning 0 on success or a negative error code on failure.

`long RenameFile(string filename, string newfilename)`
: Renames a file, returning 0 on success or a negative error code on failure.

`bool ExistFile(string filename)`
: Checks if a file or device exists (can be opened for reading), returning true or false.

`long I2C(long handle, long addr, long bufW[], long cntW, long bufR[], long cntR)`
: Handles communication over the I2C bus, particularly on Linux systems with I2C capabilities (e.g., Raspberry Pi). The function sends and receives data to/from a slave device using `addr`. The parameter `handle` is returned by the `OpenI2C` function, whose parameter defines the device name (according to the operating system). The parameter `bufW` is a buffer (an array) for the data which is sent out, `cntW` is the number of bytes to send out, `bufR` is a buffer (an array) for the data which comes in and `cntR` is the number of bytes to receive. The function returns 0 or an error code.

`long SPI(long handle, 0, long bufW[], long cntW, long bufR[], long cntR)`
: Executes a transaction over the SPI bus, particularly on Linux systems with SPI capabilities. The parameter `handle` is returned by the `OpenSPI` function, whose parameter defines the device name (according to the operating system). The second parameter is always 0 (reserved for internal use). The parameter `bufW` is a buffer (an array) for the data which is sent out, `cntW` is the number of bytes to send out, `bufR` is a buffer (an array) for the data which comes in and `cntR` is the number of bytes to receive. Note that SPI communication is full-duplex, therefore the resulting length of the SPI transaction is given by maximum of the `cntW` and `cntR` parameters, not their sum. The function returns 0 or an error code.

`long Seek(long handle, long mode[], long offset)`
: Sets the position for Read/Write commands. Parameter `mode` means:
  - `1` offset from begin of the file,
  - `2` offset from current position,
  - `3` offset from end of the file.

`long Recv(long handle, long buffer[], long count)`
: *Obsolete function. Use `Read` instead.*

`long Send(long handle, long buffer[], long count)`
: *Obsolete function. Use `Write` instead.*

`long crc16(data, length, init, poly, flags, offset)`
: Computes a 16-bit Cyclic Redundancy Code (CRC), commonly used as a checksum or hash in various communication protocols.

  `data` A byte array (represented by a long array) or a string for which the hash is computed.

  `length` The number of bytes in the input array or text. Use -1 to process the entire string.

`init` The initial vector for the CRC computation.

`poly` The control polynomial used in the computation.

`flags` Configuration flags

- `1` Reverses the bit order in both the input bytes and the resulting CRC.
- `2` The resulting CRC is XORed with 0xFFFF.
- `4` If `data` is a long array, all 4 bytes in a long are processed (LSB first).
- `8` Similar to flag 4, but processes MSB first.

`offset` The index of the first byte to be processed in the data array (usually 0).

Note: Similar functions exist for computing 32-bit and 8-bit CRCs: `long crc32(data, length, init, poly, flags, offset)` and `long crc8(data, length, init, poly, flags, offset)`. The initial vector, control polynomial, and flags for various protocols can be found at https://crccalc.com/

Examples:

- MODBUS: `crc16("123456789", -1, 0xFFFF, 0x8005, 1, 0)`
- DECT-X: `crc16("123456789", -1, 0, 0x0589, 0, 0)`

Additional Note: The `crc8(...)` and `crc32(...)` functions also exist, supporting 8-bit and 32-bit CRC calculations with the same parameter structure.

Remarks

- Data types of inputs `u0..u15`, outputs `y0..y15`, and parameters `p0..p15` are determined during the source code compilation.
- Error codes `< -99` require a `RESET` input for restarting the `REXLANG` block after addressing the cause of the error.
- ATTENTION!!! It is possible to read inputs in the `init()` function, but since other blocks usually do not set outputs in the init phase, there will always be 0. Outputs can be set, but usually this is not done.
- The `srcname` parameter can be specified with an absolute path. Otherwise, the file is searched for in the current directory and the specified directories (see the `LibraryPath` parameter of the `PARAM` block).
- Vector function parameters are primarily of type `double`, with the exception of the `n` parameter, which is of type long. Note that the functions with one vector parameter exist in three variants:

`double function(val1,...,valn)`
: Vector is defined as a sequence of values of type `double`.

`double function(n,val1,...,valn)`
: Vector is defined as in the first case, only the first parameter defines the number of values – the size of the vector. This variant is compatible with the C compiler. The `n`[2] parameter must be a number, not the so-called `const` variable and it must correspond with the number of the following elements defining the vector.

`double function(n,vec)`
: The `n` parameter is an arbitrary expression of type `long` and defines the number of elements the function takes into account.

- It's crucial to remember that arrays in the scripting language behave similarly to arrays in C: indexing begins at 0 and there is no automatic boundary checking. For instance, if you declare `double vec[10], x;`, the array `vec` will have elements indexed from 0 to 9. Accessing `vec[10]` does not trigger a syntax or runtime error, but the returned value is undefined since it's beyond the array bounds. Additionally, assigning a value to `vec[11]` (e.g., `vec[11] = x;`) can be particularly dangerous, as it may inadvertently overwrite adjacent memory locations. This could lead to unpredictable behavior or cause the program to crash.

- During the compilation process, if there are syntax errors, the compiler reports a `parser error` along with the line number where the error occurred. These reports specifically indicate issues with syntax. However, if the syntax appears correct and an error is still reported, it's advisable to check for conflicts involving identifiers, keywords, or function names, as these can also cause errors not immediately evident as syntax-related.

- All jumps are translated as relative, i.e. the corresponding code is restricted to 32767 instructions (in portable format for various platforms).

- All valid variables and the results of temporary computations are stored in the stack, which includes:
  - Global and local `static` variables are permanently located at the stack's base.
  - Return addresses for function calls.
  - Function parameters.
  - Variables local to functions.
  - The return value of a function.
  - Temporary computational results. For example, in the expression `a = b + c;`, `b` and `c` are first pushed onto the stack. Their sum is then calculated, the operands are popped off the stack, and the result is pushed onto the stack.

[2]The optional parameter `n` of the vector functions must be specified if the compatibility with C/C++ compiler is required. In such a case all the nonstandard functions must be implemented as well and the functions with variable number of parameters need to know the parameter count.

Simple variables such as `long` or `double` occupy one stack slot each. For arrays, the total occupied size matters, irrespective of the element type.

- When arrays are passed to functions, they are referenced rather than copied. This means only one stack slot is used for the reference, and the function operates directly on the original array.
- If the allocated stack size is insufficient (less than the space needed for global variables plus 10), it is automatically doubled, with an additional 100 slots for computational needs, function parameters, and local variables, especially when few global variables are defined.
- With basic debug level, various checks are conducted during script execution. These include the initialization of read values and array index boundary checks. Additionally, a few uninitialized values are inserted at both the start and end of each declared array for boundary checking, and `NOP` instructions with source file line numbers are added to the `*.ill` file.
- At full debug level, an additional check for invalid data range accesses (such as stack overflows) is enabled.
- In this context, an 'instruction' refers to a processor-independent mnemonic code. These codes are stored in the `*.ill` file.
- The `OpenCom()` function sets binary non-blocking mode without timeouts, 8 data bits, 1 stop bit, no parity, 19200 Baud. Optionally, the `baudrate` and `parity` parameters can be adjusted in the `OpenCom()` function.
- Accessing text files is significantly slower than binary files. However, text files offer the advantage of being viewable and editable without specialized software.
- The block does not automatically invoke the `parchange()` function. This function must be manually called within the `init()` function if needed.
- The `OpenFile()` function opens files in the data directory of the REXYGEN system (i.e., in Linux by default in `\rex\data`, on Windows `C:\ProgramData\REX Controls\REX_<version>\RexCore`). Subdirectories are allowed, but `..` is not permitted. Links are followed.

Debugging the code

Use the `Trace` command mentioned above.

Inputs

`HLD`	Hold – the block code is not executed if the input is set to `on`	`Bool`
`RESET`	Rising edge resets the block. The block gets initialized again (all global variables are cleared and the `Init()` function is called).	`Bool`
`u0..u15`	Input signals which are accessible from the script	`Any`

Outputs

`iE`	Runtime error code. For error codes `iE` < -99 the algorithm is stopped until it is reinitialized by the `RESET` input or by restarting the executive `0` ..... No error occurred, the whole `main()` function was executed (also the `init()` function). `-1` .... The execution was suspended using the `Suspend()` command, i.e. the execution will resume as soon as the `REXLANG` block is executed again `< -1` .. Error code of the REXYGEN system, see Appendix C `> 0` ... User-defined return values, algorithm execution without any change	`Error`
`y0..y15`	Output signals which can be set from within the script	`Any`

Parameters

`srcname`	Source file name ⊙`srcfile.c`	`String`
`srctype`	Coding of source file ⊙1 `1: C-like` Text file respecting the C-like syntax described above `2: STL` Text file respecting the IEC61131-3 standard. The standard is implemented with the same limitations as the C-like script (i.e. no structures, only INT, REAL and STRING data types, function blocks are global variables VAR_INPUT, outputs are global variables VAR_OUTPUT, parameters are global variables VAR_PARAMETER, standard functions according to specification, system and communication functions are the same as in C-like). `3: RLB` `REXLANG` binary file which results from compilation of C-like or STL scripts. Use this option if you do not wish to share the source code of your block. `4: ILL` Text file with mnemocodes, which can be compared to assembler. This choice is currently not supported.	`Long (I32)`
`stack`	Stack size defined as number of variables. Default and recommended value is 0, which enables automatic estimation of the necessary stack size.	`Long (I32)`
`debug`	Debug level – checking is safer but slows down the execution of the algorithm. Option `No check` can crash REXYGENapplication on target platform if code is incorrect. ⊙3 `1` ..... No check `2` ..... Basic check `3` ..... Full check	`Long (I32)`
`strs`	Total size of buffer for strings. Enter the maximum number of characters to allocate memory for. The default value 0 means that the buffer size is determined automatically.	`Long (I32)`
`p0..p15`	Parameters which are accessible from the script	`Any`

Example C-like

The following example shows a simple code to sum two input signals and also sum two user-defined parameters.

```
double input(0) input_u0;
double input(2) input_u2;

double parameter(0) param_p0;
double parameter(1) param_p1;

double output(0) output_y0;
double output(1) output_y1;

double my_value;

long init(void)
{
  my_value = 3.14;
  return 0;
}

long main(void)
{
  output_y0 = input_u0 + input_u2;
  output_y1 = param_p0 + param_p1 + my_value;
  return 0;
}

long exit(void)
{
  return 0;
}
```

Example STL

And here is the same example in Structured Text.

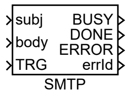
```
VAR_INPUT
  input_u0:REAL;
  input_u1:REAL;
  input_u2:REAL;
END_VAR

VAR_OUTPUT
  output_y0:REAL;
```

```
  output_y1:REAL;
END_VAR

VAR_PARAMETER
  param_p0:REAL;
  param_p1:REAL;
END_VAR

VAR
  my_value: REAL;
END_VAR

FUNCTION init : INT;
  my_value := 3.14;
  init := 0;
END_FUNCTION

FUNCTION main : INT;
  output_y0 := input_u0 + input_u2;
  output_y1 := param_p0 + param_p1 + my_value;
  main := 0;
END_FUNCTION

FUNCTION exit : INT;
  exit := 0;
END_FUNCTION
```

SMTP – Send e-mail message via SMTP

Block Symbol

Licence: ADVANCED



Function Description

The SMTP block sends a single e-mail message via standard SMTP protocol. The block acts as a simple e-mail client. It does not implement a mail server.

The contents of a message is defined by the inputs subj and body. Parameters from and to specify sender and receiver of a message. A message is sent when the TRG parameter is set. Then the BUSY output is set until the request is finished, which is signaled by the DONE output. In case of an error, the ERROR output is set. The errId output carries the last error identified by REXYGEN system error code. The domain parameter must always be set to identify the target device. The default value should work in most cases. There can be multiple recipients of the message. In such a case, the individual e-mail addresses must be comma-separated and no space character may be present.

The block may be run in non-blocking or blocking mode, which is specified by the BLOCKING parameter.

- In the *blocking mode*, the execution of a task is suspended until the sending of e-mail is completed. This mode is typically used in tasks with long execution period, $T_S \geq 10s$. If the e-mail is not successfully sent until timeout expires, an error is indicated and the execution of the task is resumed.

- In the *non-blocking mode*, the SMTP block performs only a single operation in each execution of the block and the execution of a task is not suspended. This mode is typically used in tasks with short execution period, $T_S \leq 0.1s$. In this mode, the timeout parameter should be set to at least $50 \cdot T_S$, where T_S is the execution period in seconds.

It is recommended to run the SMTP block in the non-blocking mode. It is however necessary to mention that on various operating systems some operations may not be performed in the non-blocking mode, so be careful and do not use this block in quick tasks (see QTASK) or in tasks with extremely short execution period (few milliseconds). The non-blocking mode is best supported on GNU/Linux operating system.

The block supports user authentication using standard SMTP authentication method. User name and password may be specified by the user and password parameters. The block also supports secure connection. The encryption method is selected by the tls parameter. It is also possible to let the block verify server's certificate by setting the

VERIFY parameter. SSL certificate of a server or server's trusted certificate authority must be stored in the certificate parameter in a PEM format. The block does not support any certificate storage.

The length of the whole message (subject, body and headers) is limited to a maximum of 1024 characters.

Inputs

subj	Subject of the e-mail message		String
body	Body of the e-mail message		String
TRG	Trigger of the selected action		Bool

Parameters

server	SMTP server address		String
to	E-mail of the recipient		String
from	E-mail of the sender		String
tls	Encryption method 1 ..... None 2 ..... StartTLS 3 ..... TLS	⊙1	Long (I32)
user	User name		String
password	Password		String
domain	Domain name or identification of the target device		String
auth	Authentication method 1 ..... Login 2 ..... Plain	⊙1	Long (I32)
certificate	Authentication certificate		String
VERIFY	Enable server verification (valid certificate)		Bool
timeout	Timeout interval		Double (F64)
BLOCKING	Wait for the operation to finish		Bool

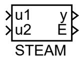
Outputs

BUSY	Sending e-mail		Bool
DONE	E-mail has been sent		Bool
ERROR	Error indicator		Bool
errId	Error code		Error

STEAM – Steam and water properties

Block Symbol

Licence: STANDARD



Function Description

The STEAM block calculates the thermodynamic properties of water and steam based on their other properties. The calculation is based on the IAPWS IF-97 standard (see http://www.iapws.org/relguide/IF97-Rev.pdf for more details). The units of temperature and pressure are defined by the parameter tunit and punit respectively; energy is in kilojoules (as it is used in IF-97 and by engineers), other properties use SI units. The function expressed by the block is defined by the func parameter. The parameter has the form <output property>_<1th input property><2nd input property> where properties is one of:

- T - Temperature
- p - Pressure
- h - Enthalpy [kJ/kg]
- v - Specific volume [m3/kg]
- rho - Density [kg/m3]
- s - Specific entropy
- u - Specific internal energy [kJ/kg]
- Cp - Specific isobaric heat capacity [kJ/kg/K]
- Cv - Specific isochoric heat capacity [kJ/kg/K]
- w - Speed of sound [m/s]
- my - Viscosity
- tc - Thermal Conductivity
- st - Surface Tension
- x - Vapour fraction
- vx - Vapour Volume Fraction

The output property can have attribute:

- sat - saturated value, i.e. for situation when water (liquid) is changed into steam (vapour)
- V - steam (vapour) for saturated conditions
- L - water (liquid) for saturated conditions

Examples:

- h_pT output is enthalpy for given pressure (1st input) and temperature (2nd input)
- Tsat_p saturated temperature (i.e. boiling temperature) for given pressure (1st input)
- hL_p enthalpy of (liquid) water for saturated conditions given by pressure (1st input)

Inputs

`u1`	1st input property		`Double (F64)`
`u2`	2nd input property (if required)		`Double (F64)`

Parameters

`func`	Calculated function	⊙1	`Long (I32)`
`punit`	Pressure unit 1 ..... MPa 2 ..... bar 3 ..... kPa	⊙1	`Long (I32)`
`tunit`	Temperature unit 1 ..... K 2 ..... °C	⊙1	`Long (I32)`

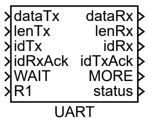
Outputs

`y`	Output property		`Double (F64)`
`E`	Error flag		`Bool`

UART – UART communication block

Block Symbol

Licence: STANDARD



Function Description

The UART block allows you to read and write data via the Universal Asynchronous Receiver-Transmitter. The port parameter specifies device name. There it is possible to use two name types:

- the address of the physical device – Usually /dev/ttyS* for Linux target or COM* for Windows. Replace "*" symbol according to the chosen serial port!
- the virtual address – REXYGEN enables the creation of a virtual UART with which you can communicate inside REXYGEN with other blocks supporting UART such as REXLANG, PYTHON, another UART block or Modbus driver. On Linux devices, the virtual port is marked with the prefix pty: (pseudo terminal) and it is possible to connect to it from another application running on the device. On Windows devices, it is possible to use the prefix vcom, which enables communication within REXYGEN. Virtual port examples: pty:/tmp/vslave, vcom:vmaster.

UART communication has several general properties that are set using parameters such as baudrate, parity, databits and stopbits. Each packet that is received or transmitted is assigned a unique ID. The ID of the next packet is always one higher than the ID of the previous packet. Once the maximum ID is reached, the next ID assigned will be 0. The maximum ID value is determined by the maxId parameter. Data is sent with the rising edge of the idTx input.

Inputs

dataTx	Vector reference to transmitted data		Reference
lenTx	Transmitted data length (0 = whole vector)	↓0	Long (I32)
idTx	ID of the transmitted data packet	↓0	Long (I32)
idRxAck	ID of the last processed received data packet	↓0	Long (I32)
WAIT	Transmission suspended flag (data is buffered) on .... The transmitted data is still in the buffer off ... The transmitted data (the entire buffer) is sent		Bool
R1	Block reset		Bool

Outputs

`dataRx`	Vector reference to received data		`Reference`
`lenRx`	Received data length	↓0	`Long (I32)`
`idRx`	ID of the received data packet	↓0	`Long (I32)`
`idTxAck`	ID of the last processed transmitted data packet	↓0	`Long (I32)`
`MORE`	Additional data in the receive buffer flag		`Bool`
`status`	Internal status indicator `0` ..... No Error `1` ..... Transmit buffer overflow `2` ..... Transmit data error `256` ... Received data error `-1` .... Failed to open port		`Long (I32)`

Parameters

`port`	Communication device name		`String`
`baudrate`	Baudrate [bis/s] (0 = not set)	↓0 ↑4000000	`Long (I32)`
`parity`	Parity `0` ..... Not set `1` ..... No parity `2` ..... Odd parity `3` ..... Even parity		`Long (I32)`
`databits`	Number of data bits (0 = not set)	↓0 ↑3	`Long (I32)`
`stopbits`	Number of stop bits (0 = not set)	↓0 ↑2	`Long (I32)`
`maxId`	Max value used as ID of a packet	↓2 ↑10000000 ⊙4	`Long (I32)`
`maxLen`	Maximum length of the received data	↓1 ↑10000000 ⊙64	`Long (I32)`
`nmax`	Allocated size of array	↓8 ↑10000000 ⊙256	`Long (I32)`

Chapter 17

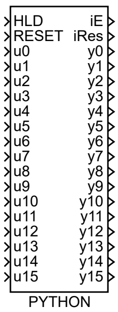
LANG – Special blocks

Contents

PYTHON – User programmable block in Python

Block Symbol

Licence: REXLANG



Function Description

The standard function blocks of the REXYGEN system cover the most typical needs in control applications. But there still exist situations where it is necessary (or more convenient) to implement an user-defined function. The REXLANG block covers this case for application where real-time behavior is strictly demanded. In the rest of the cases the PYTHON block can be used.

The PYTHON block implements an user-defined algorithm written in a Python scripting language and in comparison to the REXLANG block it provides a better user experience in the stage of development of the algorithm and can extend the feature set of REXYGEN system through various 3rd party libraries that are available in the Python environment.

Warning: the PYTHON block is intended for prototyping and experiments so please consider using the block in your application very carefully. It is an experimental block and always will be. There are many corner cases that may lead to unexpected behavior or even block the runtime. Packages may be poorly written or provide incorrect finalization and reinitialization which may even lead to a crash. Only a very limited support is provided for this block.

Scripting language

The scripting language is a standard Python v.3 language (see [13]). Every block references a script written in a *.py source file. The file can optionally contain functions with a reserved name that are then executed by REXYGEN. The `main()` function is executed periodically during runtime. Alongside the `main()` function the `init()` function is executed once at startup and after reset of the block, the `exit()` function is executed once when the control algorithm is stopped and before reset of the block and the `parchange()` function is executed on parameters change in REXYGEN.

Scripts on the target device

Standard python interpreter can load modules/scripts from various locations on the target device. The `PYTHON` block can reference any python script available for the standard interpreter and in addition the block can access scripts located in a directory `/rex/scripts/python`. User scripts can be directly uploaded to this directory or if the parameter `embedded` is set to `on` the script referenced by the block gets embedded in the REXYGEN configuration during compilation process and will be temporarily stored in the directory `/rex/scripts/python/embedded` during initialization of the block once the configuration is downloaded and executed on the target device.

Data exchange API

For the purpose of data exchange between a Python interpreter and REXYGEN system a module `PyRexExt` was developed as a native extension to the interpreter. The module contains an object `REX` that handles the data exchange operations. Use the following snippet at the start of the script to setup the data exchange API.

```
from PyRexExt import REX
```

I/O objects

`REX.u0 - REX.u15`
– objects representing block *inputs* in Python environment

`REX.p0 - REX.p15`
– objects representing block *parameters* in Python environment

`REX.y0 - REX.y15`
– objects representing block *outputs* in Python environment

Access to values

All I/O objects contain a property `v`. Reading of the property `v` performs a conversion from REXYGEN data types to Python data types. The value then can be stored in variables and used in the block algorithm. A REXYGEN array type converts into a list of values in case of one-dimensional array or into a list of lists in case of multidimensional array.
Example of reading a value of the block input:

```
x = REX.u0.v
```

Writing to the property `v`, on the other hand, performs a conversion from Python data types to REXYGEN data types and exports the value to the corresponding block output/parameter.
Example of writing a value to the block output:

```
REX.y0.v = 5
```

Arrays

Input and output objects have a readonly property `size`. It is a tuple with number of rows and columns. Arrays can be manipulated through property `v` but direct conversions between REXYGEN arrays and Python lists are not very memory efficient. However, input and output objects support indexing operator `[]` that restricts the conversion overhead only on the specified item.
Example of reading a value of the block input for one-dimensional array:

```
x = REX.u0[0]
```

Example of writing a value to the block output for multidimensional array:

```
REX.u0[1, 3] = 5
```

External items

The object `REX` contains a method `Item` that returns a handle to an external REXYGEN item based on a connection string specified in a parameter of the method.
Example of creating a handle to an external item and setting its value:

```
cns = REX.Item("myproject_task.CNS:scv")
cns.v = "abc"
```

Tracing

The object `REX` contains methods `Trace`, `TraceError`, `TraceWarning`, `TraceVerbose` and `TraceInfo` can be used to write messages into REXYGEN system log. Every message has a stacktrace attached.
Example of logging a message:

```
REX.Trace("abc")
```

Additional features

`REX.RexDataPath` – `RexDataPath` is a string constant that contains a path to a data folder of the `REX` system on the given platform. That can come handy for writing a platform independent code that requires access to the file system using absolute paths.

Inputs

`HLD`	Hold – the block code is not executed if the input is set to `on`	`Bool`
`RESET`	Rising edge resets the block. The block gets initialized again (all global variables are cleared and the `init()` function is called).	`Bool`
`u0..u15`	Input signals which are accessible from the script.	`Any`

Outputs

`iE`	Runtime error code. `0` ..... No error occurred, the whole `main()` function was executed (also the `init()` function). `xxx` ... Error code of the REXYGEN system, see Appendix C	`Error`
`iRes`	Execution result code.	`Long (I32)`
`y0..y15`	Output signals which can be set from within the script.	`Any`

Parameters

`srcname`	Source file name	⊙`program.py`	`String`
`embedded`	Embedding of the script	⊙`on`	`Bool`
`p0..p15`	Parameters which are accessible from the script.		`Any`

Data types definition

For data exchange between REXYGEN system and Python environment the data types of block inputs signals `u0..u15`, outputs signals `y0..y15` and parameters `p0..p15` must be explicitly specified. For that purpose a configuration file must be created for every python script with the same name plus a suffix `.cfg` (e.g. `program.py.cfg`). If the file is missing during the compilation process it is created with all signal types set to `double`. It is not expected this file to be edited directly. User should use a build-in editor specific to the `PYTHON` block instead. Available types for inputs outputs and parameters are `boolean`, `uint8`, `int16`, `uint16`, `int32`, `uint32`, `int64`, `float`, `double`, `string` and in addition the inputs and outputs support `array`, `numpy` and `image` data types.

For types `numpy` and `image` the `numpy` python package must be installed on the target device. Inputs of the type `numpy` expect the connected signal to be of the type `array` that gets converted in the runtime to a native `numpy` representation. Inputs of the type `image` expects the connected signal to be of the type `image` data type from the `RexVision` module that also gets converted in the runtime to a native `numpy` representation and can therefore be directly used with the `OpenCV` Python package.

Outputs of the type `numpy` expect to be set in the script from a `numpy` array object that gets converted to a regular `array`. Outputs of the type `image` expect to be set in the script from a `numpy` array object that gets converted to `image` data type defined in the `RexVision` module.

Example data types definition

The following example shows a shortened JSON file describing the data types of the program inputs and outputs.

```
{
    "types": {
        "in": [
            {
                "idx": 0,
                "type": "double"
            },
             . . .
            {
                "idx": 15,
                "type": "double"
            }
        ],
        "param": [
            {
                "idx": 0,
                "type": "double"
            },
             . . .
            {
                "idx": 15,
                "type": "double"
            }
        ],
        "out": [
            {
                "idx": 0,
                "type": "double"
            },
             . . .
            {
                "idx": 15,
                "type": "double"
            }
        ]
    }
}
```

Example Python script

The following example shows a simple code to sum two input signals and also sum two user-defined parameters.

```
from PyRexExt import REX

def main():
    REX.y0.v = REX.u0.v + REX.u1.v
    REX.y1.v = REX.p0.v + REX.p1.v
    return
```

Installation - Debian

The Python environment should be correctly installed and configured just by installing the `PythonBlk_T` debian package. To install the package with optional `numpy` and `OpenCV` packages execute these commands from the terminal.

```
sudo apt install rex-pythonblkt
sudo apt install python3-numpy python3-opencv
```

Installation - Windows

To install the correct version of Python the recommended way is to download and install the 64-bit version from official repository (https://www.python.org/ftp/python/3.9.6/). During the installation make sure to enable installation of the `pip` program and adding of the python binaries to the system variable `PATH`.

To install `numpy` and `OpenCV` as optional dependencies execute following commands from the command line.

```
pip install numpy
pip install opencv-python
```

Limitations

Due to the limitations of the standard Python interpreter implementation it is not recommended to use multiple `PYTHON` block instances at the different levels of executive. Doing so can lead to an unpredictable behavior and instability of the `RexCore` program.

Chapter 18

DSP – Digital Signal Processing blocks

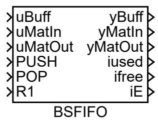
Contents

The DSP library is tailored for advanced digital signal processing. It includes blocks like `FFT` for Fast Fourier Transform operations and `PSD` for Power Spectral Density analysis. The library also features `BSFIFO`, `BSGET`, `BSGETV`, `BSSET`, and `BSSETV` for buffer storage and retrieval, enabling efficient data handling in signal processing tasks. Additionally, `MOSS` provides multi-objective signal selection capabilities. This collection of blocks is essential for sophisticated signal analysis and manipulation in digital systems.

BSFIFO – Binary Structure - Queueing serialize and deserialize

Block Symbol

Licence: ADVANCED



Function Description

This block sequentially adds or removes data to/from the buffer (passed to the `uBuff` input). The elementary unit in a buffer is a column. All matrices (ie matrices or vectors fed to the inputs `uBuff`, `uMatIn`, `uMatOut`) must have the same column size in bytes. Data is organized as either a queue (if `REV=off`) or a stack (if `REV=on`). The behavior of the block depends on the inputs in this way:

- If `PUSH=on`, the content of the `uMatIn` matrix (all defined columns) is inserted into the buffer.
- If `POP=on`, the number of columns determined by the `col` parameter is removed from the buffer and this data is inserted into the `uMatOut` matrix (it must be of sufficient size).
- If `R1=on`, the data is reloaded (mainly the number of valid columns) into the block buffer. Own data is transmitted by reference and is therefore shared. This signal has priority and blocks `PUSH`, `POP` signals.

Error states (e.g. mismatched matrix dimensions, insufficient space in some matrices, lack of data in the buffer) are indicated on the `iE` output and by a message in the SystemLog.

Inputs

`uBuff`	Binary Structure (array of bytes) input	`Reference`
`uMatIn`	Input reference to a matrix or vector (for PUSH)	`Reference`
`uMatOut`	Input reference to a matrix or vector (for POP)	`Reference`
`PUSH`	Enable push data	`Bool`
`POP`	Enable pop data	`Bool`
`R1`	Buffer reset (reload headers from `uBuff`)	`Bool`

Parameters

`OW`	Overwrite oldest items in buffer		`Bool`
`REV`	Pop last pushed item first		`Bool`
`col`	Number of output (pop) columns	⊙1	`Long (I32)`

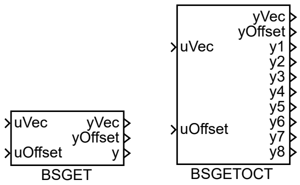
Outputs

`yBuff`	Copy of the `uBuff` input, for easy chaining	`Reference`
`yMatIn`	Output reference to a matrix or vector `uMatIn`	`Reference`
`yMatOut`	Output reference to a matrix or vector `uMatOut`	`Reference`
`iused`	Used bytes in queue	`Long (I32)`
`ifree`	Free bytes in queue	`Long (I32)`
`iE`	Error code	`Error`

BSGET, BSGETOCT – Binary Structure - Get a single value of given type

Block Symbols

Licence: ADVANCED



Function Description

This group of blocks is used for obtaining values from a binary structure (byte array). The BSSET and BSSETOCT blocks can be used to write to the binary structure.
If binary structures are received using communication, it is possible to process them directly in the block mediating communication. Typically this is a REXLANG or PYTHON programmable block. Using structures, however, it is possible to transfer data within the REXYGEN application as well. The binary structure is fed in the form of an array (vector) of bytes to the `uVec` input. The `uOffset` input specifies the offset (in bytes) of the desired value from the beginning of the structure. The value type is specified by the `type` parameter.
The `yOffset` output is the start of the next element in the structure. This is advantageous for chaining: if the structure contains several elements in a row, it is possible to connect the input `uOffset` to the output `yOffset` of the previous block and it is not necessary to calculate the offset.
The only difference between the blocks is that `BSGET` gets a single value. The `BSGETOCT` block is able to receive up to 8 values (the number is determined by the `m` parameter).

Inputs

`uVec`	Binary Structure (array of bytes) input	`Reference`
`uOffset`	Offset to start in the input Binary Structure (in bytes)	`Long (I32)`

Outputs

`yVec`	Copy of the `uVec` input, for easy chaining	`Reference`
`y`	Scalar value output (scalar type defined by parameter)	`Any`
`yOffset`	Offset after the last processed byte of the input Binary Structure (in bytes), for easy chaining	`Long (I32)`

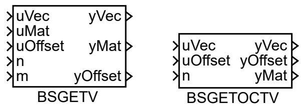
Parameters

`m`	Number of used values (for multi-blocks)	↓1 ↑8 ⊙8	`Long (I32)`
`BE`	Big-Endian byte order (default is Little-Endian, e.g. Intel)		`Bool`
`type`	Data type of item	↓2 ↑10 ⊙2	`Long (I32)`

BSGETV, BSGETOCTV – Binary Structure - Get matrix (all values of the same given type)

Block Symbols

Licence: ADVANCED



Function Description

This group of blocks is used for obtaining values from a binary structure (byte array). The BSSETV and BSSETOCTV blocks can be used to write to the binary structure.
The meaning of most of the parameters is the same as the BSGET block, but these blocks retrieve several values of the same type and store them in an array (matrix). A matrix always has m rows and n columns. For the BSGETV block, all elements are of the same type (determined by the type parameter) and the data is filled into the matrix fed to the uMat input. The BSGETOCTV block loads up to 8 vectors. Each row of the matrix can be of a different type. The block allocates the matrix itself. The matrix is available at the yMat output.

Inputs

uVec	Binary Structure (array of bytes) input	Reference
uMat	Reference of matrix for output values	Reference
uOffset	Offset to start in the input Binary Structure (in bytes)	Long (I32)
n	Number of matrix columns	Long (I32)
m	Number of active items	Long (I32)

Outputs

yVec	Copy of the uVec, for easy chaining	Reference
yMat	Copy of the uMat, for easy chaining	Reference
yOffset	Offset after the last processed byte of the input Binary Structure (in bytes), for easy chaining	Long (I32)

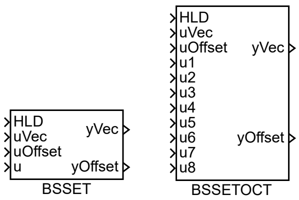
Parameters

m	Number of active items (for multi-blocks)	↓1 ↑8 ⊙8	Long (I32)
BE	Big-Endian byte order (default is Little-Endian, e.g. Intel)		Bool
nmax	Allocated size of output matrix (total number of items) yMat	↓1 ⊙32	Long (I32)
type	Data type of item	↓2 ↑10 ⊙2	Long (I32)

BSSET, BSSETOCT – Binary Structure - Set a single value of given type

Block Symbols

Licence: ADVANCED



Function Description

This group of blocks is used for setting values into a binary structure (byte array). The function is the inverse of the BSGET and BSGETOCT blocks, i.e. all signals have the same meaning, only the data is copied in the opposite direction - from the `u` input to the binary structure represented by the byte array connected to the `uVec` input. The block modifies the binary structure only if `HLD=off`.

Inputs

HLD	Hold	Bool
uVec	Binary Structure (array of bytes) input	Reference
uOffset	Offset to start in the input Binary Structure (in bytes)	Long (I32)
u	Scalar value input (scalar type defined by parameter)	Any

Outputs

yVec	Copy of the `uVec` input, for easy chaining	Reference
yOffset	Offset after the last processed byte of the input Binary Structure (in bytes), for easy chaining	Long (I32)

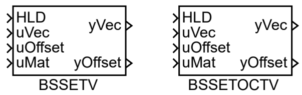
Parameters

m	Number of active items (for multi-blocks)	↓1 ↑8 ⊙8	Long (I32)
BE	Big-Endian byte order (default is Little-Endian, e.g. Intel)		Bool
type	Data type of item	↓2 ↑10 ⊙2	Long (I32)

BSSETV, BSSETOCTV – Binary Structure - Set matrix of given type

Block Symbols

Licence: ADVANCED



Function Description

This group of blocks is used to set the matrix of values into a binary structure (byte array). The function is the inverse of the BSGETV and BSGETOCTV blocks, i.e. all signals have the same meaning, only the data is copied in the opposite direction - from the `uMat` input to the binary structure represented by the byte array connected to the `uVec` input. The block modifies the binary structure only if `HLD=off`.
Unlike the BSGETV block, the numbers of rows and columns are not specified, but are determined from the actual size of the matrix connected to the `uMat` input.

Inputs

HLD	Hold	Bool
uVec	Binary Structure (array of bytes) input	Reference
uOffset	Offset to start in the input Binary Structure (in bytes)	Long (I32)
uMat	Reference of the matrix with input values	Reference

Outputs

yVec	Copy of the `uVec` input, for easy chaining	Reference
yOffset	Offset after the last processed byte of the input Binary Structure (in bytes), for easy chaining	Long (I32)

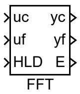
Parameters

m	Number of active items (for multi-blocks)	↓1 ↑8 ⊙8	Long (I32)
BE	Big-Endian byte order (default is Little-Endian, e.g. Intel)		Bool
type	Data type of item	↓2 ↑10 ⊙2	Long (I32)

FFT – Fast Fourier Transform block

Block Symbol

Licence: ADVANCED



Function Description

The function block FFT computes Fast Fourier Transform using the PocketFFT package [14]. The PocketFFT C99 implementation is based on FFTPack (in Fortran) [15], which is based on the chapter in [16].

Input data (a vector or a matrix) of the block are referenced by the uc input. If the input uc refers to a column vector (number of columns m = 1) with the number of elements n, the FFT will be calculated from a single signal with n elements. If uc refers to a matrix with n rows and m columns, the FFT will be computed m times (once for each column).

Input data is processed according to the mode parameter (see below), which determines whether the calculation will be performed for real or complex data and forward or backward FFT. More precisely, one of the rfft_forward(), rfft_backward(), cfft_forward() or cfft_backward() functions of the PocketFFT package is called according to the mode parameter.

Output data are referenced by the uf input. The data has the same number of n rows and m columns as the data referenced by uc. If the uf input is connected to preallocated vector/matrix then the FFT algorithm output data are referenced by the yf output. If the uf input is not connected, the FFT is calculated in place and the output data is stored in the array referenced by the yc output and the original data referenced by uc is overwritten.

The uc reference is copied to the yc output, the uf reference is copied to the yf output.

The HLD input allows the user to temporarily stop the FFT calculation.

Inputs

uc	Input reference to input/output data	Reference
uf	Input reference to optional output data	Reference
HLD	The HLD=on freezes the FFT computation	Bool

Parameters

`mode`	FFT computation mode `1` ..... Real forward `2` ..... Real backward `3` ..... Complex forward `4` ..... Complex backward	↓1 ↑4 ⊙1	`Long (I32)`

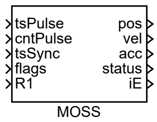
Output

`yc`	Output reference to input/output data	`Reference`
`yf`	Output reference to optional output data	`Reference`
`E`	Error indicator	`Bool`

MOSS – Motion smart sensor

Block Symbol

Licence: ADVANCED



Function Description

The MOSS block implements a precise position filter for a quadrature (incremental) encoder. The implementation requires special hardware that produce not only pulse count, but also the exact timestamp of last pulse, the direction of last pulse and the timestamp of the block start execution time (or similar reference time). Both timestamps must be from the same (or synchronized) source. The output of the MOSS block is not only the filtered position, but also the filtered velocity and acceleration. The filtering level is set by the **alpha** parameter. The setting is a compromise between noise reduction and signal delay (averaging).

Note 1: Some people think that a quadrature encoder will get a precise position value (accurate to 1 pulse) and the exact velocity could be obtained by dividing the pulse difference by the time difference. We believe that the MOSS block achieve better results. You can put both values into a graph (the TRND block) and check the differences.

Note 2: The filter is implemented as a Kalman filter for a second-order system (input is acceleration, output is position) discretized for a variable sampling period (current timestamp difference). Input and output noises are necessary parameters for Kalman filter design. If both noises are Gaussian, the only parameter is ratio of input and output noise that is the **alpha** parameter of the MOSS block.

Inputs

tsPulse	Last pulse timestamp	DWord (U32)
cntPulse	Last pulse count	DWord (U32)
tsSync	Timestamp of the Sync pulse. The Sync pulse is the time when the filtered outputs are valid.	DWord (U32)
flags	Input status flags (1: POS, 2: NEG, 4: RUN)	DWord (U32)
R1	Block reset	DWord (U32)

Parameters

freq	Source timestamp tick frequency [Hz] ↓0.0 ⊙100000000.0	Double (F64)
stall	Stalled time [s]. If no pulse is received in the stalled time interval, sensor is considered stopped and the outputs (pos, vel,acc) are set to 0. ↓0.0 ⊙0.08	Double (F64)

`alpha`	Kalman filter design parameter. A lower value means smoother (less noise) outputs, but more delayed in dynamic situation (when acceleration is changing). ↓0.0 ↑200.0 ⊙26.0	`Double (F64)`
`maxpos`	Kalman filter rounding optimization. If `pos` is greater then `maxpos`, the internal position processed by the Kalman filter is decremented by an integer multiple of `maxpos` and incremented back for output. This causes the filter algorithm to calculate small enough numbers and not reduce accuracy due to rounding errors. The default value should not normally be changed. ↓0.0 ⊙1e+10	`Double (F64)`
`mindivert`	Predictor minimal divert time [s]. If no pulse is received for a long time, the predictor output will drift. To overcome this drift, if no pulse is detected for longer then `mindivert` time, the output position is clamped to +-1 pulse from input (mesured) position. ↓0.0 ⊙0.003	`Double (F64)`

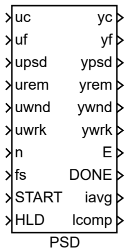
Outputs

`pos`	Filtered position	`Double (F64)`
`vel`	Filtered velocity	`Double (F64)`
`acc`	Filtered acceleration	`Double (F64)`
`status`	Output status flags (1: POS, 2: NEG, 4: RUN, 8: INIT, 16: PULSE, 32: STALLED, 64: DIVERT)	`Long (I32)`
`iE`	Error code `i` ..... REXYGEN general error	`Error`

PSD – Power Spectral Density block

Block Symbol

Licence: ADVANCED



Function Description

The function block PSD computes a power spectral density (PSD, periodogram) using the PocketFFT package [14]. The PocketFFT C99 implementation is based on FFTPack (in Fortran) [15], which is based on the chapter in [16].

PSD is most often calculated from segments of length N samples of the input signal. The data of these segments is multiplied by a window function (e.g. Hamming window), the FFT is calculated from them, and the PSD of each segment is calculated from its result. Finally, the navg of such results is averaged (the navg parameter). The input signal can be divided into segments either sequentially or with a half-overlap (Welch method [17], [18]). The resulting PSD can be calculated in decibels (dB) if the parameter DB = on.

Input data (a vector or a matrix) of the block are referenced by the uc input. If the input uc refers to a column vector (number of columns m = 1) with the number of elements n, the PSD will be calculated from a single signal. If uc refers to a matrix with n rows and m columns, the PSD will be computed m times (for each column). If the input $n > 0$ then the number of samples per segment N = n else N is set to the number of rows of the array referenced by uc.

The input uf references the internal vector of dimension $\geq$ N for FFT computing. The resulting PSD with npsd rows and m columns is referenced by upsd. Number of PSD frequencies npsd $= N/2 + 1$ for even N or npsd $= (N + 1)/2$ for odd N. Working array referenced by uwrk has the same dimension as the array referenced by upsd. If the input data contains more elements than can be processed in one execution of the PSD block, the remaining data is copied into an array referenced by urem that has N rows and m columns.

Input data is processed according to the mode and mtrig parameters (see below). The mode parameter specifies the way the PDS is calculated, whether the data in the input vector referenced by uc is real or complex, and whether segment overlapped by half will be used. The input data sampled with the frequency connected to the input fs may be acquired in a different task (e.g. with a significantly shorter sampling period) than the one in which the PSD is calculated. The method of synchronizing the start of the calculation is provided by the `mtrig` trigger mode. The calculation can be triggered every PSD block execution period or when a sufficient number of samples are available (at least equal to `N`) or by the rising edge of the `START` input.

A vector of dimension `N` is connected to the `uwnd` input to store the window function selected by the `iwin` parameter. Window functions have (optionally) an integer parameter `lwnd` and/or a real parameter `rwnd`. Some window functions are used in two variants:

Symmetric (for `lwnd=0`). The window of length $L = \mathtt{N}$ samples is computed, the first and last elements are equal. This variant is suitable for FIR filter design.

Periodic (for `lwnd=1`). The window of length $L = \mathtt{N} + 1$ is computed but only the first `N` samples is stored. The periodic version is the preferred method for spectral analysis because the discrete Fourier transform assumes periodic extension of the input vector.

Window functions are defined by the following expressions:

`iwin=1` **Bartlett-Hahn Window**

$$w(n) = 0.62 - 0.48\left|\left(\frac{n}{N-1} - 0.5\right)\right| + 0.38\cos\left[2\pi\left(\frac{n}{N-1} - 0.5\right)\right],\ 0 \le n \le N-1.$$

`iwin=2` **Bartlett Window**

$$w(n) = \begin{cases} \dfrac{2n}{N}, & 0 \le n \le \dfrac{N}{2}, \\ 2 - \dfrac{2n}{N}, & \dfrac{N}{2} \le n \le N. \end{cases}$$

`iwin=3` **Blackman Window**

$$w(n) = 0.42 - 0.5\cos\left(\frac{2\pi n}{L-1}\right) + 0.08\cos\left(\frac{4\pi n}{L-1}\right),\ 0 \le n \le M-1,$$

where M is $N/2$ when N is even and $(N+1)/2$ when N is odd.

`iwin=4` **Blackman-Harris Window**

$$w(n) = a_0 - a_1\cos\left(\frac{2\pi n}{L-1}\right) + a_2\cos\left(\frac{4\pi n}{L-1}\right) - a_3\cos\left(\frac{6\pi n}{L-1}\right),\ 0 \le n \le N-1$$

where $a_0 = 0.35875$, $a_1 = 0.48829$, $a_2 = 0.14128$ and $a_3 = 0.01168$.

`iwin=5` **Bohman Window**

$$w(x) = (1 - |x|)\cos(\pi |x|) + \frac{1}{\pi}\sin(\pi |x|),\ \ -1 \le x \le 1$$

`iwin=6` **Chebyshev Window**

Using Chebyshev polynomials of n-th order

$$T_n(x) \triangleq \begin{cases} \cos\left[n\cos^{-1}(x)\right], & |x| \le 1, \\ \cosh\left[n\cosh^{-1}(x)\right], & |x| > 1, \end{cases}$$

the Fourier transform of the Chebyshev window is

$$W(k) = \frac{T_{N-1}\left[x_0\cos(\pi k/N)\right]}{T_{N-1}(x_0)}$$

where

$$x_0 = \cosh\left[\frac{\cosh^{-1}\left(10^{r/20}\right)}{N-1}\right].$$

`iwin=7` **Flat Top Window**

$$w(n) = a_0 - a_1\cos\left(\frac{2\pi n}{L-1}\right) + a_2\cos\left(\frac{4\pi n}{L-1}\right) - a_3\cos\left(\frac{6\pi n}{L-1}\right) + a_4\cos\left(\frac{8\pi n}{L-1}\right),$$

where $0 \le n \le N-1$ and $a_0 = 0.21557895$, $a_1 = 0.41663158$, $a_2 = 0.277263158$, $a_3 = 0.083578947$ and $a_4 = 0.006947368$.

`iwin=8` **Gauss Window**

$$w(n) = e^{-\frac{1}{2}\left[\alpha\frac{n}{(N-1)/2}\right]^2} = e^{-n^2/(2\sigma^2)}$$

where $-(N-1)/2 \le n \le (N-1)/2$ and $\sigma = (N-1)/(2\alpha)$ is the standard deviation of a Gaussian probability density function.

`iwin=9` **Hamming Window**

$$w(n) = 0.54 - 0.46\cos\left(2\pi\frac{n}{L-1}\right),\ 0 \le n \le N-1,$$

`iwin=10` **Hann Window**

$$w(n) = 0.5\left[1 - \cos\left(2\pi\frac{n}{L-1}\right)\right],\ 0 \le n \le N-1,$$

`iwin=12` **Nuttall's Blackman-Harris Window**

$$w(n) = a_0 - a_1\cos\left(\frac{2\pi n}{L-1}\right) + a_2\cos\left(\frac{4\pi n}{L-1}\right) - a_3\cos\left(\frac{6\pi n}{L-1}\right),\ 0 \le n \le N-1$$

where $a_0 = 0.3635819$, $a_1 = 0.4891775$, $a_2 = 0.1365995$ and $a_3 = 0.0106411$.

`iwin=13` **Parzen Window**

$$w(n) = \begin{cases} 1 - 6\left(\dfrac{|n|}{N/2}\right)^2 + 6\left(\dfrac{|n|}{N/2}\right)^3, & 0 \le |n| \le (N-1)/4, \\ 2\left(1 - \dfrac{|n|}{N/2}\right)^3, & (N-1)/4 < |n| \le (N-1)/2. \end{cases}$$

`iwin=14` **Rectangular Window**

$$w(n) = 1,\ 0 \le n \le N-1.$$

Multiplication of all input data elements by 1 is not performed in this block, therefore the `uwnd` input may not be connected in this case.

`iwin=16` **Triangular Window**

For N odd:

$$w(n) = \begin{cases} \dfrac{2n+2}{N+1}, & 0 \le n \le (N-1)/2, \\ 2 - \dfrac{2n+2}{N+1}, & (N-1)/2 < n \le (N-1). \end{cases}$$

For N even:

$$w(n) = \begin{cases} \dfrac{2n+1}{N}, & 0 \le n \le N/2 - 1, \\ 2 - \dfrac{2n+1}{N}, & N/2 \le n \le (N-1). \end{cases}$$

`iwin=17` **Tukey Window**

$$w(x) = \begin{cases} \dfrac{1}{2}\left\{1 + \cos\left(\dfrac{2\pi}{r}\left[x - r/2\right]\right)\right\}, & 0 \le x < \dfrac{r}{2}, \\ 1, & \dfrac{r}{2} \le x < 1 - \dfrac{r}{2}, \\ \dfrac{1}{2}\left\{1 + \cos\left(\dfrac{2\pi}{r}\left[x - 1 + r/2\right]\right)\right\}, & 1 - \dfrac{r}{2} \le x < 1, \end{cases}$$

where r is so called cosine fraction (set in the parameter `rwnd`, default value 0.5).

`iwin=18` **Exponential Window**

$$w(x) = e^{-\frac{|x|}{\tau}},\ \ -1 \le x \le 1,$$

where τ is a window parameter (set in the parameter `rwnd`).

`iwin=19` **Welch Window**

$$w(x) = 1 - x^2,\ \ -1 \le x \le 1.$$

iwin=20 Externally Defined Window

If the user is not satisfied with any of the predefined windows, he/she can set his own window consisting of N samples in the vector referenced by uwnd before executing the PSD block.

The HLD input allows the user to temporarily stop the PSD calculation.

Inputs

uc	Input reference to input data	Reference
uf	Input reference to internal FFT vector	Reference
upsd	Input reference to output PSD vector/matrix	Reference
urem	Input reference to remaining (not processed) data	Reference
uwnd	Input reference to window function vector	Reference
uwrk	Input reference to working vector/matrix	Reference
n	Number of signal samples for FFT segment	Long (I32)
fs	Sampling frequency in [Hz]	Double (F64)
START	Starting signal (rising edge)	Bool
HLD	The HLD=on freezes the computation	Bool

Parameters

mode	PSD computation mode 1 ..... Real forward 2 ..... Real backward 3 ..... Complex forward 4 ..... Complex backward	↓1 ↑4 ⊙1	Long (I32)
mtrig	Computation trigger mode 1 ..... Each period 2 ..... Enough samples 3 ..... START rising edge 4 ..... Complex overlap	↓1 ↑3 ⊙1	Long (I32)
iwnd	Window function 1 ..... Bartlett-Hann 11 .... — 2 ..... Bartlett 12 .... Nuttall 3 ..... Blackman 13 .... Parzen 4 ..... Blackman-Harris 14 .... Rectangular 5 ..... Bohman 15 .... — 6 ..... Chebyshev 16 .... Triangular 7 ..... Flat top 17 .... Tukey 8 ..... Gaussian 18 .... Exponential 9 ..... Hamming 19 .... Welch 10 .... Hann 20 .... External	↓1 ↑9 ⊙1	Long (I32)
lwnd	Parameter lwnd of some window	↓1 ↑9 ⊙1	Long (I32)
rwnd	Parameter rwnd of some window	↓1 ↑9 ⊙1	Long (I32)
navg	Number of FFT segments for averaging	↓1 ⊙10	Long (I32)

`DB`	Computed PSD is converted do decibels [dB]	`Bool`

Output

`yc`	Output reference to input data	`Reference`
`yf`	Output reference to internal FFT vector	`Reference`
`ypsd`	Output reference to output PSD vector/matrix	`Reference`
`yrem`	Output reference to remaining (not processed) data	`Reference`
`ywnd`	Output reference to window function vector	`Reference`
`ywrk`	Output reference to working vector/matrix	`Reference`
`E`	Error indicator	`Bool`
`DONE`	Averaging Completion Flag	`Bool`
`iavg`	Current index of segment for averaging	`Long (I32)`
`lcomp`	Number of successfully computed PSDs	`Large (I64)`

Chapter 19

MQTTDrv – Communication via MQTT protocol

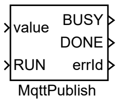
Contents

The MQTTDrv library is designed for IoT (Internet of Things) communication using the MQTT (Message Queuing Telemetry Transport) protocol. It consists of two primary blocks: MqttPublish and MqttSubscribe. The MqttPublish block is used for sending messages to an MQTT broker, enabling the publication of data to MQTT topics. Conversely, the MqttSubscribe block is designed for subscribing to topics and receiving messages from a broker. This library facilitates efficient and effective data communication in IoT applications, leveraging the lightweight and widely-used MQTT protocol for message exchange.

