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Function Blocks of the REX Control System

Reference manual

REX Controls s.r.o.

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

Chapter 1

Introduction

The manual “REX system function blocks” is a reference manual for the REX control 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 REX control system, is divided into smaller sets of logically related blocks, the so-called *categories* (sublibraries). 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 following:

1 Introduction

This introductory chapter familiarizing the readers with the content and ordering of the manual. A convention used for individual function blocks description is presented.

2 EXEC – Real-time executive configuration

Blocks used mainly for configuration of the structure, priorities and timing of individual objects linked to the real-time subsystem of the REX control system (the **RexCore** program) are described in this chapter. These blocks are not used for simulation in Simulink except two special blocks **LPBRK** and **SLEEP** which are essential for executing the simulation in Simulink environment.

3 INOUT – Input and output blocks

This sublibrary consists of the blocks used mainly for the REX control system. These blocks provide the connection between the control tasks and input/output drivers.

4 MATH – Mathematic blocks

The blocks for arithmetic operations and basic math functions. Similar blocks can be found in native Simulink libraries, but only blocks from this library can be used for applications whose target platform is the REX control system.

5 ANALOG – Analog signal processing

The integrator, derivator, time delay, moving average, various filters, comparators and selectors can be found among the blocks for analog signal processing. The starting unit block ([AVS](#)) is also very interesting.

9 GEN – Signal generators

This chapter deals with analog and logic signal generators.

7 REG – Function blocks for control

The control function blocks form the most extensive sublibrary 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 sublibrary. 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

This chapter describes blocks for combinational and sequential logic control including the simplest Boolean operations (not, and, or) and also more complex blocks like the sequential logic automat [ATMT](#) implementing the SFC standard (Sequential Function Charts, formerly Grafcet).

10 ARC – Data archiving

This sublibrary contains blocks for alarms generation and blocks for storing trend data directly on the target device. No such blocks can be found in the Simulink system.

12 PARAM – Parameter handling

This sublibrary contains blocks for parameter handling, namely saving, loading and remote manipulation with parameters.

13 MODEL – Dynamic systems modeling

The REX Control System can also be used for creating real-time mathematical models of dynamic systems. The function blocks of this sublibrary were developed for such cases.

14 MATRIX – Working with matrix and vector data

Function blocks for handling vector and matrix data in the REX Control System are included in this sublibrary.

16 MC_SINGLE – Single-axis motion control

Function blocks of this sublibrary were developed according to the PLCopen Motion Control standard for single axis motion control.

17 MC_MULTI – Multi-axes motion control

Function blocks of this sublibrary were developed according to the PLCopen Motion Control standard for motion control in multiple axes.

18 MC_COORD – Coordinated motion control

Function blocks of this sublibrary were developed according to the PLCopen Motion Control standard for coordinated motion control.

15 SPEC – Special blocks

The most interesting blocks of this sublibrary are the [REXLANG](#) and [RDC](#) blocks. It is possible to compile and interpret user algorithms using the [REXLANG](#) block, whose programming language is very similar to the C language (the syntax of the [REXLANG](#) commands is mostly the same as in the C language). The [RDC](#) block can be used for real-time communication between two Simulinks (even on two different networked computers), two [REX](#) targets or between the Simulink and the [REX](#) system. The [RDC](#) block can also provide data for the Matlab OPC server.

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

Example – 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 **Example** 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>**. **<type>**
 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. [\odot **<def>**] [\downarrow **<min>**] [\uparrow **<max>**]

The meaning of the three columns is quite obvious. The third column contains the item **<type>**. The REX control system supports the types listed in table 1.1. But the most frequently used types are **bool** for Boolean variables, **long** for integer variables and **double** for real variables (in floating point arithmetics).

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

Type	Meaning	Minimum	Maximum
bool	Boolean value 0 or 1	0	1
byte	8 bit integer number without the sign	0	255
short	16 bit integer number with the sign	-32768	32767
long	32 bit integer number with the sign	-2147483648	2147483647
word	16 bit integer number without the sign	0	65535
dword	32 bit integer number without the sign	0	4294967295
float	32 bit real number in floating point arithmetics	< -3.4E+38	>3.4E+38
double	64 bit real number in floating point arithmetics	< -1.7E+308	>1.7E+308
string	character string		

Table 1.1: Types of variables in the REX control system.