`MqttPublish` – Publish MQTT message

Block Symbol

Licence: MQTT



Function Description

This function block depends on the MQTT driver. Please read the `MQTTDrv` manual [19] before use.

The `MqttPublish` block publishes messages to an MQTT broker through the connection established by the `MQTTDrv` driver.

The first parameter is the `topic` the block will publish the messages to. MQTT delivers Application Messages according to the Quality of Service (QoS) levels. Use the `QoS` parameter to set a different Quality of Service level. See the MQTT specification [20] for more details.

If the `RETAIN` parameter is set a RETAIN flag will be set on the outgoing PUBLISH Control Packet. See the MQTT specification [20] for more details.

The `defBuffSize` parameter can be used to optimize the memory usage of the block. It states the amount of the statically allocated memory for the inner buffer for the outgoing messages. If the value is unnecessarily large the memory is being wasted. On the other hand if the value of the parameter is too small it leads to frequent dynamic memory allocations which can be time consuming.

The message to be published is constructed from the `value` input signal. The `value` input signal is expected to be a string. If it is not a string it will be converted automatically. To request a message to be published in the current period set the `RUN` flag to `on`. The `BUSY` flag is `on` if the block has a pending request and waits for a response from a broker. When the response is received in the current cycle the `DONE` flag is set to `on`.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`value`	Input signal	`String`
`RUN`	Enable execution	`Bool`

Parameter

`topic`	MQTT topic	`String`

QoS	Quality of Service 1 ..... QoS0 (At most once) 2 ..... QoS1 (At least once) 3 ..... QoS2 (Exactly once)	⊙1	Long (I32)
RETAIN	Retain last message	⊙on	Bool
defBuffSize	Default buffer size	↓1 ⊙2048	Long (I32)

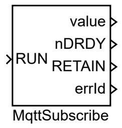
Output

BUSY	Busy flag	Bool
DONE	Indicator of finished transaction	Bool
errId	Error code	Error

`MqttSubscribe` – Subscribe to MQTT topic

Block Symbol

Licence: MQTT



Function Description

This function block depends on the MQTT driver. Please read the `MQTTDrv` manual [19] before use.

The `MqttSubscribe` block subscribes to a topic on an MQTT broker and receives Publish messages on that topic through the connection established by the `MQTTDrv` driver.

The first parameter is the `topic` the block will subscribe to. MQTT protocol delivers Application Messages according to the Quality of Service (QoS) levels. Use the `QoS` parameter to set a different Quality of Service level. See the MQTT specification [20] for more details.

By setting the `type` parameter of the block it can be specified the expected data type of the incoming message. The block converts the incoming message to the specified type and sets the `value` output signal in case of success or it sets the `errId` to the resulting error code.

The `mode` parameter has two available options: `Last value` and `Buffered values`. If `Last value` mode is used the block will always output only the last message received even if multiple messages were received in the last period. If the `mode` is set to `Buffered values` than the block buffers the incoming messages and outputs one by one in consecutive ticks of the task.

The `defBuffSize` parameter can be used to optimize the memory usage of the block. It states the amount of the statically allocated memory in the inner buffer for the incoming messages. If the value is unnecessarily large the memory is being wasted. On the other hand if the value of the parameter is too small it leads to frequent dynamic memory allocations which can be time consuming.

A Subscribe action is performed upon a rising edge (`off`→`on`) and an Unsubscribe action is performed upon a falling edge (`on`→`off`) at the `RUN` input.

The `nDRDY` output specifies how many messages were received and are available in the inner buffer. If the `mode` of the block is set to `Last value` the `nDRDY` output can only have value `0` or `1`.

The `RETAIN` output flag is set if the received Publish packet had the `RETAIN` flag set. See the MQTT specification [20] for more details.

Note that subscribing to topics containing wildcards is not supported.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

RUN	Enable execution		Bool

Parameter

topic	MQTT topic		String
QoS	Quality of Service 1 ..... QoS0 (At most once) 2 ..... QoS1 (At least once) 3 ..... QoS2 (Exactly once)	⊙1	Long (I32)
type	Expected type of incoming data 1 ..... string 2 ..... double 3 ..... long 4 ..... bool 5 ..... byte vector/blob	⊙1	Long (I32)
mode	Incoming messages buffering mode 1 ..... Last value 2 ..... Buffered values	⊙1	Long (I32)
defBuffSize	Default buffer size	↓1 ⊙2048	Long (I32)

Output

value	Output signal		Any
nDRDY	Number of received messages	↓0 ↑10	Long (I32)
RETAIN	Retain last message	⊙on	Bool
errId	Error code		Error

Chapter 20

MC_SINGLE – Motion control - single axis blocks

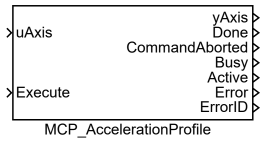
Contents

The MC_SINGLE library is designed for motion control in single-axis systems. It features blocks like MC_MoveAbsolute, MC_MoveRelative, and MC_MoveVelocity for precise positioning and speed control. The library includes MC_Home for homing operations, and MC_Power for controlling the power state of the axis. Advanced functionalities are provided by MC_AccelerationProfile, MC_PositionProfile, and MC_VelocityProfile for customizing motion profiles. It also offers monitoring and parameter adjustment capabilities through MC_ReadActualPosition, MC_ReadAxisError, MC_ReadParameter, and MC_WriteParameter. Additionally, the library contains blocks like MC_Halt, MC_Reset, and MC_Stop for emergency and control operations. This library is essential for applications requiring precise and controlled motion in single-axis configurations.

MCP_AccelerationProfile – * Acceleration profile

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`alg`	Algorithm for interpolation 1 ..... Sequence of time/value pairs 2 ..... Sequence of equidistant values 3 ..... Spline 4 ..... Equidistant spline 5 ..... Sequence of time/value pairs (+border) 6 ..... Sequence of equidistant values (+border) 7 ..... cubic aproximation (B-spline) 8 ..... quintic aproximation (B-spline) 9 ..... all linear	⊙1	`Long (I32)`
`nmax`	Number of profile segments	⊙3	`Long (I32)`
`TimeScale`	Overall scale factor in time	⊙1.0	`Double (F64)`
`AccelerationScale`	Overall scale factor in value	⊙1.0	`Double (F64)`
`Offset`	Overall profile offset in value		`Double (F64)`

BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	Long (I32)
times	Times when segments are switched	⊙[0 30]	Double (F64)
values	Values or interpolating polynomial coefficients (a0, a1, a2, ...)	⊙[0 100 100 50]	Double (F64)

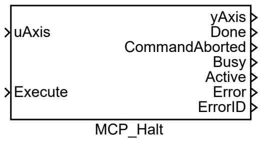
Output

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_Halt – * Stopping a movement (interruptible)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)		`Reference`
`Execute`	The block is activated on rising edge		`Bool`

Parameter

`Deceleration`	Maximal allowed deceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered	⊙1	`Long (I32)`

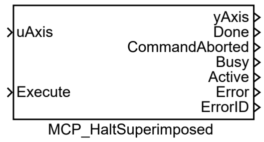
Output

`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)		`Reference`
`Done`	Algorithm finished		`Bool`
`CommandAborted`	Algorithm was aborted		`Bool`
`Busy`	Algorithm not finished yet		`Bool`
`Active`	The block is controlling the axis		`Bool`
`Error`	Error occurred		`Bool`
`ErrorID`	Result of last operation i ..... REXYGEN error code		`Error`

MCP_HaltSuperimposed – * Stopping a movement (superimposed and interruptible)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)		`Reference`
`Execute`	The block is activated on rising edge		`Bool`

Parameter

`Deceleration`	Maximal allowed deceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting `2` ..... Buffered	⊙1	`Long (I32)`

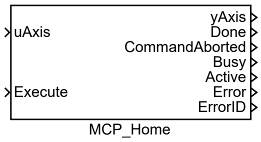
Output

`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)		`Reference`
`Done`	Algorithm finished		`Bool`
`CommandAborted`	Algorithm was aborted		`Bool`
`Busy`	Algorithm not finished yet		`Bool`
`Active`	The block is controlling the axis		`Bool`
`Error`	Error occurred		`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code		`Error`

MCP_Home – * Homing

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`TorqueLimit`	Maximal allowed torque/force	`Double (F64)`
`TimeLimit`	Maximal allowed time for the whole algorithm [s]	`Double (F64)`
`DistanceLimit`	Maximal allowed distance for the whole algorithm [unit]	`Double (F64)`
`LagLimit`	Maximal allowed lag for the whole algorithm [unit]	`Double (F64)`
`Direction`	Direction of movement (cyclic axis or special case only) ⊙3 1 ..... Positive 2 ..... Shortest 3 ..... Negative 4 ..... Current	`Long (I32)`
`Position_`	Requested target position (absolute) [unit]	`Double (F64)`

`HomingMode`	Homing mode algorithm 1 ..... Absolute switch 2 ..... Limit switch 3 ..... Reference pulse 4 ..... Direct (user reference) 5 ..... Absolute encoder 6 ..... Block 7 ..... reserved1 8 ..... reserved2	⊙1	`Long (I32)`

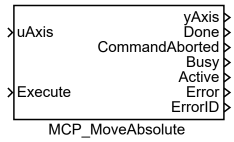
Output

`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation i ..... REXYGEN error code	`Error`

MCP_MoveAbsolute – * Move to position (absolute coordinate)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`Position_`	Requested target position (absolute) [unit]		`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]	↓0.0	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	↓0.0	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	↓0.0	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	↓0.0	`Double (F64)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`
`Direction`	Direction of movement (cyclic axis or special case only) 1 ..... Positive 2 ..... Shortest 3 ..... Negative 4 ..... Current	⊙1	`Long (I32)`

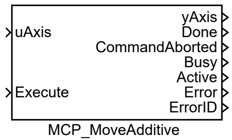
Output

`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_MoveAdditive – * Move to position (relative to previous motion)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool

Parameter

Distance	Requested target distance (relative to start point) [unit]		Double (F64)
Velocity	Maximal allowed velocity [unit/s]	↓0.0	Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]	↓0.0	Double (F64)
Deceleration	Maximal allowed deceleration [unit/s^2]	↓0.0	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	↓0.0	Double (F64)
BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	Long (I32)

Output

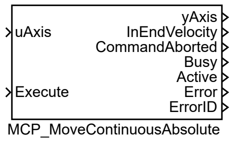
yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool

`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_MoveContinuousAbsolute – * Move to position (absolute coordinate)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`Position_`	Requested target position (absolute) [unit]		`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]	↓0.0	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	↓0.0	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	↓0.0	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	↓0.0	`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting `2` ..... Buffered `3` ..... Blending low `4` ..... Blending high `5` ..... Blending previous `6` ..... Blending next	⊙1	`Long (I32)`
`Direction`	Direction of movement (cyclic axis or special case only) `1` ..... Positive `2` ..... Shortest `3` ..... Negative `4` ..... Current	⊙1	`Long (I32)`
`EndVelocity`	End velocity		`Double (F64)`

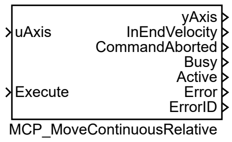
Output

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
InEndVelocity	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

`MCP_MoveContinuousRelative` – * Move to position (relative to previous motion)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)		`Reference`
`Execute`	The block is activated on rising edge		`Bool`

Parameter

`Distance`	Requested target distance (relative to execution point) [unit]		`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]	↓0.0	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	↓0.0	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	↓0.0	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	↓0.0	`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting `2` ..... Buffered `3` ..... Blending low `4` ..... Blending high `5` ..... Blending previous `6` ..... Blending next	⊙1	`Long (I32)`
`EndVelocity`	End velocity		`Double (F64)`

Output

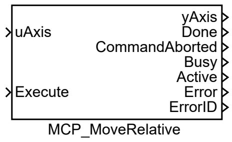
`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)		`Reference`

`InEndVelocity`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_MoveRelative – * Move to position (relative to execution point)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)		Reference
Execute	The block is activated on rising edge		Bool

Parameter

Distance	Requested target distance (relative to execution point) [unit]		Double (F64)
Velocity	Maximal allowed velocity [unit/s]	↓0.0	Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]	↓0.0	Double (F64)
Deceleration	Maximal allowed deceleration [unit/s^2]	↓0.0	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	↓0.0	Double (F64)
BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	Long (I32)

Output

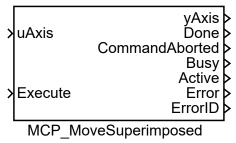
yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)		Reference
Done	Algorithm finished		Bool

`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_MoveSuperimposed – * Superimposed move

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool

Parameter

Distance	Requested target distance (relative to execution point) [unit]		Double (F64)
VelocityDiff	Maximal allowed velocity [unit/s]	↓0.0	Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]	↓0.0	Double (F64)
Deceleration	Maximal allowed deceleration [unit/s^2]	↓0.0	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	↓0.0	Double (F64)

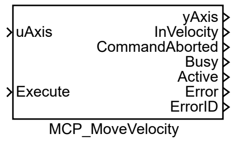
Output

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_MoveVelocity – * Move with constant velocity

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`Velocity`	Maximal allowed velocity [unit/s]		`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]		`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`
`Direction`	Direction of movement (cyclic axis or special case only) 1 ..... Positive 2 ..... Shortest 3 ..... Negative 4 ..... Current	⊙1	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`

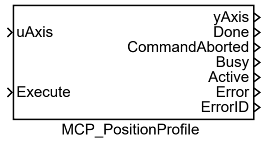
Output

`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`InVelocity`	Requested velocity reached	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_PositionProfile – * **Position profile**

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`alg`	Algorithm for interpolation 1 ..... Sequence of time/value pairs 2 ..... Sequence of equidistant values 3 ..... Spline 4 ..... Equidistant spline 5 ..... Sequence of time/value pairs (+border) 6 ..... Sequence of equidistant values (+border) 7 ..... cubic aproximation (B-spline) 8 ..... quintic aproximation (B-spline) 9 ..... all linear	⊙2	`Long (I32)`
`nmax`	Number of profile segments	⊙3	`Long (I32)`
`TimeScale`	Overall scale factor in time	⊙1.0	`Double (F64)`
`PositionScale`	Overall scale factor in value	⊙1.0	`Double (F64)`
`Offset`	Overall profile offset in value		`Double (F64)`

BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	Long (I32)
BeginVelocity	trajectory begin velocity		Double (F64)
EndVelocity	trajectory end velocity		Double (F64)
times	Times when segments are switched	⊙[0 30]	Double (F64)
values	Values or interpolating polynomial coefficients (a0, a1, a2, ...)	⊙[0 100 100 50]	Double (F64)

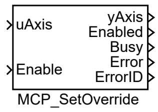
Output

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_SetOverride – * **Set override factors**

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Enable`	Block function is enabled	`Bool`

Parameter

`diff`	Minimal allowed difference of override factor	↓0.0 ↑1.0	`Double (F64)`
`VelFactor`	Velocity multiplication factor	⊙1.0	`Double (F64)`
`AccFactor`	Acceleration/deceleration multiplication factor	⊙1.0	`Double (F64)`
`JerkFactor`	Jerk multiplication factor	⊙1.0	`Double (F64)`

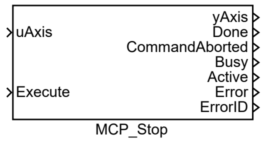
Output

`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Enabled`	Block function is enabled	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_Stop – * Stopping a movement

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`

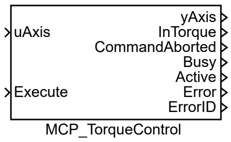
Output

`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation i ..... REXYGEN error code	`Error`

MCP_TorqueControl – * Torque/force control

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`kma`	Torque/force to acceleration ratio		`Double (F64)`
`Torque`	Maximal allowed torque/force		`Double (F64)`
`TorqueRamp`	Maximal allowed torque/force ramp		`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]		`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]		`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`
`Direction`	Direction of movement (cyclic axis or special case only) 1 ..... Positive 2 ..... Shortest 3 ..... Negative 4 ..... Current	⊙1	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`

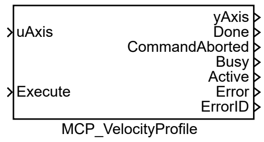
Output

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
InTorque	Requested torque/force is reached	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_VelocityProfile – * **Velocity profile**

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`alg`	Algorithm for interpolation 1 ..... Sequence of time/value pairs 2 ..... Sequence of equidistant values 3 ..... Spline 4 ..... Equidistant spline 5 ..... Sequence of time/value pairs (+border) 6 ..... Sequence of equidistant values (+border) 7 ..... cubic aproximation (B-spline) 8 ..... quintic aproximation (B-spline) 9 ..... all linear	⊙1	`Long (I32)`
`nmax`	Number of profile segments	⊙3	`Long (I32)`
`TimeScale`	Overall scale factor in time	⊙1.0	`Double (F64)`
`VelocityScale`	Overall scale factor in value	⊙1.0	`Double (F64)`
`Offset`	Overall profile offset in value		`Double (F64)`

`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`
`BeginAcceleration`	trajectory begin aceleration		`Double (F64)`
`EndAcceleration`	trajectory end acceleration		`Double (F64)`
`times`	Times when segments are switched	⊙[0 15 25 30]	`Double (F64)`
`values`	Values or interpolating polynomial coefficients (a0, a1, a2, ...)	⊙[0 100 100 50]	`Double (F64)`

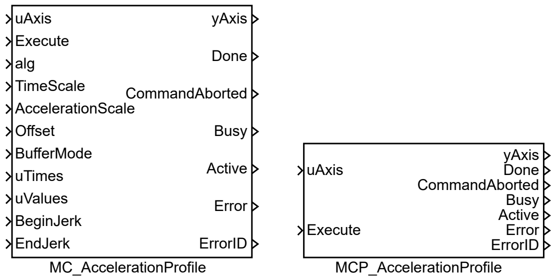
Output

`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation i ..... REXYGEN error code	`Error`

MC_AccelerationProfile, MCP_AccelerationProfile – Acceleration profile

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_AccelerationProfile *and* MCP_AccelerationProfile *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_PositionProfile block commands a time-position locked motion profile. Block implements two possibilities for definition of time-acceleration function:

1. sequence of values: the user defines a sequence of time-acceleration pairs. In each time interval, the values of velocity are interpolated. Times sequence is in array **times**, position sequence is in array values. Time sequence must be increasing and must start with zero or zero must be between the first and last point. Execution always starts from zero time, so if the sequence start with negative time, part of the profile is not executed (could be used for debugging or time shift). For MC_VelocityProfile and MC_AccelerationProfile interpolation is linear, but for MC_PositionProfile, 3rd order polynomial is used in order to avoid steps in velocity.

2. spline: time sequence is the same as in previous case. Each interval is interpolated by 5th order polynomial $p(x) = a_5x^5 + a_4x^4 + a_3x^3 + a_2x^2 + a_1x + a_0$ where beginning of the time-interval is for $x = 0$, end of time-interval is for $x = 1$ and factors a_i are put in array **values** in ascending order (e.g. array **values** contains 6 values for each interval). This method allows smaller number of intervals and there is special editor for synthesis of the interpolating spline function.

For both case, the time sequence could be equally spaced and then array **times** includes only the first (usually zero) and last point.

Note 1: input **TimePosition** is missing, because all path data are in parameters of the block.

Note 2: parameter **values** must be set as vector in all cases, e.g. text string must not include semicolon.

Note 3: incorrect parameter cSeg (higher then real size of arrays times and/or values) leads to unpredictable result and in some cases crashes whole runtime execution (The problem is platform dependent and currently it is known only for SIMULINK - crash of whole MATLAB).

Note 4: in the spline mode, polynomial is always 5th order and always in position (also for sibling block MC_PositionProfile and MC_VelocityProfile) and it couldn't be changed. As the special editor exists, this is not important limitation.

Note 5: The block does not include ramp-in mode. If start position and/or velocity of profile is different from actual (commanded) position of axis, block fails with error -707 (step). It is recommended to use BufferMode=BlendingNext to eliminate the problem with start velocity.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool
TimeScale	Overall scale factor in time	Double (F64)
AccelerationScale	Overall scale factor in value	Double (F64)
Offset	Overall profile offset in value	Double (F64)
BufferMode	Buffering mode 1 ..... Aborting (start immediately) 2 ..... Buffered (start after finish of previous motion) 3 ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 4 ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 5 ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) 6 ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	Long (I32)

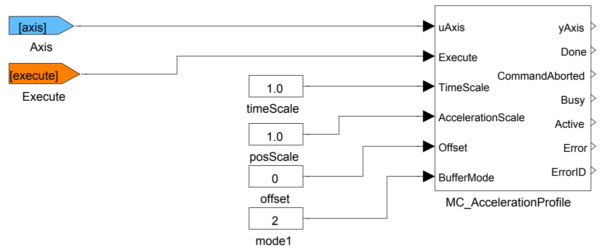
Outputs

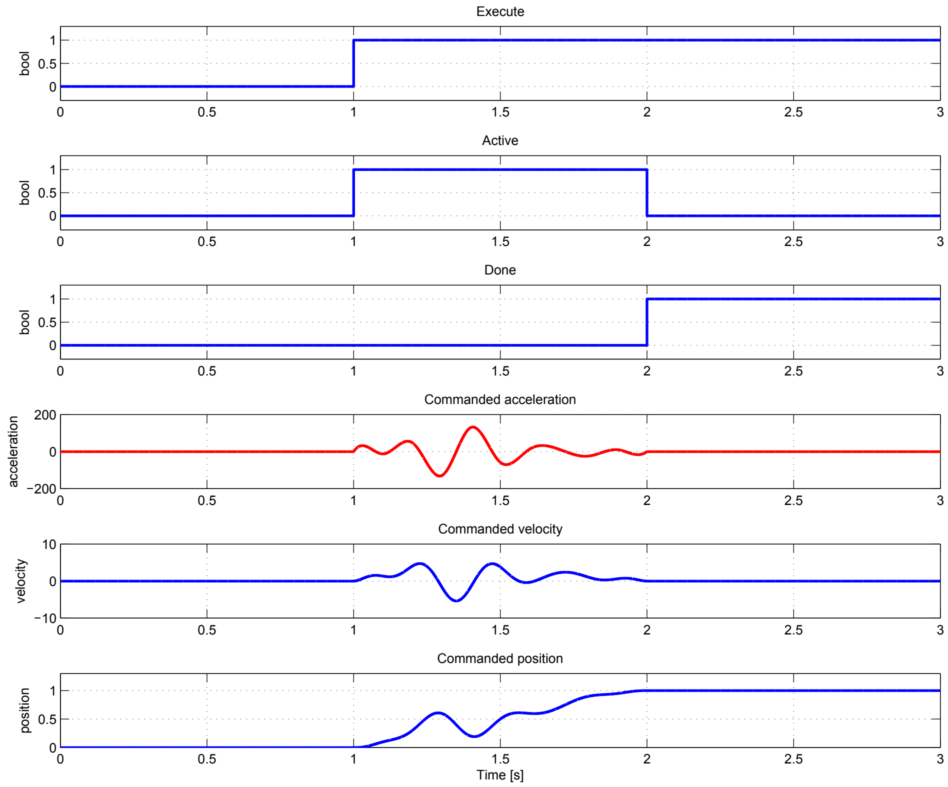
yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

Parameters

`alg`	Algorithm for interpolation `1` ..... Sequence of time/value pairs `2` ..... Sequence of equidistant values `3` ..... Spline `4` ..... Equidistant spline	⊙2	`Long (I32)`
`nmax`	Number of profile segments	⊙3	`Long (I32)`
`times`	Times when segments are switched		`Reference`
`values`	Values or interpolating polynomial coefficients (a0, a1, a2, ...)		`Reference`

Example

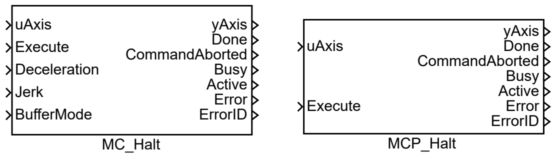

[axis]
Axis
[execute]
Execute
1.0
timeScale
1.0
posScale
0
offset
2
mode1
uAxis
Execute
TimeScale
AccelerationScale
Offset
BufferMode
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_AccelerationProfile


Execute
Active
Done
Commanded acceleration
Commanded velocity
Commanded position
bool
acceleration
velocity
position
Time [s]

MC_Halt, MCP_Halt – Stopping a movement (interruptible)

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_Halt *and* MCP_Halt *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_Halt block commands a controlled motion stop and transfers the axis to the state DiscreteMotion. After the axis has reached zero velocity, the Done output is set to true immediately and the axis state is changed to Standstill.

Note 1: Block MC_Halt is intended for temporary stop of an axis under normal working conditions. Any next motion command which cancels the MC_Halt can be executed in nonbuffered mode (opposite to MC_Stop, which cannot be interrupted). The new command can start even before the stopping sequence was finished.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool
Deceleration	Maximal allowed deceleration [unit/s^2]	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	Double (F64)

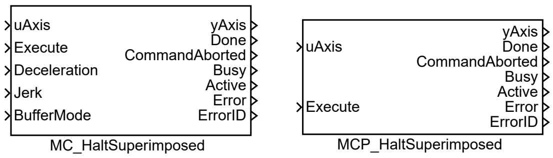
Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_HaltSuperimposed, MCP_HaltSuperimposed – Stopping a movement (superimposed and interruptible)

Block Symbols

Licence: MOTION CONTROL



Function Description

The `MC_HaltSuperimposed` *and* `MCP_HaltSuperimposed` *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* `MCP_` *version of the block.*

Block `MC_HaltSuperimposed` commands a halt to all superimposed motions of the axis. The underlying motion is not interrupted.

Inputs

`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`

Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_Home, MCP_Home – Homing

Block Symbols

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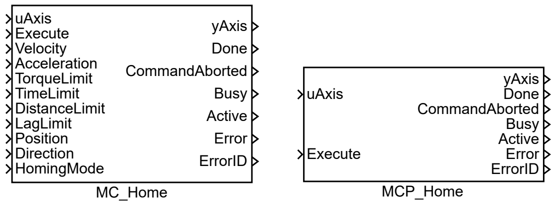

Function Description

The MC_Home *and* MCP_Home *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_Home block commands the axis to perform the "search home" sequence. The details of this sequence are described in PLCopen and can be set by parameters of the block. The "Position" input is used to set the absolute position when reference signal is detected. This Function Bock completes at "StandStill".

Note 1: Parameter/input BufferMode is not supported. Mode is always Aborting. It is not limitation, because homing is typically done once in initialization sequence before some regular movement is proceeded.

Note 2: Homing procedure requires some of RM_Axis block input connected. Depending on homing mode, ActualPos, ActualTorque, LimP, LimZ, LimN can be required. It is expected that only one method is used. Therefore, there are no separate inputs for zero switch and encoder reference pulse (both must be connected to LimZ).

Note 3: HomingMode=4(Direct) only sets the actual position. Therefore, the MC_SetPosition block is not implemented. HomingMode=5(Absolute) only switches the axis from state Homing to state StandStill.

Note 4: Motion trajectory for homing procedure is implemented in simpler way than for regular motion commands - acceleration and deceleration is same (only one parameter) and jerk is not used. For extremely precise homing (position set), it is recommended to run homing procedure twice. First, homing procedure is run with "high" velocity to move near zero switch, then small movement (out of zero switch) follows and finally second homing procedure with "small" velocity is performed.

Note 5: HomingMode=6(Block) detect home-position when the actual torque reach value in parameter TorqueLimit or position lag reach value in parameter MaxPositionLag in attached RM_Axis block (only if the parameter has positive value).

Inputs

`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`TorqueLimit`	Maximal allowed torque/force	`Double (F64)`
`TimeLimit`	Maximal allowed time for the whole algorithm [s]	`Double (F64)`
`DistanceLimit`	Maximal allowed distance for the whole algorithm [unit]	`Double (F64)`
`Position`	Requested target position (absolute) [unit]	`Double (F64)`
`Direction`	Direction of movement (cyclic axis or special case only) `1` ..... Positive `2` ..... Shortest `3` ..... Negative `4` ..... Current	`Long (I32)`
`HomingMode`	Homing mode algorithm `1` ..... Absolute switch `2` ..... Limit switch `3` ..... Reference pulse `4` ..... Direct (user reference) `5` ..... Absolute encoder `6` ..... Block	`Long (I32)`

Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_MoveAbsolute, MCP_MoveAbsolute – Move to position (absolute coordinate)

Block Symbols

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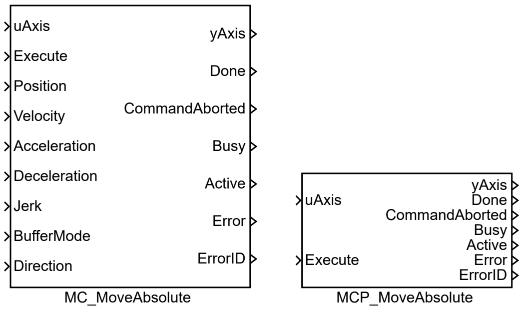


Function Description

The MC_MoveAbsolute *and* MCP_MoveAbsolute *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_MoveAbsolute block moves an axis to specified position as fast as possible. If no further action is pending, final velocity is zero (axis moves to position and stops) otherwise it depends on blending mode. For blending purposes, start and stop velocity of this block is maximum velocity with direction respecting current and final position. If start velocity of next pending block is in opposite direction, then blending velocity is always zero.

If next pending block is executed too late in order to reach requested velocity the generated output depends on jerk setting. If no limit for jerk is used (block input Jerk is zero or unconnected) block uses maximum acceleration or deceleration to reach the desired velocity as near as possible. If jerk is limited it is not possible to say what is the nearest velocity because also acceleration is important. For this reason, the axis is stopped and moved backward and blending velocity is always reached. Although this seems to be correct solution, it might look confusing in a real situation. Therefore, it is recommended to reorganize execution order of the motion blocks and avoid this situation.

The MC_MoveRelative block act almost same as MC_MoveAbsolute. The only difference is the final position is computed adding input Distance to current (when rising edge on input Execute occurred) position.

The MC_MoveAdditive block act almost same as MC_MoveRelative. The only difference is the final position is computed adding input Distance to final position of the previous block.

The MC_MoveSuperimposed block acts almost the same as the MC_MoveRelative block. The only difference is the current move is not aborted and superimposed move is executed immediately and added to current move. Original move act like superimposed move is not run.

The following table describes all inputs, parameters and outputs which are used in some of the blocks in the described block suite.

Inputs

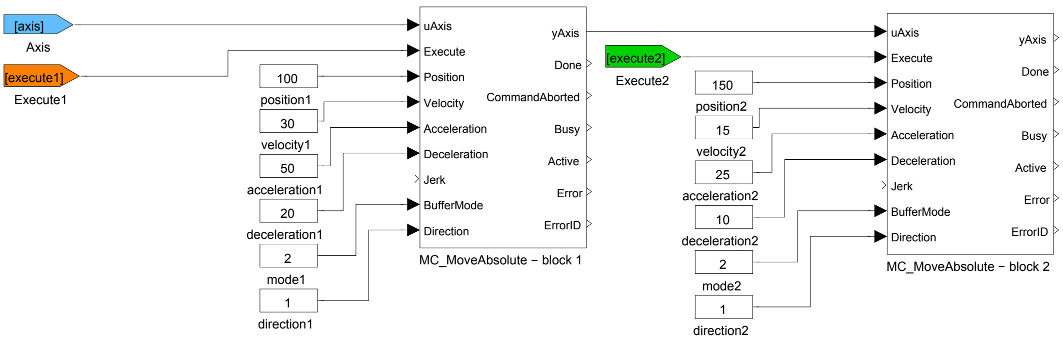
`uAxis`	AAxis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Position`	Requested target position (absolute) [unit]	`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`BufferMode`	Buffering mode 1 ..... Aborting (start immediately) 2 ..... Buffered (start after finish of previous motion) 3 ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 4 ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 5 ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) 6 ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`
`Direction`	Direction of movement (cyclic axis or special case only) 1 ..... Positive 2 ..... Shortest 3 ..... Negative 4 ..... Current	`Long (I32)`

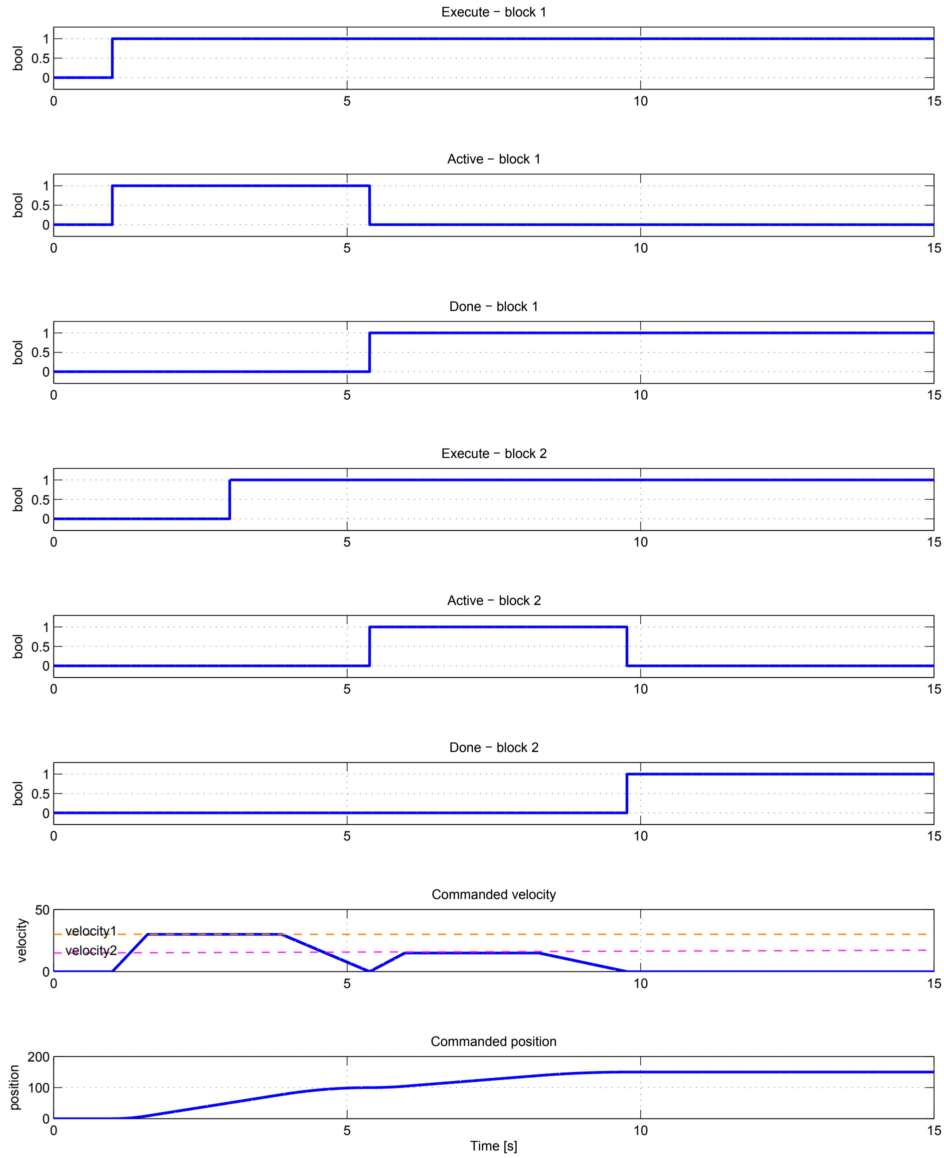
Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`

`ErrorID`	Result of the last operation `i` . . . . . REXYGEN general error	`Error`

Example

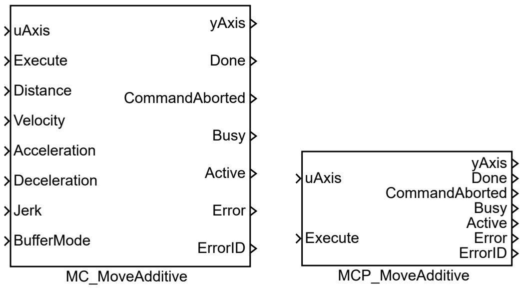

[axis]
Axis
[execute1]
Execute1
100
position1
30
velocity1
50
acceleration1
20
deceleration1
2
mode1
1
direction1
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAbsolute − block 1
[execute2]
Execute2
150
position2
15
velocity2
25
acceleration2
10
deceleration2
2
mode2
1
direction2
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAbsolute − block 2


Execute − block 1
Active − block 1
Done − block 1
Execute − block 2
Active − block 2
Done − block 2
bool
Commanded velocity
velocity
velocity1
velocity2
Commanded position
position
Time [s]

MC_MoveAdditive, MCP_MoveAdditive – Move to position (relative to previous motion)

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_MoveAdditive *and* MCP_MoveAdditive *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_MoveAdditive block moves an axis to specified position as fast as possible. The final position is determined by adding the value of Distance parameter to final position of previous motion block which was controlling the axis. If no further action is pending, final velocity is zero (axis moves to position and stops) otherwise it depends on blending mode. For blending purposes, start and stop velocity of this block is maximum velocity with direction respecting current and final position. If start velocity of next pending block is in opposite direction, then blending velocity is always zero.

If next pending block is executed too late in order to reach requested velocity the generated output depends on jerk setting. If no limit for jerk is used (block input Jerk is zero or unconnected) block uses maximum acceleration or deceleration to reach the desired velocity as near as possible. If jerk is limited it is not possible to say what is the nearest velocity because also acceleration is important. For this reason, the axis is stopped and moved backward and blending velocity is always reached. Although this seems to be correct solution, it might look confusing in a real situation. Therefore, it is recommended to reorganize execution order of the motion blocks and avoid this situation.

Inputs

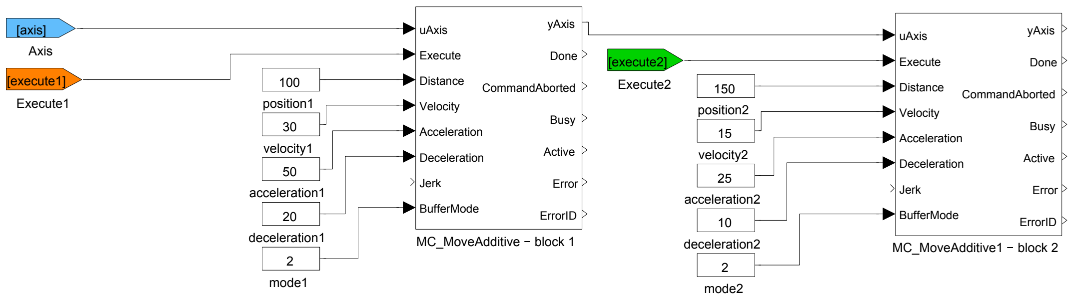
uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool
Distance	Requested target distance (relative to start point) [unit]	Double (F64)

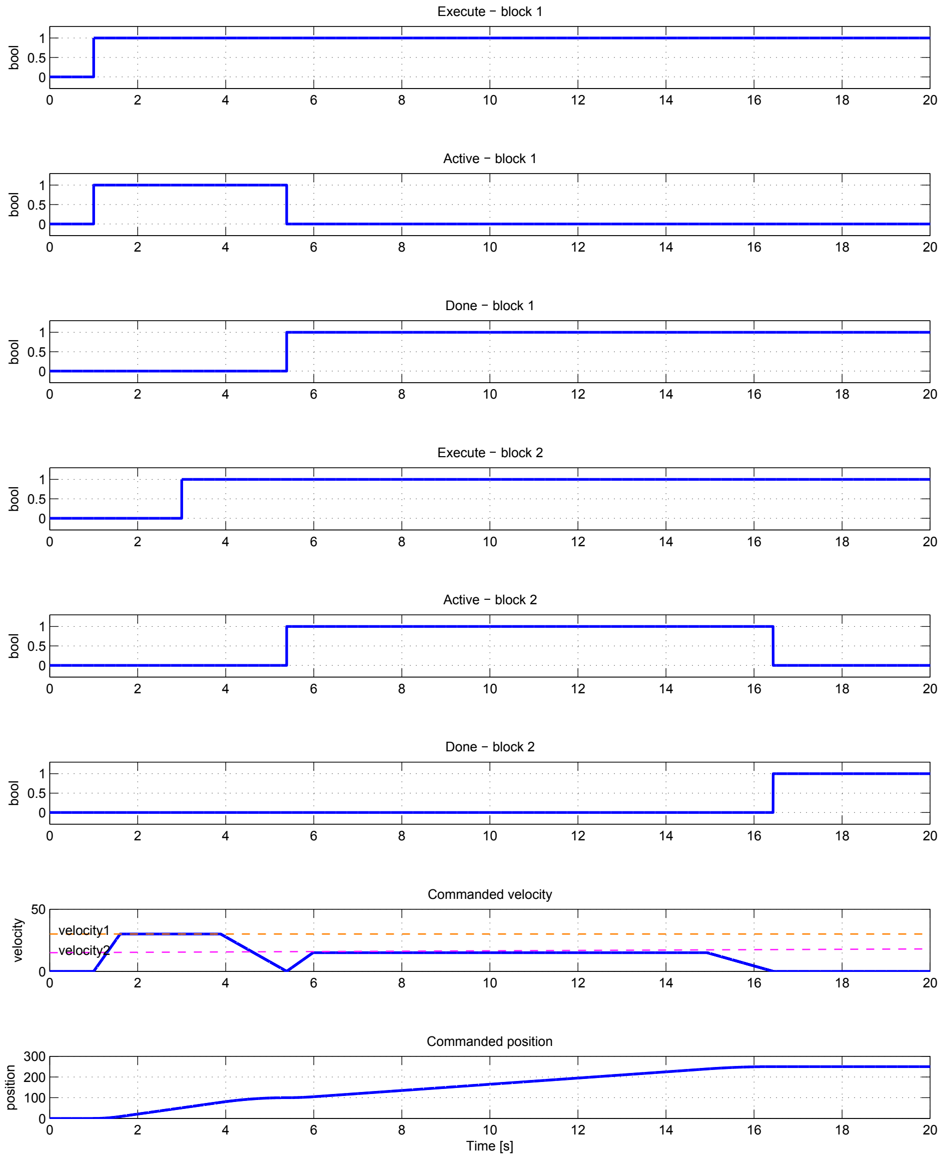
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting (start immediately) `2` ..... Buffered (start after finish of previous motion) `3` ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `4` ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `5` ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) `6` ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`

Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

Example

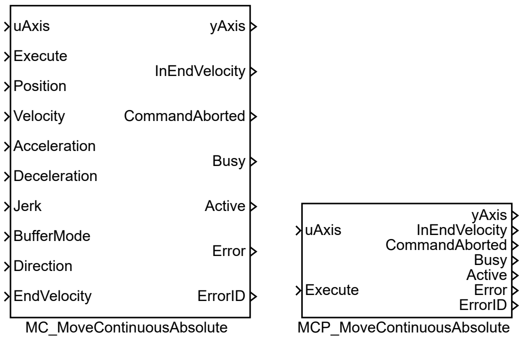

[axis]
Axis
[execute1]
Execute1
100
position1
30
velocity1
50
acceleration1
20
deceleration1
2
mode1
uAxis
Execute
Distance
Velocity
Acceleration
Deceleration
Jerk
BufferMode
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAdditive – block 1
[execute2]
Execute2
150
position2
15
velocity2
25
acceleration2
10
deceleration2
2
mode2
MC_MoveAdditive1 – block 2


Execute – block 1
Active – block 1
Done – block 1
Execute – block 2
Active – block 2
Done – block 2
bool
Commanded velocity
velocity
velocity1
velocity2
Commanded position
position
Time [s]

MC_MoveContinuousAbsolute, MCP_MoveContinuousAbsolute – Move to position (absolute coordinate)

Block Symbols

Licence: MOTION CONTROL



Function Description

The `MC_MoveContinuousAbsolute` *and* `MCP_MoveContinuousAbsolute` *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* `MCP_` *version of the block.*

The `MC_MoveContinuousAbsolute` block moves an axis to specified position as fast as possible. If no further action is pending, final velocity is specified by parameter `EndVelocity`. For blending purposes, start and stop velocity of this block is maximum velocity with direction respecting current and final position. If start velocity of next pending block is in opposite direction, then blending velocity is always zero.

If next pending block is executed too late in order to reach requested velocity the generated output depends on jerk setting. If no limit for jerk is used (block input `Jerk` is zero or unconnected) block uses maximum acceleration or deceleration to reach the desired velocity as near as possible. If jerk is limited it is not possible to say what is the nearest velocity because also acceleration is important. For this reason, the axis is stopped and moved backward and blending velocity is always reached. Although this seems to be correct solution, it might look confusing in a real situation. Therefore, it is recommended to reorganize execution order of the motion blocks and avoid this situation.

Note 1: If the `EndVelocity` is set to zero value, the block behaves in the same way as `MC_MoveAbsolute`.

Note 2: If next motion command is executed before the final position is reached, the block behaves in the same way as `MC_MoveAbsolute`.

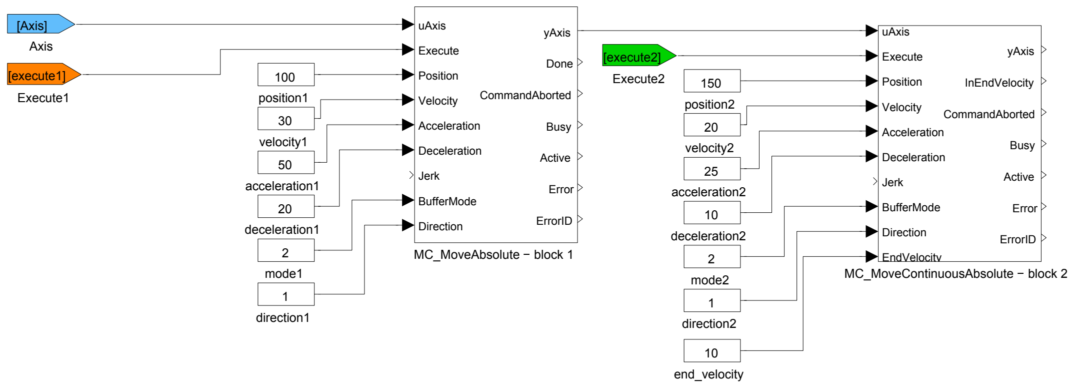
Inputs

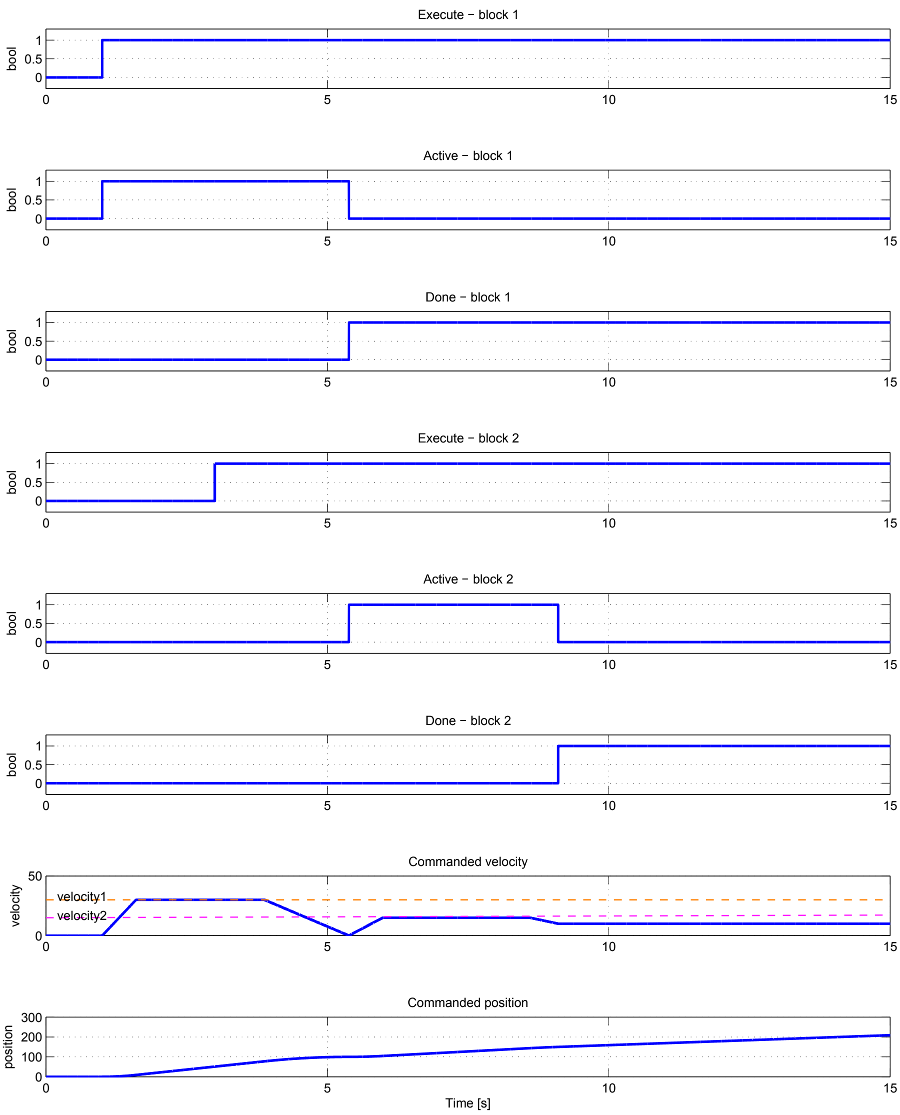
`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Position`	Requested target position (absolute) [unit]	`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting (start immediately) `2` ..... Buffered (start after finish of previous motion) `3` ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `4` ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `5` ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) `6` ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`
`Direction`	Direction of movement (cyclic axis or special case only) `1` ..... Positive `2` ..... Shortest `3` ..... Negative `4` ..... Current	`Long (I32)`
`EndVelocity`	End velocity	`Double (F64)`

Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`InEndVelocity`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

Example

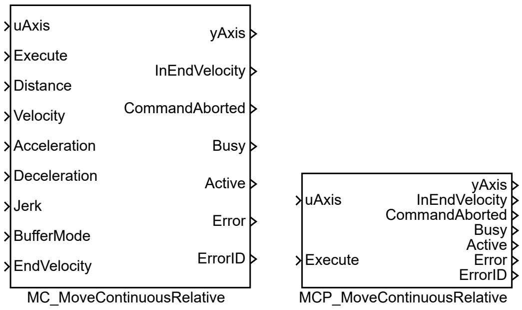

[Axis]
Axis
[execute1]
Execute1
100
position1
30
velocity1
50
acceleration1
20
deceleration1
2
mode1
1
direction1
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAbsolute − block 1
[execute2]
Execute2
150
position2
20
velocity2
25
acceleration2
10
deceleration2
2
mode2
1
direction2
10
end_velocity
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
EndVelocity
yAxis
InEndVelocity
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveContinuousAbsolute − block 2


Execute − block 1
Active − block 1
Done − block 1
Execute − block 2
Active − block 2
Done − block 2
bool
0
0.5
1
0
5
10
15
Commanded velocity
velocity
velocity1
velocity2
50
Commanded position
position
0
100
200
300
Time [s]

MC_MoveContinuousRelative, MCP_MoveContinuousRelative – Move to position (relative to previous motion)

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_MoveContinuousRelative *and* MCP_MoveContinuousRelative *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_MoveContinuousRelative block moves an axis to specified position as fast as possible. The final position is determined by adding the value of Distance parameter to the actual position at the moment of triggering the Execute input. If no further action is pending, final velocity is specified by parameter EndVelocity. For blending purposes, start and stop velocity of this block is maximum velocity with direction respecting current and final position. If start velocity of next pending block is in opposite direction, then blending velocity is always zero.

If next pending block is executed too late in order to reach requested velocity the generated output depends on jerk setting. If no limit for jerk is used (block input Jerk is zero or unconnected) block uses maximum acceleration or deceleration to reach the desired velocity as near as possible. If jerk is limited it is not possible to say what is the nearest velocity because also acceleration is important. For this reason, the axis is stopped and moved backward and blending velocity is always reached. Although this seems to be correct solution, it might look confusing in a real situation. Therefore, it is recommended to reorganize execution order of the motion blocks and avoid this situation.

Note 1: If the EndVelocity is set to zero value, the block behaves in the same way as MC_MoveRelative.

Note 2: If next motion command is executed before the final position is reached, the block behaves in the same way as MC_MoveRelative.

If next pending block is executed too late in order to reach requested velocity the generated output depends on jerk setting. If no limit for jerk is used (block input Jerk is zero or unconnected) block uses maximum acceleration or deceleration to reach the desired velocity as near as possible. If jerk is limited it is not possible to say what is the nearest velocity because also acceleration is important. For this reason, the axis is stopped and moved backward and blending velocity is always reached. Although this seems to be correct solution, it might look confusing in a real situation. Therefore, it is recommended to reorganize execution order of the motion blocks and avoid this situation.

If next pending block is executed too late in order to reach requested velocity the generated output depends on jerk setting. If no limit for jerk is used (block input `Jerk` is zero or unconnected) block uses maximum acceleration or deceleration to reach the desired velocity as near as possible. If jerk is limited it is not possible to say what is the nearest velocity because also acceleration is important. For this reason, the axis is stopped and moved backward and blending velocity is always reached. Although this seems to be correct solution, it might look confusing in a real situation. Therefore, it is recommended to reorganize execution order of the motion blocks and avoid this situation.

If next pending block is executed too late in order to reach requested velocity the generated output depends on jerk setting. If no limit for jerk is used (block input `Jerk` is zero or unconnected) block uses maximum acceleration or deceleration to reach the desired velocity as near as possible. If jerk is limited it is not possible to say what is the nearest velocity because also acceleration is important. For this reason, the axis is stopped and moved backward and blending velocity is always reached. Although this seems to be correct solution, it might look confusing in a real situation. Therefore, it is recommended to reorganize execution order of the motion blocks and avoid this situation.

Inputs

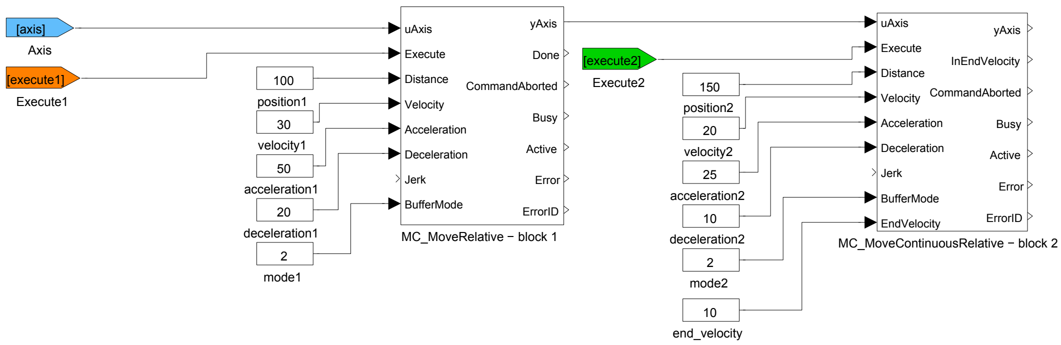
`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Distance`	Requested target distance (relative to execution point) [unit]	`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`

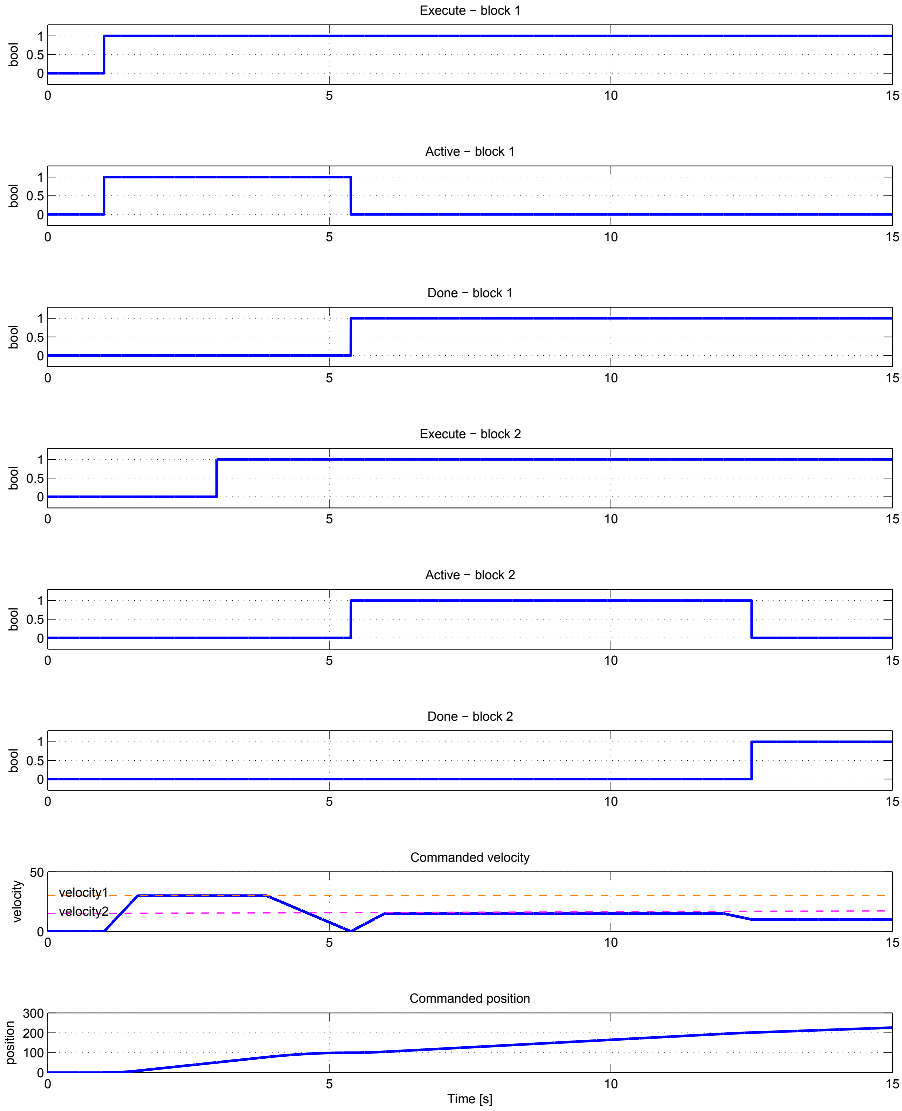
`BufferMode`	Buffering mode `1` ..... Aborting (start immediately) `2` ..... Buffered (start after finish of previous motion) `3` ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `4` ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `5` ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) `6` ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`
`EndVelocity`	End velocity	`Long (I32)`

Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`InEndVelocity`	PLCopen Done (algorithm finished)	`Bool`
`CommandAborted`	PLCopen CommandAborted (algorithm was aborted)	`Bool`
`Busy`	PLCopen Busy (algorithm not finished yet)	`Bool`
`Active`	PLCopen Active (the block is controlling the axis)	`Bool`
`Error`	PLCopen Error (error occurred)	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

Example

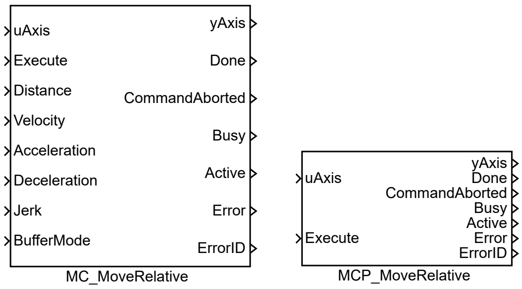

[axis]
Axis
[execute1]
Execute1
100
position1
30
velocity1
50
acceleration1
20
deceleration1
2
mode1
uAxis
Execute
Distance
Velocity
Acceleration
Deceleration
Jerk
BufferMode
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveRelative − block 1
[execute2]
Execute2
150
position2
20
velocity2
25
acceleration2
10
deceleration2
2
mode2
10
end_velocity
uAxis
Execute
Distance
Velocity
Acceleration
Deceleration
Jerk
BufferMode
EndVelocity
yAxis
InEndVelocity
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveContinuousRelative − block 2


Execute − block 1
Active − block 1
Done − block 1
Execute − block 2
Active − block 2
Done − block 2
bool
Commanded velocity
velocity
velocity1
velocity2
Commanded position
position
Time [s]

MC_MoveRelative, MCP_MoveRelative – Move to position (relative to execution point)

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_MoveRelative *and* MCP_MoveRelative *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_MoveRelative block moves an axis to specified position as fast as possible. The final position is determined by adding the value of Distance parameter to the actual position at the moment of triggering the Execute input. If no further action is pending, final velocity is zero (axis moves to position and stops) otherwise it depends on blending mode. For blending purposes, start and stop velocity of this block is maximum velocity with direction respecting current and final position. If start velocity of next pending block is in opposite direction, then blending velocity is always zero.

If next pending block is executed too late in order to reach requested velocity the generated output depends on jerk setting. If no limit for jerk is used (block input Jerk is zero or unconnected) block uses maximum acceleration or deceleration to reach the desired velocity as near as possible. If jerk is limited it is not possible to say what is the nearest velocity because also acceleration is important. For this reason, the axis is stopped and moved backward and blending velocity is always reached. Although this seems to be correct solution, it might look confusing in a real situation. Therefore, it is recommended to reorganize execution order of the motion blocks and avoid this situation.

Inputs

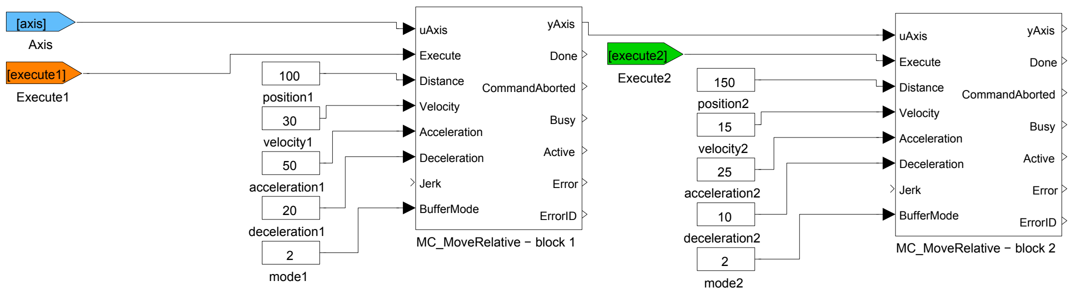
uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool
Distance	Requested target distance (relative to execution point) [unit]	Double (F64)

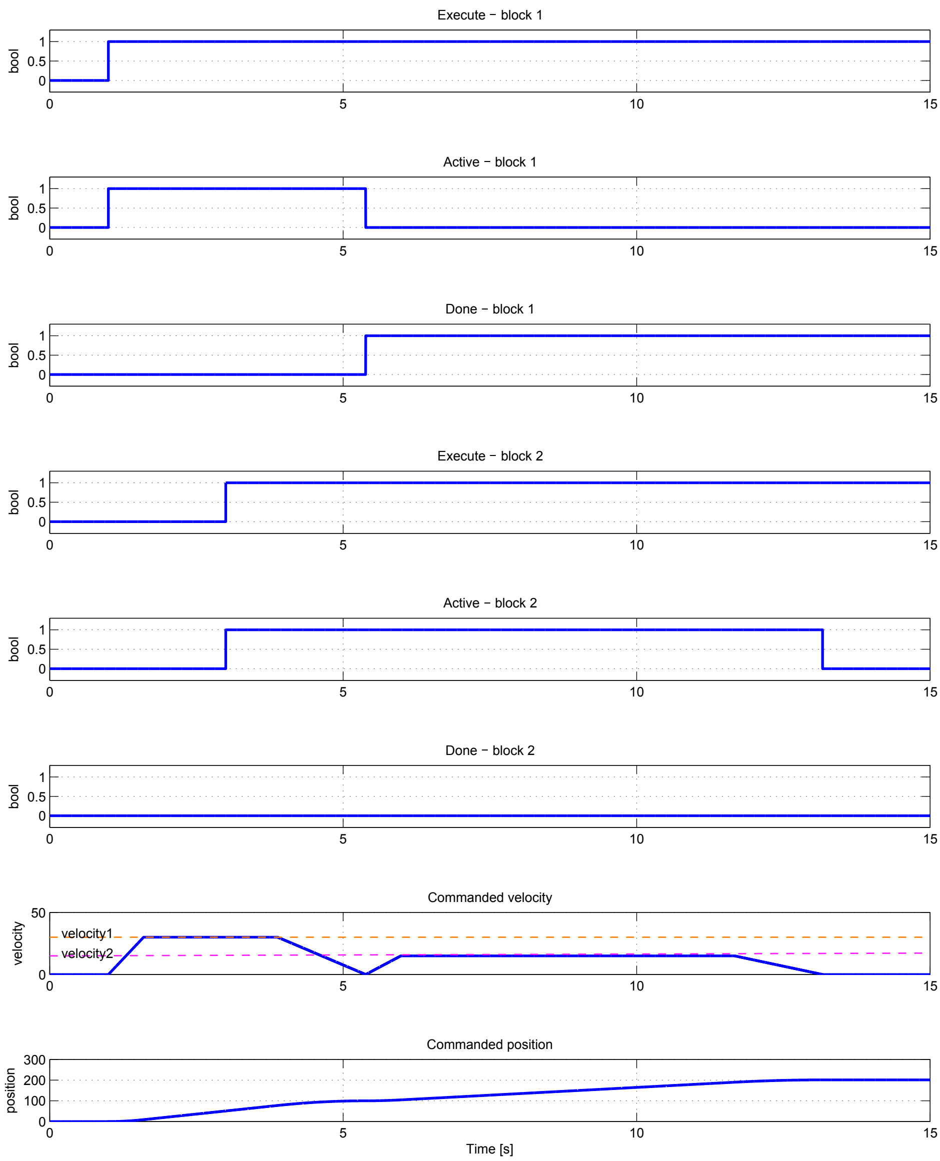
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [[unit/s^2]	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [[unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [[unit/s^3]	`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting (start immediately) `2` ..... Buffered (start after finish of previous motion) `3` ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `4` ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `5` ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) `6` ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`

Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

Example

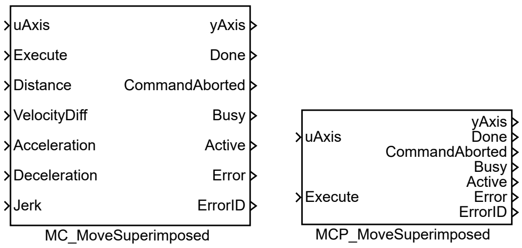

[axis]
Axis
[execute1]
Execute1
100
position1
30
velocity1
50
acceleration1
20
deceleration1
2
mode1
uAxis
Execute
Distance
Velocity
Acceleration
Deceleration
Jerk
BufferMode
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveRelative − block 1
[execute2]
Execute2
150
position2
15
velocity2
25
acceleration2
10
deceleration2
2
mode2
uAxis
Execute
Distance
Velocity
Acceleration
Deceleration
Jerk
BufferMode
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveRelative − block 2


Execute − block 1
Active − block 1
Done − block 1
Execute − block 2
Active − block 2
Done − block 2
bool
0
0.5
1
0
5
10
15
Commanded velocity
velocity
velocity1
velocity2
50
Commanded position
position
300
200
100
Time [s]

MC_MoveSuperimposed, MCP_MoveSuperimposed – Superimposed move

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_MoveSuperimposed *and* MCP_MoveSuperimposed *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_MoveSuperimposed block moves an axis to specified position as fast as possible (with respect to set limitations). Final position is specified by input parameter Distance. In case that the axis is already in motion at the moment of execution of the MC_MoveSuperimposed block, the generated values of position, velocity and acceleration are added to the values provided by the previous motion block. If there is no previous motion, the block behaves in the same way as the MC_MoveRelative command.

Note:There is no BufferMode parameter which is irrelevant in the superimposed mode. If there is already an superimposed motion running at the moment of execution, the new block is started immediately (analogous to aborting mode).

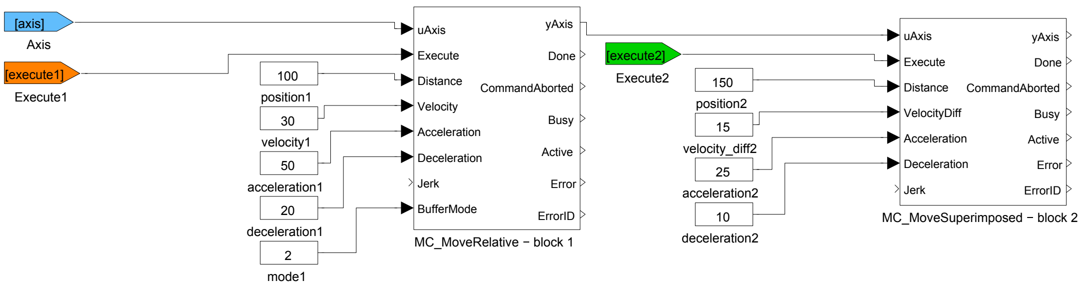
Inputs

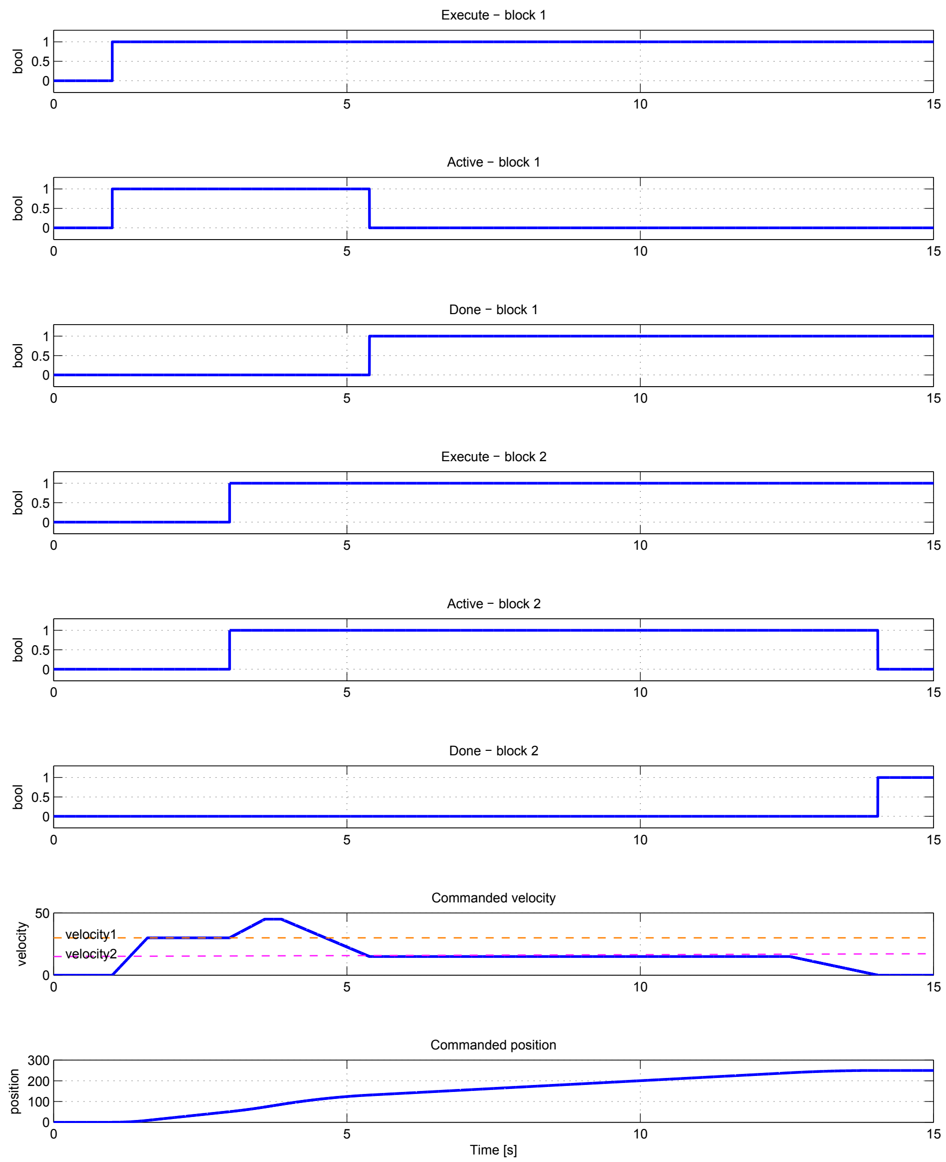
uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool
Distance	Requested target distance (relative to execution point) [unit]	Double (F64)
VelocityDiff	Maximal allowed velocity [unit/s]	Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]	Double (F64)
Deceleration	Maximal allowed deceleration [unit/s^2]	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	Double (F64)

Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

Example

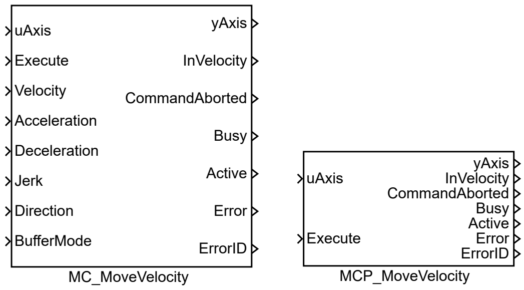

[axis]
Axis
[execute1]
Execute1
100
position1
30
velocity1
50
acceleration1
20
deceleration1
2
mode1
uAxis
Execute
Distance
Velocity
Acceleration
Deceleration
Jerk
BufferMode
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveRelative − block 1
[execute2]
Execute2
150
position2
15
velocity_diff2
25
acceleration2
10
deceleration2
VelocityDiff
MC_MoveSuperimposed − block 2


Execute − block 1
Active − block 1
Done − block 1
Execute − block 2
Active − block 2
Done − block 2
bool
Commanded velocity
velocity
velocity1
velocity2
Commanded position
position
Time [s]

`MC_MoveVelocity`, `MCP_MoveVelocity` – Move with constant velocity

Block Symbols

Licence: MOTION CONTROL



Function Description

The `MC_MoveVelocity` *and* `MCP_MoveVelocity` *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* `MCP_` *version of the block.*

The `MC_MoveVelocity` block changes axis velocity to specified value as fast as possible and keeps the specified velocity until the command is aborted by another block or event.

Note: parameter `Direction` enumerate also `shortest_way` although for this block it is not valid value.

Inputs

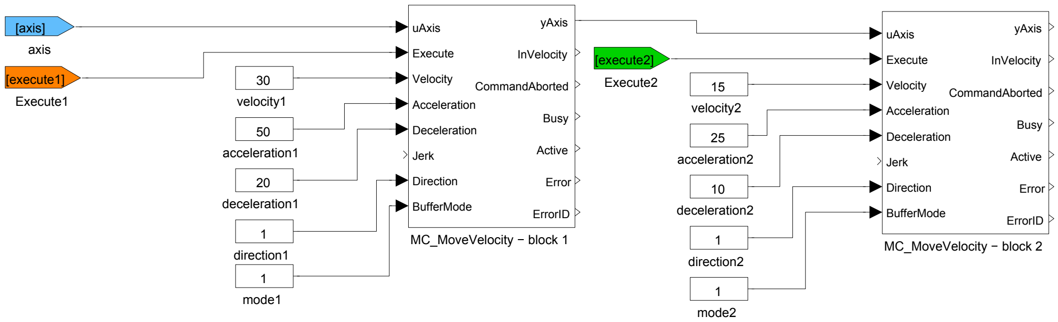
`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration unit/s^2]	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`Direction`	Direction of movement (cyclic axis or special case only) `1` ..... Positive `2` ..... Shortest `3` ..... Negative `4` ..... Current	`Long (I32)`

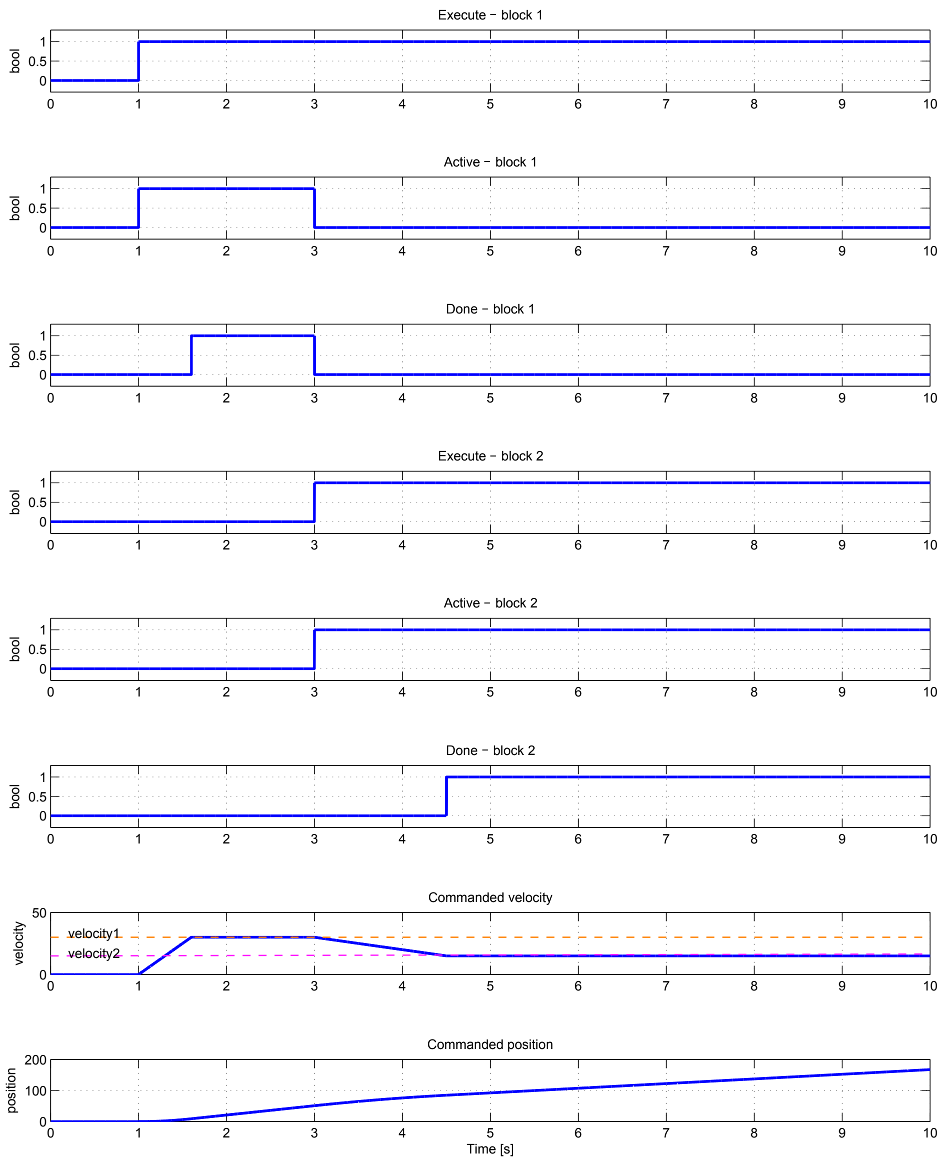
BufferMode	Buffering mode 1 ..... Aborting (start immediately) 2 ..... Buffered (start after finish of previous motion) 3 ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 4 ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 5 ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) 6 ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	Long (I32)

Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
InVelocity	Requested velocity reached	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

Example

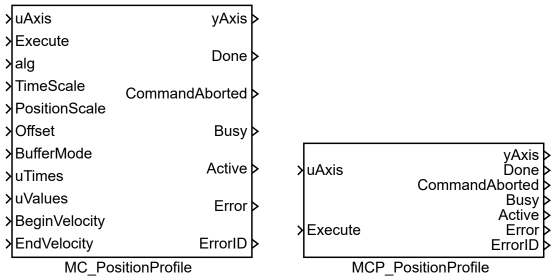

[axis]
axis
[execute1]
Execute1
30
velocity1
50
acceleration1
20
deceleration1
1
direction1
1
mode1
uAxis
Execute
Velocity
Acceleration
Deceleration
Jerk
Direction
BufferMode
yAxis
InVelocity
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveVelocity − block 1
[execute2]
Execute2
15
velocity2
25
acceleration2
10
deceleration2
1
direction2
1
mode2
uAxis
Execute
Velocity
Acceleration
Deceleration
Jerk
Direction
BufferMode
yAxis
InVelocity
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveVelocity − block 2


Execute − block 1
Active − block 1
Done − block 1
Execute − block 2
Active − block 2
Done − block 2
bool
1
0.5
0
0
1
2
3
4
5
6
7
8
9
10
Commanded velocity
velocity
50
velocity1
velocity2
Commanded position
position
200
100
Time [s]

MC_PositionProfile, MCP_PositionProfile – Position profile

Block Symbols

Licence: MOTION CONTROL



Function Description

The `MC_PositionProfile` *and* `MCP_PositionProfile` *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* `MCP_` *version of the block.*

The `MC_PositionProfile` block commands a time-position locked motion profile. Block implements two possibilities for definition of time-position function:

1. sequence of values: the user defines a sequence of time-position pairs. In each time interval, the values of position are interpolated. Times sequence is in array `times`, position sequence is in array values. Time sequence must be increasing and must start with zero or zero must be between the first and last point. Execution always starts from zero time, so if the sequence start with negative time, part of the profile is not executed (could be used for debugging or time shift). For `MC_VelocityProfile` and `MC_AccelerationProfile` interpolation is linear, but for `MC_PositionProfile`, 3rd order polynomial is used in order to avoid steps in velocity.

2. spline: time sequence is the same as in previous case. Each interval is interpolate byd 5th order polynomial $p(x) = a_5x^5 + a_4x^4 + a_3x^3 + a_2x^2 + a_1x + a_0$ where beginning of the time-interval is for $x = 0$, end of time-interval is for $x = 1$ and factors a_i are put in array `values` in ascending order (e.g. array `values` contains 6 values for each interval). This method allows smaller number of intervals and there is special editor for synthesis of the interpolating spline function.

For both case, the time sequence could be equally spaced and then array `times` includes only the first (usually zero) and last point.

Note 1: input `TimePosition` is missing, because all path data are in parameters of the block.

Note 2: parameter `values` must be set as vector in all cases, e.g. text string must not include semicolon.

Note 3: incorrect parameter `cSeg` (higher then real size of arrays `times` and/or `values`) leads to unpredictable result and in some cases crashes whole runtime execution (The problem is platform dependent and currently it is known only for SIMULINK - crash of whole MATLAB).

Note 4: in the spline mode, polynomial is always 5th order and always in position (also for sibling block `MC_VelocityProfile` and `MC_AccelerationProfile`) and it couldn't be changed. As the special editor exists, this is not important limitation.

Note 5: The block does not include ramp-in mode. If start position and/or velocity of profile is different from actual (commanded) position of axis, block fails with error `-707` (step). It is recommended to use `BufferMode=BlendingNext` to eliminate the problem with start velocity.

Inputs

`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`TimeScale`	Overall scale factor in time	`Double (F64)`
`PositionScale`	Overall scale factor in value	`Double (F64)`
`Offset`	Overall profile offset in value	`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting (start immediately) `2` ..... Buffered (start after finish of previous motion) `3` ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `4` ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `5` ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) `6` ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`

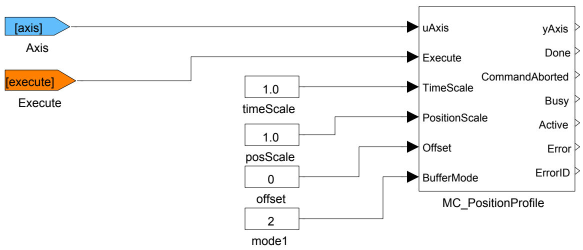
Outputs

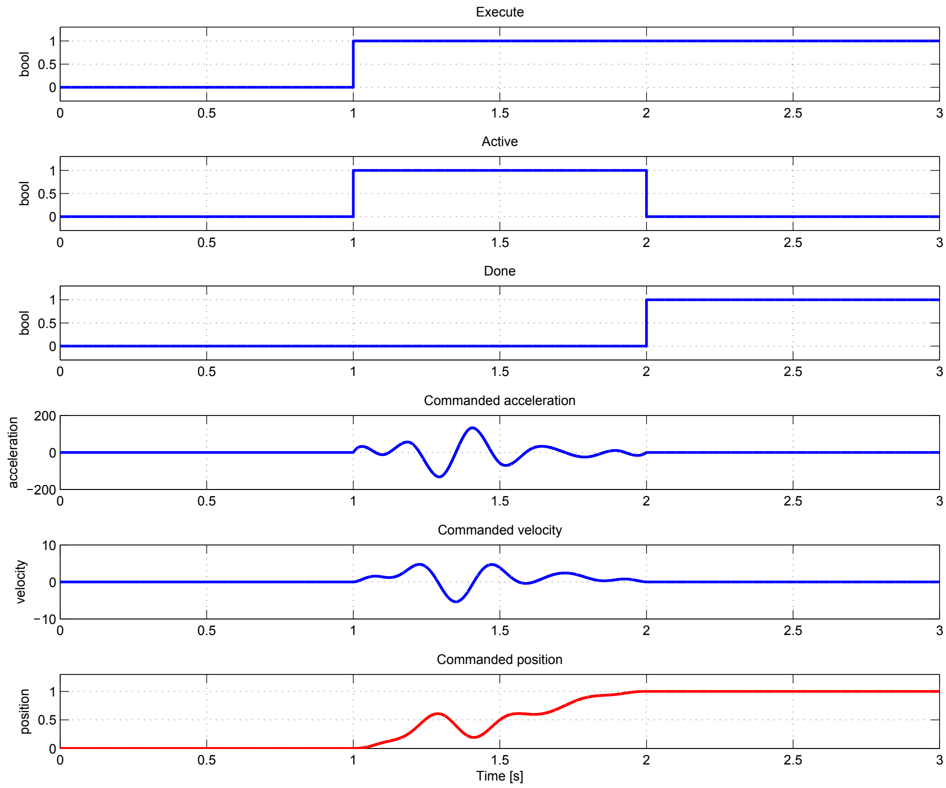
`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

Parameters

`alg`	Algorithm for interpolation `1` ..... Sequence of time/value pairs `2` ..... Sequence of equidistant values `3` ..... Spline `4` ..... Equidistant spline	⊙2	`Long (I32)`
`nmax`	Number of profile segments	⊙3	`Long (I32)`
`times`	Times when segments are switched		`Reference`
`values`	Values or interpolating polynomial coefficients (a0, a1, a2, ...)		`Reference`

Example

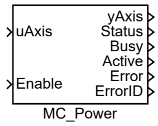

[axis]
Axis
[execute]
Execute
1.0
timeScale
1.0
posScale
0
offset
2
mode1
uAxis
Execute
TimeScale
PositionScale
Offset
BufferMode
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_PositionProfile


Execute
Active
Done
bool
Commanded acceleration
acceleration
Commanded velocity
velocity
Commanded position
position
Time [s]

MC_Power – Axis activation (power on/off)

Block Symbol

Licence: MOTION CONTROL



Function Description

The MC_Power block must be used with all axes. It is the only way to switch an axis from disable state to standstill (e.g. operation) state. The Enable input must be set (non zero value) for whole time the axis is active. The Status output can be used for switch on and switch off of the motor driver (logical signal for enabling the power stage of the drive).

The block does not implement optional parameters/inputs Enable_Positive, Enable_Negative. The same functionality can be implemented by throwing the limit switches (inputs limP and limN of block RM_Axis).

If the associated axis is turned off (by setting the Enable input to zero) while a motion is processed (commanded velocity is not zero), error stoping sequence is activated and the status is switched to off/diabled when the motion stops (commanded velocity reaches zero value).

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Enable	Block function is enabled	Bool

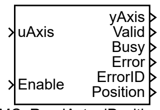
Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Status	Effective state of the power stage	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_ReadActualPosition – Read actual position

Block Symbol

Licence: MOTION CONTROL



MC_ReadActualPosition

Function Description

The block MC_ReadActualPosition displays actual value of position of a connected axis on the output Position. The output is valid only while the block is enabled by the logical input signal Enable.

The block displays logical position value which is entered into all of the motion blocks as position input. In case that no absolute position encoder is used or the internal position is set in other way (e.g. via MC_Home block), the CommandedPosition output of the corresponding RM_Axis may display different value.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Enable	Block function is enabled	Bool

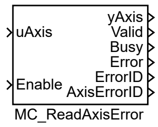
Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Valid	Output value is valid	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error
Position	Actual absolute position	Double (F64)

MC_ReadAxisError – Read axis error

Block Symbol

Licence: MOTION CONTROL



Function Description

The block MC_ReadAxisError displays actual error code of a connected axis on the output AxisErrorID. In case of no error, the output is set to zero. The error value is valid only while the block is enabled by the logical input signal Enable. This block is implemented for sake of compatibility with PLCOpen specification as it displays duplicit information about an error which is also accessible on the ErrorID output of the RM_Axis block.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Enable	Block function is enabled	Bool

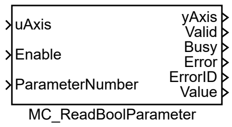
Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Valid	Output value is valid	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error
AxisErrorID	Result of the last operation read from axis i ..... REXYGEN general error	Error

MC_ReadBoolParameter – Read axis parameter (bool)

Block Symbol

Licence: MOTION CONTROL



Function Description

The block MC_ReadBoolParameter displays actual value of various signals related to the connected axis on its Value output. The user chooses from a set of accessible logical variables by setting the ParameterNumber input. The output value is valid only while the block is activated by the logical Enable input.

The block displays the parameters and outputs of RM_Axis block and is implemented for sake of compatibility with the PLCOpen specification.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Enable	Block function is enabled	Bool
ParameterNumber	Parameter ID 4 ..... Enable sw positive limit 5 ..... Enable sw negative limit 6 ..... Enable position lag monitoring	Long (I32)

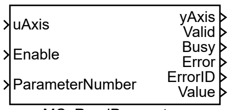
Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Valid	Output value is valid	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error
Value	Parameter value	Bool

MC_ReadParameter – Read axis parameter

Block Symbol

Licence: MOTION CONTROL



MC_ReadParameter

Function Description

The block MC_ReadParameter displays actual value of various system variables of the connected axis on its Value output. The user chooses from a set of accessible variables by setting the ParameterNumber input. The output value is valid only while the block is activated by the logical Enable input.

The block displays the parameters and outputs of RM_Axis block and is implemented for sake of compatibility with the PLCOpen specification.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Enable	Block function is enabled	Bool
ParameterNumber	Parameter ID 1 ..... Commanded position 2 ..... Positive sw limit switch 3 ..... Negative sw limit switch 7 ..... Maximal position lag 8 ..... Maximal velocity (system) 9 ..... Maximal velocity (appl) 10 .... Actual velocity 11 .... Commanded velocity 12 .... Maximal acceleration (system) 13 .... Maximal acceleration (appl.) 14 .... Maximal deceleration (system) 15 .... Maximal deceleration (appl.) 16 .... Maximal jerk 1000 .. Actual position 1001 .. Maximal torque/force 1003 .. Actual torque/force 1004 .. Commanded torque/force	Long (I32)

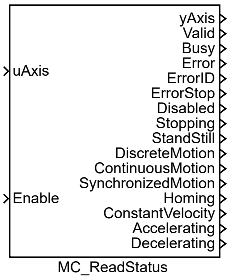
Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Valid	Output value is valid	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error
Value	Parameter value	Double (F64)

MC_ReadStatus – **Read axis status**

Block Symbol

Licence: MOTION CONTROL



Function Description

The block `MC_ReadStatus` indicates the state of the connected axis on its logical output signals. The values of the states are valid only while the `Enable` input is set to nonzero value. This state is indicated by `Valid` output.

Inputs

`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Enable`	Block function is enabled	`Bool`

Outputs

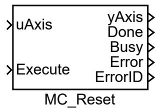
`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Valid`	Output value is valid	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`
`ErrorStop`	Axis is in the ErrorStop state	`Bool`
`Disabled`	Axis is in the Disabled state	`Bool`
`Stopping`	Axis is in the Stoping state	`Bool`
`StandStill`	Axis is in the StandStill state	`Bool`
`DiscreteMotion`	Axis is in the DiscreteMotion state	`Bool`
`ContinuousMotion`	Axis is in the ContinuousMotion state	`Bool`
`SynchronizedMotion`	Axis is in the SynchronizedMotion state	`Bool`
`Homing`	Axis is in the Homing state	`Bool`

`ConstantVelocity`	Axis is moving with constant velocity	`Bool`
`Accelerating`	Axis is accelerating	`Bool`
`Decelerating`	Axis is decelerating	`Bool`

MC_Reset – **Reset axis errors**

Block Symbol

Licence: MOTION CONTROL



Function Description

The `MC_Reset` block makes the transition from the state ErrorStop to StandStill by resetting all internal axis-related errors.

Inputs

`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

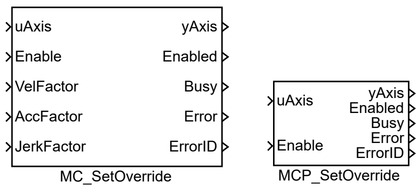
Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_SetOverride, MCP_SetOverride – Set override factors

Block Symbols

Licence: MOTION CONTROL



Function Description

The `MC_SetOverride` *and* `MCP_SetOverride` *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* `MCP_` *version of the block.*

The `MC_SetOverride` block sets the values of override for the whole axis, and all functions that are working on that axis. The override parameters act as a factor that is multiplied to the commanded velocity, acceleration, deceleration and jerk of the move function block.

This block is level-sensitive (not edge-sensitive like other motion control blocks). So factors are update in each step while input `Enable` is not zero. It leads to reacalculation of movement's path if a block like `MC_MoveAbsolute` commands the axis. This recalculation needs lot of CPU time and also numerical problem could appear. For this reasons, a deadband (parameter `diff`) is established. The movement's path recalculation is proceeded only if one of the factors is changed more then the deadband.

Note: all factor must be positive. Factor greater then 1.0 are possible, but often lead to overshooting of axis limits and failure of movement (with `errorID=-700` - invalid parameter; if factor is set before start of block) or error stop of axis (with `errorID=-701` - out of range; if factor is changed within movement and actual value overshoot limit).

Inputs

`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Enable`	Block function is enabled	`Bool`
`VelFactor`	Velocity multiplication factor	`Double (F64)`
`AccFactor`	Acceleration/deceleration multiplication factor	`Double (F64)`
`JerkFactor`	Jerk multiplication factor	`Double (F64)`

Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Enabled	Block function is enabled	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

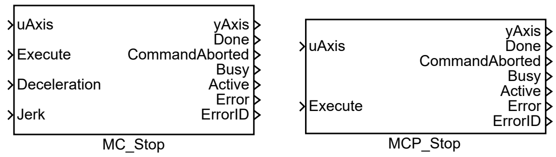
Parameter

diff	Deadband (difference for recalculation)	↓0.0 ↑1.0 ⊙0.1	Double (F64)

MC_Stop, MCP_Stop – **Stopping a movement**

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_Stop *and* MCP_Stop *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_Stop block commands a controlled motion stop and transfers the axis to the state Stopping. It aborts any ongoing Function Block execution. While the axis is in state Stopping, no other FB can perform any motion on the same axis. After the axis has reached velocity zero, the Done output is set to true immediately. The axis remains in the state Stopping as long as Execute is still true or velocity zero is not yet reached. As soon as Done=true and Execute=false the axis goes to state StandStill.

Note 1: parameter/input BufferMode is not supported. Mode is always Aborting.

Note 2: Failing stop-command could be dangerous. This block does not generate invalid-parameter-error but tries to stop the axis anyway (e.g. uses parameteres from RM_Axis or generates error-stop-sequence).

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed	Reference
Execute	The block is activated on rising edge	Bool
Deceleration	Maximal allowed deceleration [unit/s^2]	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	Double (F64)

Outputs

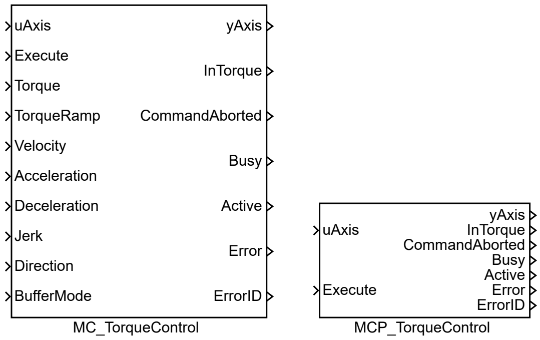
yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool

`ErrorID`	Result of the last operation `i` . . . . . REXYGEN general error	`Error`

MC_TorqueControl, MCP_TorqueControl – Torque/force control

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_TorqueControl *and* MCP_TorqueControl *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MCP_TorqueControl block generates constant slope torque/force ramp until maximum requested value has been reached. Similar profile is generated for velocity. The motion trajectory is limited by maximum velocity, acceleration / deceleration, and jerk, or by the value of the torque, depending on the mechanical circumstances.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool
Torque	Maximal allowed torque/force	Double (F64)
TorqueRamp	Maximal allowed torque/force ramp	Double (F64)
Velocity	Maximal allowed velocity [unit/s]	Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]	Double (F64)
Deceleration	Maximal allowed deceleration [uunit/s^2]	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	Double (F64)
Direction	Direction of movement (cyclic axis or special case only) 1 ..... Positive 2 ..... Shortest 3 ..... Negative 4 ..... Current	Long (I32)

`BufferMode`	Buffering mode 1 ..... Aborting (start immediately) 2 ..... Buffered (start after finish of previous motion) 3 ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 4 ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 5 ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) 6 ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`

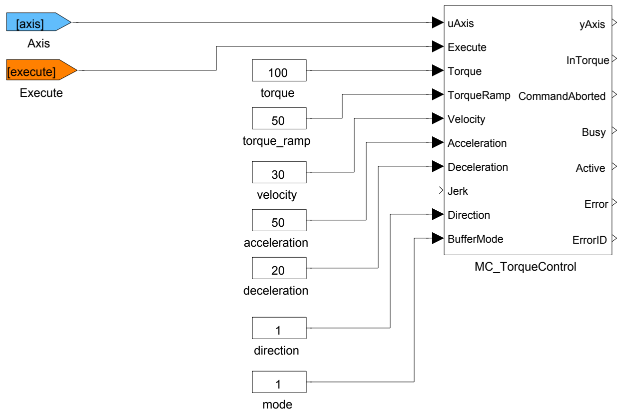
Outputs

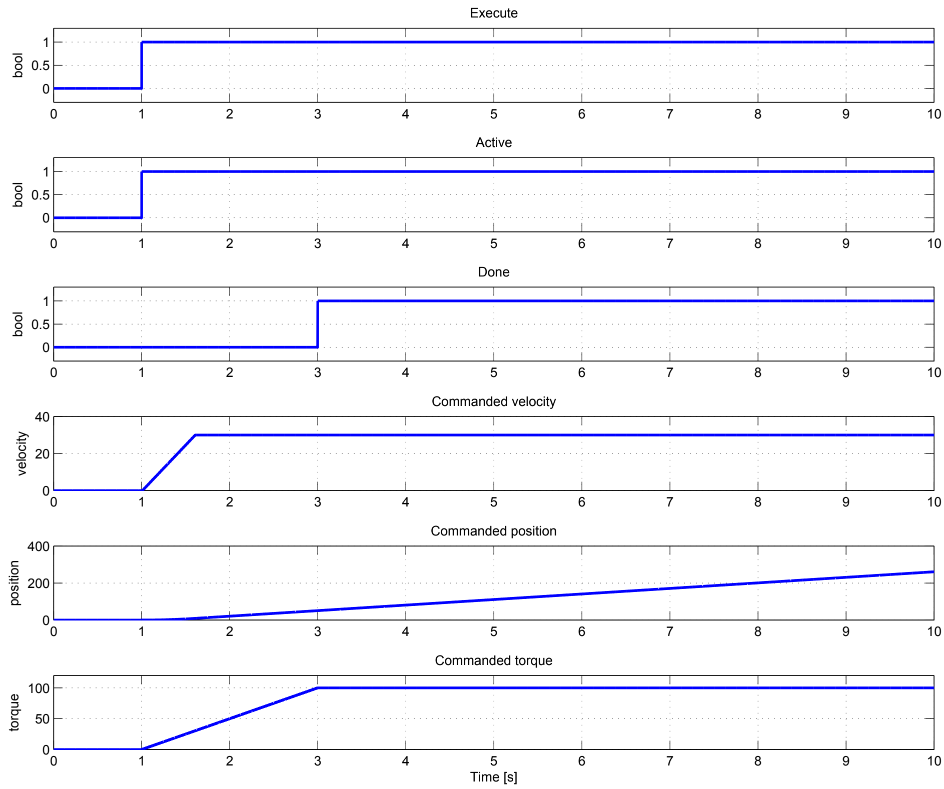
`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`InTorque`	Requested torque/force is reached	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`

Parameter

`kma`	Torque/force to acceleration ratio	`Double (F64)`

Example

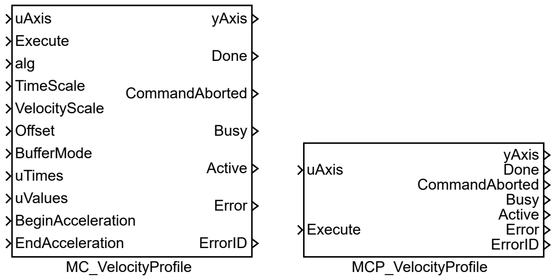

[axis]
Axis
[execute]
Execute
100
torque
50
torque_ramp
30
velocity
50
acceleration
20
deceleration
1
direction
1
mode
uAxis
Execute
Torque
TorqueRamp
Velocity
Acceleration
Deceleration
Jerk
Direction
BufferMode
yAxis
InTorque
CommandAborted
Busy
Active
Error
ErrorID
MC_TorqueControl


Execute
Active
Done
Commanded velocity
Commanded position
Commanded torque
bool
velocity
position
torque
Time [s]

MC_VelocityProfile, MCP_VelocityProfile – Velocity profile

Block Symbols

Licence: MOTION CONTROL



Function Description

The `MC_PositionProfile` block commands a time-position locked motion profile. Block implements two possibilities for definition of time-velocity function:

1. sequence of values: the user defines a sequence of time-velocity pairs. In each time interval, the values of velocity are interpolated. Times sequence is in array `times`, position sequence is in array values. Time sequence must be increasing and must start with zero or zero must be between the first and last point. Execution always starts from zero time, so if the sequence start with negative time, part of the profile is not executed (could be used for debugging or time shift). For `MC_VelocityProfile` and `MC_AccelerationProfile` interpolation is linear, but for `MC_PositionProfile`, 3rd order polynomial is used in order to avoid steps in velocity.