1.3 Conventions for variables, blocks and subsystems naming

Several conventions are used to simplify the use of the REX 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:

bool – for two-state logic variables, e.g. on/off, yes/no or true/false. The logic one (yes,

true, on) is referred to as **on** in this manual. Similarly the logic zero (no, false, off) is represented by **off**. Nevertheless, some tools may display these values as **on** for 1 and **off** for 0 for Matlab-Simulink compatibility reasons. The names of logic variables consist of uppercase letters, e.g. **RUN**, **YCN**, **R1**, **UP**, etc.

long – 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**, **pptype1**, **pfac** and **afac** in the **TRND** block, etc.

double – 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. **k**, **hilim**, **y**, **ti**, **tt**.

The function block names in the **REX** control 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 **RexComp** compiler which generates warnings if inappropriate characters are found.

1.4 The signal quality corresponding with OPC

Every signal (input, output, parameter) in the **REX** control system has the so-called *quality flags* in addition to its own value of corresponding type (table 1.1). The quality flags in the **REX** control system correspond with the OPC (OLE for Process Control) 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.

Chapter 2

EXEC – Real-time executive configuration

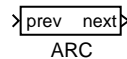
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ARC – The REX system archive

Block Symbol

Licence: [STANDARD](#)



Function Description

The ARC block is intended for archives configuration in the REX 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 REX control 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 **Target** tab in the **RexView** 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.

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
-------------	---	-------------

Output

next	Output for creating sequences of archives by connecting to the prev input of the following archive	long
-------------	---	-------------

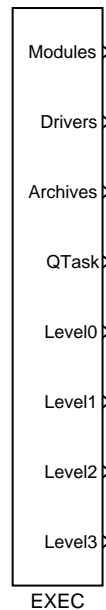
Parameters

atype	Archive type	⊙1	long
	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
nmarks	Number of time stamps for speeding-up sequential seeking in the archive	↓2 ⊙720	long
ldaymax	Maximum size of archive per day [bytes]	↓1000 ↑2147480000 ⊙1048576	large
period	Period of writing data to disk [s]	⊙60.0	double

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 **REX** control 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 **RexComp** compiler during building of the overall **REX** control system application.

The **REX** control 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 **RexComp** compiler as its limits vary by selected target platform. Generally speaking, the lower period is used, the higher computational requirements of the **REX** Control 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 **REX** control

system. The REX control system uses 32 logical priorities, which are internally mapped to the target platform operating system dependent priorities. The highest logical priority of the REX control 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!

Outputs

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

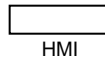
Parameters

target	Target device Generic target device	⊙PC - Windows	string
tick	The base period (tick) of the REX control system core and also the quick task (QTASK) period (in seconds)	⊙0.05	double
ntick0	The multiplication <code>tick*ntick0</code> determines the period of tasks connected to <code>Level0</code>	↓1 ⊙10	long
ntick1	The multiplication <code>tick*ntick1</code> determines the period of tasks connected to <code>Level1</code>	↓ntick0+1 ⊙50	long
ntick2	The multiplication <code>tick*ntick2</code> determines the period of tasks connected to <code>Level2</code>	↓ntick1+1 ⊙100	long
ntick3	The multiplication <code>tick*ntick3</code> determines the period of tasks connected to <code>Level3</code>	↓ntick2+1 ⊙1200	long
pri0	Priority of all <code>Level0</code> tasks	↓3 ↑31 ⊙5	long
pri1	Priority of all <code>Level1</code> tasks	↓pri0+1 ↑31 ⊙9	long
pri2	Priority of all <code>Level2</code> tasks	↓pri1+1 ↑31 ⊙13	long
pri3	Priority of all <code>Level3</code> tasks	↓pri2+1 ↑31 ⊙18	long

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 **REX** Control System currently provides three straightforward methods of how to create Human-Machine Interface:

- **WebWatch** is an auto-generated HMI from the **RexDraw** development tool during project compilation. It has similar look, attributes and functions as the online mode of the **RexDraw** 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 with the **RexHMI Designer** with the *RexHMI* extensions. The **RexHMI 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 **RexDraw** development tool and the **RexHMI Designer** must be installed.