2. spline: time sequence is the same as in previous case. Each interval is interpolated by 5th order polynomial $p(x) = a_5x^5 + a_4x^4 + a_3x^3 + a_2x^2 + a_1x + a_0$ where beginning of the time-interval is for $x = 0$, end of time-interval is for $x = 1$ and factors a_i are put in array `values` in ascending order (e.g. array `values` contains 6 values for each interval). This method allows smaller number of intervals and there is special editor for synthesis of the interpolating spline function.

For both case, the time sequence could be equally spaced and then array `times` includes only the first (usually zero) and last point.

Note 1: input `TimePosition` is missing, because all path data are in parameters of the block.

Note 2: parameter `values` must be set as vector in all cases, e.g. text string must not include semicolon.

Note 3: incorrect parameter `cSeg` (higher then real size of arrays `times` and/or `values`) leads to unpredictable result and in some cases crashes whole runtime execution (The problem is platform dependent and currently it is known only for SIMULINK - crash of whole MATLAB).

Note 4: in the spline mode, polynomial is always 5th order and always in position (also for sibling block MC_PositionProfile and MC_AccelerationProfile) and it couldn't be changed. As the special editor exists, this is not important limitation.

Note 5: The block does not include ramp-in mode. If start position and/or velocity of profile is different from actual (commanded) position of axis, block fails with error -707 (step). It is recommended to use BufferMode=BlendingNext to eliminate the problem with start velocity.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool
TimeScale	Overall scale factor in time	Double (F64)
VelocityScale	Overall scale factor in value	Double (F64)
Offset	Overall profile offset in value	Double (F64)
BufferMode	Buffering mode 1 ..... Aborting (start immediately) 2 ..... Buffered (start after finish of previous motion) 3 ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 4 ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 5 ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) 6 ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	Long (I32)

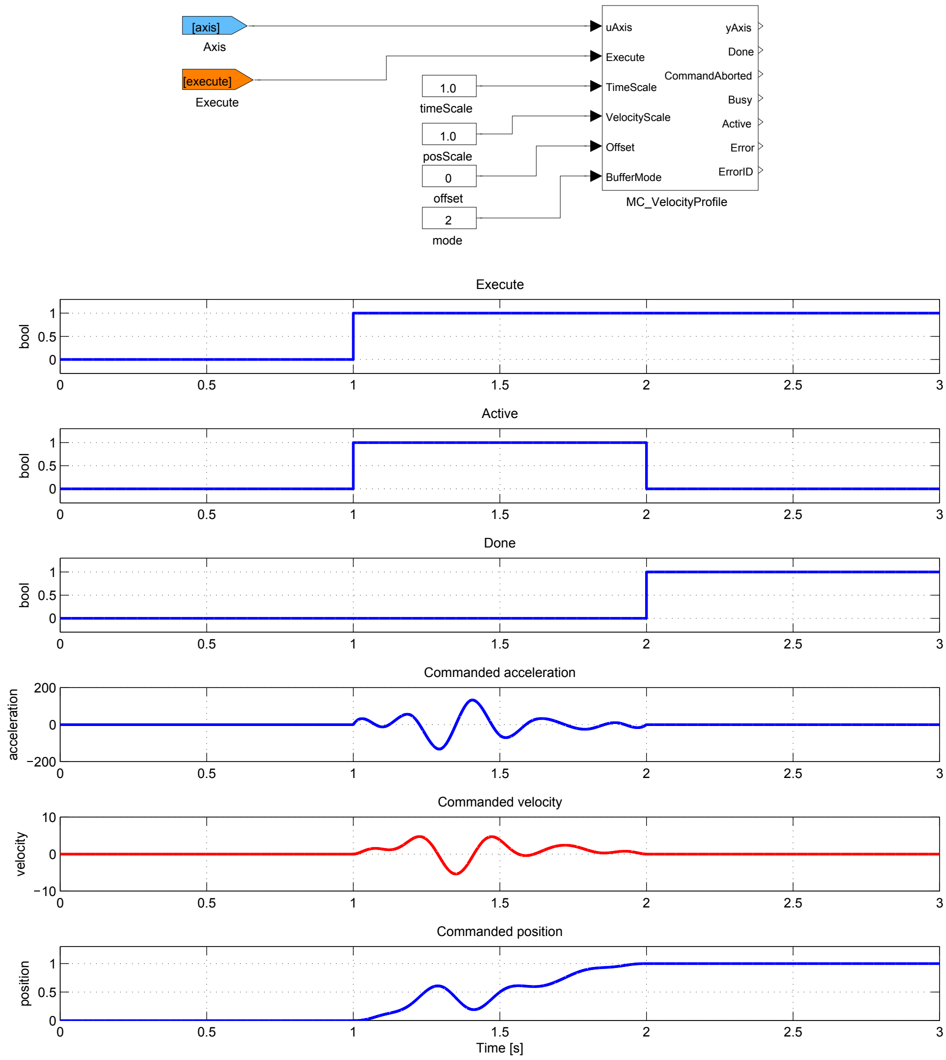
Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

Parameters

`alg`	Algorithm for interpolation `1` ..... Sequence of time/value pairs `2` ..... Sequence of equidistant values `3` ..... Spline `4` ..... Equidistant spline	⊙2	`Long (I32)`
`nmax`	Number of profile segments	⊙3	`Long (I32)`
`times`	Times when segments are switched		`Reference`
`values`	Values or interpolating polynomial coefficients (a0, a1, a2, ...)		`Reference`

Example

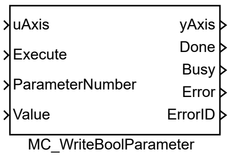


[axis]
Axis
[execute]
Execute
1.0
timeScale
1.0
posScale
0
offset
2
mode
uAxis
Execute
TimeScale
VelocityScale
Offset
BufferMode
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_VelocityProfile
Execute
Active
Done
Commanded acceleration
Commanded velocity
Commanded position
bool
acceleration
velocity
position
Time [s]

MC_WriteBoolParameter – Write axis parameter (bool)

Block Symbol

Licence: MOTION CONTROL



Function Description

The block MC_WriteBoolParameter writes desired value of various system parameters entered on its Value input to the connected axis. The user chooses from a set of accessible logical variables by setting the ParameterNumber input.

The block is implemented for sake of compatibility with the PLCOpen specification as the parameters can be written by the SETPB block.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool
ParameterNumber	Parameter ID 4 ..... Enable sw positive limit 5 ..... Enable sw negative limit 6 ..... Enable position lag monitoring	Long (I32)
Value	Parameter value	Bool

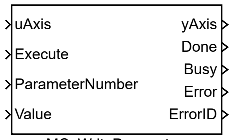
Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_WriteParameter – Write axis parameter

Block Symbol

Licence: MOTION CONTROL



MC_WriteParameter

Function Description

The block `MC_WriteParameter` writes desired value of various system parameters entered on its `Value` input to the connected axis. The user chooses from a set of accessible variables by setting the `ParameterNumber` input.

The block is implemented for sake of compatibility with the `PLCOpen` specification as the parameters can be written by the `SETPR` block.

Inputs

`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`ParameterNumber`	Parameter ID `2` ..... Positive sw limit switch `3` ..... Negative sw limit switch `7` ..... Maximal position lag `8` ..... Maximal velocity (system) `9` ..... Maximal velocity (appl) `13` .... Maximal acceleration (appl.) `15` .... Maximal deceleration (appl.) `16` .... Maximal jerk `1001` .. Maximal torque/force	`Long (I32)`
`Value`	Parameter value	`Double (F64)`

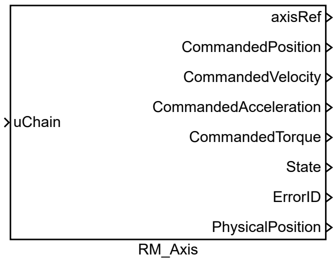
Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

RM_Axis – Motion control axis

Block Symbol

Licence: MOTION CONTROL



Function Description

The RM_AXIS block is a cornerstone of the motion control solution within the REXYGEN system. This base block keeps all status values and implements basic algorithm for one motion control axis (one motor), which includes limits checking, emergency stop, etc. The block is used for both real and virtual axes. The real axis must have a position feedback controller, which is out of this block's scope. The key status values are commanded position, velocity, acceleration and torque, as well as state of the axis, axis error code and a reference to the block, which controls the axis.

This block (like all blocks in the motion control library) does not implement a feedback controller which would keep the actual position as near to the commanded position as possible. Such a controller must be provided by using other blocks (e.g. PIDU) or external (hardware) controller. The feedback signals are used for lag checking, homing and could be used in special motion control blocks. The feedback signals are connected throw the RM_AxisSpline block.

The parameters of this block correspond with the requirements of the PLCopen standard for an axis. If improper parameters are set, the errorID output is set to -700 (invalid parameter) and all motion blocks fail with -703 error code (invalid state).

The parameters for limit velocity, acceleration and deceleration are twofold. One for application, e.g. limit value which could be set into movtion blocks. This value could be exceeded in some cases. Second limit is for system. The system limits must be higher then application limits and it is never exceeded. If some motion block generate path, that exceed system limit, error stop seqvence is activated.

Note that the default values for position, velocity and acceleration limits are intentionally set to 0, which makes them invalid. Limits must always be set by the user according to the real axis and the axis actuator.

Inputs

uChain	Input is not used by the block. User can connect any signal to define order of block's execution	Long (I32)

Outputs

`axisRef`	Axis reference (only `RM_Axis.axisRef-uAxis` or `yAxis-uAxis` connections are allowed)	`Reference`
`CommandedPosition`	Requested (commanded) position of the axis. The value is logical position that is put into the motion blocks. The position is different from `PhysicalPosition` if the axis is circular or homed.	`Double (F64)`
`CommandedVelocity`	Requested (commanded) velocity of the axis	`Double (F64)`
`CommandedAcceleration`	Requested (commanded) acceleration of the axis	`Double (F64)`
`CommandedTorque`	Requested (commanded) torque in the axis	`Double (F64)`
`State`	State of the axis `0` ..... Disabled `1` ..... Stand still `2` ..... Homing `3` ..... Discrete motion `4` ..... Continuous motion `5` ..... Synchronized motion `6` ..... Coordinated motion `7` ..... Stopping `8` ..... Error stop `9` ..... Drive error(simillar to Error stop, but fault is caused by external signnal)	`Long (I32)`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`
`PhysicalPosition`	Requested (commanded) position of the axis. The value is physical position that is put into the feedback controller. The position is different from `CommandedPosition` if the axis is circular or homed.	`Double (F64)`

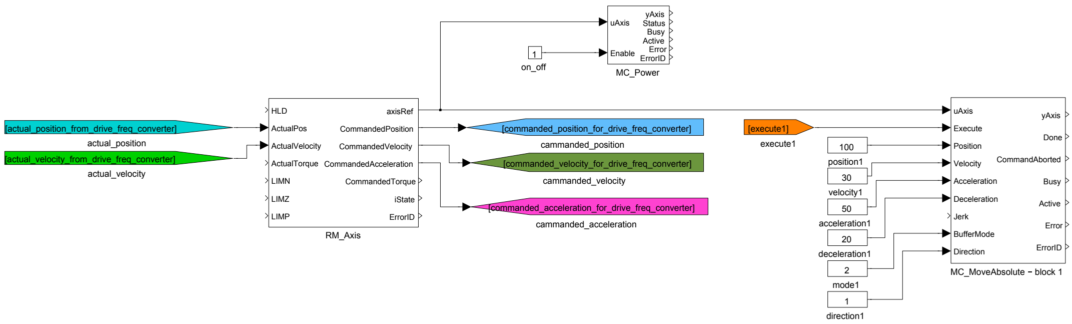
Parameters

`AxisType`	Type of the axis ⊙1 `1` ..... Linear axis `2` ..... Cyclic axis with cyclic position sensor `3` ..... Cyclic axis with linear position sensor `4` ..... Linear axis in testing mode. In this mode, position limits and limit switches are disabled. This type is intended for testing and commissioning, sometimes it can also be suitable for continuous operation on cyclic axes.	`Long (I32)`
`EnableLimitPos`	Enable positive position limit checking (e.g. if checked, `MaxPosAppl` is valid)	`Bool`
`MaxPosAppl`	Positive position limit for application (MC blocks). The value should be smaller then (before the) `MaxPosSystem` for linear axis. The value limit cyclic axis with linear senzor for few revolution (useful for robotic application) and must be bigger then (beyond the) `MaxPosSystem`.	`Double (F64)`

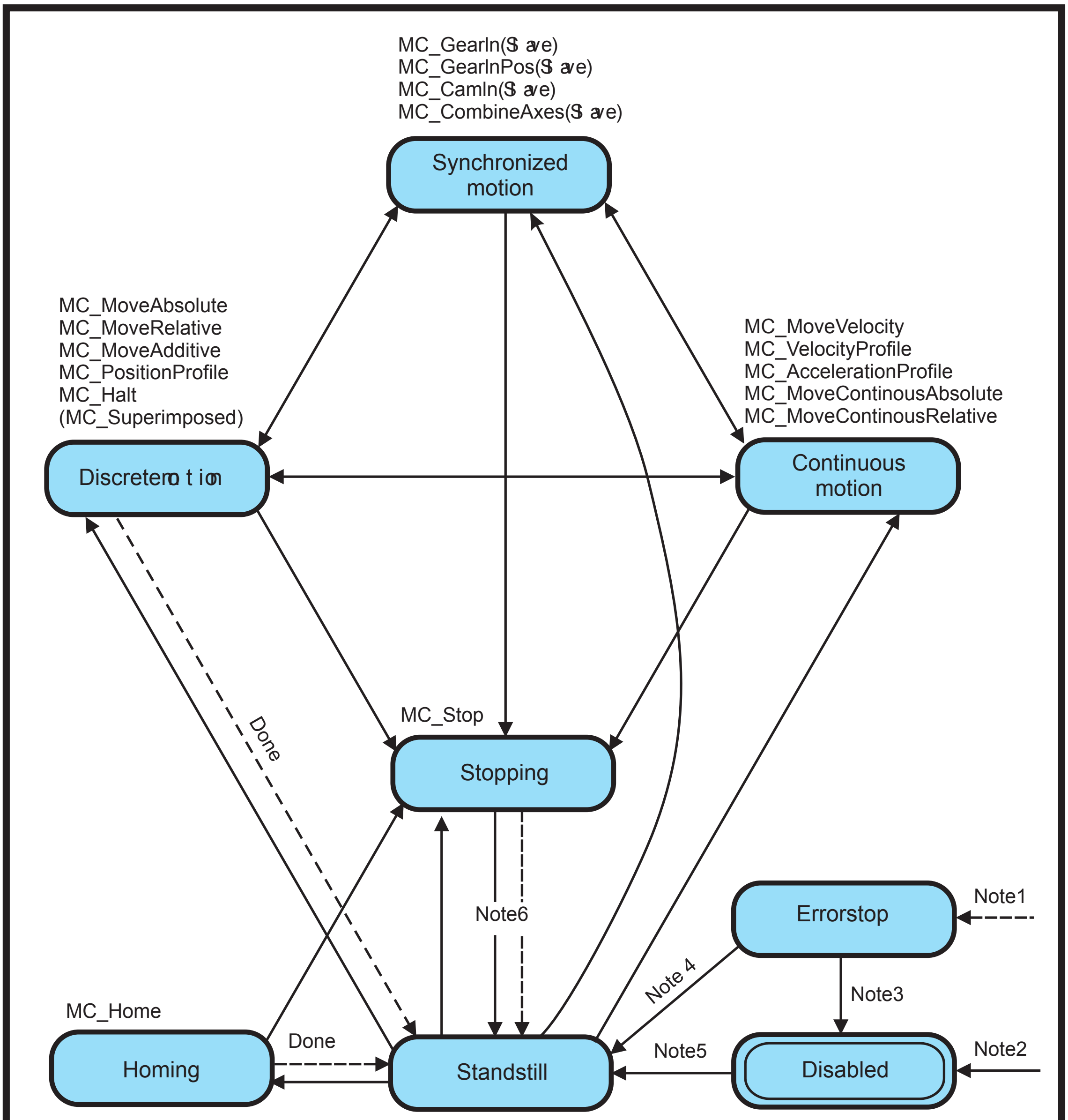
`MaxPosSystem`	Positive position limit for system. The value is never exceeded for linear axis. The value is end of revolution for cyclic axis.	`Double (F64)`
`EnableLimitNeg`	Enable negative position limit checking (e.g. if checked, `MinPosAppl` is valid)	`Bool`
`MinPosAppl`	Negative position limit for application (MC blocks) The value should be bigger then (before the) `MinPosSystem` for linear axis. The value limit cyclic axis with linear senzor for few revolution (useful for robotic application) and must be smaller then (beyond the) `MinPosSystem`.	`Double (F64)`
`MinPosSystem`	Negative position limit for system. The value is never exceeded for linear axis. The value is begin of revolution for cyclic axis.	`Double (F64)`
`EnablePosLagMonitor`	Enable monitoring of position lag (e.g. if checked, `MaxPositionLag` is valid)	`Bool`
`MaxPositionLag`	Maximal position lag. Any moving is stopped and the axis is switched into error stop state if different between `PhysicalPosition` and `ActualPosition` exceed this value.	`Double (F64)`
`MaxVelocitySystem`	Maximal allowed velocity for system	`Double (F64)`
`MaxVelocityAppl`	Maximal allowed velocity for application (MC blocks)	`Double (F64)`
`MaxAccelerationSystem`	Maximal allowed acceleration for system	`Double (F64)`
`MaxAccelerationAppl`	Maximal allowed acceleration for application (MC blocks)	`Double (F64)`
`MaxDecelerationSystem`	Maximal allowed deceleration for system	`Double (F64)`
`MaxDecelerationAppl`	Maximal allowed deceleration for application (MC blocks)	`Double (F64)`
`DefaultJerk`	Maximal recomended jerk [unit/s^3]. Real jerk is not checked and could overcome this value.	`Double (F64)`
`MaxTorque`	Maximal motor torque/force (0=not used)	`Double (F64)`
`TorqueRatio`	Torque-Acceleration ratio. The requested torque value is useful for feedback controller. The most block don't generate it. The requested torque value is comuted as reqested acceleration multiplied by this parameter.	`Double (F64)`
`LoopDelay`	delay between commanded and actual values[s] The actual position value is deleyed from commanded value due communication with feedback controller, feedback loop, value interpolation and sampling period. The delay could be set into this parameter and then position lag is computed more precisely. (not yet implemented)	`Double (F64)`
`StartMode`	Some options when axis is enabled ⊙1 1 ..... start stopped 2 ..... start tracking	`Long (I32)`
`HomingRequired`	Homing is required before any move	`Bool`

Example

Following example illustrates basic principle of use of motion control blocks. It presents the minimal configuration which is needed for operation of a physical or virtual axis. The axis is represented by `RM_Axis` block. The limitations imposed on the motion trajectory in form of maximum velocity, acceleration, jerk and position have to be set in parameters of the `RM_Axis` block. The inputs can be connected to supply the values of actual position, speed and torque (feedback for slip monitoring) or logical limit switch signals for homing procedure. The `axisRef` output signal needs to be connected to any motion control block related to the corresponding axis. The axis has to be activated by enabling the `MC_Power` block. The state of the axis changes from Disabled to Standstill (see the following state transition diagram) and any discrete, continuous or synchronized motion can be started by executing a proper functional block (e.g. `MC_MoveAbsolute`). The trajectory of motion in form of desired position, velocity and acceleration is generated in output signals of the `RM_Axis` block. The reference values are provided to an actuator control loop which is implemented locally in REXYGEN system in the same or different task or they are transmitted via a serial communication interface to end device which controls the motor motion (servo amplifier, frequency inverter etc.). In case of any error, the axis performs an emergency stop and indicates the error ID. The error has to be confirmed by executing the `MC_Reset` block prior to any subsequent motion command. The following state diagram demonstrates the state transitions of an axis.



Axis state transition diagram



Note 1: From any state. An error in the axis occurred.

Note 2: From any state. MC_Power.Enable = FALSE and there is no error in the axis.

Note 3: MC_Reset AND MC_Power.Status = FALSE

Note 4: MC_Reset AND MC_Power.Status = TRUE AND MC_Power.Enable = TRUE

Note 5: MC_Power.Enable = TRUE AND MC_Power.Status = TRUE

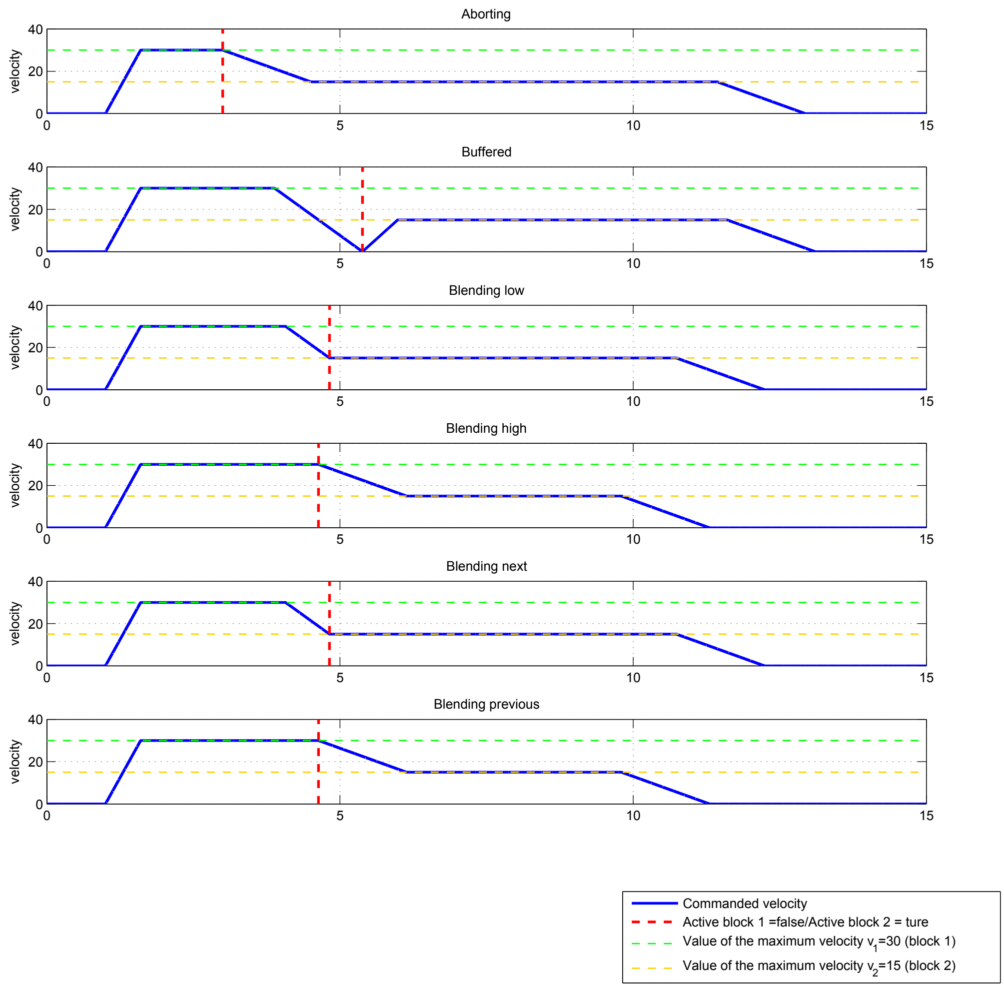
Note 6: MC_Stop.Done = TRUE AND MC_Stop.Execute = FALSE

Motion blending

According to `PLCOpen` specification, number of motion control blocks allow to specify `BufferMode` parameter, which determines a behaviour of the axis in case that a motion command is interrupted by another one before the first motion is finished. This transition from one motion to another (called "Blending") can be handled in various ways. The following table presents a brief explanation of functionality of each blending mode and the resulting shapes of generated trajectories are illustrated in the figure. For detailed description see full `PLCOpen` specification.

Aborting	The new motion is executed immediately
Buffered	the new motion is executed immediately after finishing the previous one, there is no blending
Blending low	the new motion is executed immediately after finishing the previous one, but the axis will not stop between the movements, the first motion ends with the lower limit for maximum velocity of both blocks at the first end-position
Blending high	the new motion is executed immediately after finishing the previous one, but the axis will not stop between the movements, the first motion ends with the higher limit for maximum velocity of both blocks at the first end-position
Blending previous	the new motion is executed immediately after finishing the previous one, but the axis will not stop between the movements, the first motion ends with the limit for maximum velocity of first block at the first end-position
Blending next	the new motion is executed immediately after finishing the previous one, but the axis will not stop between the movements, the first motion ends with the limit for maximum velocity of second block at the first end-position

Illustration of blending modes



RM_AxisOut – **Axis output**

Block Symbol

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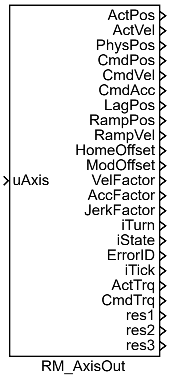


Function Description

The RM_AxisOut block allows an access to important states of block RM_Axis. Same outputs are also available directly on RM_Axis (some of them), but this direct output is one step delayed. Blocks are ordered for execution by flow of a signal, so RM_Axis is first then all motion blocks (that actualize RM_Axis state), then RM_AxisOut (should be last) and finally waiting for next period.

Note: almost all blocks do not work with torque so commanded torque is 0. Commanded acceleration and torque should be used as feed-forward value for position/velocity controller so this value does not make any problem.

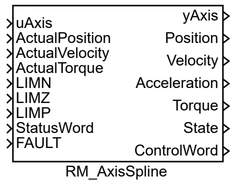
Inputs

uAxis	axis reference that must be connected to axisRef of the RM_Axis block (direct or indirect throw output yAxis of some other block)	Reference

RM_AxisSpline – **Commanded values interpolation**

Block Symbol

Licence: MOTION CONTROL



Function Description

The purpose of the block is to connect a virtual axis (represented by the `RM_Axis` block) to the motor or rather the servo drive and transform virtual axis into physical one. It includes some independent functions that are covered by this block.

The block has commanded and actual (feedback) signals to connect feedback controller. It includes inputs `ActualPosition`, `ActualVelocity`, `ActualTorque` and outputs `Position`, `Velocity`, `Acceleration`, `Torque`.

The feedback controller or servo drive usually works with different units (position unit is usually in encoder's tick that is transformed by gear ratio). The `RM_AxisSpline` block transforms drive unit into axis logical unit. The function is controlled by the `DriveUnits` and `AxisUnits` parameters.

The servo drive often uses integer types for compute or communicate position, velocity and torque. Position can overflow range of integer value when motor is running one direction long time. The `RM_AxisSpline` block expects this situation and set correct position if feedback signal overflow from maximum integer value to minimal integer value. This feature is controlled by the `DriveBits` and must be also supported by the servo drive to work correctly.

The servo drive has different working state and operation mode and require some sequence to switch into operation mode where motor follow requested position. The most common standard for the mode and sequencing is CiA402. The `RM_AxisSpline` block support the CiA402 standard by the `StatusWord` input, the `ControlWord` output and the `DriveMode`, `DriveTimeout` parameters. The servo drive must be set to Cyclic Synchronous Position Mode (or mode with similar functionality). There is also possible to use Velocity Mode, but position loop regulator must be realized in control system (typically by a `PIDU` block).

There are a lot of motion control blocks which implement complicated algorithms so they require bigger sampling period (typical update rate is from 10 to 200 ms). On the other side, the motor driver usually requires small sampling period for smooth/waveless movement. The `RM_AxisSpline` block solves this problem of multirate execution of motion planning and motion control levels. The block can run in another task than other motion control blocks with highest possible sampling period. It interpolates commanded position, velocity, acceleration and torque and generates smooth curve which is more suited for motor driver controllers.

There are many possibilities how to compute position (and velocity, acceleration, torque) between sampled points by slower task. This could be chosen by the `InterpolationMode` parameter, but torque is interpolated always by linear function. The supported methods include:

1: **linear**: Position is interpolated linearly, velocity as the derivative of position, acceleration is 0 (i.e., velocity is a piecewise constant function with jumps).

2: **cubic spline**: Position is a 3rd order polynomial calculated based on the position and velocity at the beginning and end of the interval; velocity is the derivative of position, acceleration is the derivative of velocity.

3: **quintic spline**: Position is a 5th order polynomial calculated based on the position, velocity, and acceleration at the beginning and end of the interval; velocity is the derivative of position, acceleration is the derivative of velocity.

4: **cubic aproximation (B-spline)**: Position is a 3rd order polynomial calculated based on two positions before and two positions after the current interval; the interpolated function may not exactly pass through the given points; velocity is the derivative of position, acceleration is the derivative of velocity.

5: **quintic aproximation (B-spline)**: Position is a 5th order polynomial calculated based on three positions before and three positions after the current interval; the interpolated function may not exactly pass through the given points; velocity is the derivative of position, acceleration is the derivative of velocity.

6: **all linear**: Position, velocity, and acceleration are independently interpolated linearly, i.e., velocity does not precisely correspond to the derivative of position, and acceleration does not precisely correspond to the derivative of velocity.

7: **all cubic**: Both position and velocity are interpolated by a 3rd order polynomial independently, i.e., velocity does not exactly correspond to the derivative of position.

8: *reserved for future use.*

9: *reserved for future use.*

Most simple is linear interpolation, but it leads to steps in velocity. Better possibility is higher order polynom (e.g. 3th or 5th order). It generates a smooth curve, but leads to a huge acceleration if the original trajectory isn't the same polynomial. Drawback of polynomial interpolation could be solved by Bspline approximation, but it requires more samples and therefore bigger delay. Some original position values can be changed with this method.

Note 1: Because the execution time of motion blocks is varying in time, the block uses one or two step prediction for interpolation depending on actual conditions and timing of the motion blocks in slower tasks. The use of predicted values is signalized by states `Run1, Run2, Run3`.

Note 2: The interpolation functionality requires to put the block into different (faster) task than `RM_Axis`. For this reason, the block `RM_AxisSpline` has an internally safe solution for connecting axis references by the block `Inport` and `Outport` between different tasks.

Input

`uAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`ActualPosition`	Current position of the axis (feedback) [drive unit]	`Double (F64)`
`ActualVelocity`	Current velocity of the axis (feedback) [drive unit/s]	`Double (F64)`
`ActualTorque`	Current torque in the axis (feedback)	`Double (F64)`
`LIMN`	Limit switch in negative direction	`Bool`
`LIMZ`	Absolute switch or reference pulse for homing	`Bool`
`LIMP`	Limit switch in positive direction	`Bool`
`StatusWord`	Status register for drive control according CiA402 specification	`Long (I32)`
`FAULT`	External fault signal	`Bool`

Outputs

`yAxis`	Axis reference (only `RM_Axis.axisRef`–`uAxis` or `yAxis`–`uAxis` connections are allowed)	`Reference`
`Position`	Commanded interpolated position [drive unit]	`Double (F64)`
`Velocity`	Commanded interpolated velocity [drive unit/s]	`Double (F64)`
`Acceleration`	Commanded interpolated acceleration [drive unit/s/s]	`Double (F64)`
`Torque`	Commanded interpolated torque/force	`Double (F64)`

`State`	Interpolator state/error 0 ..... Off (interpolator is disabled, actual data put on output) 1 ..... Wait (not enough data in buffer, waiting) 2 ..... Run1 (interpolator running, data from first buffered interval) 3 ..... Run2 (interpolator running, data from second buffered interval) 4 ..... Run3 (interpolator running, data from third buffered interval) -1 .... Overflow (interpolation buffer overflow, the interpolation restarts automatically, but a bump in output values may occur) -2 .... Underflow (interpolation buffer underflow, the interpolation restarts automatically, but a bump in output values may occur) -3 .... Busy (data from `RM_Axis` cannot be read consistently, it usually indicates, that some task is overloaded) -4 .... Slow (the task with `RM_AxisSpline` has longer period then a task with `RM_Axis`)	`Long (I32)`
`ControlWord`	Control register for drive control according CiA402 specification	`Long (I32)`

Parameters

`InterpolationMode`	Algorithm for interpolation ⊙9 1 ..... linear 2 ..... cubic spline 3 ..... quintic spline 4 ..... cubic aproximation (B-spline) 5 ..... quintic aproximation (B-spline) 6 ..... all linear 7 ..... all cubic 8 ..... — 9 ..... —	`Long (I32)`
`ReverseLimit`	Invert meaning of LIMN, LIMZ and LIMP inputs	`Bool`
`InterpolationMode`	Drive control mode ⊙9 1 ..... Simplified CiA402 (only basic check of `StatusWord`, e.g. fault bit only, and direct switching of `ControlWord`, e.g. without sequencing) 2 ..... Strict CiA402 (full check of `StatusWord` in each state and full sequencing of `ControlWord`)	`Long (I32)`
`DriveTimeout`	Drive control response timeout [s] (for Strict CiA402 mode only)	`Double (F64)`
`DriveBits`	number of valid bits (negative value means signed number) in the `Position` output and the `ActualPosition` input ↓-64 ↑63 ⊙-32	`Long (I32)`

DriveUnits	Distance in drive units for position transformation (value correspond to AxisUnits)	Double (F64)
AxisUnits	Distance in axis units for position transformation (value correspond to DriveUnits)	Double (F64)
VelocityCalculate	if checked, the input ActualVelocity is ignored and velocity is calculated by actual position difference	Bool

RM_HomeOffset – * Homing by setting offset

Block Symbol

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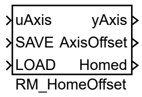

Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
SAVE	Set HomeOffset from the axis to the block parameter	Bool
LOAD	Set HomeOffset from the block parameter to the axis	Bool

Parameter

SavedOffset	Homing offset value	Double (F64)

Output

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
AxisOffset	Current home offset in axis	Bool
Homed	Axis homed flag	Bool

RM_Track – **Tracking and inching**

Block Symbol

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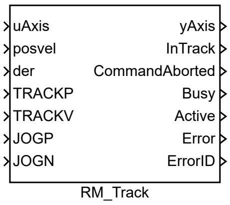


Function Description

The RM_Track block includes few useful functions.

If the input TRACK is active (not zero), the block tries to track requested position (input pos) with respect to the limits for velocity, acceleration/decelertation and jerk. The block expects that requested position is changed in each step and therefore recalculates the path in each step. This is difference to MC_MoveAbsolute block, which does not allow to change target position while the movement is not finished. This mode is useful if position is generated out of the motion control subsystem, even thought the MC_PositionProfile block is better if whole path is known.

If the input JOGP is active (not zero), the block works like the MC_MoveVelocity block (e.g. moves axis with velocity given by parameter pv in positive direction with respect to maximum acceleration and jerk). When input JOGP is released (switched to zero), the block activates stopping sequence and releases the axis when the sequence is finished. This mode is useful for jogging (e.g. setting of position of axis by an operator using up/down buttons).

Input JOGN works like JOGP, but direction is negative.

Note 1: This block hasn't parameter BufferMode. Mode is always aborting.

Note 2: If more functions are selected, only the first one is activated. Order is TRACK, JOGP, JOGN. Simultaneous activation of more than one function is not recommended.

Inputs

uAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
posvel	Requested target position or velocity [unit]	Double (F64)
TRACKP	Position tracking mode	Bool
TRACKV	Velocity tracking mode	Bool
JOGP	Moving positive direction mode	Bool
JOGN	Moving negative direction mode	Bool

Parameters

pv	Maximal allowed velocity [unit/s]		Double (F64)
pa	Maximal allowed acceleration [unit/s^2]		Double (F64)
pd	Maximal allowed deceleration [unit/s^2]		Double (F64)
pj	Maximal allowed jerk [unit/s^3]		Double (F64)
iLen	Length of buffer for estimation	⊙10	Long (I32)

Outputs

yAxis	Axis reference (only RM_Axis.axisRef–uAxis or yAxis–uAxis connections are allowed)	Reference
InTrack	Requested position is reached	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

Chapter 21

MC_MULTI – Motion control - multi axis blocks

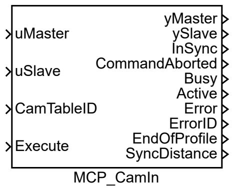
Contents

The MC_MULTI library is specialized for multi-axis motion control. It includes blocks like MC_CombineAxes for synchronizing multiple axes, MC_GearIn and MC_GearOut for gearing operations, and MC_PhasingAbsolute, MC_PhasingRelative for precise axis phasing. The library offers MC_CamIn and MC_CamOut for camming functionalities, allowing complex motion profiles to be followed. Additionally, MCP_CamTableSelect provides flexibility in selecting cam tables, and MC_GearInPos enables position-based gearing. This library is essential for advanced applications requiring coordinated motion control across multiple axes.

MCP_CamIn – * Engage the cam

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uMaster`	Master axis reference		`Reference`
`uSlave`	Slave axis reference		`Reference`
`CamTableID`	Cam table reference (connect to MCP_CamTableSelect.CamTableID)		`Reference`
`Execute`	The block is activated on rising edge		`Bool`

Parameter

`MasterOffset`	Offset in cam table on master side [unit]		`Double (F64)`
`SlaveOffset`	Offset in cam table on slave side [unit]		`Double (F64)`
`MasterScaling`	Overall scaling factor in cam table on master side	⊙`1.0`	`Double (F64)`
`SlaveScaling`	Overall scaling factor in cam table on slave side	⊙`1.0`	`Double (F64)`
`StartMode`	Select relative or absolute cam table 1 ..... Master relative 2 ..... Slave relative 3 ..... Both relative 4 ..... Both absolute	⊙`4`	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙`1`	`Long (I32)`

`RampIn`	RampIn factor (0 = RampIn mode not used)	`Double (F64)`

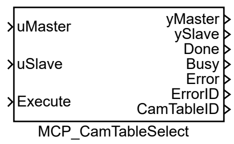
Output

`yMaster`	Master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`InSync`	Slave axis reached the cam profile	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`
`EndOfProfile`	Indicate end of cam profile (not periodic cam only)	`Bool`
`SyncDistance`	Position deviation of the slave axis from synchronized position	`Double (F64)`

MCP_CamTableSelect – Cam definition

Block Symbol

Licence: MOTION CONTROL



Function Description

The MCP_CamTableSelect block defines a cam profile. The definition is similar to MC_PositionProfile block, but the time axis is replaced by master position axis. There are also two possible ways for cam profile definition:

1. sequence of values: given sequence of master-slave position pairs. In each master position interval, value of slave position is interpolated by 3rd-order polynomial (simple linear interpolation would lead to steps in velocity at interval border). Master position sequence is in array/parameter mvalues, slave position sequence is in array/parameter svalues. Master position sequence must be increasing.

2. spline: master position sequence is the same as in previous case. Each interval is interpolated by 5th-order polynomial $p(x) = a_5x^5 + a_4x^4 + a_3x^3 + a_2x^2 + a_1x + a_0$ where beginning of time-interval is defined for $x = 0$, end of time-interval holds for $x = 1$ and factors a_i are put in array/parameter svalues in ascending order (e.g. array/parameter svalues contain 6 values for each interval). This method allows to reduce the number of intervals and there is special graphical editor available for interpolating curve synthesis.

For both cases the master position sequence can be equidistantly spaced in time and then the time array includes only first and last point.

Note 1: input CamTable which is defined in PLCOpen specification is missing, because all path data are set in the parameters of the block.

Note 2: parameter svalues must be set as a vector in all cases, e.g. text string must not include a semicolon.

Note 3: incorrect parameter value cSeg (higher then real size of arrays times and/or values) can lead to unpredictable results and in some cases to crash of the whole runtime execution (The problem is platform dependent and currently it is observed only for SIMULINK version).

Inputs

uMaster	Master axis reference	Reference
uSlave	Slave axis reference	Reference
Execute	The block is activated on rising edge	Bool

Outputs

yMaster	Master axis reference		Reference
ySlave	Slave axis reference		Reference
Done	Algorithm finished		Bool
Busy	Algorithm not finished yet		Bool
Error	Error occurred		Bool
ErrorID	Result of the last operation i ..... REXYGEN general error		Error
CamTableID	Cam table reference (connect to MC_CamIn.CamTableID)		Reference

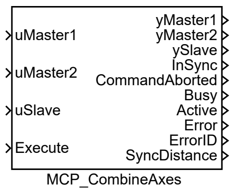
Parameters

alg	Algorithm for interpolation 1 ..... Sequence of time/value pairs 2 ..... Sequence of equidistant values 3 ..... Spline 4 ..... Equidistant spline	⊙2	Long (I32)
nmax	Number of profile segments	⊙3	Long (I32)
Periodic	Indicate periodic cam profile	⊙on	Bool
camname	Filename of special editor data file (filename is generated by system if parameter is empty)		String
mvalues	Master positions where segments are switched	⊙[0 30]	Double (F64)
sValues	Slave positions or interpolating polynomial coefficients (a0, a1, a2, ...)	⊙[0 100 100 0]	Double (F64)

MCP_CombineAxes – * Combine the motion of 2 axes into a third axis

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uMaster1`	First master axis reference	`Reference`
`uMaster2`	Second master axis reference	`Reference`
`uSlave`	Slave axis reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`GearRatioNumeratorM1`	Numerator for the gear factor for master axis 1 ⊙1	`Long (I32)`
`GearRatioDenominatorM1`	Denominator for the gear factor for master axis 1 ⊙1	`Long (I32)`
`GearRatioNumeratorM2`	Numerator for the gear factor for master axis 2 ⊙1	`Long (I32)`
`GearRatioDenominatorM2`	Denominator for the gear factor for master axis 2 ⊙1	`Long (I32)`
`BufferMode`	Buffering mode ⊙1 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	`Long (I32)`

CombineMode	axis combination mode 1 ..... addition 2 ..... subtraction	⊙1	Long (I32)
RampIn	RampIn factor (0 = RampIn mode not used)		Double (F64)

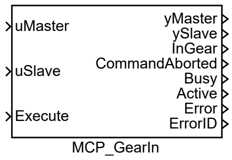
Output

yMaster1	First master axis reference	Reference
yMaster2	Second master axis reference	Reference
ySlave	Slave axis reference	Reference
InSync	Slave axis reached the cam profile	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error
SyncDistance	Position deviation of the slave axis from synchronized position	Double (F64)

MCP_GearIn – * Engage the master/slave velocity ratio

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uMaster`	Master axis reference	`Reference`
`uSlave`	Slave axis reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`RatioNumerator`	Gear ratio Numerator	⊙1	`Long (I32)`
`RatioDenominator`	Gear ratio Denominator	⊙1	`Long (I32)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]		`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`

Output

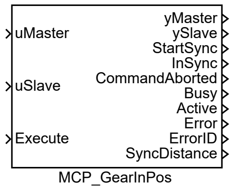
`yMaster`	Master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`InGear`	Slave axis reached gearing ratio	`Bool`

`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_GearInPos – * Engage the master/slave velocity ratio in defined position

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uMaster`	Master axis reference	`Reference`
`uSlave`	Slave axis reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`RatioNumerator`	Gear ratio Numerator	⊙1	`Long (I32)`
`RatioDenominator`	Gear ratio Denominator	⊙1	`Long (I32)`
`MasterSyncPosition`	Master position for synchronization		`Double (F64)`
`SlaveSyncPosition`	Slave position for synchronization		`Double (F64)`
`MasterStartDistance`	Master distance for starting gear in procedure		`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]		`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]		`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`

`SyncMode`	Synchronization mode (cyclic axes only) 1 ..... CatchUp 2 ..... Shortest 3 ..... SlowDown	⊙2	`Long (I32)`

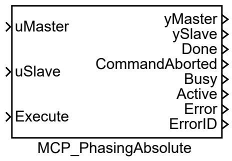
Output

`yMaster`	Master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`StartSync`	Commanded gearing starts	`Bool`
`InSync`	Slave axis reached the cam profile	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation i ..... REXYGEN error code	`Error`
`SyncDistance`	Position deviation of the slave axis from synchronized position	`Double (F64)`

MCP_PhasingAbsolute – * Create phase shift (absolute coordinate)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uMaster`	Master axis reference	`Reference`
`uSlave`	Slave axis reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`PhaseShift`	Requested phase shift (distance on master axis) for cam		`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]		`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]		`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered	⊙1	`Long (I32)`

Output

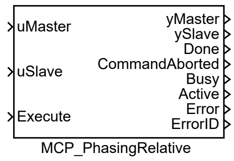
`yMaster`	Master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`

`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_PhasingRelative – * Create phase shift (relative to previous motion)

Block Symbol

Licence: MOTION CONTROL



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uMaster	Master axis reference	Reference
uSlave	Slave axis reference	Reference
Execute	The block is activated on rising edge	Bool

Parameter

PhaseShift	Requested phase shift (distance on master axis) for cam		Double (F64)
Velocity	Maximal allowed velocity [unit/s]		Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]		Double (F64)
Deceleration	Maximal allowed deceleration [unit/s^2]		Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]		Double (F64)
BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered	⊙1	Long (I32)

Output

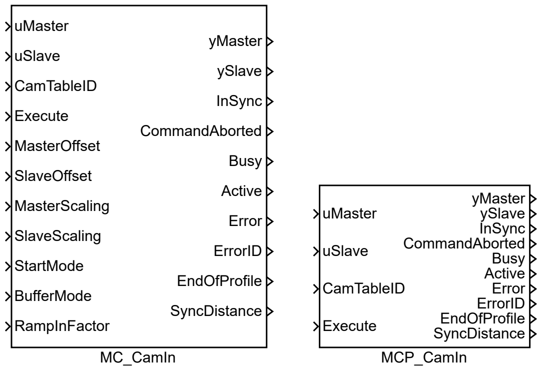
yMaster	Master axis reference	Reference
ySlave	Slave axis reference	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool

Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MC_CamIn, MCP_CamIn – Engage the cam

Block Symbols

Licence: MOTION CONTROL



Function Description

The `MC_CamIn` *and* `MCP_CamIn` *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* `MCP_` *version of the block.*

The `MC_CamIn` block switches on a mode in which the slave axis is commanded to position which corresponds to the position of master axis transformed with with a function defined by the `MCP_CamTableSelect` block (connected to `CamTableID` input). Denoting the transformation as $Cam(x)$, master axis position $PosM$ and slave axis position $PosS$, we obtain (for absolute relationship, without phasing): $PosS = Cam((PosM - MasterOffset)/MasterScaling) * SlaveScaling + SlaveOffset$. This form of synchronized motion of the slave axis is called electronic cam.

The cam mode is switched off by executing other motion block on slave axis with mode `aborting` or by executing a `MC_CamOut` block. The cam mode is also finished when the master axis leaves a non-periodic cam profile. This situation is indicated by the `EndOfProfile` output.

In case of a difference between real position and/or velocity of slave axis and cam-profile slave axis position and velocity, some transient trajectory must be generated to cancel this offset. This mode is called ramp-in. The ramp-in function is added to the cam profile to eliminate the difference in start position. The `RampIn` parametr is an average velocity of the ramp-in function. Ramp-in path is not generated for `RampIn=0` and error `-707` (position or velocity step) is invoked if some difference is detected. Recommended value for the `RampIn` parametr is 0.1 to 0.5 of maximal slave axis velocity. The parameter has to be lowered if maximal velocity or acceleration error is detected.

Inputs

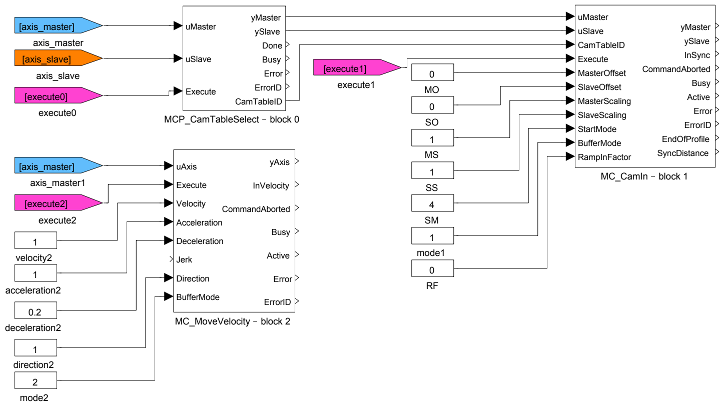
uMaster	Master axis reference	Reference
uSlave	Slave axis reference	Reference
CamTableID	Cam table reference (connect to MCP_CamTableSelect.CamTableID)	Reference
Execute	The block is activated on rising edge	Bool
MasterOffset	Offset in cam table on master side [unit]	Double (F64)
SlaveOffset	Offset in cam table on slave side [unit]	Double (F64)
MasterScaling	Overall scaling factor in cam table on master side	Double (F64)
SlaveScaling	Overall scaling factor in cam table on slave side	Double (F64)
StartMode	Select relative or absolute cam table 1 ..... Master relative 2 ..... Slave relative 3 ..... Both relative 4 ..... Both absolute	Long (I32)
BufferMode	Buffering mode 1 ..... Aborting (start immediately) 2 ..... Buffered (start after finish of previous motion) 3 ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 4 ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 5 ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) 6 ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	Long (I32)
RampIn	RampIn factor (0 = RampIn mode not used); average additive velocity (absolute value) during ramp-in process	Double (F64)

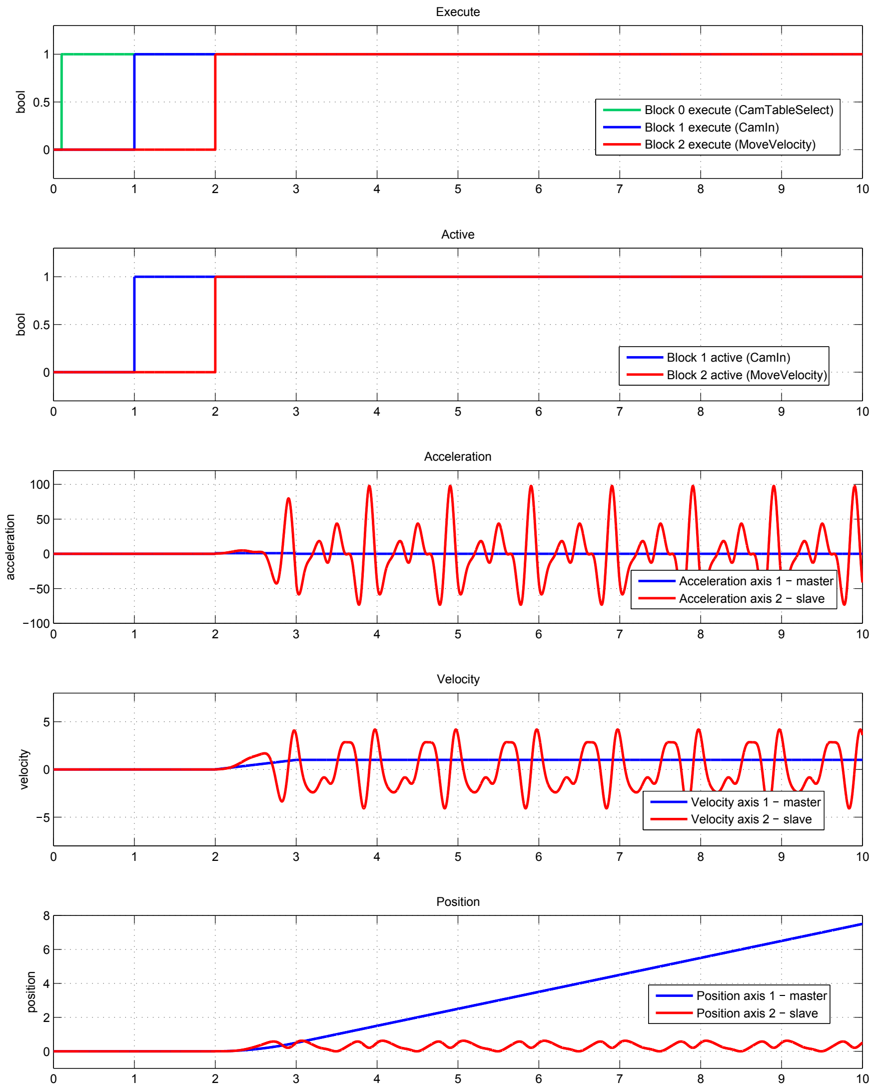
Outputs

yMaster	Master axis reference	Reference
ySlave	Slave axis reference	Reference
InSync	Slave axis reached the cam profile	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error
EndOfProfile	Indicate end of cam profile (not periodic cam only)	Bool

SyncDistance	Position deviation of the slave axis from synchronized position	Double (F64)

Example

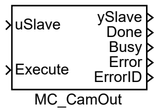

[axis_master]
axis_master
[axis_slave]
axis_slave
[execute0]
execute0
uMaster
uSlave
Execute
yMaster
ySlave
Done
Busy
Error
ErrorID
CamTableID
MCP_CamTableSelect - block 0
[execute1]
execute1
0
MO
0
SO
1
MS
1
SS
4
SM
1
mode1
0
RF
uMaster
uSlave
CamTableID
Execute
MasterOffset
SlaveOffset
MasterScaling
SlaveScaling
StartMode
BufferMode
RampInFactor
yMaster
ySlave
InSync
CommandAborted
Busy
Active
Error
ErrorID
EndOfProfile
SyncDistance
MC_CamIn - block 1
[axis_master]
axis_master1
[execute2]
execute2
1
velocity2
1
acceleration2
0.2
deceleration2
1
direction2
2
mode2
uAxis
Execute
Velocity
Acceleration
Deceleration
Jerk
Direction
BufferMode
yAxis
InVelocity
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveVelocity - block 2


Execute
bool
Block 0 execute (CamTableSelect)
Block 1 execute (CamIn)
Block 2 execute (MoveVelocity)
Active
bool
Block 1 active (CamIn)
Block 2 active (MoveVelocity)
Acceleration
acceleration
Acceleration axis 1 − master
Acceleration axis 2 − slave
Velocity
velocity
Velocity axis 1 − master
Velocity axis 2 − slave
Position
position
Position axis 1 − master
Position axis 2 − slave

MC_CamOut – Disengage the cam

Block Symbol

Licence: MOTION CONTROL



Function Description

The MC_CamOut block switches off the cam mode on slave axis. If cam mode is not active, the block does nothing (no error is activated).