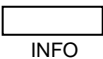
Parameters

<code>IncludeHMI</code>	Include HMI files in the project	<input type="radio"/> on	bool
<code>HmiDir</code>	Output folder for HMI files	<input type="radio"/> hmi	string
<code>SourceDir</code>	Source directory	<input type="radio"/> hmisrc	string
<code>GenerateWebWatch</code>	Generate WebWatch HMI files	<input type="radio"/> on	bool
<code>GenerateRexHMI</code>	Generate HMI from SVG and JS files	<input type="radio"/> on	bool
<code>RedirectToHMI</code>	Web server will automatically redirect to HMI webpage if enabled otherwise it will serve a standard home page as a starting page.	<input type="radio"/> on	bool
<code>Compression</code>	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.

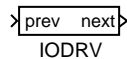
Parameters

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

IODRV – The REX control system input/output driver

Block Symbol

Licence: [STANDARD](#)



Function Description

The input/output drivers of the REX control system are implemented as extension modules (see the [MODULE](#) block). A module can contain several drivers, which are added to the REX control 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 REX control 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 REX control system driver.

The majority of drivers stores its own configuration data in files with **.rio** extension (REX 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 **RexDraw** program of the REX 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 last 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 RexView diagnostic program.

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
-------------	--	-------------

Output

next	Output for connecting to the prev input of the succeeding driver	long
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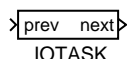
Parameters

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!	\odot DrvClass string
cfgname	Name of the driver configuration file	\odot iodrv.rio string
factor	Multiple of the EXEC block's tick parameter defining the driver's task execution period	$\downarrow 1 \odot 10$ long
stack	Stack size of the driver's task in bytes	$\downarrow 1024 \odot 10240$ long
pri	Logical priority of the driver's task	$\downarrow 1 \uparrow 31 \odot 3$ long
timer	Driver is a source of time	bool

IOTASK – Driver-triggered task of the REX control system

Block Symbol

Licence: [STANDARD](#)



Function Description

Standard tasks of the REX control 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

<code>prev</code>	Input for connecting the first task to the <code>Tasks</code> output of the TIODRV block or for connecting to the previous task's <code>next</code> output	<code>long</code>
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Output

<code>next</code>	Output for sequencing the tasks by connecting to the <code>prev</code> input of the following task	<code>long</code>
-------------------	--	-------------------

Parameters

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

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 **REX** control system function blocks. The block is usually placed in all feedback loops in the scheme. Its behavior differs in the **REX** control 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 **RexComp** 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 **RexComp** 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 **REX** control system and the Simulink system.

Input

u	Input signal	double
---	--------------	--------

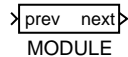
Output

y	Output signal	double
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MODULE – Extension module of the REX control system

Block Symbol

Licence: [STANDARD](#)



Function Description

The REX control 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 REX control system configuration 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 configuration. There can be only one module connected to the **next** output of the **MODULE** block. The **next** output of the last module in the configuration remains unconnected. This means that the modules create a unidirectional chain which defines the order of initialization and execution of the individual modules.

Each module exists in two versions: one for the development platform (**Host**) and one for the target platform (**Target**). The modules are implemented as DLL libraries in Windows and Windows CE operating systems. The naming `<modname>_H.dll` (for development platform) and `<modname>_T.dll` (for target platform) is used, where `<modname>` is the module name.

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
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Output

next	Output for connecting to the prev input of the succeeding module	long
-------------	---	------

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 and so it belongs to the `EXEC` category.

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

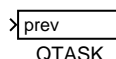
Parameters

- | | | |
|----------------------------|--|---------------------|
| <code>CompileParams</code> | Command-line options which are passed to the RexComp during project compilation. | <code>string</code> |
| <code>TargetURL</code> | URL address of a target on which the configuration should be run. The address is inserted into all connection dialogs automatically. | <code>string</code> |

QTASK – Quick task of the REX control 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 **REX** control 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 **REX** 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 execution time of the block is displayed in the **RexView** diagnostic program.

Input

prev	Input for connecting the task with the QTask output of the EXEC block	long
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Parameters

factor	Multiple of the EXEC block's tick parameter defining the quick task execution period	long ⊙1
stack	Stack size [bytes]	⊙10240 long
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 **REX** control 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).