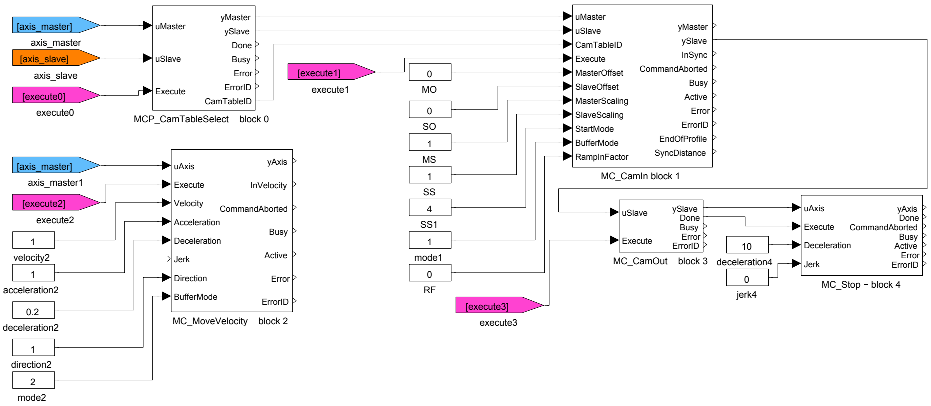
Inputs

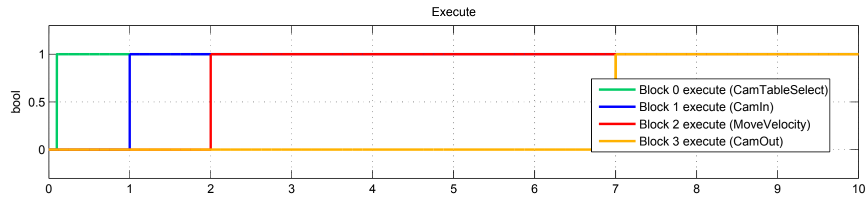
uSlave	Slave axis reference	Reference
Execute	The block is activated on rising edge	Bool

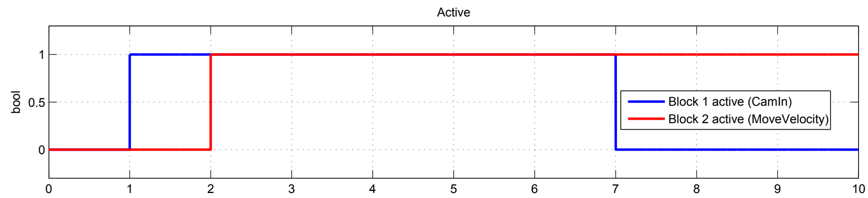
Outputs

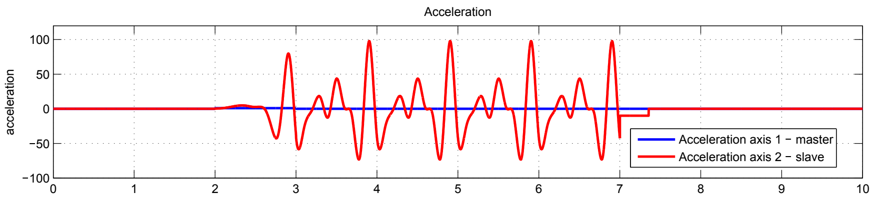
ySlave	Slave axis reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

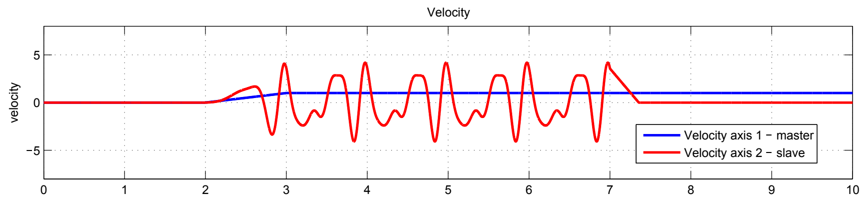
Example

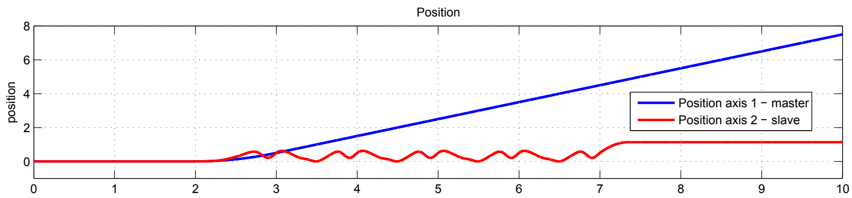

[axis_master]
axis_master
[axis_slave]
axis_slave
[execute0]
execute0
MCP_CamTableSelect - block 0
[execute1]
execute1
MO
SO
MS
SS
SS1
mode1
RF
[execute3]
execute3
MC_CamIn block 1
MC_CamOut - block 3
deceleration4
jerk4
MC_Stop - block 4
axis_master1
[execute2]
execute2
velocity2
acceleration2
deceleration2
direction2
mode2
MC_MoveVelocity - block 2


Execute
bool
Block 0 execute (CamTableSelect)
Block 1 execute (CamIn)
Block 2 execute (MoveVelocity)
Block 3 execute (CamOut)


Active
bool
Block 1 active (CamIn)
Block 2 active (MoveVelocity)


Acceleration
acceleration
Acceleration axis 1 − master
Acceleration axis 2 − slave

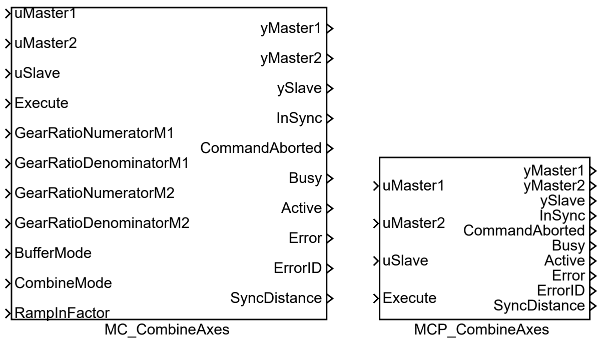

Velocity
velocity
Velocity axis 1 − master
Velocity axis 2 − slave


Position
position
Position axis 1 − master
Position axis 2 − slave

MC_CombineAxes, MCP_CombineAxes – Combine the motion of 2 axes into a third axis

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_CombineAxes block combines a motion of two master axes into a slave axis command. The slave axis indicates synchronized motion state. Following relationship holds:

$$\begin{aligned} \texttt{SlavePosition} &= \texttt{Master1Position} \cdot \frac{\texttt{GearRatioNumeratorM1}}{\texttt{GearRatioDenominatorM1}} + \\ &+ \texttt{Master2Position} \cdot \frac{\texttt{GearRatioNumeratorM2}}{\texttt{GearRatioDenominatorM2}} \end{aligned}$$

Negative number can be set in GearRatio... parameter to obtain the resulting slave movement in form of difference of master axes positions.

Inputs

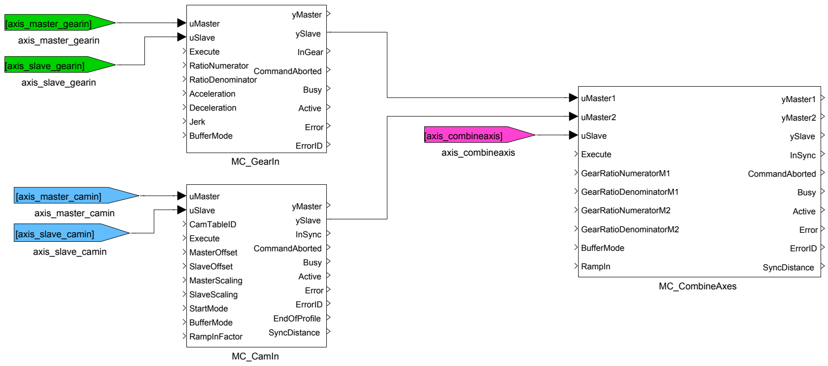
uMaster1	First master axis reference	Reference
uMaster2	Second master axis reference	Reference
uSlave	Slave axis reference	Reference
Execute	The block is activated on rising edge	Bool
GearRatioNumeratorM1	Numerator for the gear factor for master axis 1	Long (I32)
GearRatioDenominatorM1	Denominator for the gear factor for master axis 1	Long (I32)
GearRatioNumeratorM2	Numerator for the gear factor for master axis 2	Long (I32)
GearRatioDenominatorM2	Denominator for the gear factor for master axis 2	Long (I32)

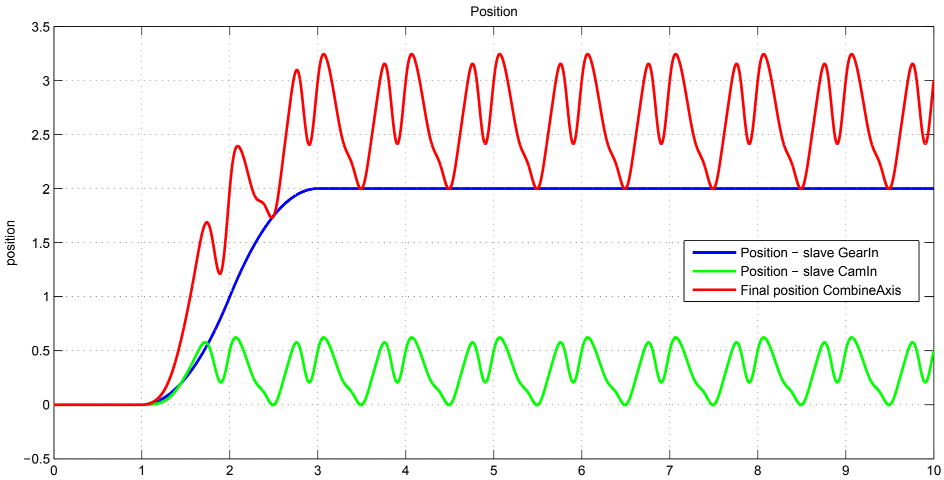
`BufferMode`	Buffering mode `1` ..... Aborting (start immediately) `2` ..... Buffered (start after finish of previous motion) `3` ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `4` ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) `5` ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) `6` ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`
`RampIn`	RampIn factor (0 = RampIn mode not used)	`Double (F64)`

Outputs

`yMaster1`	First master axis reference	`Reference`
`yMaster2`	Second master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`InSync`	Slave axis reached the cam profile	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`
`SyncDistance`	Position deviation of the slave axis from synchronized position	`Double (F64)`

Example

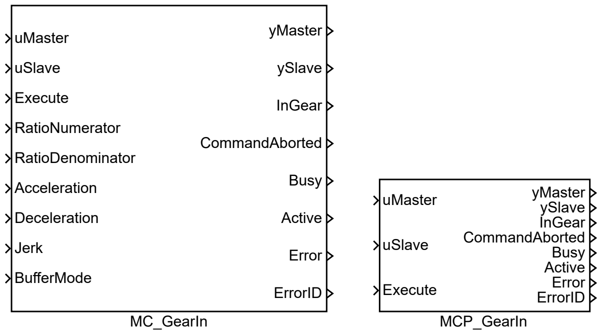

[axis_master_gearin]
axis_master_gearin
[axis_slave_gearin]
axis_slave_gearin
uMaster
uSlave
Execute
RatioNumerator
RatioDenominator
Acceleration
Deceleration
Jerk
BufferMode
yMaster
ySlave
InGear
CommandAborted
Busy
Active
Error
ErrorID
MC_GearIn
[axis_master_camin]
axis_master_camin
[axis_slave_camin]
axis_slave_camin
uMaster
uSlave
CamTableID
Execute
MasterOffset
SlaveOffset
MasterScaling
SlaveScaling
StartMode
BufferMode
RampInFactor
yMaster
ySlave
InSync
CommandAborted
Busy
Active
Error
ErrorID
EndOfProfile
SyncDistance
MC_CamIn
[axis_combineaxis]
axis_combineaxis
uMaster1
uMaster2
uSlave
Execute
GearRatioNumeratorM1
GearRatioDenominatorM1
GearRatioNumeratorM2
GearRatioDenominatorM2
BufferMode
RampIn
yMaster1
yMaster2
ySlave
InSync
CommandAborted
Busy
Active
Error
ErrorID
SyncDistance
MC_CombineAxes


Position
position
Position − slave GearIn
Position − slave CamIn
Final position CombineAxis

MC_GearIn, MCP_GearIn – Engange the master/slave velocity ratio

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_GearIn *and* MCP_GearIn *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_GearIn block commands the slave axis motion in such a way that a preset ratio between master and slave velocities is maintained. Considering the velocity of master axis $VelM$ and velocity of slave axis $VelS$, following relation holds (without phasing): $VelS = VelM * RatioNumerator/RatioDenominator$. Position and acceleration is commanded to be consistent with velocity; position/distance ratio is also locked. This mode of synchronized motion is called electronic gear.

The gear mode is switched off by executing other motion block on slave axis with mode aborting or by executing a MC_GearIn block.

Similarly to the MC_CamIn block, ramp-in mode is activated if initial velocity of slave axis is different from master axis and gearing ratio. Parameters Acceleration, Deceleration, Jerk are used during ramp-in mode.

Inputs

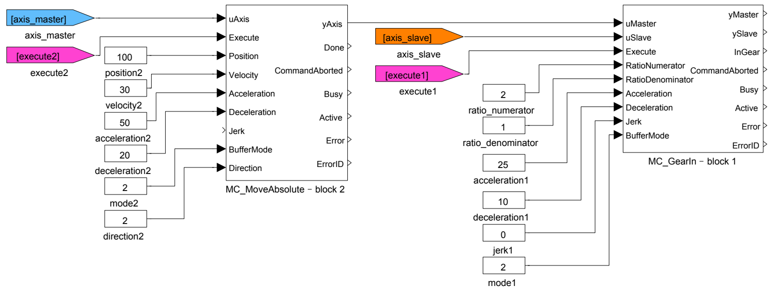
uMaster	Master axis reference	Reference
uSlave	Slave axis reference	Reference
Execute	The block is activated on rising edge	Bool
RatioNumerator	Gear ratio Numerator	Long (I32)
RatioDenominator	Gear ratio Denominator	Long (I32)
Acceleration	Maximal allowed acceleration [unit/s^2]	Double (F64)
Deceleration	Maximal allowed deceleration [unit/s^2]	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	Double (F64)

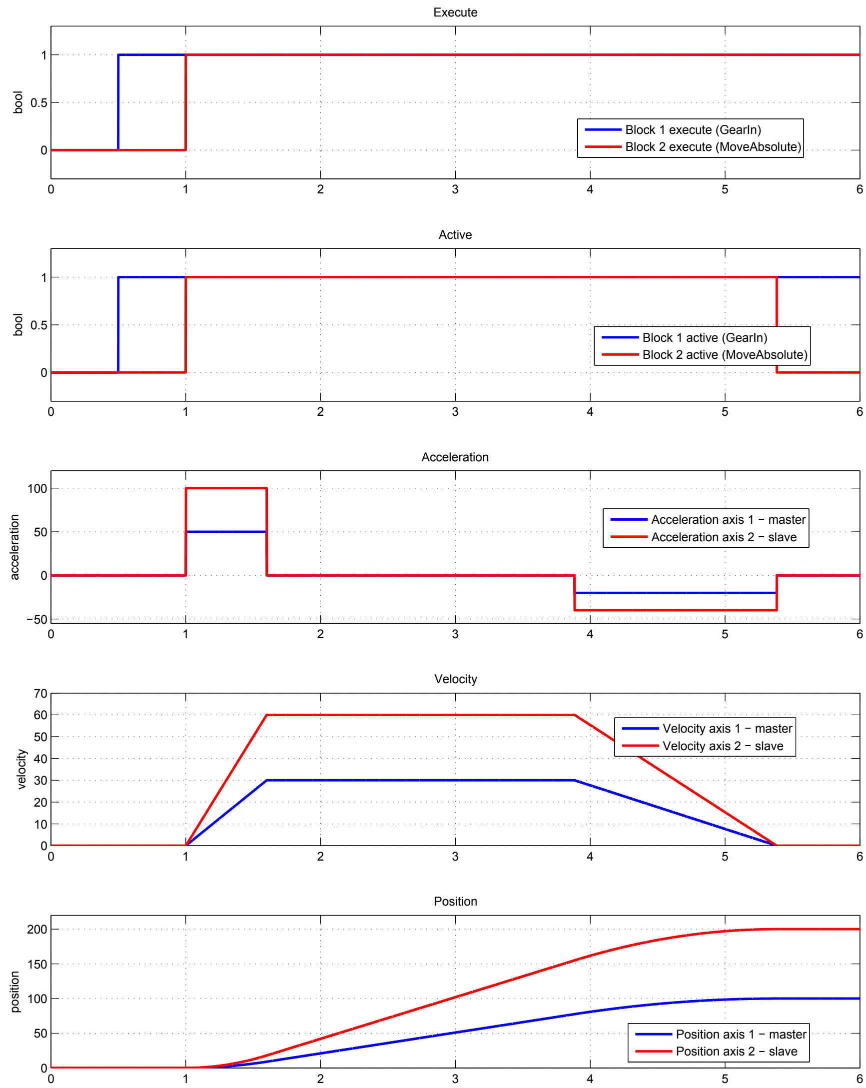
`BufferMode`	Buffering mode 1 ..... Aborting (start immediately) 2 ..... Buffered (start after finish of previous motion) 3 ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 4 ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 5 ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) 6 ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`

Outputs

`yMaster`	Master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`InGear`	Slave axis reached gearing ratio	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`

Example

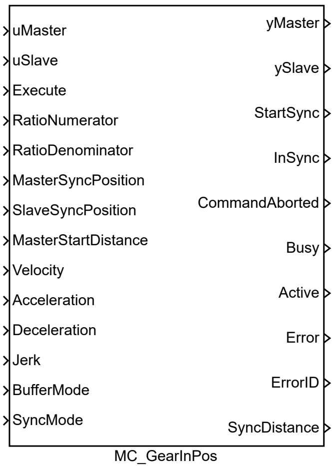

[axis_master]
axis_master
[execute2]
execute2
100
position2
30
velocity2
50
acceleration2
20
deceleration2
2
mode2
2
direction2
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAbsolute – block 2
[axis_slave]
axis_slave
[execute1]
execute1
2
ratio_numerator
1
ratio_denominator
25
acceleration1
10
deceleration1
0
jerk1
2
mode1
uMaster
uSlave
Execute
RatioNumerator
RatioDenominator
Acceleration
Deceleration
Jerk
BufferMode
yMaster
ySlave
InGear
CommandAborted
Busy
Active
Error
ErrorID
MC_GearIn – block 1

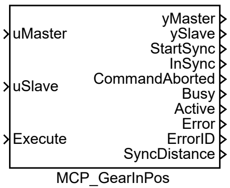

Execute
bool
Block 1 execute (GearIn)
Block 2 execute (MoveAbsolute)
Active
bool
Block 1 active (GearIn)
Block 2 active (MoveAbsolute)
Acceleration
acceleration
Acceleration axis 1 – master
Acceleration axis 2 – slave
Velocity
velocity
Velocity axis 1 – master
Velocity axis 2 – slave
Position
position
Position axis 1 – master
Position axis 2 – slave

MC_GearInPos, MCP_GearInPos – Engage the master/slave velocity ratio in defined position

Block Symbols

Licence: MOTION CONTROL





Function Description

The MC_GearInPos *and* MCP_GearInPos *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The functional block MC_GearInPos engages a synchronized motion of master and slave axes in such a way that the ratio of velocities of both axes is maintained at a constant value. Compared to MC_GearIn, also the master to slave *position ratio* is determined in a given reference point, i.e. following relation holds:

$$\frac{SlavePosition - SlaveSyncPosition}{MasterPosition - MasterSyncPosition} = \frac{\texttt{RatioNumerator}}{\texttt{RatioDenominator}}.$$

In case that the slave position does not fulfill this condition of synchronicity at the moment of block activation (i.e. in an instant of positive edge of Execute input and after execution of previous commands in buffered mode), synchronization procedure is started and indicated by output StartSync. During this procedure, proper slave trajectory which results in smooth synchronization of both axes is generated with respect to actual master motion and slave limits for Velocity, Acceleration, Deceleration and Jerk (these limits are not applied from the moment of successful synchronization). Parameter setting MasterStartDistance=0 leads to immediate start of synchronization procedure at the moment of block activation (by the Execute input). Otherwise, the synchronization starts as soon as the master position enters the interval `MasterSyncPosition` ± `MasterStartDistance`.

Notes:
1. The synchronization procedure uses two algorithms: I. The algorithm implemented in `MC_MoveAbsolute` is recomputed in every time instant in such a way, that the end velocity is set to actual velocity of master axis. II. The position, velocity and acceleration is generated in the same manner as in the synchronized motion and a proper 5th order interpolation polynomial is added to achieve smooth transition to the synchronized state. The length of interpolation trajectory is computed in such a way that maximum velocity, acceleration and jerk do not violate the specified limits (for the interpolation polynomial). The first algorithm cannot be used for nonzero acceleration of the master axis whereas the second does not guarantee the compliance of maximum limits for the overall slave trajectory. Both algorithms are combined in a proper way to achieve the synchronized motion of both axes.

2. The block parameters (execution of synchronization and velocity/acceleration limits) have to be chosen so that the slave position is close to `SlaveSyncPosition` approximately at the moment when the master position enters the range for synchronization given by `MasterSyncPosition` and `MasterStartDistance`. Violation of this rule can lead to unpredictable behaviour of the slave axis during the synchronization or to an overrun of the specified limits for slave axis. However, the motion of both axes is usually well defined and predictable in standard applications and correct synchronization can be performed easily by proper configuration of motion commands and functional block parameters.

Inputs

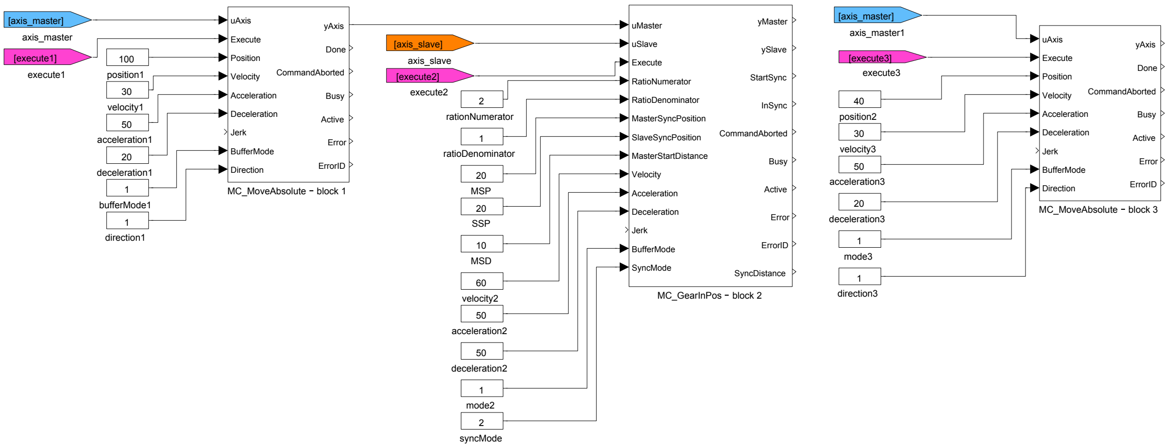
`uMaster`	Master axis reference	`Reference`
`uSlave`	Slave axis reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`RatioNumerator`	Gear ratio Numerator	`Long (I32)`
`RatioDenominator`	Gear ratio Denominator	`Long (I32)`
`MasterSyncPosition`	Master position for synchronization	`Double (F64)`
`SlaveSyncPosition`	Slave position for synchronization	`Double (F64)`
`MasterStartDistance`	Master distance for starting gear in procedure	`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`

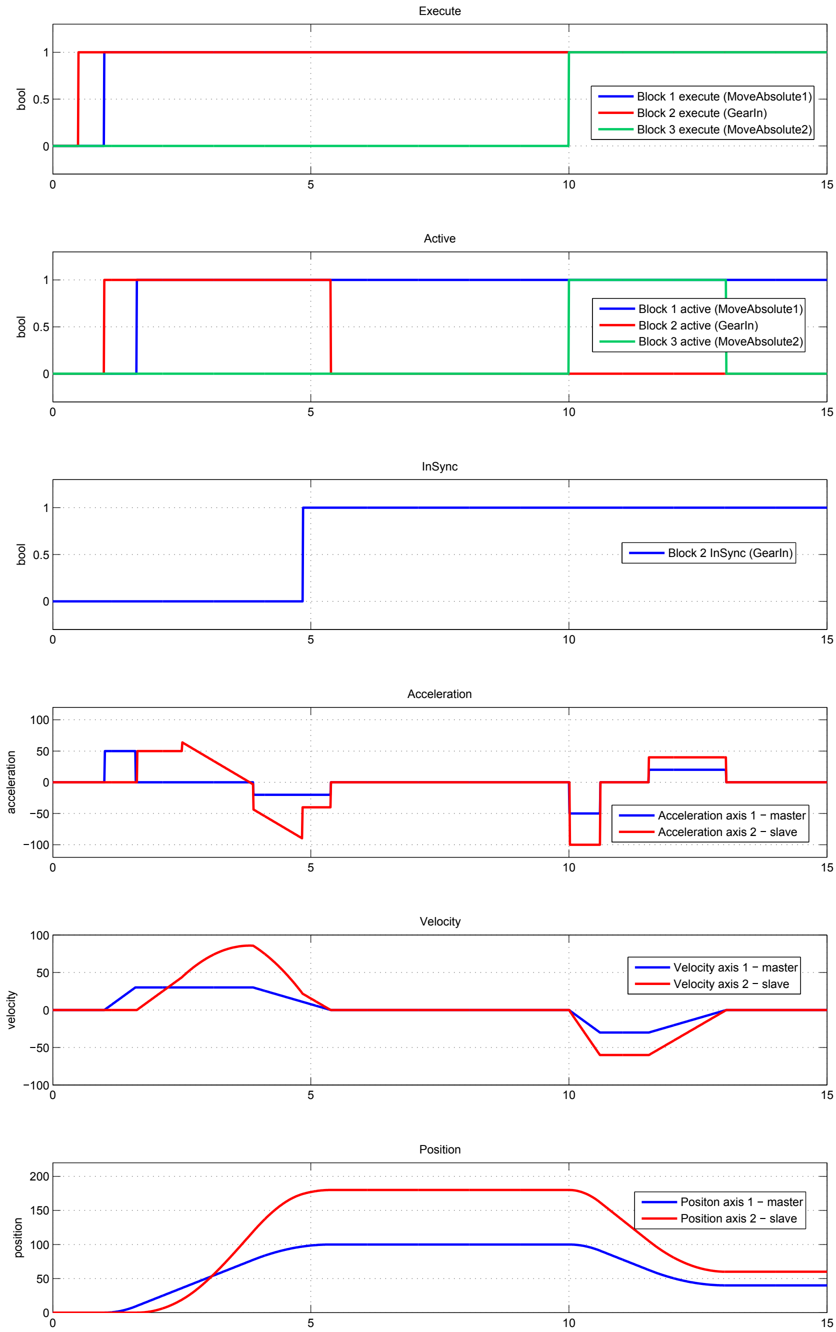
`BufferMode`	Buffering mode 1 ..... Aborting (start immediately) 2 ..... Buffered (start after finish of previous motion) 3 ..... Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 4 ..... Blending high (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands) 5 ..... Blending previous (start after finishing the previous motion, previous motion finishes with its final velocity) 6 ..... Blending next (start after finishing the previous motion, previous motion finishes with the starting velocity of the next block)	`Long (I32)`
`SyncMode`	Synchronization mode (cyclic axes only) 1 ..... CatchUp 2 ..... Shortest 3 ..... SlowDown	`Long (I32)`

Outputs

`yMaster`	Master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`StartSync`	Commanded gearing starts	`Bool`
`InSync`	Slave axis reached the cam profile	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`
`SyncDistance`	Position deviation of the slave axis from synchronized position	`Double (F64)`

Example

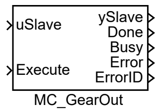

[axis_master]
axis_master
[execute1]
execute1
100
position1
30
velocity1
50
acceleration1
20
deceleration1
1
bufferMode1
1
direction1
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAbsolute - block 1
[axis_slave]
axis_slave
[execute2]
execute2
2
rationNumerator
1
ratioDenominator
20
MSP
20
SSP
10
MSD
60
velocity2
50
acceleration2
50
deceleration2
1
mode2
2
syncMode
uMaster
uSlave
Execute
RatioNumerator
RatioDenominator
MasterSyncPosition
SlaveSyncPosition
MasterStartDistance
Velocity
Acceleration
Deceleration
Jerk
BufferMode
SyncMode
yMaster
ySlave
StartSync
InSync
CommandAborted
Busy
Active
Error
ErrorID
SyncDistance
MC_GearInPos - block 2
[axis_master]
axis_master1
[execute3]
execute3
40
position2
30
velocity3
50
acceleration3
20
deceleration3
1
mode3
1
direction3
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAbsolute - block 3


Execute
bool
Block 1 execute (MoveAbsolute1)
Block 2 execute (GearIn)
Block 3 execute (MoveAbsolute2)
Active
bool
Block 1 active (MoveAbsolute1)
Block 2 active (GearIn)
Block 3 active (MoveAbsolute2)
InSync
bool
Block 2 InSync (GearIn)
Acceleration
acceleration
Acceleration axis 1 − master
Acceleration axis 2 − slave
Velocity
velocity
Velocity axis 1 − master
Velocity axis 2 − slave
Position
position
Positon axis 1 − master
Position axis 2 − slave

MC_GearOut – Disengange the master/slave velocity ratio

Block Symbol

Licence: MOTION CONTROL



Function Description

The **MC_GearOut** block switches off the gearing mode on the slave axis. If gearing mode is not active (no MC_GearIn block commands slave axis at this moment), block does nothing (no error is activated).

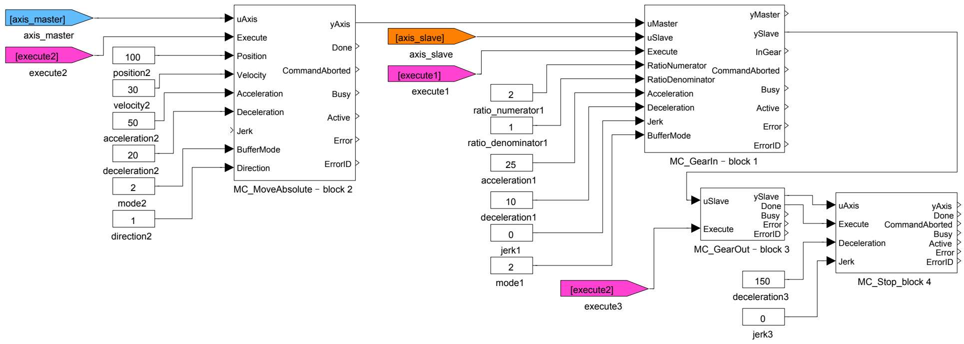
Inputs

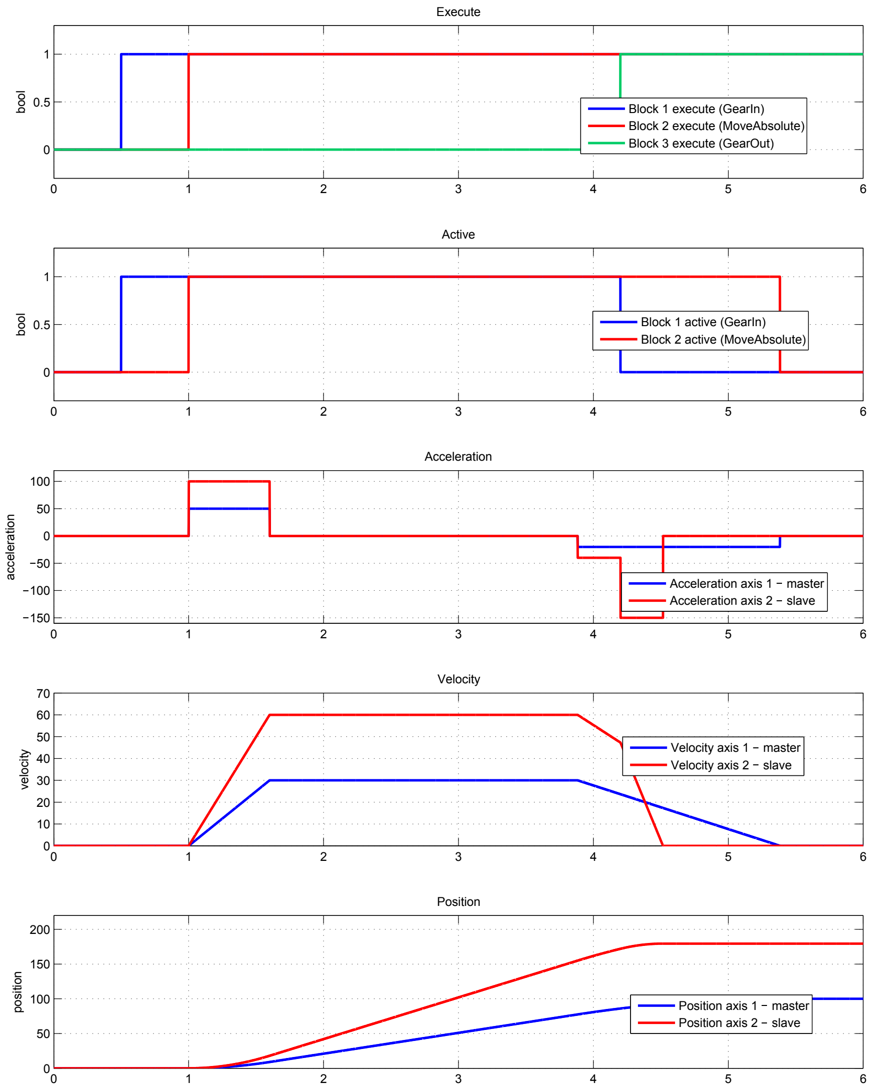
uSlave	Slave axis reference	Reference
Execute	The block is activated on rising edge	Bool

Outputs

ySlave	Slave axis reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

Example

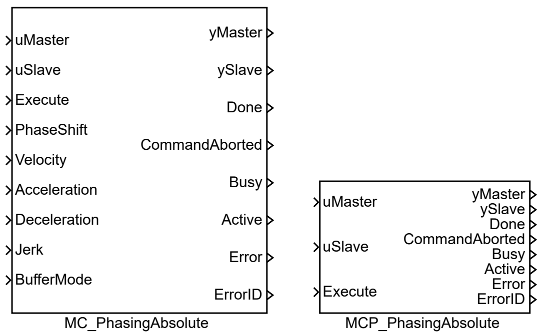

[axis_master]
axis_master
[execute2]
execute2
100
position2
30
velocity2
50
acceleration2
20
deceleration2
2
mode2
1
direction2
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAbsolute - block 2
[axis_slave]
axis_slave
[execute1]
execute1
2
ratio_numerator1
1
ratio_denominator1
25
acceleration1
10
deceleration1
0
jerk1
2
mode1
uMaster
uSlave
Execute
RatioNumerator
RatioDenominator
Acceleration
Deceleration
Jerk
BufferMode
yMaster
ySlave
InGear
CommandAborted
Busy
Active
Error
ErrorID
MC_GearIn - block 1
uSlave
Execute
ySlave
Done
Busy
Error
ErrorID
MC_GearOut - block 3
[execute2]
execute3
150
deceleration3
0
jerk3
uAxis
Execute
Deceleration
Jerk
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_Stop_block 4


Execute
bool
Block 1 execute (GearIn)
Block 2 execute (MoveAbsolute)
Block 3 execute (GearOut)
Active
bool
Block 1 active (GearIn)
Block 2 active (MoveAbsolute)
Acceleration
acceleration
Acceleration axis 1 – master
Acceleration axis 2 – slave
Velocity
velocity
Velocity axis 1 – master
Velocity axis 2 – slave
Position
position
Position axis 1 – master
Position axis 2 – slave

MC_PhasingAbsolute, MCP_PhasingAbsolute – Phase shift in synchronized motion (absolute coordinates)

Block Symbols

Licence: MOTION CONTROL



Function Description

The MC_PhasingAbsolute *and* MCP_PhasingAbsolute *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The MC_PhasingAbsolute block introduces an additional phase shift in master-slave relation defined by an electronic cam (MC_CamIn) or electronic gear (MC_GearIn). The functionality of this command is very similar to MC_MoveSuperimposed (additive motion from 0 to PhaseShift position with respect to maximum velocity acceleration and jerk). The only difference is that the additive position/velocity/acceleration is added to master axis reference position in the functional dependence defined by a cam or gear ratio for the computation of slave motion instead of its direct summation with master axis movement. The absolute value of final phase shift is specified by PhaseShift parameter.

Note: The motion command is analogous to rotation of a mechanical cam by angle PhaseShift

Inputs

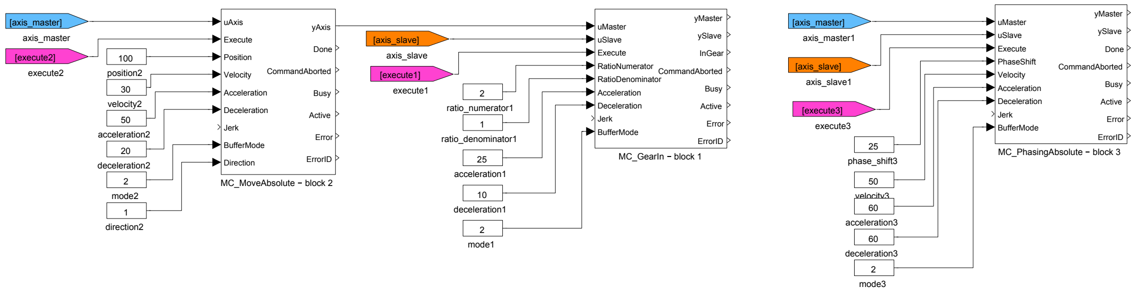
uMaster	Master axis reference	Reference
uSlave	Slave axis reference	Reference
Execute	The block is activated on rising edge	Bool
PhaseShift	Requested phase shift (distance on master axis) for cam	Double (F64)
Velocity	Maximal allowed velocity [unit/s]	Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]	Double (F64)
Deceleration	Maximal allowed deceleration [unit/s^2]	Double (F64)

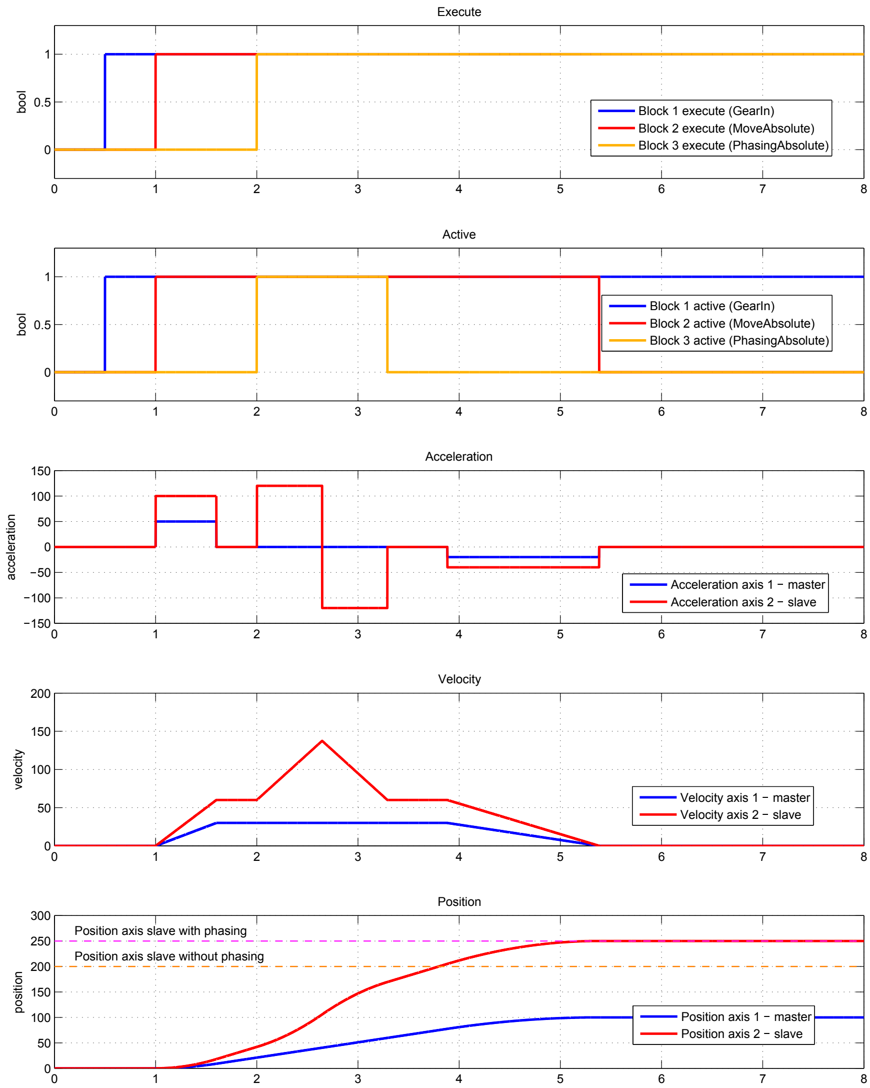
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting `2` ..... Buffered	`Long (I32)`

Outputs

`yMaster`	Master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

Example

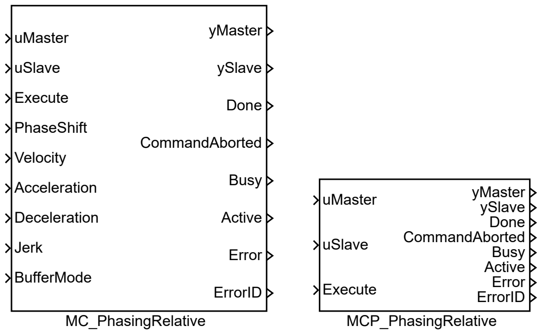

[axis_master]
axis_master
[execute2]
execute2
100
position2
30
velocity2
50
acceleration2
20
deceleration2
2
mode2
1
direction2
uAxis
Execute
Position
Velocity
Acceleration
Deceleration
Jerk
BufferMode
Direction
yAxis
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveAbsolute - block 2
[axis_slave]
axis_slave
[execute1]
execute1
2
ratio_numerator1
1
ratio_denominator1
25
acceleration1
10
deceleration1
2
mode1
uMaster
uSlave
Execute
RatioNumerator
RatioDenominator
Acceleration
Deceleration
Jerk
BufferMode
yMaster
ySlave
InGear
CommandAborted
Busy
Active
Error
ErrorID
MC_GearIn - block 1
[axis_master]
axis_master1
[axis_slave]
axis_slave1
[execute3]
execute3
25
phase_shift3
50
velocity3
60
acceleration3
60
deceleration3
2
mode3
uMaster
uSlave
Execute
PhaseShift
Velocity
Acceleration
Deceleration
Jerk
BufferMode
yMaster
ySlave
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_PhasingAbsolute - block 3


Execute
bool
Block 1 execute (GearIn)
Block 2 execute (MoveAbsolute)
Block 3 execute (PhasingAbsolute)
Active
bool
Block 1 active (GearIn)
Block 2 active (MoveAbsolute)
Block 3 active (PhasingAbsolute)
Acceleration
acceleration
Acceleration axis 1 − master
Acceleration axis 2 − slave
Velocity
velocity
Velocity axis 1 − master
Velocity axis 2 − slave
Position
position
Position axis slave with phasing
Position axis slave without phasing
Position axis 1 − master
Position axis 2 − slave

MC_PhasingRelative, MCP_PhasingRelative – Phase shift in synchronized motion (relative coordinates)

Block Symbols

Licence: MOTION CONTROL



Function Description

The `MC_PhasingRelative` *and* `MCP_PhasingRelative` *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* `MCP_` *version of the block.*

The `MC_PhasingRelative` introduces an additional phase shift in master-slave relation defined by an electronic cam (`MC_CamIn`) or electronic gear (`MC_GearIn`). The functionality of this command is very similar to `MC_MoveSuperimposed` (additive motion from 0 to `PhaseShift` position with respect to maximum velocity acceleration and jerk). The only difference is that the additive position/velocity/acceleration is added to master axis reference position in the functional dependence defined by a cam or gear ratio for the computation of slave motion instead of its direct summation with master axis movement. The relative value of final phase shift with respect to previous value is specified by `PhaseShift` parameter. Note: The motion command is analogous to rotation of a mechanical cam by angle `PhaseShift`

Inputs

`uMaster`	Master axis reference	`Reference`
`uSlave`	Slave axis reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`PhaseShift`	Requested phase shift (distance on master axis) for cam	`Double (F64)`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`

`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`BufferMode`	Buffering mode `1` ..... Aborting `2` ..... Buffered	`Long (I32)`

Outputs

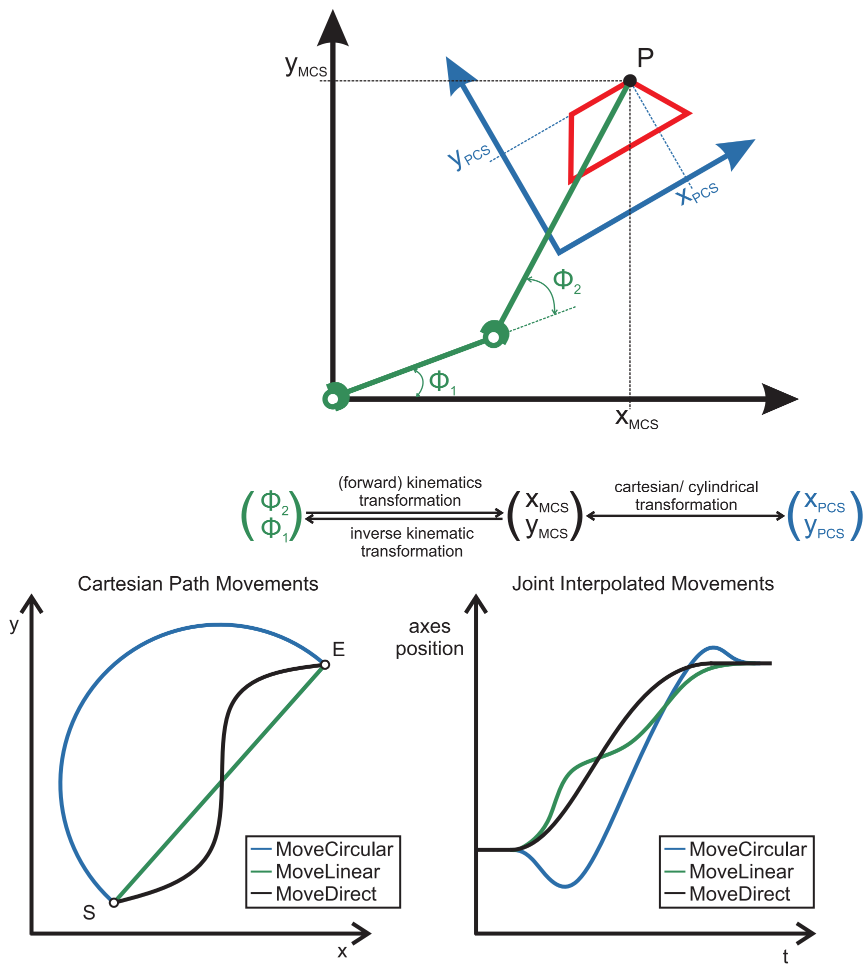
`yMaster`	Master axis reference	`Reference`
`ySlave`	Slave axis reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

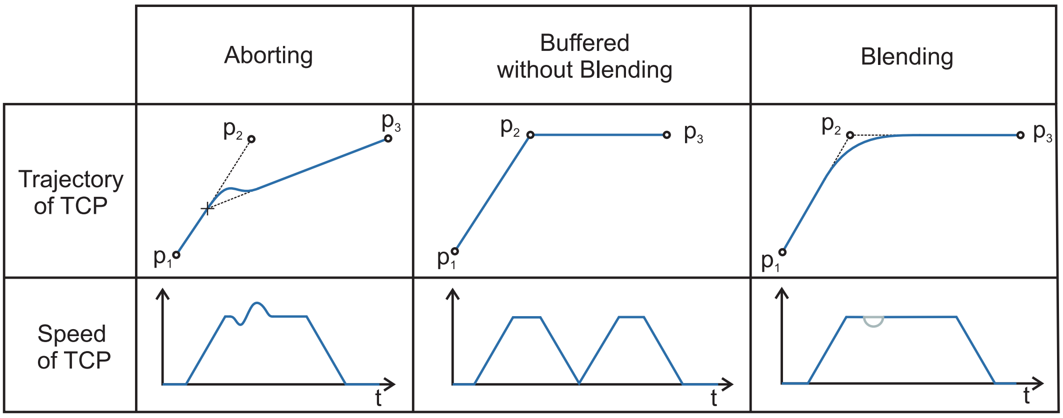
Chapter 22

MC_COORD – Motion control - coordinated movement blocks

Contents

The MC_COORD library is specifically designed for the coordination of multi-axis motion control within complex systems. It encompasses a variety of blocks, including MC_MoveLinearAbsolute for executing precise linear movements, complemented by MC_MoveLinearRelative for relative linear motion. For the execution of circular motion, the library incorporates MC_MoveCircularAbsolute alongside MC_MoveCircularRelative, ensuring detailed circular trajectories. In the context of managing group axis control, this library introduces MC_AddAxisToGroup, which is further supported by functionalities such as MC_GroupEnable for activation, MC_GroupDisable for deactivation, and MC_GroupHalt for immediate stopping of grouped axes. Furthermore, the library provides MC_MoveDirectAbsolute and MC_MoveDirectRelative, enabling direct control over axis movements. For navigating through complex paths, MC_MovePath is made available. Essential monitoring and control features are facilitated by MC_GroupReadActualPosition for positional data, MC_GroupReadActualVelocity for velocity insights, MC_GroupReadError for error detection, and MC_GroupReadStatus for status updates. Additionally, the library integrates MC_ReadCartesianTransform and MC_SetCartesianTransform, which are vital for Cartesian transformation processes. This collection of functionalities underscores the library's significance in applications that demand the synchronized control of multiple axes, particularly in the realms of robotics and automation systems.

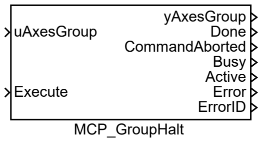



Aborting
Buffered
without Blending
Blending
Trajectory
of TCP
Speed
of TCP
p_1
p_2
p_3
t

MCP_GroupHalt – * Stopping a group movement (interruptible)

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference		Reference
Execute	The block is activated on rising edge		Bool

Parameter

Deceleration	Maximal allowed deceleration [unit/s^2]		Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]		Double (F64)
BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered	⊙1	Long (I32)
LimitMode	Velocity/Acceleration/Jerk limits meaning 1 ..... Relative [part of default] 2 ..... Absolute[unit/s unit/s^2 ...]	⊙1	Long (I32)
Superimposed	start as superimposed motion flag		Bool

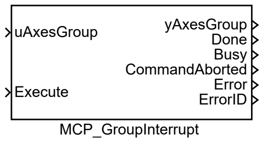
Output

yAxesGroup	Axes group reference		Reference
Done	Algorithm finished		Bool
CommandAborted	Algorithm was aborted		Bool
Busy	Algorithm not finished yet		Bool
Active	The block is controlling the axis		Bool
Error	Error occurred		Bool
ErrorID	Result of last operation i ..... REXYGEN error code		Error

MCP_GroupInterrupt – * Read a group interrupt

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference		Reference
Execute	The block is activated on rising edge		Bool

Parameter

Deceleration	Maximal allowed deceleration [unit/s^2]		Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]		Double (F64)
LimitMode	Velocity/Acceleration/Jerk limits meaning 1 ..... Relative [part of default] 2 ..... Absolute[unit/s unit/s^2 ...]	⊙1	Long (I32)

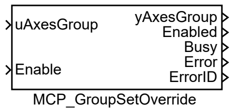
Output

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
CommandAborted	Algorithm was aborted	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_GroupSetOverride – * Set group override factors

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference	Reference
Enable	Block function is enabled	Bool

Parameter

diff	Deadband (difference for recalculation)	⊙0.05	Double (F64)
VelFactor	Velocity multiplication factor	⊙1.0	Double (F64)
AccFactor	Acceleration/deceleration multiplication factor	⊙1.0	Double (F64)
JerkFactor	Jerk multiplication factor	⊙1.0	Double (F64)

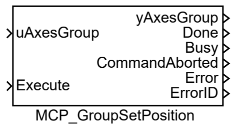
Output

yAxesGroup	Axes group reference	Reference
Enabled	Signal that the override faktor are set successfully	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_GroupSetPosition – * Sets the position of all axes in a group

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`Relative`	Mode of position inputs		`Bool`
`CoordSystem`	Reference to the coordinate system used `1` ..... ACS `2` ..... MCS `3` ..... PCS `4` ..... TCS	⊙3	`Long (I32)`
`Position_`	Array of coordinates (positions and orientations)	⊙`[0.0 0.0 0.0 0.0 0.0 0.0]`	`Double (F64)`

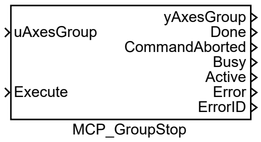
Output

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_GroupStop – * Stopping a group movement

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool

Parameter

Deceleration	Maximal allowed deceleration [unit/s^2]	Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]	Double (F64)

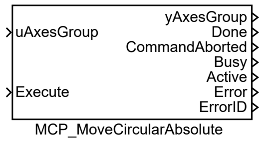
Output

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_MoveCircularAbsolute – * Circular move to position (absolute coordinates)

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`CircMode`	Specifies the meaning of the input signals AuxPoint and CircDirection ⊙1 1 ..... BORDER 2 ..... CENTER 3 ..... RADIUS	`Long (I32)`
`PathChoice`	Choice of path ⊙1 1 ..... Clockwise 2 ..... CounterClockwise	`Long (I32)`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`CoordSystem`	Reference to the coordinate system used ⊙1 1 ..... ACS 2 ..... MCS 3 ..... PCS 4 ..... TCS	`Long (I32)`

`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`
`LimitMode`	Velocity/Acceleration/Jerk limits meaning 1 ..... Relative [part of default] 2 ..... Absolute[unit/s unit/s^2 ...]	⊙1	`Long (I32)`
`TransitionMode`	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	⊙1	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)		`Double (F64)`
`Superimposed`	start as superimposed motion flag		`Bool`
`AuxPoint`	Next coordinates to define circle (depend on CircMode)	⊙[0.0 0.0 0.0 0.0 0.0 0.0]	`Double (F64)`
`EndPoint`	Target axes coordinates position	⊙[0.0 0.0 0.0 0.0 0.0 0.0]	`Double (F64)`

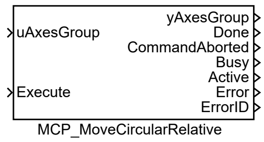
Output

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation i ..... REXYGEN error code	`Error`

MCP_MoveCircularRelative – * Circular move to position (relative to execution point)

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`CircMode`	Specifies the meaning of the input signals AuxPoint and CircDirection ⊙1 1 ..... BORDER 2 ..... CENTER 3 ..... RADIUS	`Long (I32)`
`PathChoice`	Choice of path ⊙1 1 ..... Clockwise 2 ..... CounterClockwise	`Long (I32)`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`CoordSystem`	Reference to the coordinate system used ⊙1 1 ..... ACS 2 ..... MCS 3 ..... PCS 4 ..... TCS	`Long (I32)`

BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	Long (I32)
LimitMode	Velocity/Acceleration/Jerk limits meaning 1 ..... Relative [part of default] 2 ..... Absolute[unit/s unit/s^2 ...]	⊙1	Long (I32)
TransitionMode	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	⊙1	Long (I32)
TransitionParameter	Parametr for transition (depends on transition mode)		Double (F64)
Superimposed	start as superimposed motion flag		Bool
AuxPoint	Next coordinates to define circle (depend on CircMode)	⊙[0.0 0.0 0.0 0.0 0.0 0.0]	Double (F64)
EndPoint	Target axes coordinates position	⊙[0.0 0.0 0.0 0.0 0.0 0.0]	Double (F64)

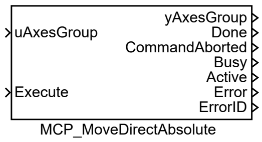
Output

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_MoveDirectAbsolute – * **Direct move to position (absolute coordinates)**

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`CoordSystem` Reference to the coordinate system used ⊙1 `Long (I32)`
- 1 ..... ACS
- 2 ..... MCS
- 3 ..... PCS
- 4 ..... TCS

`BufferMode` Buffering mode ⊙1 `Long (I32)`
- 1 ..... Aborting
- 2 ..... Buffered
- 3 ..... Blending low
- 4 ..... Blending high
- 5 ..... Blending previous
- 6 ..... Blending next

`TransitionMode` Transition mode in blending mode ⊙1 `Long (I32)`
- 1 ..... TMNone
- 2 ..... TMStartVelocity
- 3 ..... TMConstantVelocity
- 4 ..... TMCornerDistance
- 5 ..... TMMaxCornerDeviation
- 11 .... Smooth

`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`
`Superimposed`	start as superimposed motion flag	`Bool`
`Position_`	Array of coordinates (positions and orientations) ⊙`[0.0 0.0 0.0 0.0 0.0 0.0]`	`Double (F64)`

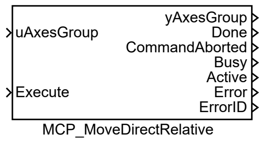
Output

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_MoveDirectRelative – * Direct move to position (relative to execution point)

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameter

`CoordSystem` Reference to the coordinate system used ⊙1 `Long (I32)`
- 1 ..... ACS
- 2 ..... MCS
- 3 ..... PCS
- 4 ..... TCS

`BufferMode` Buffering mode ⊙1 `Long (I32)`
- 1 ..... Aborting
- 2 ..... Buffered
- 3 ..... Blending low
- 4 ..... Blending high
- 5 ..... Blending previous
- 6 ..... Blending next

`TransitionMode` Transition mode in blending mode ⊙1 `Long (I32)`
- 1 ..... TMNone
- 2 ..... TMStartVelocity
- 3 ..... TMConstantVelocity
- 4 ..... TMCornerDistance
- 5 ..... TMMaxCornerDeviation
- 11 .... Smooth

`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`
`Superimposed`	start as superimposed motion flag	`Bool`
`Distance`	Array of coordinates (relative distances and orientations) ⊙`[0.0 0.0 0.0 0.0 0.0 0.0]`	`Double (F64)`

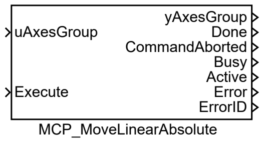
Output

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_MoveLinearAbsolute – * Linear move to position (absolute coordinates)

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference		Reference
Execute	The block is activated on rising edge		Bool

Parameter

Velocity	Maximal allowed velocity [unit/s]		Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]		Double (F64)
Jerk	Maximal allowed jerk [unit/s^3]		Double (F64)
CoordSystem	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS 4 ..... TCS	⊙1	Long (I32)
BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	Long (I32)
LimitMode	Velocity/Acceleration/Jerk limits meaning 1 ..... Relative [part of default] 2 ..... Absolute[unit/s unit/s^2 ...]	⊙1	Long (I32)

`TransitionMode`	Transition mode in blending mode `1` ..... TMNone `2` ..... TMStartVelocity `3` ..... TMConstantVelocity `4` ..... TMCornerDistance `5` ..... TMMaxCornerDeviation `11` .... Smooth	⊙1	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)		`Double (F64)`
`Superimposed`	start as superimposed motion flag		`Bool`
`Position_`	Array of coordinates (positions and orientations)	⊙`[0.0 0.0 0.0 0.0 0.0 0.0]`	`Double (F64)`

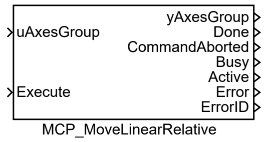
Output

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_MoveLinearRelative – * Linear move to position (relative to execution point)

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxesGroup`	Axes group reference		`Reference`
`Execute`	The block is activated on rising edge		`Bool`

Parameter

`Velocity`	Maximal allowed velocity [unit/s]		`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS 4 ..... TCS	⊙1	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`
`LimitMode`	Velocity/Acceleration/Jerk limits meaning 1 ..... Relative [part of default] 2 ..... Absolute[unit/s unit/s^2 ...]	⊙1	`Long (I32)`

`TransitionMode`	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	⊙1	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)		`Double (F64)`
`Superimposed`	start as superimposed motion flag		`Bool`
`Distance`	Array of coordinates (relative distances and orientations)	⊙[0.0 0.0 0.0 0.0 0.0 0.0]	`Double (F64)`

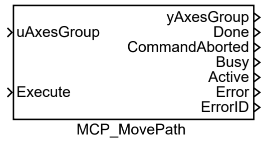
Output

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation i ..... REXYGEN error code	`Error`

MCP_MovePath – * **General spatial trajectory generation**

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxesGroup`	Axes group reference		`Reference`
`Execute`	The block is activated on rising edge		`Bool`

Parameter

`TotalTime`	Time [s] for whole move		`Double (F64)`
`RampTime`	Time [s] for acceleration/deceleration		`Double (F64)`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS 4 ..... TCS	⊙2	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	`Long (I32)`
`TransitionMode`	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	⊙1	`Long (I32)`

TransitionParameter	Parametr for transition (depends on transition mode)		Double (F64)
RampIn	RampIn factor (0 = RampIn mode not used)		Double (F64)
Superimposed	start as superimposed motion flag		Bool
pc	Control-points matrix	⊙[0.0 1.0 2.0; 0.0 1.0 1.0; 0.0 1.0 0.0]	Double (F64)
pk	Knot-points vector	⊙[0.0 0.0 0.0 0.0 0.5 1.0 1.0]	Double (F64)
pw	Weighting vector	⊙[1.0 1.0 1.0]	Double (F64)
pv	Polynoms for feedrate definition	⊙[0.0 0.05 0.95; 0.0 0.1 0.1; 0.0 0.0 0.0; 0.1 0.0 -0.1; -0.05 0.0 0.05; 0.0 0.0 0.0]	Double (F64)
pt	Knot-points (time [s]) for feedrate	⊙[0.0 1.0 10.0 11.0]	Double (F64)
user	Only for special edit	⊙[0.0 1.0 2.0 3.0]	Double (F64)

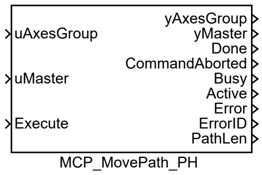
Output

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_MovePath_PH – * General spatial trajectory generation PH

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference	Reference
uMaster	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
Execute	The block is activated on rising edge	Bool

Parameter

CoordSystem	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS 4 ..... TCS	⊙2	Long (I32)
BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	Long (I32)
Cyclic	Profile is cyclic flag		Bool
RampIn	RampIn factor (0 = RampIn mode not used)		Double (F64)
Superimposed	start as superimposed motion flag		Bool
UZV1		⊙[]	Double (F64)
Points		⊙[]	Double (F64)

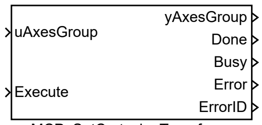
Output

yAxesGroup	Axes group reference	Reference
yMaster	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	Reference
Done	Algorithm finished	Bool
CommandAborted	Algorithm was aborted	Bool
Busy	Algorithm not finished yet	Bool
Active	The block is controlling the axis	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation	Error
PathLen		Double (F64)

MCP_SetCartesianTransform – * Sets Cartesian transformation

Block Symbol

Licence: COORDINATED MOTION



MCP_SetCartesianTransform

Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool

Parameter

SelTrans	Coordinate transformation to set/get 1 ..... PCS offset 2 ..... Tool offset 3 ..... Machine base offset	⊙1	Long (I32)
TransX	X-component of translation vector		Double (F64)
TransY	Y-component of translation vector		Double (F64)
TransZ	Z-component of translation vector		Double (F64)
RotAngle1	Rotation angle component		Double (F64)
RotAngle2	Rotation angle component		Double (F64)
RotAngle3	Rotation angle component		Double (F64)
Relative	Mode of position inputs		Bool
SSF	Simple shift flag		Bool

Output

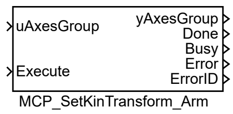
yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool

`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MCP_SetKinTransform_Arm – * Kinematic transformation robot ARM

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool

Parameter

arot	Angle for one revolute (ACS)	⊙6.28318531	Double (F64)
mrot	Angle for one revolute (MCS)	⊙6.28318531	Double (F64)
irt	Rotation format 1 ..... ZYX angles 2 ..... Quaternion	⊙1	Long (I32)
a1		⊙400.0	Double (F64)
a2		⊙300.0	Double (F64)
a3			Double (F64)
d1			Double (F64)
d23			Double (F64)
d4		⊙200.0	Double (F64)
d6		⊙100.0	Double (F64)
xe			Double (F64)
ye			Double (F64)
ze			Double (F64)
gamaE			Double (F64)
betaE			Double (F64)
alphaE			Double (F64)

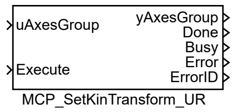
Output

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of last operation i ..... REXYGEN error code	Error

MCP_SetKinTransform_UR – * Kinematic transformation for UR robot

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool

Parameter

arot	Angle for one revolute (ACS)	⊙6.28318531	Double (F64)
mrot	Angle for one revolute (MCS)	⊙6.28318531	Double (F64)
irt	Rotation format 1 ..... ZYX angles 2 ..... Quaternion	⊙1	Long (I32)
l1			Double (F64)
l2			Double (F64)
l3			Double (F64)
l4		⊙400.0	Double (F64)
l5		⊙400.0	Double (F64)
l6		⊙400.0	Double (F64)
l7		⊙400.0	Double (F64)
l8		⊙400.0	Double (F64)

Output

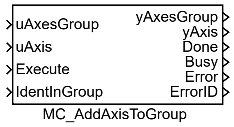
yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool

`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation `i` ..... REXYGEN error code	`Error`

MC_AddAxisToGroup – Adds one axis to a group

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block `MC_AddAxisToGroup` adds one `uAxis` to the group in a structure `uAxesGroup`. Axes Group is implemented by the function block `RM_AxesGroup`. The input `uAxis` must be defined by the function block `RM_Axis` from the MC_SINGLE library.

Note 1: Every `IdentInGroup` is unique and can be used only for one time otherwise the error is set.

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`uAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`IdentInGroup`	The order of axes in the group (0 = first unassigned)	`Long (I32)`

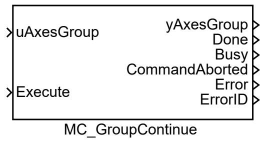
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`yAxis`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_GroupContinue – Continuation of interrupted movement

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block MC_GroupContinue transfers the program back to the situation at issuing MC_GroupInterrupt. It uses internally the data set as stored at issuing MC_GroupInterrupt, and at the end (output Done set) transfer the control on the group back to the original FB doing the movements on the axes group, meaning also that at the originally interrupted FB the output Busy is still high and the output Active is set again.

Inputs

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool

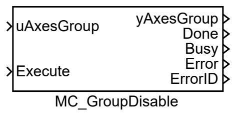
Outputs

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
CommandAborted	Algorithm was aborted	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_GroupDisable – Changes the state of a group to GroupDisabled

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block MC_GroupDisable changes the state for the group uAxesGroup to "GroupDisabled". If the axes are not standing still while issuing this command the state of the group is changed to "Stopping". It is mean stopping with the maximal allowed deceleration. When stopping is done the state of the group is changed to "GroupDisabled".

Inputs

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool

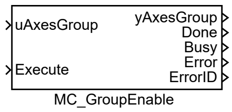
Outputs

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_GroupEnable – Changes the state of a group to GroupEnable

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block `MC_GroupEnable` changes the state for the group `uAxesGroup` from "GroupDisabled" to "GroupStandby".

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

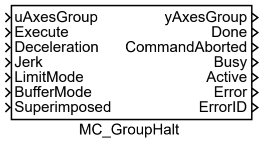
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_GroupHalt – Stopping a group movement (interruptible)

Block Symbol

Licence: COORDINATED MOTION



Function Description

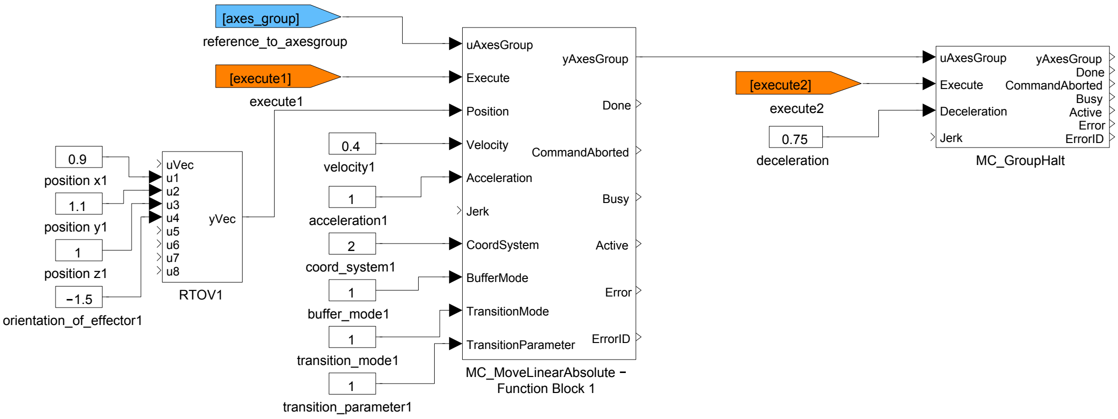
The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

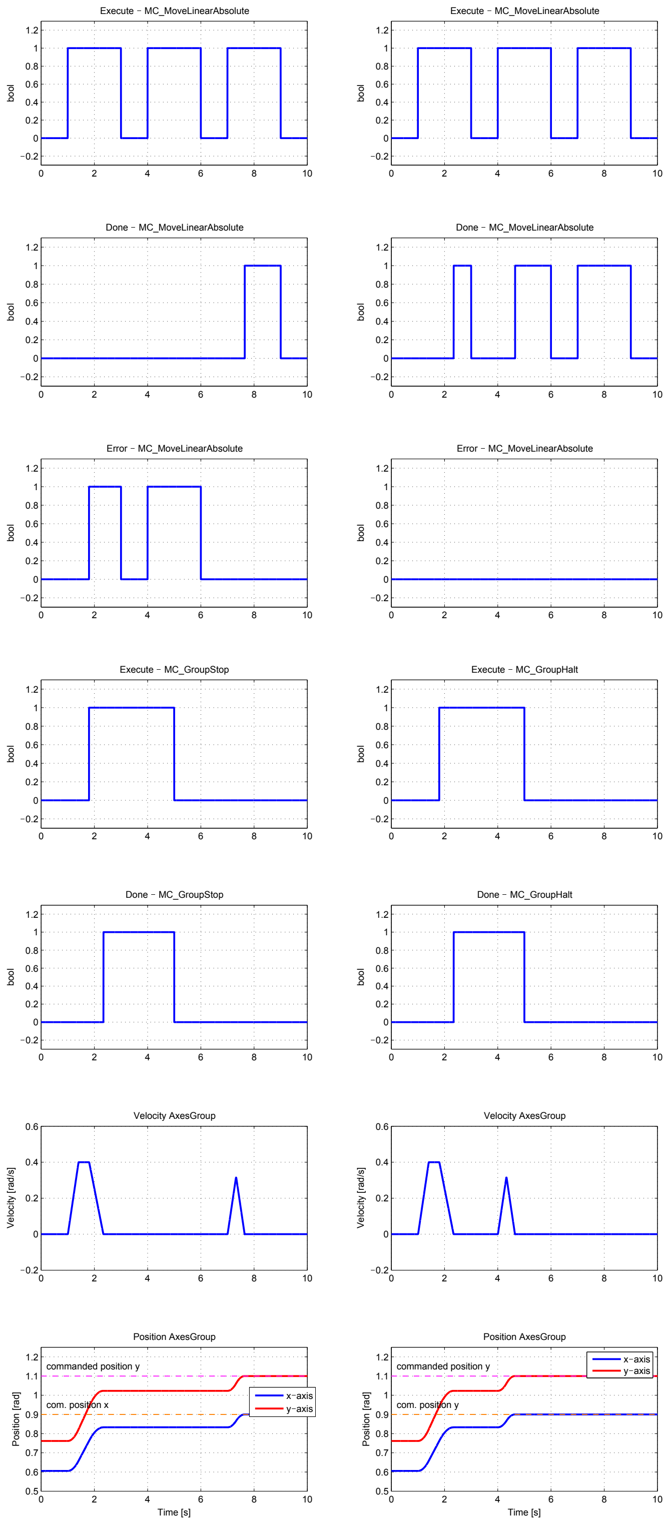
Inputs

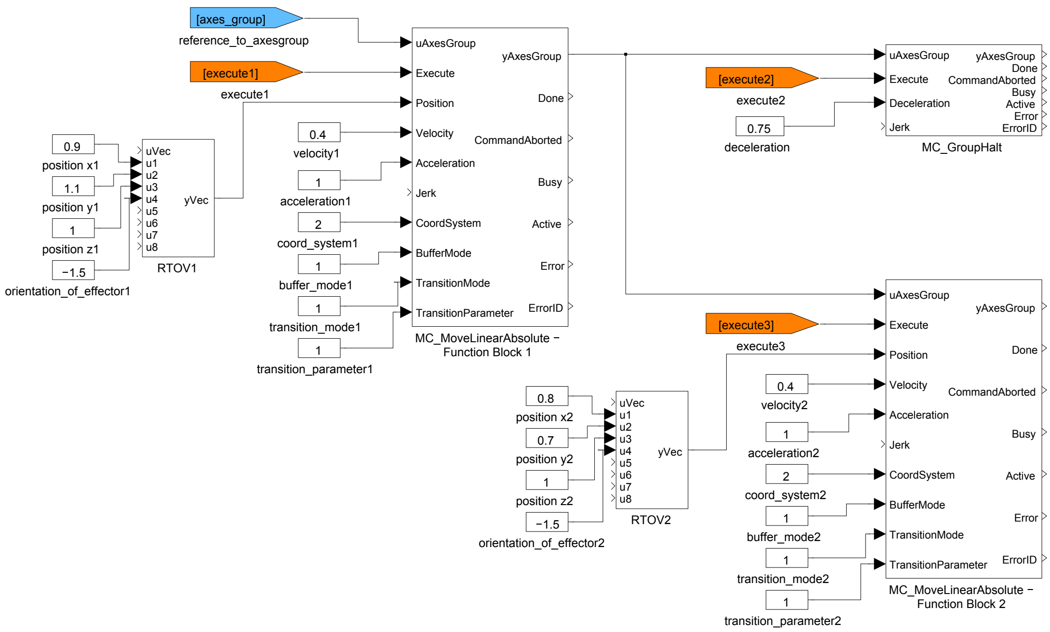
`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`

Outputs

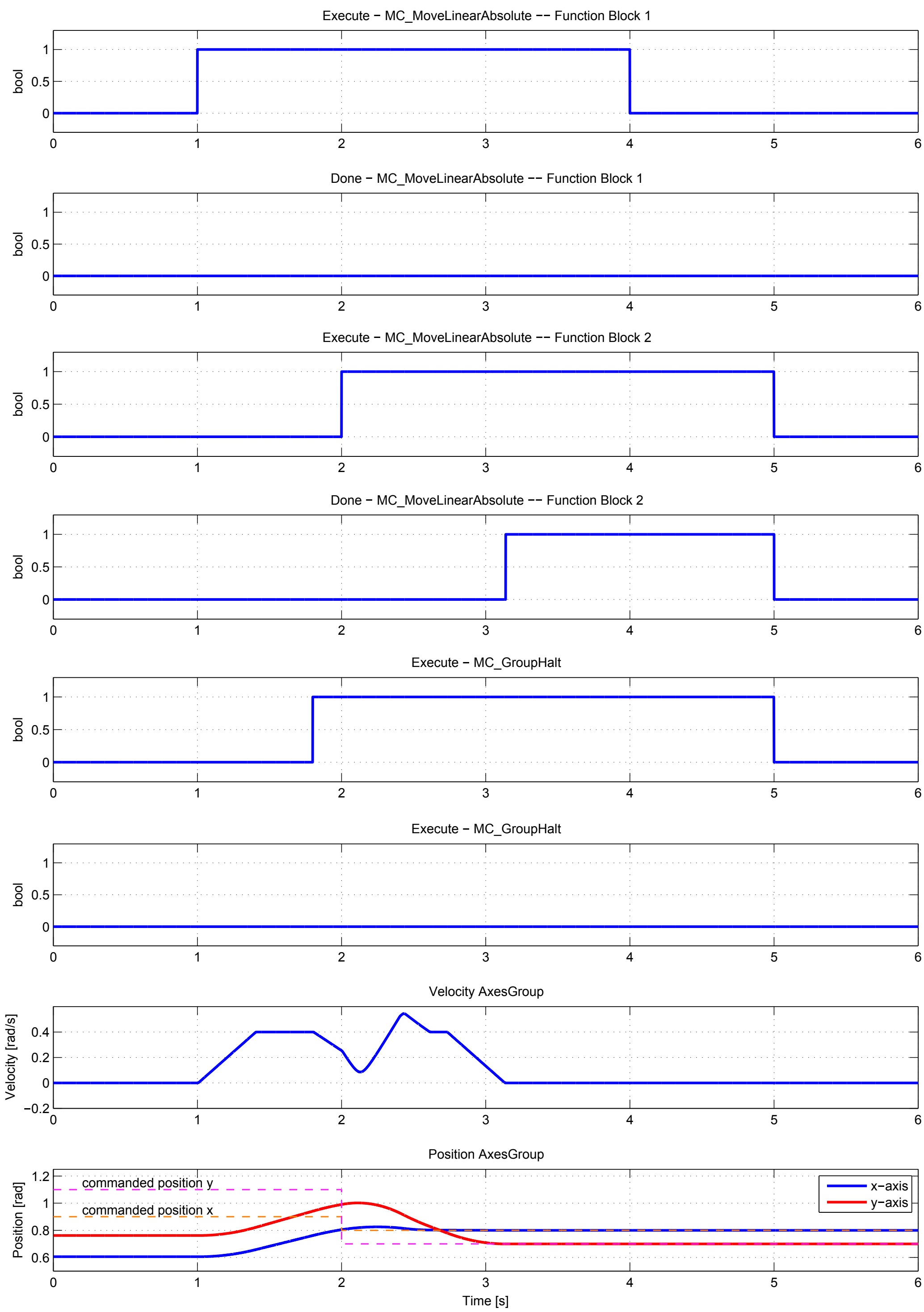
`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`


[axes_group]
reference_to_axesgroup
[execute1]
execute1
0.9
position x1
1.1
position y1
1
position z1
−1.5
orientation_of_effector1
uVec
u1
u2
u3
u4
u5
u6
u7
u8
yVec
RTOV1
0.4
velocity1
1
acceleration1
2
coord_system1
1
buffer_mode1
1
transition_mode1
1
transition_parameter1
uAxesGroup
Execute
Position
Velocity
Acceleration
Jerk
CoordSystem
BufferMode
TransitionMode
TransitionParameter
yAxesGroup
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveLinearAbsolute -
Function Block 1
[execute2]
execute2
0.75
deceleration
uAxesGroup
Execute
Deceleration
Jerk
yAxesGroup
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_GroupHalt


Execute – MC_MoveLinearAbsolute
Execute – MC_MoveLinearAbsolute
Done – MC_MoveLinearAbsolute
Done – MC_MoveLinearAbsolute
Error – MC_MoveLinearAbsolute
Error – MC_MoveLinearAbsolute
Execute – MC_GroupStop
Execute – MC_GroupHalt
Done – MC_GroupStop
Done – MC_GroupHalt
bool
Velocity AxesGroup
Velocity AxesGroup
Velocity [rad/s]
Position AxesGroup
Position AxesGroup
Position [rad]
commanded position y
com. position x
com. position y
x–axis
y–axis
Time [s]



[axes_group]
reference_to_axesgroup
[execute1]
execute1
0.9
position x1
1.1
position y1
1
position z1
−1.5
orientation_of_effector1
uVec
u1
u2
u3
u4
u5
u6
u7
u8
yVec
RTOV1
0.4
velocity1
1
acceleration1
2
coord_system1
1
buffer_mode1
1
transition_mode1
1
transition_parameter1
uAxesGroup
Execute
Position
Velocity
Acceleration
Jerk
CoordSystem
BufferMode
TransitionMode
TransitionParameter
yAxesGroup
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveLinearAbsolute − Function Block 1
[execute2]
execute2
0.75
deceleration
Deceleration
MC_GroupHalt
[execute3]
execute3
0.8
position x2
0.7
position y2
1
position z2
−1.5
orientation_of_effector2
RTOV2
0.4
velocity2
1
acceleration2
2
coord_system2
1
buffer_mode2
1
transition_mode2
1
transition_parameter2
MC_MoveLinearAbsolute − Function Block 2

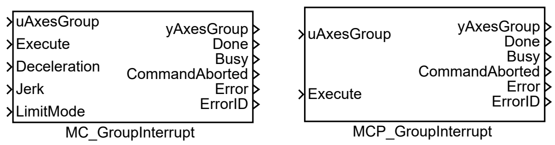


Execute − MC_MoveLinearAbsolute −− Function Block 1
Done − MC_MoveLinearAbsolute −− Function Block 1
Execute − MC_MoveLinearAbsolute −− Function Block 2
Done − MC_MoveLinearAbsolute −− Function Block 2
Execute − MC_GroupHalt
Execute − MC_GroupHalt
bool
Velocity AxesGroup
Velocity [rad/s]
Position AxesGroup
Position [rad]
commanded position y
commanded position x
x−axis
y−axis
Time [s]

MC_GroupInterrupt, MCP_GroupInterrupt – **Read a group interrupt**

Block Symbols

Licence: COORDINATED MOTION



Function Description

The `MC_GroupInterrupt` *and* `MCP_GroupInterrupt` *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* `MCP_` *version of the block.*

The function block `MC_GroupInterrupt` interrupts the on-going motion and stops the group from moving, however does not abort the interrupted motion (meaning that at the interrupted FB the output `CommandAborted` will not be Set, `Busy` is still high and `Active` is reset). It stores all relevant track or path information internally at the moment it becomes active. The `uAxesGroup` stays in the original state even if the velocity zero is reached and the `Done` output is set.

Note 1: This function block is complementary to the function block `MC_GroupContinue` which execution the `uAxesGroup` state is reset to the original state (before `MC_GroupInterrupt` execution)

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`

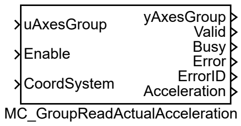
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_GroupReadActualAcceleration – Read actual acceleration in the selected coordinate system

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block `MC_GroupReadActualAcceleration` returns the actual velocity in the selected coordinate system of an axes group. The position is valid only if the output `Valid` is true which is achieved by setting the input `Enable` on true.

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Enable`	Block function is enabled	`Bool`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	`Long (I32)`

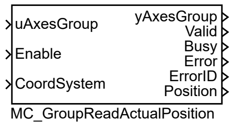
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Valid`	Output value is valid	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`
`Acceleration`	xxx	`Reference`

MC_GroupReadActualPosition – Read actual position in the selected coordinate system

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block `MC_GroupReadActualPosition` returns the actual position in the selected coordinate system of an axes group. The position is valid only if the output `Valid` is true which is achieved by setting the input `Enable` on true.

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Enable`	Block function is enabled	`Bool`
`CoordSystem`	Reference to the coordinate system used `1` ..... ACS `2` ..... MCS `3` ..... PCS	`Long (I32)`

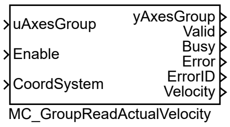
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Valid`	Output value is valid	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`
`Position`	xxx	`Reference`

MC_GroupReadActualVelocity – Read actual velocity in the selected coordinate system

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block **MC_GroupReadActualVelocity** returns the actual velocity in the selected coordinate system of an axes group. The position is valid only if the output **Valid** is true which is achieved by setting the input **Enable** on true.

Inputs

uAxesGroup	Axes group reference	Reference
Enable	Block function is enabled	Bool
CoordSystem	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	Long (I32)

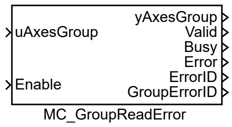
Outputs

yAxesGroup	Axes group reference	Reference
Valid	Output value is valid	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error
Velocity	xxx	Reference

MC_GroupReadError – Read a group error

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block MC_GroupReadError describes general error on the uAxesGroup which is not relating to the function blocks. If the output GroupErrorID is equal to 0 there is no error on the axes group. The actual error code GroupErrorID is valid only if the output Valid is true which is achieved by setting the input Enable on true.

Note 1: This function block is implemented because of compatibility with the PLCopen norm. The same error value is on the output ErrorID of the function block RM_AxesGroup.

Inputs

uAxesGroup	Axes group reference	Reference
Enable	Block function is enabled	Bool

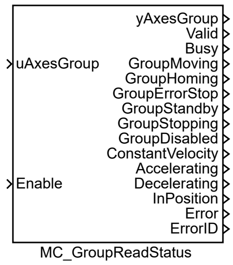
Outputs

yAxesGroup	Axes group reference	Reference
Valid	Output value is valid	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error
GroupErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_GroupReadStatus – Read a group status

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block `MC_GroupReadStatus` returns the status of the `uAxesGroup`. The status is valid only if the output `Valid` is true which is achieved by setting the input `Enable` on true.

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Enable`	Block function is enabled	`Bool`

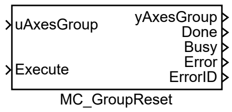
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Valid`	Output value is valid	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`GroupMoving`	State GroupMoving	`Bool`
`GroupHoming`	State GroupHoming	`Bool`
`GroupErrorStop`	State ErrorStop	`Bool`
`GroupStandby`	State Standby	`Bool`
`GroupStopping`	State Stopping	`Bool`
`GroupDisabled`	State Disabled	`Bool`
`ConstantVelocity`	Constant velocity motion	`Bool`
`Accelerating`	Accelerating	`Bool`
`Decelerating`	Decelerating	`Bool`
`InPosition`	Symptom achieve the desired position	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_GroupReset – Reset axes errors

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block **MC_GroupReset** makes the transition from the state "GroupErrorStop" to "GroupStandBy" by resetting all internal group-related errors. This function block also resets all axes in this group like the function block MC_Reset from the MC_SINGLE library.

Inputs

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool

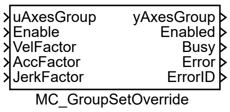
Outputs

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_GroupSetOverride – Set group override factors

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

uAxesGroup	Axes group reference	Reference
Enable	Block function is enabled	Bool
VelFactor	Velocity multiplication factor	Double (F64)
AccFactor	Acceleration/deceleration multiplication factor	Double (F64)
JerkFactor	Jerk multiplication factor	Double (F64)

Parameter

diff	Deadband (difference for recalculation)	⊙0.05	Double (F64)

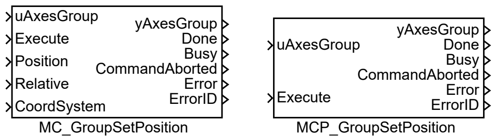
Outputs

yAxesGroup	Axes group reference	Reference
Enabled	Signal that the override faktor are set successfully	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_GroupSetPosition, MCP_GroupSetPosition – Sets the position of all axes in a group

Block Symbols

Licence: COORDINATED MOTION



Function Description

The MC_GroupSetPosition *and* MCP_GroupSetPosition *blocks offer the same functionality, the only difference is that some of the inputs are available as parameters in the* MCP_ *version of the block.*

The function block MC_GroupSetPosition sets the position of all axes in the group uAxesGroup without moving the axes. The new coordinates are described by the input Position. With the coordinate system input CoordSystem the according coordinate system is selected. The function block MC_GroupSetPosition shifts position of the addressed coordinate system and affect the higher level coordinate systems (so if ACS selected, MCS and PCS are affected).

Inputs

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool
Position	Array of coordinates (positions and orientations)	Reference
Relative	Mode of position inputs off ... absolute on .... relative	Bool
CoordSystem	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	Long (I32)

Outputs

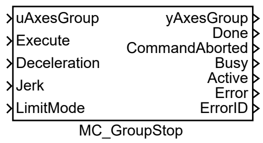
yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
CommandAborted	Algorithm was aborted	Bool
Error	Error occurred	Bool

ErrorID	Result of the last operation i ..... REXYGEN general error	Error

MC_GroupStop – Stopping a group movement

Block Symbol

Licence: COORDINATED MOTION



Function Description

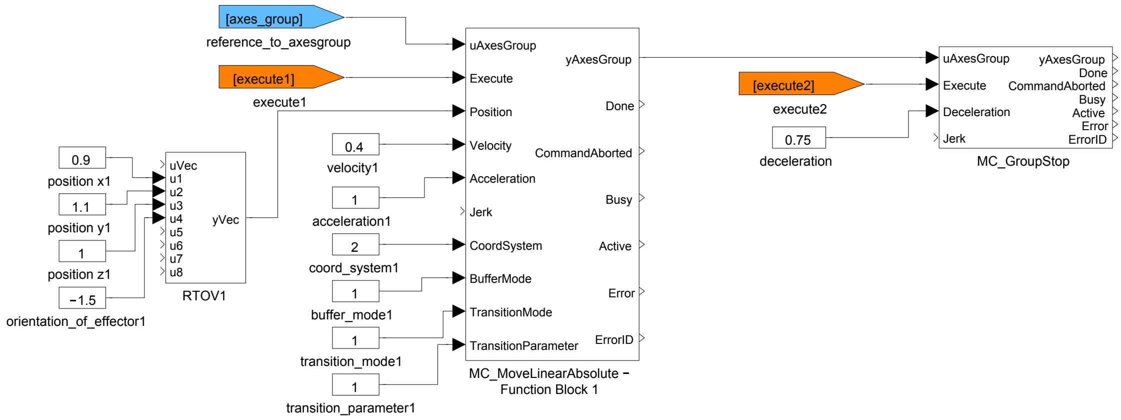
The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

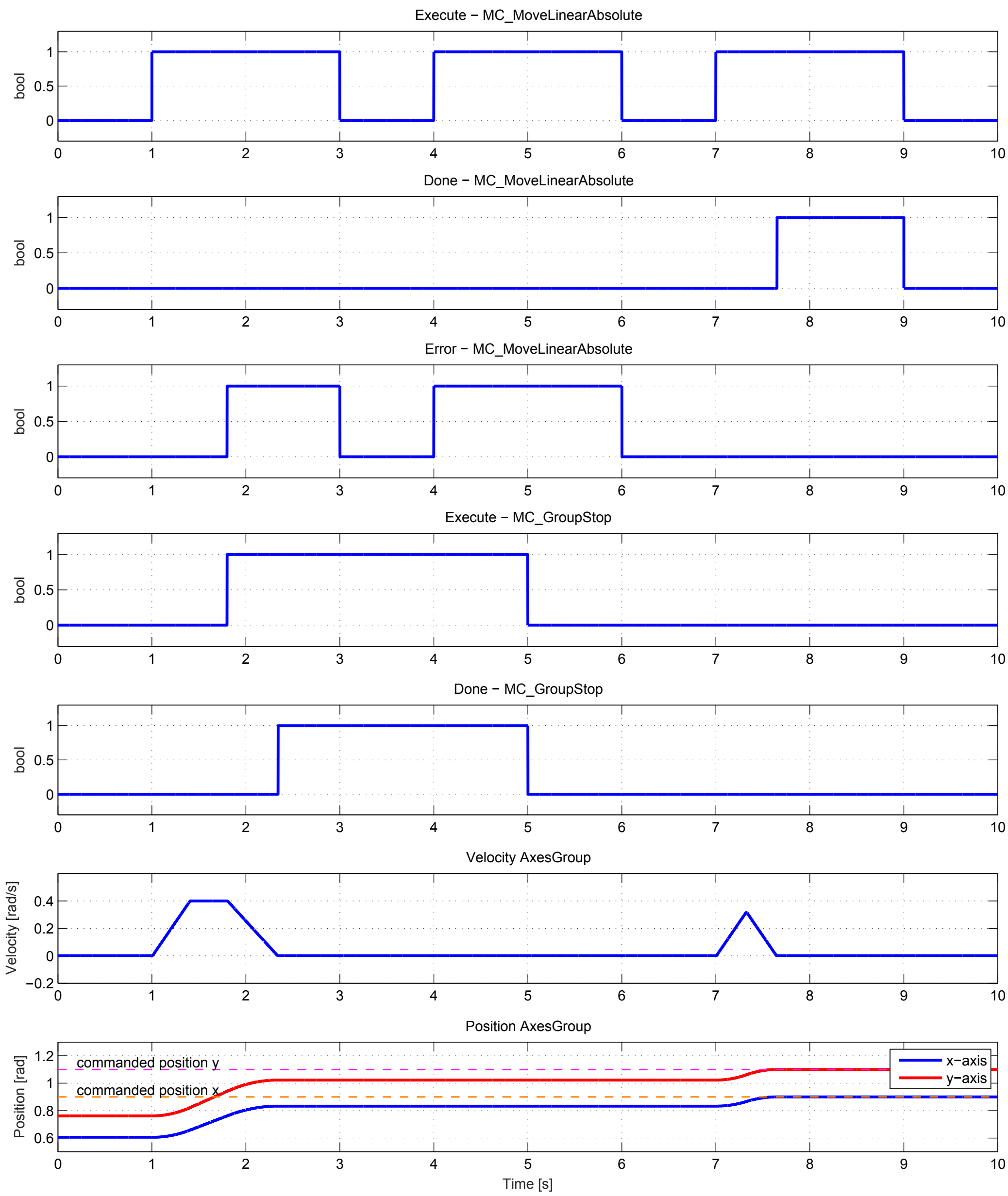
Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Deceleration`	Maximal allowed deceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`

Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

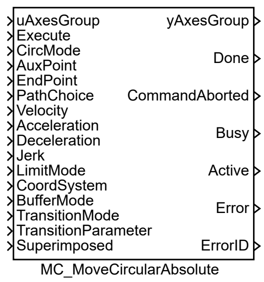

[axes_group]
reference_to_axesgroup
[execute1]
execute1
0.9
position x1
1.1
position y1
1
position z1
−1.5
orientation_of_effector1
uVec
u1
u2
u3
u4
u5
u6
u7
u8
yVec
RTOV1
0.4
velocity1
1
acceleration1
2
coord_system1
1
buffer_mode1
1
transition_mode1
1
transition_parameter1
uAxesGroup
Execute
Position
Velocity
Acceleration
Jerk
CoordSystem
BufferMode
TransitionMode
TransitionParameter
yAxesGroup
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_MoveLinearAbsolute – Function Block 1
[execute2]
execute2
0.75
deceleration
uAxesGroup
Execute
Deceleration
Jerk
yAxesGroup
Done
CommandAborted
Busy
Active
Error
ErrorID
MC_GroupStop


Execute − MC_MoveLinearAbsolute
Done − MC_MoveLinearAbsolute
Error − MC_MoveLinearAbsolute
Execute − MC_GroupStop
Done − MC_GroupStop
Velocity AxesGroup
Position AxesGroup
bool
Velocity [rad/s]
Position [rad]
commanded position y
commanded position x
x−axis
y−axis
Time [s]

MC_MoveCircularAbsolute – Circular move to position (absolute coordinates)

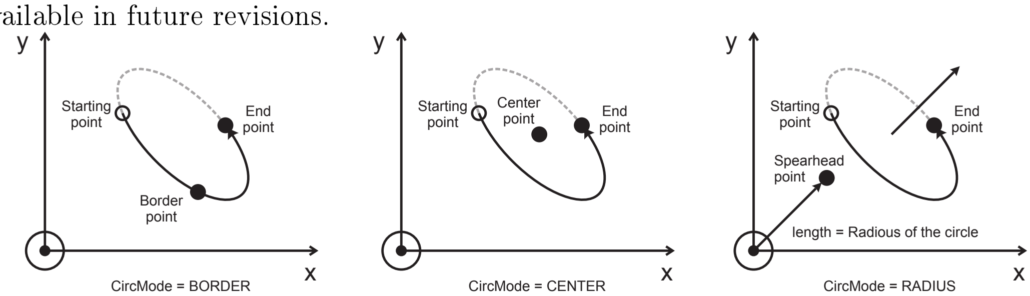
Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.



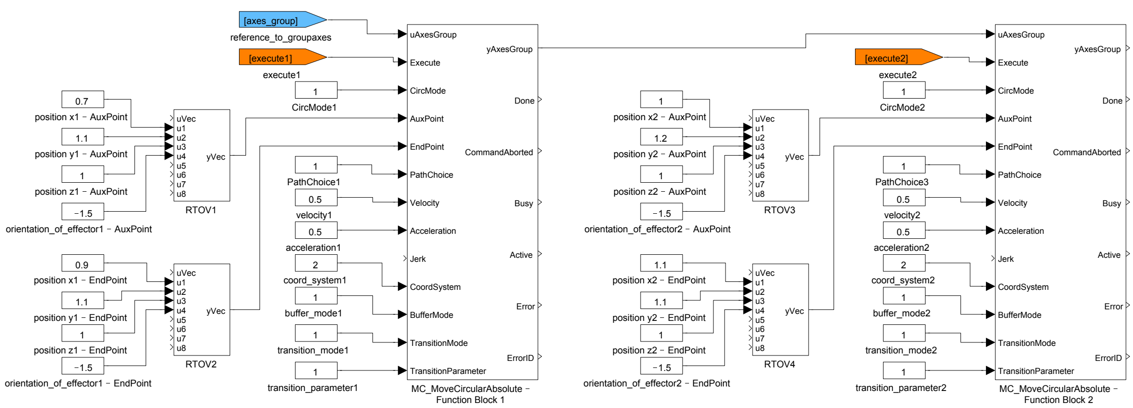
Inputs

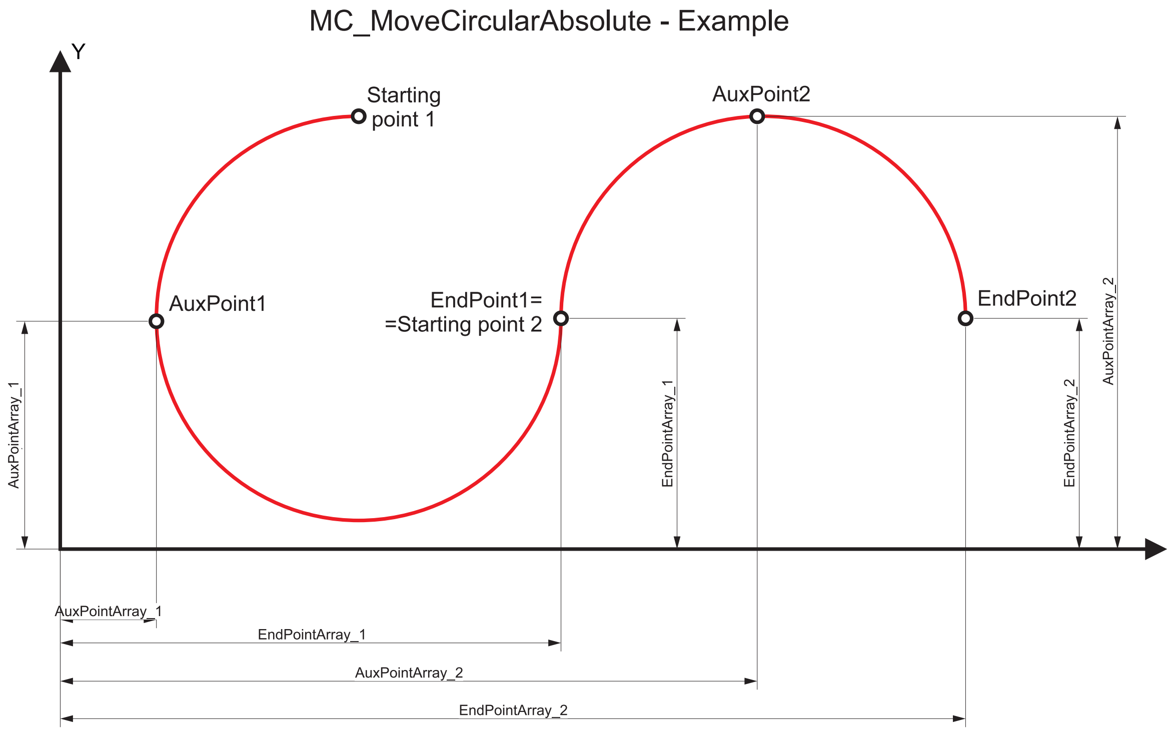
uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool
CircMode	Specifies the meaning of the input signals AuxPoint and CircDirection 1 ..... BORDER 2 ..... CENTER 3 ..... RADIUS	Long (I32)
AuxPoint	Next coordinates to define circle (depend on CircMode)	Reference
EndPoint	Target axes coordinates position	Reference
PathChoice	Choice of path 1 ..... Clockwise 2 ..... CounterClockwise	Long (I32)
Velocity	Maximal allowed velocity [unit/s]	Double (F64)
Acceleration	Maximal allowed acceleration [unit/s^2]	Double (F64)

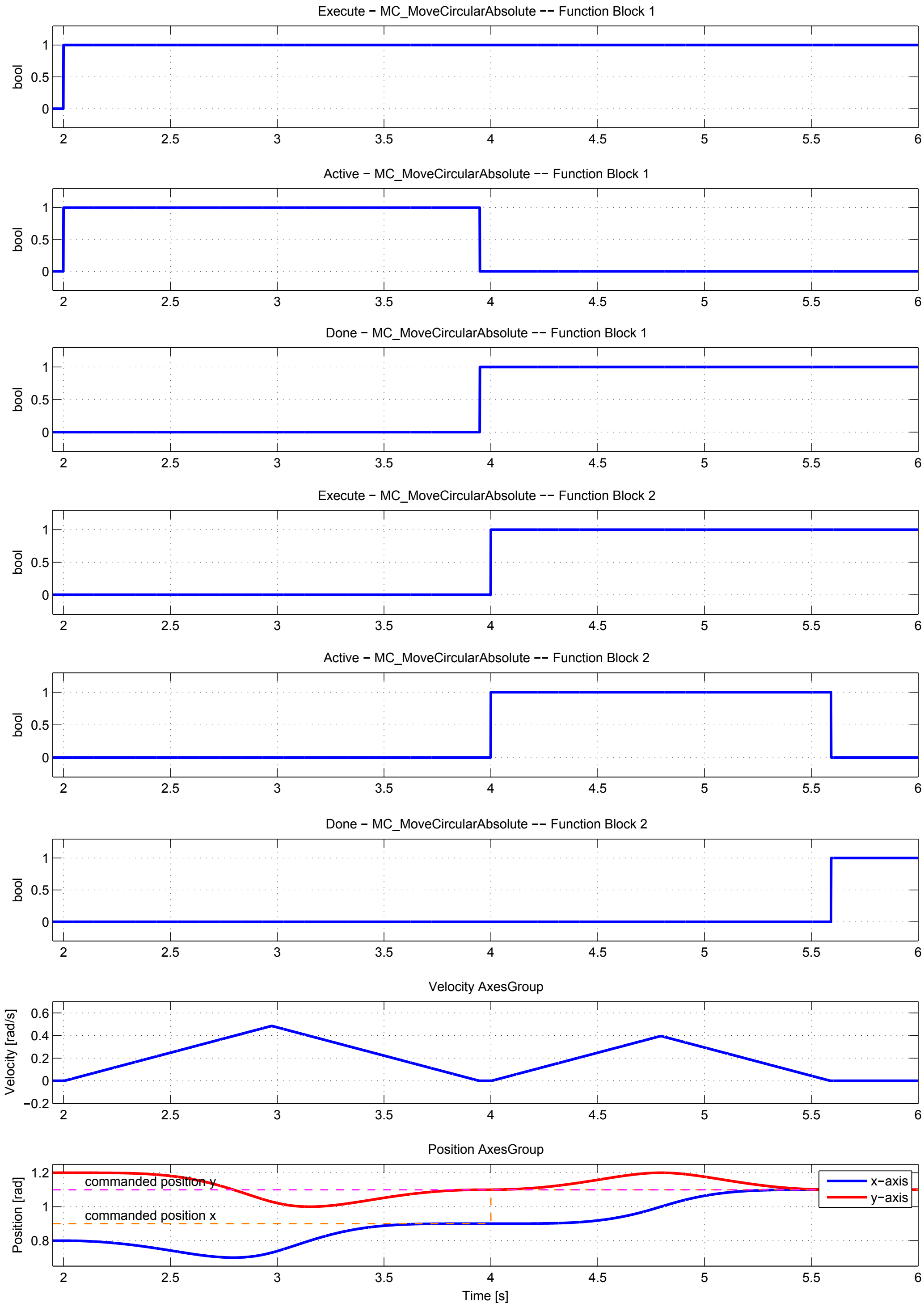
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	`Long (I32)`
`TransitionMode`	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`

Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`




MC_MoveCircularAbsolute - Example
Y
Starting
point 1
AuxPoint2
AuxPoint1
EndPoint1=
=Starting point 2
EndPoint2
AuxPointArray_1
EndPointArray_1
EndPointArray_2
AuxPointArray_2
AuxPointArray_1
EndPointArray_1
AuxPointArray_2
EndPointArray_2

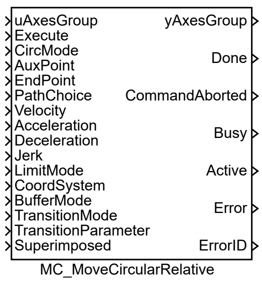


Execute − MC_MoveCircularAbsolute −− Function Block 1
Active − MC_MoveCircularAbsolute −− Function Block 1
Done − MC_MoveCircularAbsolute −− Function Block 1
Execute − MC_MoveCircularAbsolute −− Function Block 2
Active − MC_MoveCircularAbsolute −− Function Block 2
Done − MC_MoveCircularAbsolute −− Function Block 2
bool
Velocity AxesGroup
Velocity [rad/s]
Position AxesGroup
Position [rad]
commanded position y
commanded position x
x−axis
y−axis
Time [s]

MC_MoveCircularRelative – Circular move to position (relative to execution point)

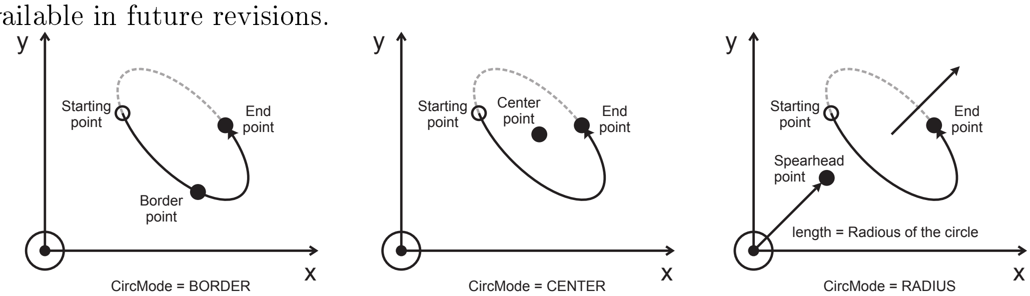
Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.



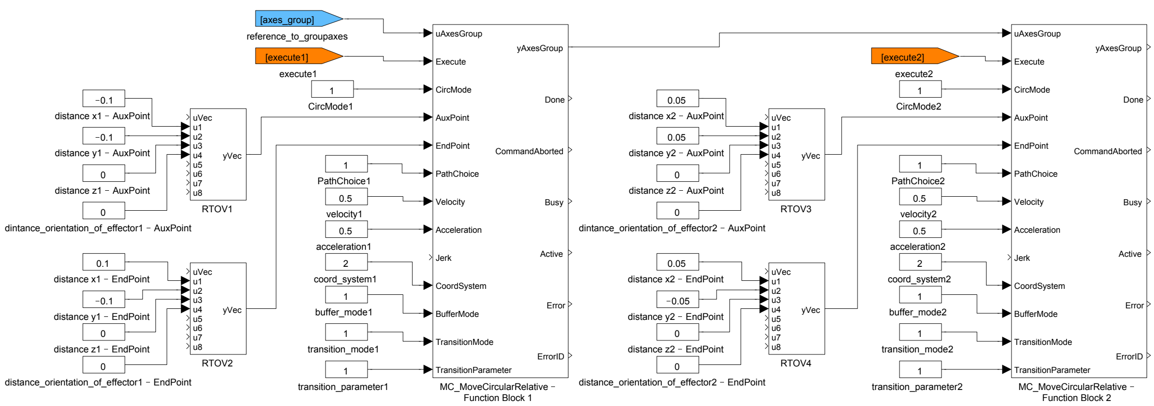
Inputs

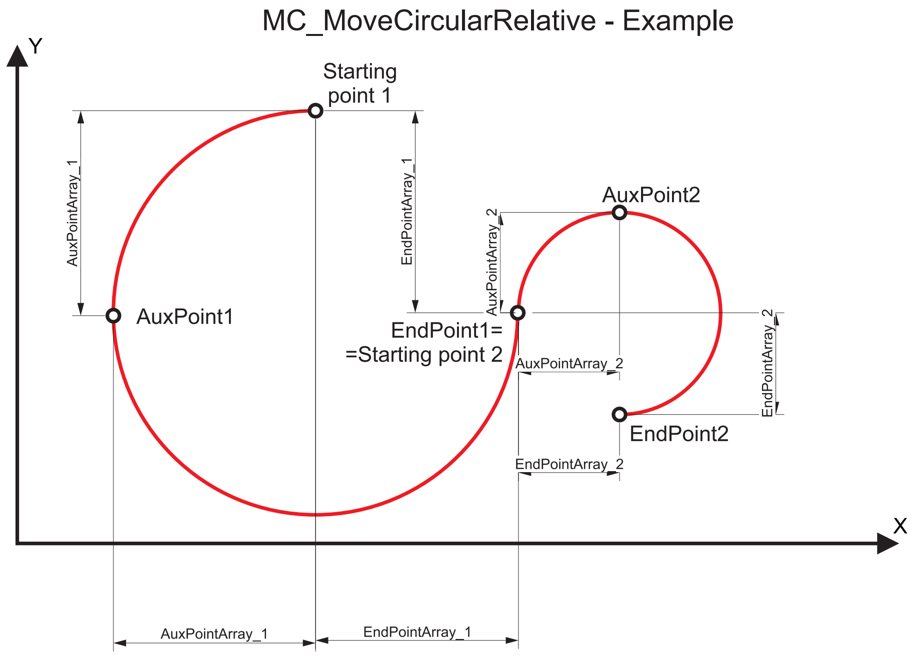
`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`CircMode`	Specifies the meaning of the input signals AuxPoint and CircDirection 1 ..... BORDER 2 ..... CENTER 3 ..... RADIUS	`Long (I32)`
`AuxPoint`	Next coordinates to define circle (depend on CircMode)	`Reference`
`EndPoint`	Target axes coordinates position	`Reference`
`PathChoice`	Choice of path 1 ..... Clockwise 2 ..... CounterClockwise	`Long (I32)`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`

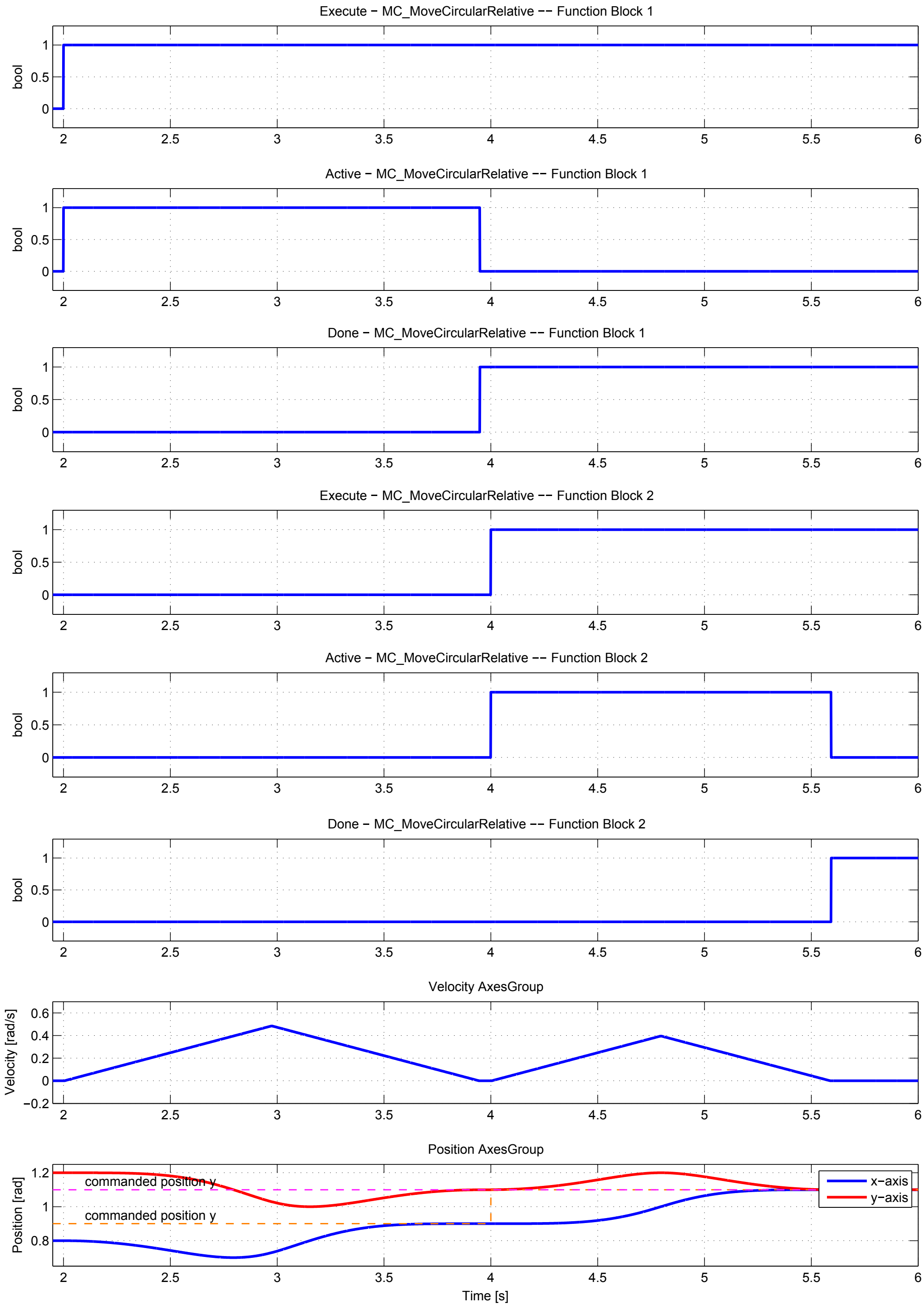
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	`Long (I32)`
`TransitionMode`	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`

Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`



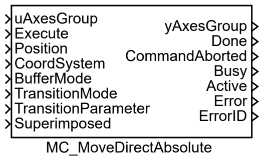

MC_MoveCircularRelative - Example
Y
X
Starting point 1
AuxPoint1
AuxPoint2
EndPoint1= =Starting point 2
EndPoint2
AuxPointArray_1
EndPointArray_1
AuxPointArray_2
EndPointArray_2
AuxPointArray_1
EndPointArray_1
AuxPointArray_2
EndPointArray_2


Execute − MC_MoveCircularRelative −− Function Block 1
Active − MC_MoveCircularRelative −− Function Block 1
Done − MC_MoveCircularRelative −− Function Block 1
Execute − MC_MoveCircularRelative −− Function Block 2
Active − MC_MoveCircularRelative −− Function Block 2
Done − MC_MoveCircularRelative −− Function Block 2
bool
Velocity AxesGroup
Velocity [rad/s]
Position AxesGroup
Position [rad]
commanded position y
commanded position y
x−axis
y−axis
Time [s]

MC_MoveDirectAbsolute – Direct move to position (absolute coordinates)

Block Symbol

Licence: COORDINATED MOTION



Function Description

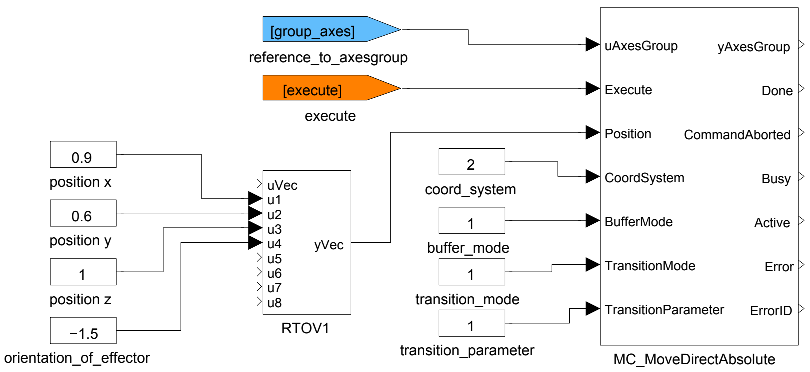
The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

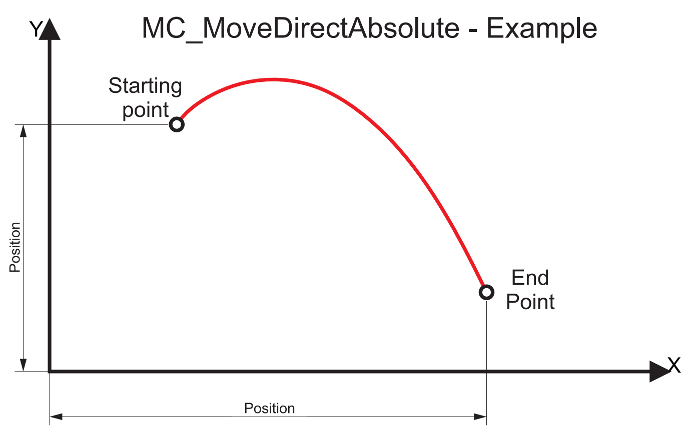
Inputs

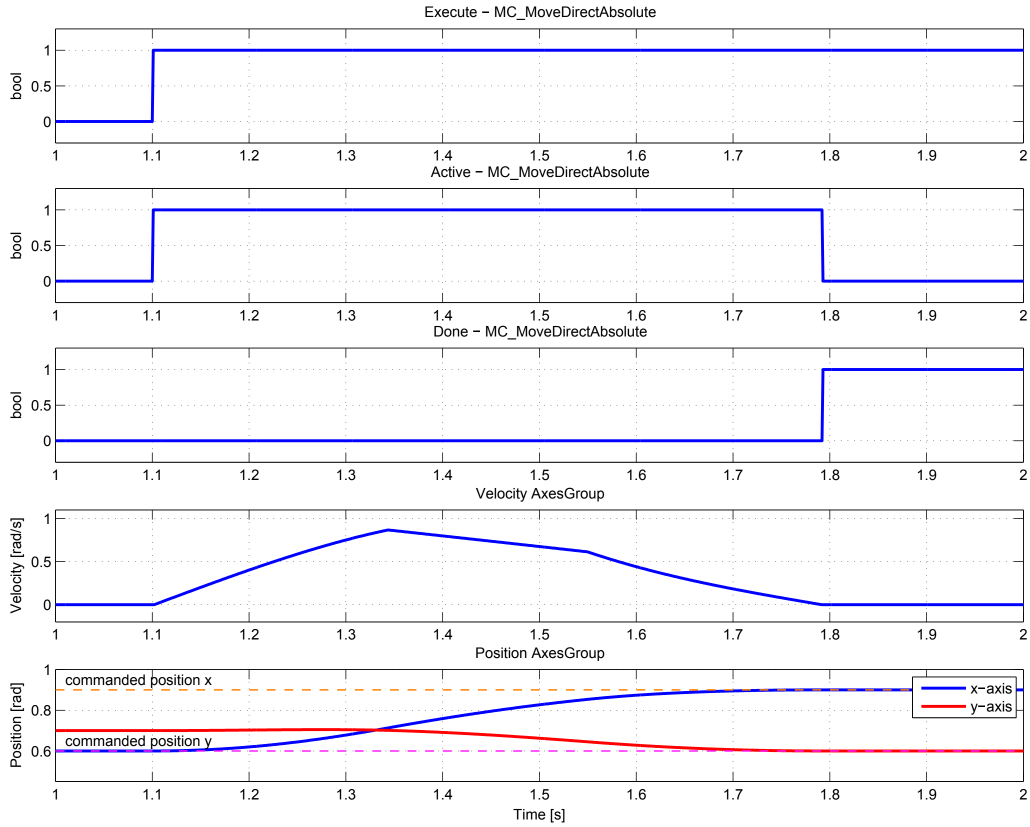
`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Position`	Array of coordinates (positions and orientations)	`Reference`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	`Long (I32)`
`TransitionMode`	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`

Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`



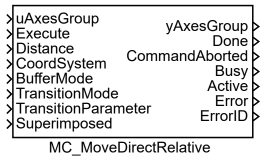



Execute − MC_MoveDirectAbsolute
Active − MC_MoveDirectAbsolute
Done − MC_MoveDirectAbsolute
bool
1
0.5
0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
Velocity AxesGroup
Velocity [rad/s]
Position AxesGroup
Position [rad]
0.8
0.6
commanded position x
commanded position y
x−axis
y−axis
Time [s]

MC_MoveDirectRelative – Direct move to position (relative to execution point)

Block Symbol

Licence: COORDINATED MOTION



Function Description

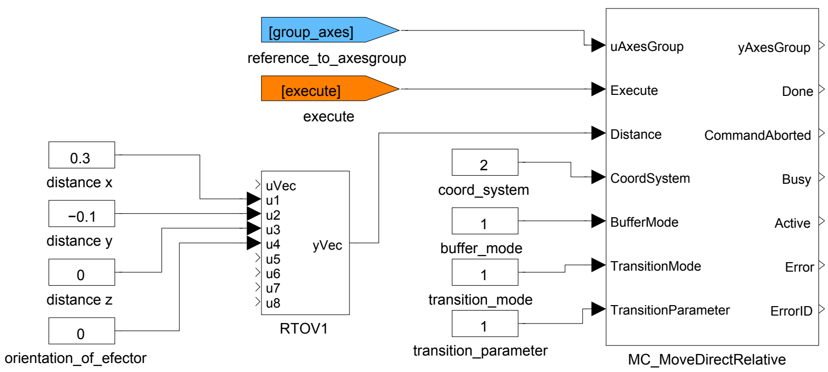
The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

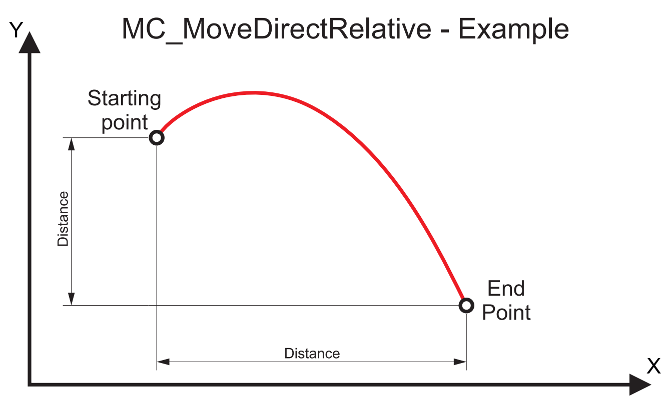
Inputs

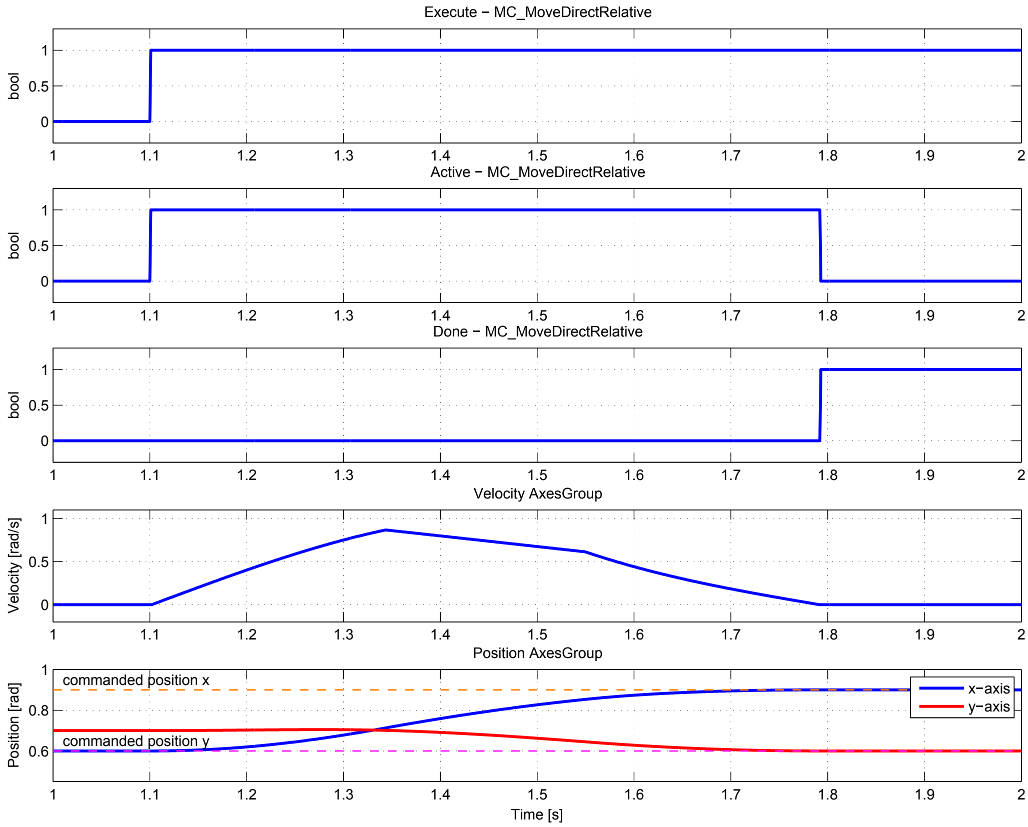
`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Distance`	Array of coordinates (relative distances and orientations)	`Reference`
`CoordSystem`	Reference to the coordinate system used `1` ..... ACS `2` ..... MCS `3` ..... PCS	`Long (I32)`
`BufferMode`	Buffering mode `1` ..... Aborting `2` ..... Buffered `3` ..... Blending low `4` ..... Blending high `5` ..... Blending previous `6` ..... Blending next	`Long (I32)`
`TransitionMode`	Transition mode in blending mode `1` ..... TMNone `2` ..... TMStartVelocity `3` ..... TMConstantVelocity `4` ..... TMCornerDistance `5` ..... TMMaxCornerDeviation `11` .... Smooth	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`

Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`



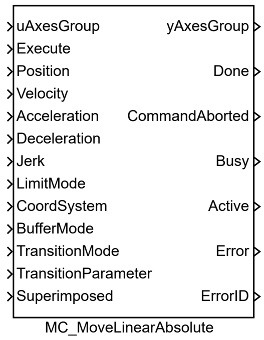



Execute − MC_MoveDirectRelative
bool
Active − MC_MoveDirectRelative
Done − MC_MoveDirectRelative
Velocity AxesGroup
Velocity [rad/s]
Position AxesGroup
Position [rad]
commanded position x
commanded position y
x−axis
y−axis
Time [s]

MC_MoveLinearAbsolute – Linear move to position (absolute coordinates)

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

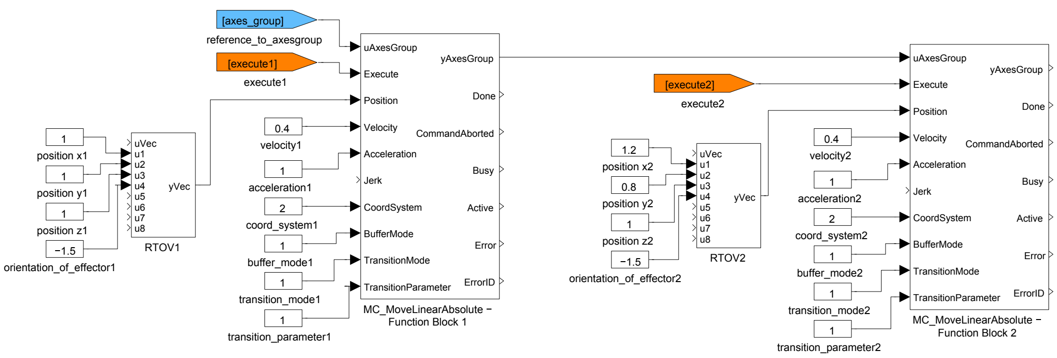
Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Position`	Array of coordinates (positions and orientations)	`Reference`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	`Long (I32)`

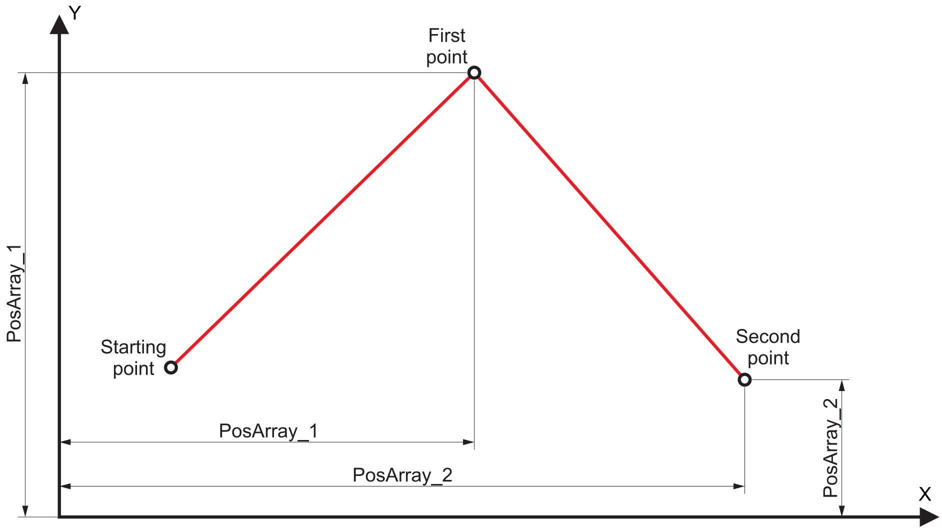
`TransitionMode`	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`

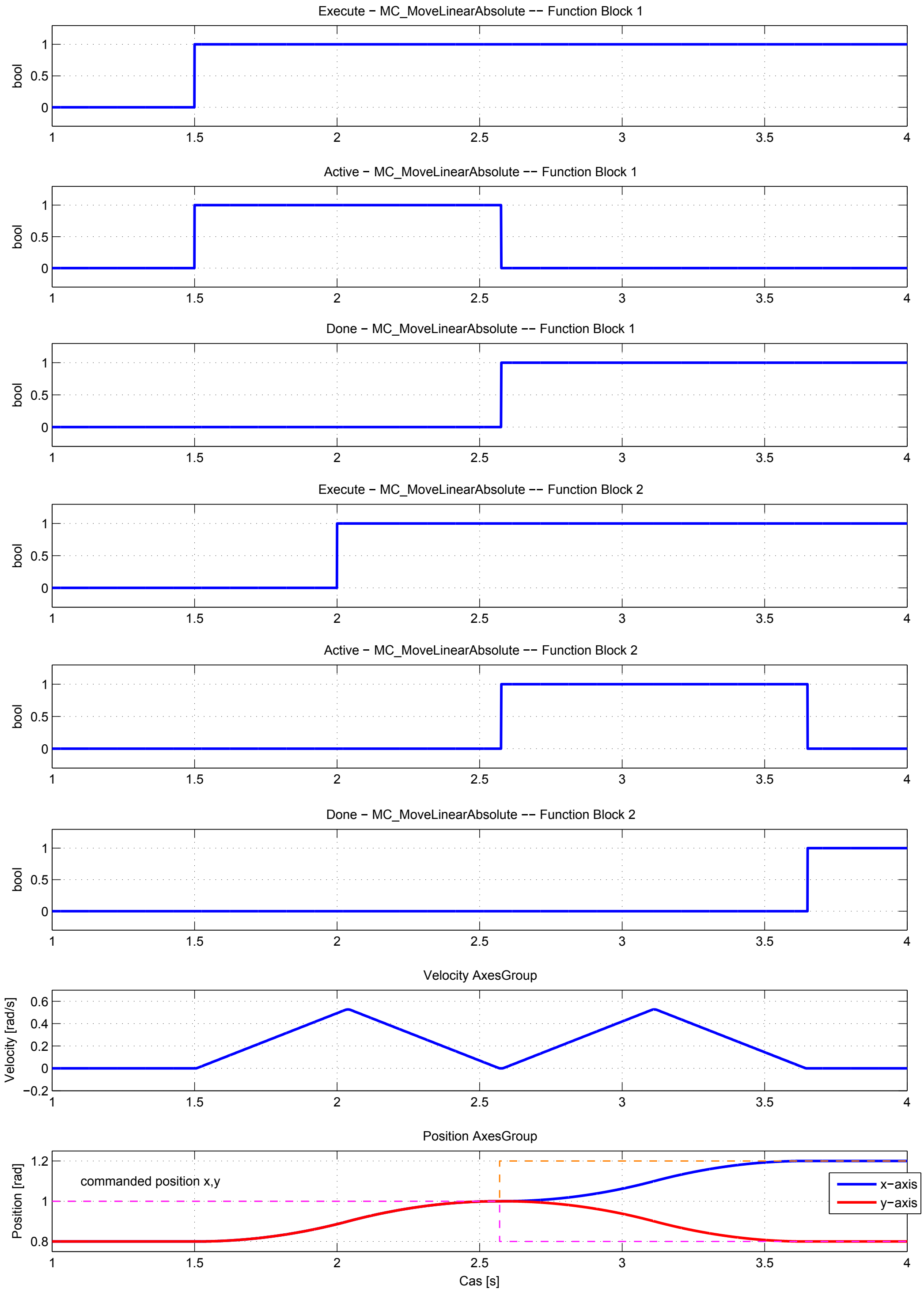
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`



Sequence of two complete motions (Done>Execute)

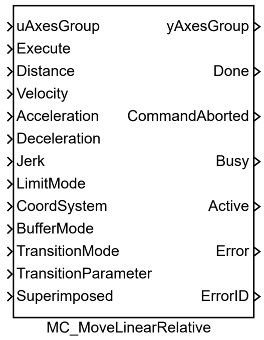



Execute − MC_MoveLinearAbsolute −− Function Block 1
Active − MC_MoveLinearAbsolute −− Function Block 1
Done − MC_MoveLinearAbsolute −− Function Block 1
Execute − MC_MoveLinearAbsolute −− Function Block 2
Active − MC_MoveLinearAbsolute −− Function Block 2
Done − MC_MoveLinearAbsolute −− Function Block 2
bool
Velocity AxesGroup
Velocity [rad/s]
Position AxesGroup
Position [rad]
commanded position x,y
x−axis
y−axis
Cas [s]

`MC_MoveLinearRelative` – Linear move to position (relative to execution point)

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

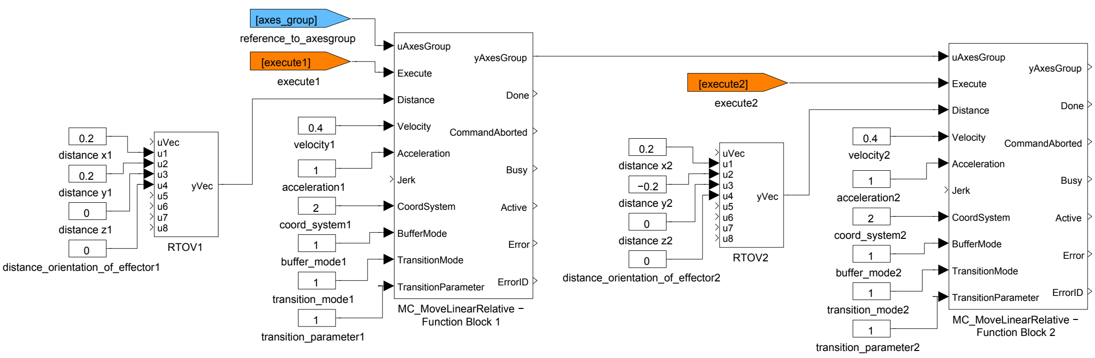
Inputs

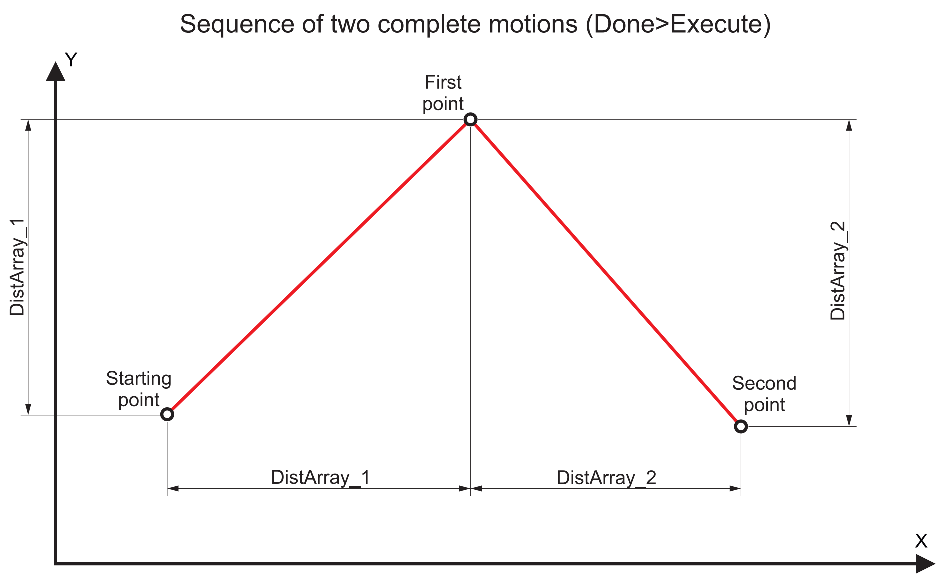
`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`Distance`	Array of coordinates (relative distances and orientations)	`Reference`
`Velocity`	Maximal allowed velocity [unit/s]	`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]	`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]	`Double (F64)`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	`Long (I32)`

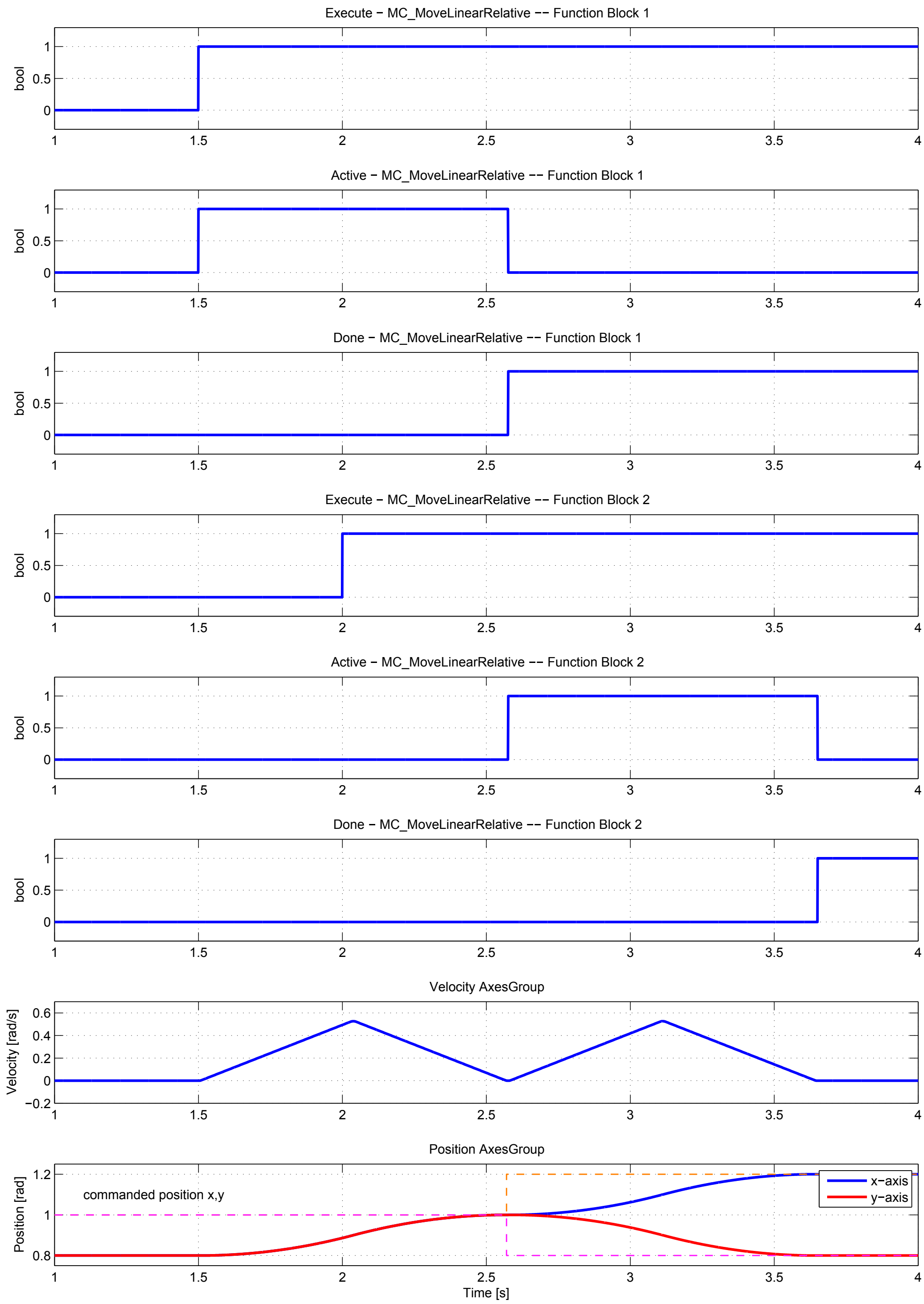
`TransitionMode`	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`

Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`



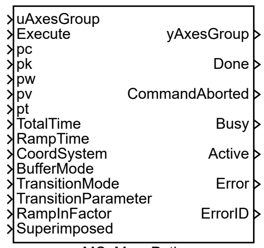

Sequence of two complete motions (Done>Execute)
Y
First point
DistArray_1
Starting point
DistArray_2
Second point
DistArray_1
DistArray_2
X


Execute − MC_MoveLinearRelative −− Function Block 1
Active − MC_MoveLinearRelative −− Function Block 1
Done − MC_MoveLinearRelative −− Function Block 1
Execute − MC_MoveLinearRelative −− Function Block 2
Active − MC_MoveLinearRelative −− Function Block 2
Done − MC_MoveLinearRelative −− Function Block 2
bool
0
0.5
1
1.5
2
2.5
3
3.5
4
Velocity AxesGroup
Velocity [rad/s]
−0.2
0.2
0.4
0.6
Position AxesGroup
Position [rad]
0.8
1.2
commanded position x,y
x−axis
y−axis
Time [s]

MC_MovePath – General spatial trajectory generation

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`TotalTime`	Time [s] for whole move	`Double (F64)`
`RampTime`	Time [s] for acceleration/deceleration	`Double (F64)`
`CoordSystem`	Reference to the coordinate system used `1` ..... ACS `2` ..... MCS `3` ..... PCS	`Long (I32)`
`BufferMode`	Buffering mode `1` ..... Aborting `2` ..... Buffered `3` ..... Blending low `4` ..... Blending high `5` ..... Blending previous `6` ..... Blending next	`Long (I32)`
`TransitionMode`	Transition mode in blending mode `1` ..... TMNone `2` ..... TMStartVelocity `3` ..... TMConstantVelocity `4` ..... TMCornerDistance `5` ..... TMMaxCornerDeviation `11` .... Smooth	`Long (I32)`
`TransitionParameter`	Parametr for transition (depends on transition mode)	`Double (F64)`
`RampIn`	RampIn factor (0 = RampIn mode not used)	`Double (F64)`

Parameters

`pc`	Control-points matrix	⊙[0.0 1.0 2.0; 0.0 1.0 1.0; 0.0 1.0 0.0]	`Double (F64)`
`pk`	Knot-points vector	⊙[0.0 0.0 0.0 0.0 0.5 1.0 1.0]	`Double (F64)`
`pw`	Weighting vector	⊙[1.0 1.0 1.0]	`Double (F64)`
`pv`	Polynoms for feedrate definition	⊙[0.0 0.05 0.95; 0.0 0.1 0.1; 0.0 0.0 0.0; 0.1 0.0 -0.1; -0.05 0.0 0.05; 0.0 0.0 0.0]	`Double (F64)`
`pt`	Knot-points (time [s]) for feedrate	⊙[0.0 1.0 10.0 11.0]	`Double (F64)`
`user`	Only for special edit	⊙[0.0 1.0 2.0 3.0]	`Double (F64)`

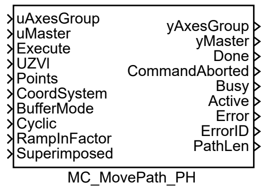
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_MovePath_PH – * General spatial trajectory generation PH

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

This block does not propagates the signal quality. More information can be found in the 1.4 section.

Input

`uAxesGroup`	Axes group reference	`Reference`
`uMaster`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Execute`	The block is activated on rising edge	`Bool`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS 4 ..... TCS	`Long (I32)`
`BufferMode`	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	`Long (I32)`
`Cyclic`	Profile is cyclic flag	`Bool`
`RampIn`	RampIn factor (0 = RampIn mode not used)	`Double (F64)`
`UZVl`		`Reference`
`Points`		`Reference`

Parameter

`Superimposed`	start as superimposed motion flag	`Bool`

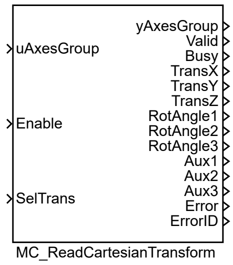
Output

`yAxesGroup`	Axes group reference	`Reference`
`yMaster`	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis connections are allowed)	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of last operation	`Error`
`PathLen`		`Double (F64)`

MC_ReadCartesianTransform – Reads the parameter of the cartesian transformation

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block `MC_ReadCartesianTransform` reads the parameter of the cartesian transformation that is active between the MCS and PCS. The parameters are valid only if the output `Valid` is true which is achieved by setting the input `Enable` on true. If more than one transformation is active, the resulting cartesian transformation is given.

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Enable`	Block function is enabled	`Bool`

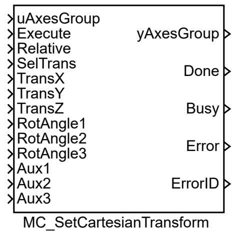
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Valid`	Output value is valid	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`TransX`	X-component of translation vector	`Double (F64)`
`TransY`	Y-component of translation vector	`Double (F64)`
`TransZ`	Z-component of translation vector	`Double (F64)`
`RotAngle1`	Rotation angle component	`Double (F64)`
`RotAngle2`	Rotation angle component	`Double (F64)`
`RotAngle3`	Rotation angle component	`Double (F64)`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

MC_SetCartesianTransform – Sets Cartesian transformation

Block Symbol

Licence: COORDINATED MOTION



Function Description

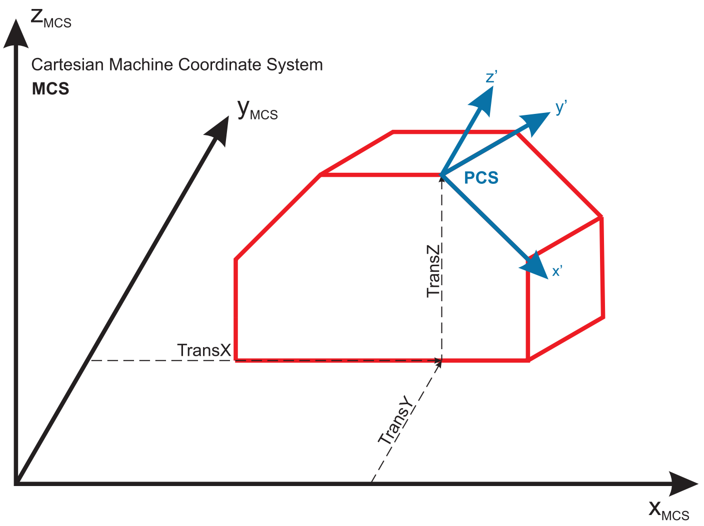
The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

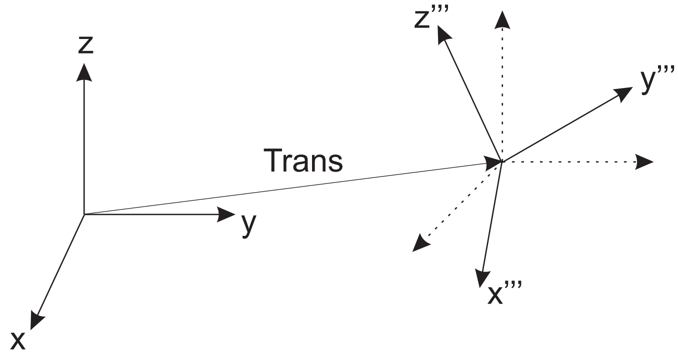
Inputs

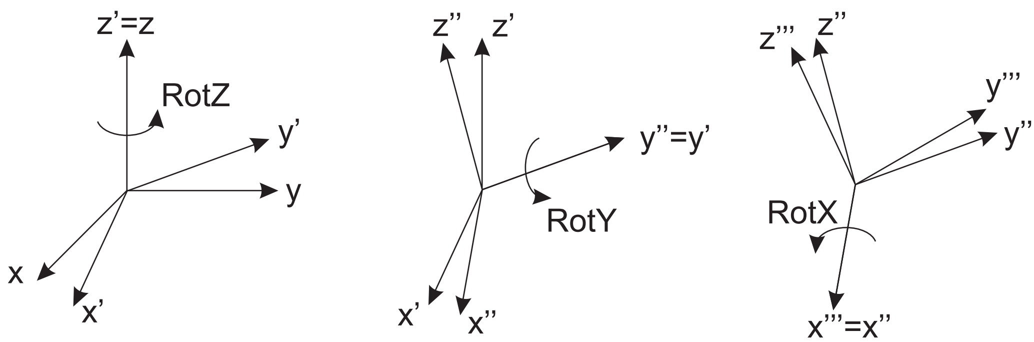
uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool
TransX	X-component of translation vector	Double (F64)
TransY	Y-component of translation vector	Double (F64)
TransZ	Z-component of translation vector	Double (F64)
RotAngle1	Rotation angle component	Double (F64)
RotAngle2	Rotation angle component	Double (F64)
RotAngle3	Rotation angle component	Double (F64)
Relative	Mode of position inputs	Bool

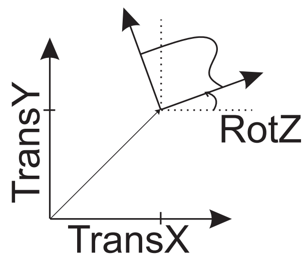
Outputs

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error


Cartesian Machine Coordinate System
MCS
PCS
TransX
TransY
TransZ


Trans

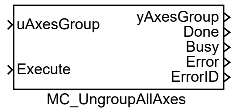

RotZ
RotY
RotX


TransY
TransX
RotZ

MC_UngroupAllAxes – Removes all axes from the group

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block MC_UngroupAllAxes removes all axes from the group uAxesGroup. After finalization the state is changed to "GroupDisabled".

Note 1: If the function block is execute in the group state "GroupDisabled", "GroupStandBy" or "GroupErrorStop" the error is set and the block is not execute.

Inputs

uAxesGroup	Axes group reference	Reference
Execute	The block is activated on rising edge	Bool

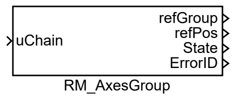
Outputs

yAxesGroup	Axes group reference	Reference
Done	Algorithm finished	Bool
Busy	Algorithm not finished yet	Bool
Error	Error occurred	Bool
ErrorID	Result of the last operation i ..... REXYGEN general error	Error

RM_AxesGroup – Axes group for coordinated motion control

Block Symbol

Licence: COORDINATED MOTION



Function Description

Note 1: Applicable for all non-administrative (moving) function blocks.
Note 2: In the states GroupErrorStop or GroupStopping, all Function Blocks canbe called, although they will not be executed, except MC_GroupReset for GroupErrorStop and any occurring Error– they will generate the transition to GroupStandby or GroupErrorStop respectively
Note 3: MC_GroupStop.DONE AND NOT MC_GroupStop.EXECUTE
Note 4: Transition is applicable if last axis is removed from the group
Note 5: Transition is applicable while group is not empty.
Note 6: MC_GroupDisable and MC_UngroupAllAxes can be issued in all states and will change the state to GroupDisabled.

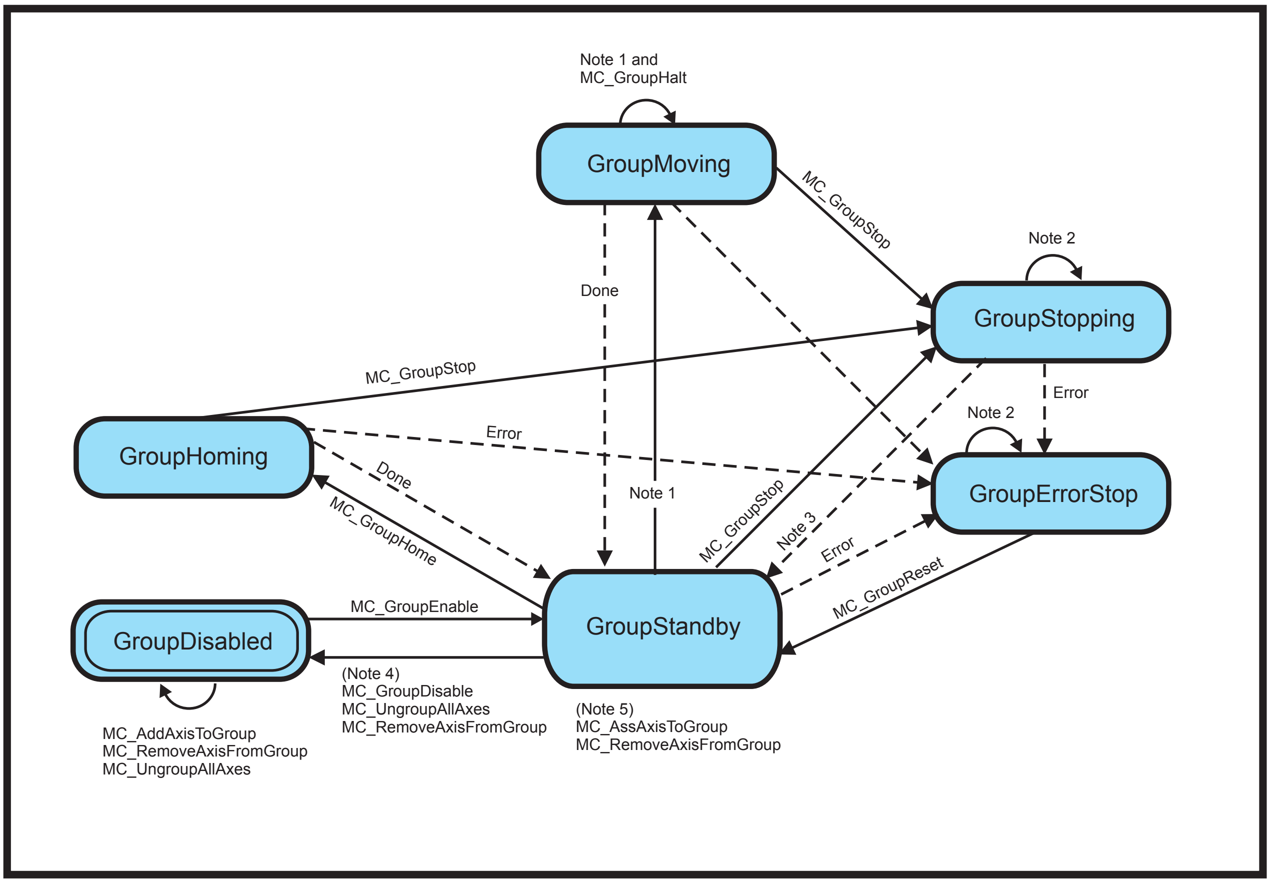
Parameters

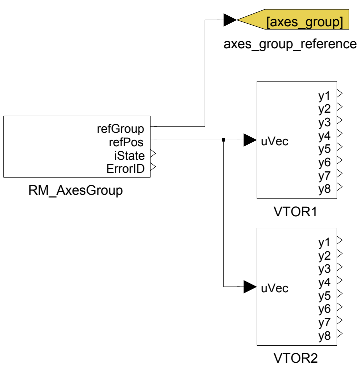
`McsCount`	Number of axis in MCS	↓1 ↑6 ⊙6	`Long (I32)`
`AcsCount`	Number of axis in ACS	↓1 ↑16 ⊙6	`Long (I32)`
`PosCount`	Number of position axis	↓1 ↑6 ⊙3	`Long (I32)`
`Velocity`	Maximal allowed velocity [unit/s]		`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^3]		`Double (F64)`

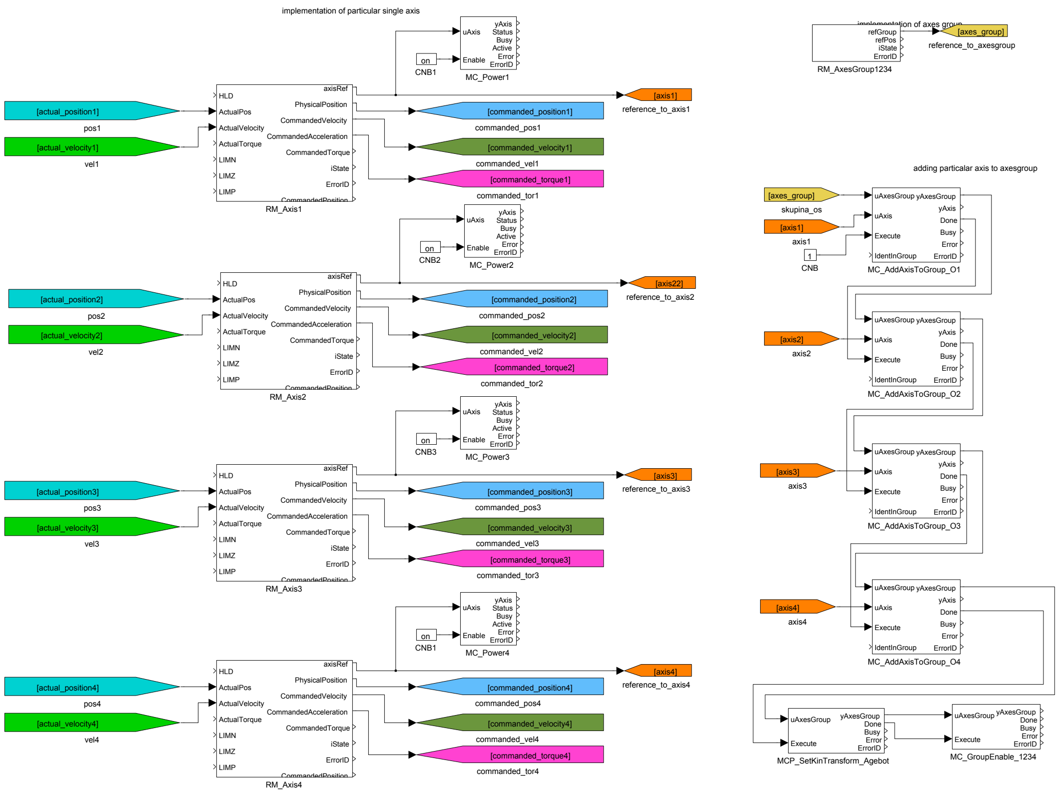
Outputs

`refGroup`	Axes group reference	`Reference`
`refPos`	Position, velocity and acceleration vector	`Reference`
`iState`	Group status 0 ..... Disabled 1 ..... Standby 2 ..... Homing 6 ..... Moving 7 ..... Stopping 8 ..... Error stop	`Long (I32)`
`ErrorID`	Result of the last operation i ..... REXYGEN general error	`Error`

The State Diagram of AxesGroup



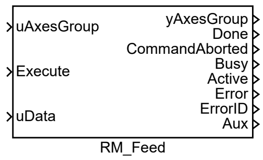



implementation of particular single axis
implementation of axes group
adding particalar axis to axesgroup
[actual_position1]
pos1
[actual_velocity1]
vel1
RM_Axis1
MC_Power1
CNB1
[axis1]
reference_to_axis1
[commanded_position1]
commanded_pos1
[commanded_velocity1]
commanded_vel1
[commanded_torque1]
commanded_tor1
[actual_position2]
pos2
[actual_velocity2]
vel2
RM_Axis2
MC_Power2
CNB2
[axis22]
reference_to_axis2
[commanded_position2]
commanded_pos2
[commanded_velocity2]
commanded_vel2
[commanded_torque2]
commanded_tor2
[actual_position3]
pos3
[actual_velocity3]
vel3
RM_Axis3
MC_Power3
CNB3
[axis3]
reference_to_axis3
[commanded_position3]
commanded_pos3
[commanded_velocity3]
commanded_vel3
[commanded_torque3]
commanded_tor3
[actual_position4]
pos4
[actual_velocity4]
vel4
RM_Axis4
MC_Power4
CNB1
[axis4]
reference_to_axis4
[commanded_position4]
commanded_pos4
[commanded_velocity4]
commanded_vel4
[commanded_torque4]
commanded_tor4
RM_AxesGroup1234
[axes_group]
reference_to_axesgroup
skupina_os
axis1
CNB
MC_AddAxisToGroup_O1
axis2
MC_AddAxisToGroup_O2
axis3
MC_AddAxisToGroup_O3
axis4
MC_AddAxisToGroup_O4
MCP_SetKinTransform_Agebot
MC_GroupEnable_1234

RM_Feed – * MC Feeder ???

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`Execute`	The block is activated on rising edge	`Bool`

Parameters

`Filename`	0		`String`
`VelFactor`	0	↓0.01 ↑100.0 ⊙1.0	`Double (F64)`
`Relative`	0		`Bool`
`CoordSystem`	0	↓1 ↑3 ⊙2	`Long (I32)`
`BufferMode`	0	↓1 ↑6 ⊙1	`Long (I32)`
`TransitionMode`	0	↓0 ↑15 ⊙1	`Long (I32)`
`TransitionParameter`	0		`Double (F64)`

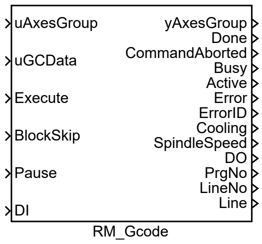
Outputs

`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation	`Error`
`Aux`	0	`Double (F64)`

RM_Gcode – * CNC motion control

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

uAxesGroup	Axes group reference		Reference
Execute	The block is activated on rising edge		Bool
BlockSkip	MILAN		Bool

Parameters

BaseDir	Directory of the G-code files		String
MainFile	Source file number		Long (I32)
CoordSystem	0	↓1 ↑3 ⊙3	Long (I32)
BufferMode	Buffering mode 1 ..... Aborting 2 ..... Buffered 3 ..... Blending low 4 ..... Blending high 5 ..... Blending previous 6 ..... Blending next	⊙1	Long (I32)
TransitionMode	Transition mode in blending mode 1 ..... TMNone 2 ..... TMStartVelocity 3 ..... TMConstantVelocity 4 ..... TMCornerDistance 5 ..... TMMaxCornerDeviation 11 .... Smooth	⊙1	Long (I32)
TransitionParameter	Parametr for transition (depends on transition mode)		Double (F64)

`workOffsets`	Sets with initial coordinate	⊙[0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0]	`Double (F64)`
`toolOffsets`	Sets of tool offset	⊙[0 0 0]	`Double (F64)`
`cutterOffsets`	Tool radii	⊙[0 0 0]	`Double (F64)`

Outputs

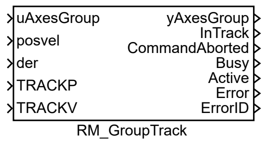
`yAxesGroup`	Axes group reference	`Reference`
`Done`	Algorithm finished	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`
`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`
`Cooling`	Cooling	`Bool`
`LineNo`	Current executed line number	`Long (I32)`
`Line`	Current line of G-code	`String`
`SpindleSpeed`	Spindle speed	`Double (F64)`

RM_GroupTrack – T

racking position/velocity

Block Symbol

Licence: COORDINATED MOTION



Function Description

The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

`uAxesGroup`	Axes group reference	`Reference`
`posvel`	Vector of desired position or velocity	`Reference`
`TRACKP`	Position tracking	`Bool`
`TRACKV`	Velocity tracking	`Bool`

Parameters

`Velocity`	Maximal allowed velocity [unit/s]		`Double (F64)`
`Acceleration`	Maximal allowed acceleration [unit/s^2]		`Double (F64)`
`Jerk`	Maximal allowed jerk [unit/s^2]		`Double (F64)`
`CoordSystem`	Reference to the coordinate system used 1 ..... ACS 2 ..... MCS 3 ..... PCS	⊙2	`Long (I32)`
`iLen`	Number of samples to estimate the velocity / acceleration	↓-1 ↑99	`Long (I32)`

Outputs

`yAxesGroup`	Axes group reference	`Reference`
`InTrack`	Position / velocity track flag	`Bool`
`CommandAborted`	Algorithm was aborted	`Bool`
`Busy`	Algorithm not finished yet	`Bool`
`Active`	The block is controlling the axis	`Bool`
`Error`	Error occurred	`Bool`

`ErrorID`	Result of the last operation `i` ..... REXYGEN general error	`Error`

Chapter 23

CanDrv – Communication via CAN bus

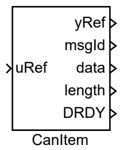
Contents

The CanDrv library is dedicated to handling CAN (Controller Area Network) bus communication in REXYGEN system. It features CanItem for managing CAN data items, CanRecv for receiving messages from the bus, and CanSend for sending messages. This library provides essential tools for efficient and reliable communication over CAN networks, facilitating data exchange and control commands between various system components.

CanItem – Secondary received CAN message

Block Symbol

Licence: CANDRV



Function Description

The block is used with the CanRecv block. The **uRef** input of the **CanItem** block must be connected to the **itemRef** output of some CanRecv block or to the **yRef** output of another **CanItem** block.

This block shows the previous message that has passed the filter in the CanRecv block.

If more than one **CanItem** block is connected (directly or indirectly through the **yRef** output of the **CanItem** block already connected to the CanRecv block) then the first executed **CanItem** block shows the first message before the last received message (which is shown by the **CanRecv** block), the second executed **CanItem** block shows the second message before the last received message (which is shown by the **CanRecv** block) etc. It is strongly recommended to connect the **CanItem** blocks in a daisy chain. Unexpected ordering of messages may occur if the blocks are connected in a tree-like structure.

If no message has been received since start of the CAN driver, the data outputs have fallback values **msgId** = `-1` and **length** = `-1`.

The **DRDY** output is set to DRDY= **on** if the message has been received during the last period, i.e. after previous execution of the **CanItem** block. At the same moment, the outputs **msgId**, **data** and **length** are updated. If there is no new data, **DRDY** output is set to DRDY= **off** and the data values are kept on the other outputs (**msgId**, **data** and **length**).

Input

uRef	Secondary received packet reference		Reference

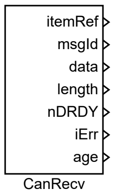
Outputs

yRef	Secondary received packet reference		Reference
msgId	CAN message ID (COB-ID)		Long (I32)
data	Message data (8 bytes maximum, LSB first)	↓-9.22337E+18 ↑9.22337E+18	Large (I64)
length	Message length (number of bytes of data)	↓0 ↑8	Long (I32)
DRDY	Received message in the last period flag		Bool

CanRecv – Receive CAN message

Block Symbol

Licence: CANDRV



Function Description

The CanRecv block receives message via CAN bus. The message is defined by the msgId, data and length inputs and the RTR and EXT parameters.

Number of messages received in the current task period (i.e. since the previous execution) is indicated by the nDRDY output.

The data from the last received message is available at the msgId, data and length outputs. Previous messages (with respect to the nmax parameter) are available using the CanItem block(s) linked to the itemRef output.

The block must be linked with the CanDrv driver. The driver must be configured to use the simple CAN mode (i.e. the parameter NodeMode = 256).

The block's name must be in the form <DRV>__<blkname> (see e.g. OUTQUAD or OUTOCT blocks for details about referencing data from I/O drivers). The <blkname> part of the name has no special meaning in this case and it is recommended to keep the original CanRecv.

The block supports short (11-bit) and long (29-bit) message IDs (see the EXT parameter) and RequestToReceive messages (see the RTR parameter). FD mode which allows up to 64 data bytes in a single message is not supported.

Outputs

itemRef	Secondary received packet reference		Reference
msgId	CAN message ID (COB-ID)		Long (I32)
data	Message data (8 bytes maximum, LSB first)	↓-9.22337E+18 ↑9.22337E+18	Large (I64)
length	Message length (number of bytes of data)	↓0 ↑8	Long (I32)
nDRDY	Number of received messages in the last period	↑255	Word (U16)
iErr	Error code		Error
age	Elapsed time since the last received message [s]	↓0.0	Double (F64)

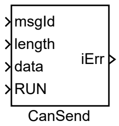
Parameters

`filterId`	MessageId of packets to receive by this block	↓0 ↑536870911	`Long (I32)`
`filterIdMask`	Mask for the `filterId` parameter (marks valid bits)	↓0 ↑536870911	`Long (I32)`
`filterLength`	Data length of packets to receive by this block (-1 allows all lengths)	↓-1 ↑8	`Long (I32)`
`RTR`	Request To Receive flag	⊙on	`Bool`
`EXT`	Extended message ID (29bits)	⊙on	`Bool`
`timeout`	Error is indicated if no packet is received within the timeout interval [s]	↓0.0	`Double (F64)`
`nmax`	Maximum number of received messages in one period	↓1 ↑255	`Long (I32)`

CanSend – Send CAN message

Block Symbol

Licence: CANDRV



Function Description

The CanSend block sends message via CAN bus. The message content is defined by the msgId, data and length inputs and the RTR and EXT parameters. Message is sent only if the input RUN is set to RUN = on.

The block must be linked with the CanDrv driver. The driver must be configured to use the simple CAN mode (i.e. the parameter NodeMode = 256).

The block's name must be in the form <DRV>__<blkname> (see e.g. OUTQUAD or OUTOCT blocks for details about referencing data from I/O drivers). The <blkname> part of the name has no special meaning in this case and it is recommended to keep the original CanSend.

The block supports short (11-bit) and long (29-bit) message IDs (see the EXT parameter) and RequestToReceive messages (see the RTR parameter). FD mode which allows up to 64 data bytes in a single message is not supported.

Inputs

msgId	CAN message ID (COB-ID)	↓0 ↑536870911	Long (I32)
length	Message length (number of bytes of data)	↓0 ↑8	Long (I32)
data	Message data (8 bytes maximum, LSB first)	↓-9.22337E+18 ↑9.22337E+18	Large (I64)
RUN	Sending message is enabled		Bool

Output

iErr	Error code	Error

Parameters

RTR	Request To Receive flag	⊙on	Bool
EXT	Extended message ID (29bits)	⊙on	Bool

Chapter 24

OpcUaDrv – Communication using OPC UA

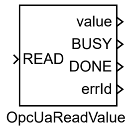
Contents

The OpcUaDrv library is specialized in interfacing with OPC UA (Open Platform Communications Unified Architecture) servers for industrial automation. It comprises three key blocks: OpcUaReadValue, OpcUaServerValue, and OpcUaWriteValue. The OpcUaReadValue block is designed for reading data from servers, making it pivotal for data acquisition in automated systems. The OpcUaWriteValue block enables writing data to servers, allowing for control and command execution. Additionally, the OpcUaServerValue block facilitates the monitoring and management of server values. This library serves as a critical tool for seamless communication and interaction with OPC UA servers, enhancing the capabilities of automation systems.

OpcUaReadValue – Read value from OPC UA Server

Block Symbol

Licence: ADVANCED



Function Description

This function block depends on the OpcUa driver. Please read the OpcUaDrv manual [21] before use.

The OpcUaReadValue block reads value of an OPC UA Node through a connection established by the OPC UA client driver.

The first two parameters are NodeId and NodeId_type. The NodeId_type specifies what type of information it is expected to be entered as the NodeId parameter. If the value is string, numeric, guid than the NodeId parameter should contain the id of the actual OPC UA Node on the server prefixed with the index of the namespace declared in the configuration of the driver separated by a colon (e.g. 1:myNode).

If the value of the NodeId_type parameter is set to path than the NodeId parameter should contain the path to the desired Node in the server structure. Every segment of the path is composed from the attribute BrowserName of the node and the BrowserName is similarly with regular NodeId types prefixed with the index of the namespace declared in the configuration of the driver separated by a colon (e.g. /1:myDevice/1:myNode). The path is relative to the *Objects* folder in the OPC UA server structure.

The parameter type specifies the expected Node's value data type. The block converts the Node's value to the specified type and sets the value output signal in case of success or it sets the errId to the resulting error code.

Input

READ	Enable execution	Bool

Parameters

NodeId	OPC UA Node Id		String
NodeId_type	Type of Node ID 1 ..... string 2 ..... numeric 3 ..... guid 4 ..... path	⊙1	Long (I32)

`type`	Expected type of incoming data 1 ..... string 2 ..... double 3 ..... long 4 ..... bool	⊙1	`Long (I32)`

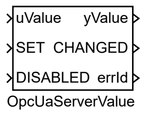
Outputs

`value`	Output signal	`Any`
`BUSY`	Busy flag	`Bool`
`DONE`	Indicator of finished transaction	`Bool`
`errId`	Error code	`Error`

OpcUaServerValue – Expose value as an OPC UA Node

Block Symbol

Licence: ADVANCED



Function Description

This function block depends on the OpcUa driver. Please read the `OpcUaDrv` manual [21] before use.

The `OpcUaServerValue` block exposes an OPC UA Node through OPC UA server driver.

The first two parameters are `NodeId` and `NodeId_type`. The `NodeId_type` specifies how the value entered as the `NodeId` parameter should be treated. The parameter `NodeId` specifies the *NodeId* that the OPC UA Node represented by the block should be exposed with.

The input `DISABLE` controls whether the OPC UA Node is exposed on the server or not. When the `SET` input is set to `on` the value on the input `uValue` port is set to the OPC UA Node's value. If the parameter `READONLY` is set to `off` the Node's value can also be changed from outside of the algorithm through the OPC UA communication protocol.

The output signal `yValue` is set to the Node's value on every tick. The parameter `type` specifies the Node's value data type, the data type of the `uValue` input and `yValue` output.

Inputs

`uValue`	Input signal	`Any`
`SET`	Set the input value to OPC UA Node value	`Bool`
`DISABLE`	Disable OPC UA Node	`Bool`

Parameters

`NodeId`	OPC UA Node Id		`String`
`NodeId_type`	OPC UA Node Id type 1 ..... string 2 ..... numeric 3 ..... guid	⊙1	`String`

type	Value data type 1 ..... string 2 ..... double 3 ..... long 4 ..... bool	⊙1	Long (I32)
BrowseName	OPC UA Node Browse name		String
Description	OPC UA Node description		String
DisplayName	OPC UA Node display name		String
READONLY	Set OPC Node value as read only	⊙on	Bool

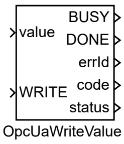
Outputs

yValue	Output signal	Any
CHANGED	Value of the node changed though the OPC UA protocol	Bool
errId	Error code	Error

OpcUaWriteValue – Write value to OPC UA Server

Block Symbol

Licence: ADVANCED



Function Description

This function block depends on the OpcUa driver. Please read the OpcUaDrv manual [21] before use.

The OpcUaWriteValue block writes value to the OPC UA Node through a connection established by the OPC UA client driver.

The first two parameters are NodeId and NodeId_type. The NodeId_type specifies what type of information it is expected to be entered as the NodeId parameter. If the value is string, numeric, guid than the NodeId parameter should contain the id of the actual OPC UA Node on the server prefixed with the index of the namespace declared in the configuration of the driver separated by a colon (e.g. 1:myNode).

If the value of the NodeId_type parameter is set to path than the NodeId parameter should contain the path to the desired Node in the server structure. Every segment of the path is composed from the attribute BrowserName of the node and the BrowserName is similarly with regular NodeId types prefixed with the index of the namespace declared in the configuration of the driver separated by a colon (e.g. /1:myDevice/1:myNode). The path is relative to the *Objects* folder in the OPC UA server structure.

The parameter type specifies the expected Node's value data type. The input signal value is converted to the specified type and is than written to the Node's value attribute.

When the process of writing the value is finished the result code defined by OPC UA is set to the code output and it's textual representation is set to the status output.

Inputs

value	Input signal	Any
WRITE	Enable execution	Bool

Parameters

NodeId	OPC UA Node Id	String

NodeId_type	Type of Node ID 1 ..... string 2 ..... numeric 3 ..... guid 4 ..... path	⊙1	Long (I32)
type	Value data type 1 ..... string 2 ..... double 3 ..... long 4 ..... bool	⊙1	Long (I32)

Outputs

BUSY	Busy flag	Bool
DONE	Indicator of finished transaction	Bool
errId	Error code	Error
code	OPC UA result status code	DWord (U32)
status	OPC UA result status string	String

Appendix A

Licensing options

From the licensing point of view, there are several versions of the RexCore runtime module to provide maximum flexibility for individual projects. The table below compares the individual variants.

The function blocks are divided into several licensing groups. The `STANDARD` function blocks are always available, the other groups require activation by a corresponding licence.

	RexCore DEMO	RexCore Starter	RexCore Plus	RexCore Professional	RexCore Ultimate
Function blocks					
STANDARD	•	•	•	•	•
ADVANCED	•	–	•	•	•
REXLANG	•	–	•	•	•
MOTION CONTROL	•	–	◦	◦	•
COORDINATED MOTION	•	–	◦	◦	•
AUTOTUNING	–	–	◦	◦	•
MATRIX	•	–	◦	◦	•
I/O drivers					
Basic I/O drivers	•	•	•	•	•
Additional I/O drivers	•	◦	◦	•	•

(• . . . included, ◦ . . . optional, – . . . not available)

See Appendix B for details about licensing of individual function blocks.

Appendix B

Licensing of individual function blocks

To maximize flexibility for individual projects, function blocks of the REXYGEN system are divided into several licensing groups. The table below shows the groups the function blocks belong to. See Appendix A for detailed information about the individual licensing options.

Function block name	Licensing group	
	STANDARD	Other
ABS_	•	
ABSROT		ADVANCED
ACD	•	
ADD	•	
ADDHEXD	•	
ADDOCT	•	
ADDQUAD	•	
AFLUSH	•	
ALB	•	
ALBI	•	
ALN	•	
ALNI	•	
ARS	•	
AND_	•	
ANDHEXD	•	
ANDOCT	•	
ANDQUAD	•	
ANLS	•	
ARC	•	
ARLY	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
ASW		ADVANCED
ATMT	•	
AVG	•	
AVS		ADVANCED
BDHEXD	•	
BDOCT	•	
BINS	•	
BIS	•	
BISR	•	
BITOP	•	
BMHEXD	•	
BMOCT	•	
BPF	•	
CanItem		CANDRV
CanRecv		CANDRV
CanSend		CANDRV
CDELSSM		ADVANCED
CMP	•	
CNA	•	
CNB	•	
CNDR	•	
CNE	•	
CNI	•	
CNR	•	
CNS	•	
CONCAT	•	
COND		
COUNT	•	
CSSM		ADVANCED
DATE_	•	
DATETIME	•	
DDELSSM		ADVANCED
DEL	•	
DELM	•	
DER	•	
DFIR		ADVANCED
DIF_	•	
Display	•	
DIV	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
DSSM		ADVANCED
EAS	•	
EATMT		ADVANCED
EDGE_	•	
EKF		MODEL
EMD	•	
EPC		ADVANCED
EQ	•	
EVAR	•	
EXEC	•	
FIND	•	
FLCU		ADVANCED
FNX	•	
FNXY	•	
FOPDT	•	
FRID		ADVANCED
From	•	
GAIN	•	
GETPA	•	
GETPB	•	
GETPI	•	
GETPR	•	
GETPS	•	
Goto	•	
GotoTagVisibility	•	
GRADS		ADVANCED
HMI	•	
HTTP		ADVANCED
HTTP2		ADVANCED
I3PM		ADVANCED
IADD	•	
IDIV	•	
IMOD	•	
IMUL	•	
INFO	•	
INHEXD	•	
INOCT	•	
Inport	•	
INQUAD	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
INSTD	•	
INTE	•	
INTSM	•	
IODRV	•	
IOTASK	•	
ISSW	•	
ISUB	•	
ITOI	•	
ITOS	•	
KDER		ADVANCED
LC	•	
LEN	•	
LIN	•	
LLC	•	
LPBRK	•	
LPF	•	
MC_AccelerationProfile		MOTION CONTROL
MC_AddAxisToGroup		COORDINATED MOTION
MC_CamIn		MOTION CONTROL
MC_CamOut		MOTION CONTROL
MC_CombineAxes		MOTION CONTROL
MC_GearIn		MOTION CONTROL
MC_GearInPos		MOTION CONTROL
MC_GearOut		MOTION CONTROL
MC_GroupContinue		COORDINATED MOTION
MC_GroupDisable		COORDINATED MOTION
MC_GroupEnable		COORDINATED MOTION
MC_GroupHalt		COORDINATED MOTION
MC_GroupInterrupt		COORDINATED MOTION
MC_GroupReadActualAcceleration		COORDINATED MOTION
MC_GroupReadActualPosition		COORDINATED MOTION
MC_GroupReadActualVelocity		COORDINATED MOTION
MC_GroupReadError		COORDINATED MOTION
MC_GroupReadStatus		COORDINATED MOTION
MC_GroupReset		COORDINATED MOTION
MC_GroupSetOverride		COORDINATED MOTION
MC_GroupSetPosition		COORDINATED MOTION
MC_GroupStop		COORDINATED MOTION
MC_Halt		MOTION CONTROL

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
MC_HaltSuperimposed		MOTION CONTROL
MC_Home		MOTION CONTROL
MC_MoveAbsolute		MOTION CONTROL
MC_MoveAdditive		MOTION CONTROL
MC_MoveCircularAbsolute		COORDINATED MOTION
MC_MoveCircularRelative		COORDINATED MOTION
MC_MoveContinuousAbsolute		MOTION CONTROL
MC_MoveContinuousRelative		MOTION CONTROL
MC_MoveDirectAbsolute		COORDINATED MOTION
MC_MoveDirectRelative		COORDINATED MOTION
MC_MoveLinearAbsolute		COORDINATED MOTION
MC_MoveLinearRelative		COORDINATED MOTION
MC_MovePath		COORDINATED MOTION
MC_MovePath_PH		COORDINATED MOTION
MC_MoveRelative		MOTION CONTROL
MC_MoveSuperimposed		MOTION CONTROL
MC_MoveVelocity		MOTION CONTROL
MC_PhasingAbsolute		MOTION CONTROL
MC_PhasingRelative		MOTION CONTROL
MC_PositionProfile		MOTION CONTROL
MC_Power		MOTION CONTROL
MC_ReadActualPosition		MOTION CONTROL
MC_ReadAxisError		MOTION CONTROL
MC_ReadBoolParameter		MOTION CONTROL
MC_ReadCartesianTransform		COORDINATED MOTION
MC_ReadParameter		MOTION CONTROL
MC_ReadStatus		MOTION CONTROL
MC_Reset		MOTION CONTROL
MC_SetCartesianTransform		COORDINATED MOTION
MC_SetOverride		MOTION CONTROL
MC_Stop		MOTION CONTROL
MC_TorqueControl		MOTION CONTROL
MC_UngroupAllAxes		COORDINATED MOTION
MC_VelocityProfile		MOTION CONTROL
MC_WriteBoolParameter		MOTION CONTROL
MC_WriteParameter		MOTION CONTROL
MCP_AccelerationProfile		MOTION CONTROL
MCP_CamIn		MOTION CONTROL
MCP_CamTableSelect		MOTION CONTROL

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
MCP_CombineAxes		MOTION CONTROL
MCP_GearIn		MOTION CONTROL
MCP_GearInPos		MOTION CONTROL
MCP_GroupHalt		COORDINATED MOTION
MCP_GroupInterrupt		COORDINATED MOTION
MCP_GroupSetOverride		COORDINATED MOTION
MCP_GroupSetPosition		COORDINATED MOTION
MCP_GroupStop		COORDINATED MOTION
MCP_Halt		MOTION CONTROL
MCP_HaltSuperimposed		MOTION CONTROL
MCP_Home		MOTION CONTROL
MCP_MoveAbsolute		MOTION CONTROL
MCP_MoveAdditive		MOTION CONTROL
MCP_MoveCircularAbsolute		COORDINATED MOTION
MCP_MoveCircularRelative		COORDINATED MOTION
MCP_MoveContinuousAbsolute		MOTION CONTROL
MCP_MoveContinuousRelative		MOTION CONTROL
MCP_MoveDirectAbsolute		COORDINATED MOTION
MCP_MoveDirectRelative		COORDINATED MOTION
MCP_MoveLinearAbsolute		COORDINATED MOTION
MCP_MoveLinearRelative		COORDINATED MOTION
MCP_MovePath		COORDINATED MOTION
MCP_MovePath_PH		COORDINATED MOTION
MCP_MoveRelative		MOTION CONTROL
MCP_MoveSuperimposed		MOTION CONTROL
MCP_MoveVelocity		MOTION CONTROL
MCP_PhasingAbsolute		MOTION CONTROL
MCP_PhasingRelative		MOTION CONTROL
MCP_PositionProfile		MOTION CONTROL
MCP_SetCartesianTransform		COORDINATED MOTION
MCP_SetKinTransform_Arm		COORDINATED MOTION
MCP_SetKinTransform_Schunk		COORDINATED MOTION
MCP_SetKinTransform_UR		COORDINATED MOTION
MCP_SetOverride		MOTION CONTROL
MCP_Stop		MOTION CONTROL
MCP_TorqueControl		MOTION CONTROL
MCP_VelocityProfile		MOTION CONTROL
MCU	•	
MDL	•	

The list continues on the next page...

Function block name	Licensing group STANDARD	Other
MDLI	•	
MID	•	
MINMAX	•	
MODULE	•	
MP	•	
MqttPublish		MQTTDRV
MqttSubscribe		MQTTDRV
MUL	•	
MVD	•	
NOT_	•	
NSCL	•	
NSSM		MODEL
OpcUaReadValue		ADVANCED
OpcUaServerValue		ADVANCED
OpcUaWriteValue		ADVANCED
OR_	•	
ORHEXD	•	
OROCT	•	
ORQUAD	•	
OSD	•	
OSCALL	•	
OUTHEXD	•	
OUTOCT	•	
Outport	•	
OUTQUAD	•	
OUTRHEXD		ADVANCED
OUTROCT		ADVANCED
OUTRQUAD		ADVANCED
OUTRSTD		ADVANCED
OUTSTD	•	
PARA	•	
PARB	•	
PARE	•	
PARI	•	
PARR	•	
PARS	•	
PGAVR		
PGBAT		
PGBUS		

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
PGCB		
PGENG		
PGGEN		
PGGS		
PGINV		
PGLOAD		
PGMAINS		
PGSENS		
PGSG		
PGSIM		
PGSOLAR		
PGWIND		
PIDAT		AUTOTUNING
PIDE		ADVANCED
PIDGS		ADVANCED
PIDMA		AUTOTUNING
PIDU	•	
PIDUI		ADVANCED
PJROCT	•	
PJSEXOCT	•	
PJSEXOCT	•	
PJSOCT	•	
POL	•	
POUT	•	
PRBS	•	
PRGM	•	
PROJECT	•	
PSMPC		ADVANCED
PWM	•	
PYTHON		REXLANG
QFC		ADVANCED
QFD		ADVANCED
QTASK	•	
QP_MPC2QP		ADVANCED
QP_UPDATE		ADVANCED
QP_OASES		ADVANCED
QCEDPOPT		ADVANCED
RDC		ADVANCED
REC	•	

The list continues on the next page...

Function block name	Licensing group STANDARD	Other
REGEXP		ADVANCED
REL	•	
REPLACE	•	
REXLANG		REXLANG
RLIM	•	
RLY	•	
RM_AxesGroup		COORDINATED MOTION
RM_Axis		MOTION CONTROL
RM_AxisOut		MOTION CONTROL
RM_AxisSpline		MOTION CONTROL
RM_DirectTorque		MOTION CONTROL
RM_DirectVelocity		MOTION CONTROL
RM_DriveMode		MOTION CONTROL
RM_Feed		COORDINATED MOTION
RM_Gcode		COORDINATED MOTION
RM_GroupTrack		COORDINATED MOTION
RM_HomeOffset		MOTION CONTROL
RM_Track		MOTION CONTROL
RS	•	
RTOI	•	
RTOS	•	
RTOV	•	
S_AND		
S_BC		
S_CMP		
S_CTS		
S_LB		
S_NOT		
S_OR		
S_PULS		
S_PV		
S_RS		
S_SEL		
S_SELVAL		
S_SR		
S_SUMC		
S_TDE		
S_TDR		
S_TLATCH		

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
S_VALB		
S_VALC		
S1OF2		ADVANCED
SAI		ADVANCED
SAT	•	
SC2FA		AUTOTUNING
SCU	•	
SCUV	•	
SEL	•	
SELHEXD	•	
SELOCT	•	
SELQUAD	•	
SELSOCT	•	
SELU	•	
SETPA	•	
SETPB	•	
SETPI	•	
SETPR	•	
SETPS	•	
SG	•	
SGI	•	
SGSLP		ADVANCED
SHIFTOCT	•	
SHLD	•	
SILO	•	
SILOS	•	
SINT	•	
SLEEP	•	
SMHCC		ADVANCED
SMHCCA		AUTOTUNING
SMTP		ADVANCED
SOPDT	•	
SPIKE		ADVANCED
SQR	•	
SQRT_	•	
SR	•	
SRTF		ADVANCED
SSW	•	
STEAM	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
STOR	•	
SUB	•	
SubSystem	•	
SWR	•	
SWU	•	
SWVMR	•	
TASK	•	
TIME	•	
TIMER_	•	
TIODRV	•	
TRND	•	
TRNDV	•	
TSE	•	
UTOI	•	
VDEL	•	
VIN		ADVANCED
VOUT		ADVANCED
VTOR	•	
WASM		REXLANG
WSCH	•	
WWW	•	
ZV4IS		ADVANCED
DFIR		ADVANCED
PGSIM		
PGMAINS		
PGBUS		
PGLOAD		
PGGEN		
PGCB		
PGSENS		
PGENG		
PGAVR		
PGSG		
PGINV		
PGSOLAR		
PGWIND		
PGBAT		
PGGS		
CanSend		CANDRV

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
CanRecv		CANDRV
CanItem		CANDRV
MqttPublish		MQTTDRV
MqttSubscribe		MQTTDRV
EKF		MODEL
NSSM		MODEL
RM_HomeOffset		MOTION CONTROL
PARE	•	
EQ	•	
PYTHON		REXLANG
WASM		REXLANG
RM_DriveMode		MOTION CONTROL
RM_DirectTorque		MOTION CONTROL
RM_DirectVelocity		MOTION CONTROL
COND		
TESTS		
S_CMPT		
S_RCK		
S_POR		
OpcUaReadValue		
OpcUaWriteValue		
OpcUaServerValue		
STEAM	•	
PJSEXOCT	•	
BISR	•	
DP2M		
MBAL		
MOFN		
TB1		
TB2		
TB3		
TB6		
VAC		
OSD	•	
CNT	•	
CNDT	•	
CONCAT_DT	•	
SPLIT_DT	•	
STR2DT	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
DT2STR	•	
WEEK	•	
T2STR	•	
TZ2UTC	•	
UTC2TZ	•	
SYSLOG	•	
SYSEVENT	•	
ALM	•	
ALARMS	•	
TRIM	•	

Appendix C

Error codes of the REXYGEN system

Success codes

- `0` .... Success
- `-1` ...... False
- `-2` ...... First value is greater
- `-3` ...... Second value is greater
- `-4` ...... Parameter changed
- `-5` ...... Success, no server transaction done
- `-6` ...... Value too big
- `-7` ...... Value too small
- `-8` ...... Operation in progress
- `-9` ...... REXYGEN I/O driver warning
- `-10` ..... No more archive items
- `-11` ..... Object is array
- `-12` ..... Closed
- `-13` ..... End of file
- `-14` ..... Parameter may be incorrect

General failure codes

- `-100` .... Not enough memory
- `-101` .... Assertion failure
- `-102` .... Timeout
- `-103` .... General input variable error
- `-104` .... Invalid configuration version
- `-105` .... Not implemented
- `-106` .... Invalid parameter
- `-107` .... COM/OLE error
- `-108` .... REXYGEN Module error - some driver or block is not installed or licensed

-109 .... REXYGEN I/O driver error
-110 .... Task creation error
-111 .... Operating system call error
-112 .... Invalid operating system version
-113 .... Access denied by operating system
-114 .... Block period has not been set
-115 .... Initialization failed
-116 .... REXYGEN configuration is being changed
-117 .... Invalid target device
-118 .... Access denied by REXYGEN security mechanism
-119 .... Block or object is not installed or licensed
-120 .... Checksum mismatch
-121 .... Object already exists
-122 .... Object doesn't exist
-123 .... System user doesn't belong to any REXYGEN group
-124 .... Password mismatch
-125 .... Bad user name or password
-126 .... Target device is not compatible
-127 .... Resource is locked by another module and can not be used
-128 .... String is not valid in UTF8 codepage
-129 .... Start of executive not allowed
-130 .... Some resource count reached limit
-131 .... Text value has been truncated
-132 .... Unsufficient buffer for requested operation
-133 .... Block execution halted due to runtime error

Class registration, symbol and validation error codes

-200 .... Class not registered
-201 .... Class already registered
-202 .... Not enough space for registry
-203 .... Registry index out of range
-204 .... Invalid context
-205 .... Invalid identifier
-206 .... Invalid input flag
-207 .... Invalid input mask
-208 .... Invalid object type
-209 .... Invalid variable type
-210 .... Invalid object workspace
-211 .... Symbol not found
-212 .... Symbol is ambiguous
-213 .... Range check error
-214 .... Not enough search space
-215 .... Write to read-only variable denied
-216 .... Data not ready

- -217 .... Value out of range
- -218 .... Input connection error
- -219 .... Loop of type UNKNOWN detected
- -220 .... REXLANG compilation error

Stream and file system codes

- -300 .... Stream overflow
- -301 .... Stream underflow
- -302 .... Stream send error
- -303 .... Stream receive error
- -304 .... Stream download error
- -305 .... Stream upload error
- -306 .... File creation error
- -307 .... File open error
- -308 .... File close error
- -309 .... File read error
- -310 .... File write error
- -311 .... Invalid format
- -312 .... Unable to compress files
- -313 .... Unable to extract files

Communication errors

- -400 .... Network communication failure
- -401 .... Communication already initialized
- -402 .... Communication finished successfully
- -403 .... Communicaton closed unexpectedly
- -404 .... Unknown command
- -405 .... Unexpected command
- -406 .... Communicaton closed unexpectedly, probably 'Too many clients'
- -407 .... Communication timeout
- -408 .... Target device not found
- -409 .... Link failed
- -410 .... REXYGEN configuration has been changed
- -411 .... REXYGEN executive is being terminated
- -412 .... REXYGEN executive was terminated
- -413 .... Connection refused
- -414 .... Target device is unreachable
- -415 .... Unable to resolve target in DNS
- -416 .... Error reading from socket
- -417 .... Error writing to socket
- -418 .... Invalid operation on socket
- -419 .... Reserved for socket 1
- -420 .... Reserved for socket 2
- -421 .... Reserved for socket 3

- -422 .... Reserved for socket 4
- -423 .... Reserved for socket 5
- -424 .... Unable to create SSL context
- -425 .... Unable to load certificate
- -426 .... SSL handshake error
- -427 .... Certificate verification error
- -428 .... Reserved for SSL 2
- -429 .... Reserved for SSL 3
- -430 .... Reserved for SSL 4
- -431 .... Reserved for SSL 5
- -432 .... Relay rejected
- -433 .... STARTTLS rejected
- -434 .... Authentication method rejected
- -435 .... Authentication failed
- -436 .... Send operation failed
- -437 .... Receive operation failed
- -438 .... Communication command failed
- -439 .... Receiving buffer too small
- -440 .... Sending buffer too small
- -441 .... Invalid header
- -442 .... HTTP server responded with error
- -443 .... HTTP server responded with redirect
- -444 .... Operation would blok
- -445 .... Invalid operation
- -446 .... Communication closed
- -447 .... Connection cancelled

Numerical error codes

- -500 .... General numeric error
- -501 .... Division by zero
- -502 .... Numeric stack overflow
- -503 .... Invalid numeric instruction
- -504 .... Invalid numeric address
- -505 .... Invalid numeric type
- -506 .... Not initialized numeric value
- -507 .... Numeric argument overflow/underflow
- -508 .... Numeric range check error
- -509 .... Invalid subvector/submatrix range
- -510 .... Numeric value too close to zero

Archive system codes

- -600 .... Archive seek underflow
- -601 .... Archive semaphore fatal error
- -602 .... Archive cleared

-603 .... Archive reconstructed from saved vars
-604 .... Archive reconstructed from normal vars
-605 .... Archive check summ error
-606 .... Archive integrity error
-607 .... Archive sizes changed
-608 .... Maximum size of disk archive file exceeded

Motion control codes

-700 .... MC - Invalid parameter
-701 .... MC - Out of range
-702 .... MC - Position not reachable
-703 .... MC - Invalid axis state
-704 .... MC - Torque limit exceeded
-705 .... MC - Time limit exceeded
-706 .... MC - Distance limit exceeded
-707 .... MC - Step change in position or velocity
-708 .... MC - Base axis error or invalid state
-709 .... MC - Stopped by drive FAULT
-710 .... MC - Stopped by POSITION limit
-711 .... MC - Stopped by VELOCITY limit
-712 .... MC - Stopped by ACCELERATION limit
-713 .... MC - Stopped by LIMITSWITCH
-714 .... MC - Stopped by position LAG
-715 .... MC - Axis disabled during motion
-716 .... MC - Transition failed
-717 .... MC - Servodrive failed or disabled
-718 .... MC - Not used
-719 .... MC - Not used
-720 .... MC - General failure
-721 .... MC - Not implemented
-722 .... MC - Command is aborted
-723 .... MC - Conflict in block and axis periods
-724 .... MC - Busy, waiting for activation

Licensing codes

-800 .... Unable to identify Ethernet interface
-801 .... Unable to identify CPU
-802 .... Unable to identify HDD
-803 .... Invalid device code
-804 .... Invalid licensing key
-805 .... Not licensed

Webserver-related errors

- -900 .... Web request too large
- -901 .... Web reply too large
- -902 .... Invalid format
- -903 .... Invalid parameter

RexVision-related errors

- -1000 ... Result is not evaluated
- -1001 ... The searched object/pattern can not be found
- -1002 ... The search criterion returned more corresponding objects

FMI standard related errors

- -1100 ... FMI Context allocation failure
- -1101 ... Invalid FMU version
- -1102 ... FMI XML parsing error
- -1103 ... FMI Model Exchange kind required
- -1104 ... FMI Co-Simulation kind required
- -1105 ... Could not create FMU loading mechanism
- -1106 ... Instantiation of FMU failed
- -1107 ... Termination of FMU failed
- -1108 ... FMU reset failed
- -1109 ... FMU Experiment setup failed
- -1110 ... Entering FMU initialization mode failed
- -1111 ... Exiting FMU initialization mode failed
- -1112 ... Error getting FMU variable list
- -1113 ... Error getting FMU real variable
- -1114 ... Error setting FMU real variable
- -1115 ... Error getting FMU integer variable
- -1116 ... Error setting FMU integer variable
- -1117 ... Error getting FMU boolean variable
- -1118 ... Error setting FMU boolean variable
- -1119 ... Doing a FMU simulation step failed
- -1120 ... FMU has too many inputs
- -1121 ... FMU has too many ouputs
- -1122 ... FMU has too many parameters

Appendix D

Special signals of the REXYGEN system

There is a list of Special signals which can be read within REXYGEN. For details on how to use it have a look at example *0001_Special_Signals*.

Parameter	**Desc**	**Data Type**	**Possibilities**
perf	Performance counter frequency	LARGE	EXEC
period	Level, task, or block period	DOUBLE	LEVEL, TASK, SEQ, IODRV, QTASK, BLOCK, ARCHIVE
nblocks	Task or sequence number of blocks	SHORT	TASK, SEQ, QTASK
stack	Task stack size	LONG	TASK, IODRV, QTASK
exfac	Task execution factor	DWORD	TASK, IODRV, QTASK
start	Task start tick	DWORD	TASK
stop	Task stop tick	DWORD	TASK
ntasks	Exec or level number of tasks	SHORT	LEVEL, IODRV, EXEC
ntick	Number of level ticks	DWORD	LEVEL
pri	Level priority	SHORT	LEVEL, IODRV, QTASK
tick	Executive timer tick	LARGE	EXEC
nlevels	Number of executive levels	SHORT	EXEC
nmodules	Number of executive modules	SHORT	EXEC
ndrivers	Number of executive drivers	SHORT	EXEC
narchives	Number of executive archives	SHORT	EXEC
nqtasks	Number of executive quicktasks	SHORT	EXEC
tcomp	Time when executive was compiled [ns from epoch]	LARGE	EXEC
tdnld	Executive download time [ns from epoch]	LARGE	EXEC
bufsize	(Archive) buffer size	LONG	ARCHIVE
timesize	(Archive) index-buffer size	LONG	ARCHIVE
daysize	(Archive) day-buffer(file) size	LARGE	ARCHIVE
errblk	Index of block with exec error	SHORT	TASK, SEQ, QTASK
errno	Exec error code	SHORT	TASK, SEQ, QTASK, IODRV
status	(Driver) status code	LONG	IODRV
over	(Qtask) number of overlap/colisions	LARGE	QTASK, TASK, IODRV
excnt	Count of task's starts	LARGE	LEVEL, TASK, SEQ, IODRV, QTASK
tlast	Number of last execution [performance-counter-ticks]	LARGE	LEVEL, TASK, SEQ, IODRV, QTASK
tmin	Minimum number of execution [performance-counter-ticks]	LARGE	LEVEL, TASK, SEQ, IODRV, QTASK
tmax	Maximum number of execution [performance-counter-ticks]	LARGE	LEVEL, TASK, SEQ, IODRV, QTASK
tsum	Execution sum [ns or ticks]	LARGE	LEVEL, TASK, SEQ, IODRV, QTASK
tavg	Execution ticks average (tsum/excnt)[performance-counter-ticks]	LARGE	LEVEL, TASK, SEQ, IODRV, QTASK
dstart	Start tick delay [performance-counter-ticks]	LARGE	IODRV, TASK
dstop	Stop tick delay [performance-counter-ticks]	LARGE	IODRV, TASK

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