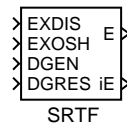
Parameter

ts	Simulation scheme execution period (in seconds)	⊙0.1 double
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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 **REX** control system. This block is not meant for use in Matlab-Simulink. When describing this block, the term object refers to a **REX** control system object running in real-time, i.e. input/output driver, one of the tasks, subsystem or a simple function block of the **REX** control 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 **RexView** diagnostic program.
- **One-shot execution** of the object. If the object execution is disabled by the **EXDIS = on** input or by the **RexView** 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 diagnostic pane of the corresponding tab (**I/O Driver**, **Level**, **Quick Task**, **Task**, **I/O Task**, **Sequence**) in the **RexView** program.
- **Reset diagnostic data** of the given object by **DGRES = on**. The same flag can be set by the **Reset** button in the diagnostic pane of the corresponding tab in the **RexView** 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 **REX** control 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
	0 No error	
	1 The object specified by the bname parameter was not found	
	2 REX control system internal error (invalid pointers)	
	3 Flag could not be set (timeout)	

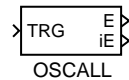
Parameter

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: ^ 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> .	string
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OSCALL – Operating system calls

Block Symbol

Licence: [STANDARD](#)



Function Description

The **OSCALL** block is intended for executing operating system functions from within the REX Control 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
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Outputs

E	Error flag	bool
iE	Error code	long
	i REX general error	

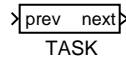
Parameter

action	System function to perform	⊙1 long
	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	

TASK – Standard task of the REX control system

Block Symbol

Licence: [STANDARD](#)



Function Description

The overall control algorithm of the REX control 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 REX control 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 REX control system. The individual levels are ordered from **Level0** to **Level3** (the [QTASK](#) block precedes **Level0**).

All the tasks of the given level *<i>* are executed with the same priority given by the **pri<i>** parameter of the [EXEC](#) block. The execution period of the task is given by a multiple of the **factor** parameter and the base tick of the given level *<i>* **ntick<i>*****tick** in the [EXEC](#) block. The time allocated for the task to execute starts at the **start** tick and ends at the **stop** tick, where the inequality $0 \leq \text{start} < \text{stop} \leq \text{ntick< i> * tick}$ must hold for the **start** and **stop** parameters. The **RexComp** compiler further checks whether the **stop** parameter of the preceding task is less or equal to the **stop** parameter of the succeeding task, i.e. the allocated time intervals for individual tasks cannot overlap. In the case the timing of individual levels is inappropriate, the tasks are interrupted by tasks and other events with higher priority and might not execute in the allocated time. In such a case the execution is not aborted but delayed (in contrary to the [QTASK](#) block). The **RexView** program diagnoses 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
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Output

<code>next</code>	Output for connecting to the <code>prev</code> input of the succeeding task in the given level	<code>long</code>
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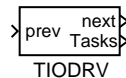
Parameters

<code>factor</code>	Execution factor; multiple of the execution period of the <code>i</code> -th level of the <code>EXEC</code> block defining the execution period of the task: $\text{factor} * \text{tick} * \text{ntick} \langle i \rangle$	<code>long</code> $\odot 1$
<code>start</code>	Number of tick of the given computational level which should trigger the task execution $\downarrow 0 \uparrow \text{ntick} \langle i \rangle \odot 0$	<code>long</code>
<code>stop</code>	Number of tick of the given computational level by which the task execution should finish $\downarrow \text{start} + 1 \uparrow \text{ntick} \langle i \rangle \odot 1$	<code>long</code>
<code>stack</code>	Stack size [bytes] $\odot 10240$	<code>long</code>
<code>filename</code>	Name of the file with the <code>.mdl</code> extension which contains the task algorithm. In the case <code>filename</code> is not specified, the filename is given by the name of the <code>TASK</code> block in the project main file (the <code>.mdl</code> extension is attached automatically)	<code>string</code>

TIODRV – The REX control system input/output driver with tasks

Block Symbol

Licence: [STANDARD](#)



Function Description

The **TIODRV** block is used for configuration of special drivers of the REX control 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 **RexComp** 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 **RexView** program.

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
-------------	--	-------------

Outputs

next	Output for connecting to the prev input of the succeeding driver	long
Tasks	The IOTASK blocks executed by the driver are connected to this output using the prev input	long

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!	string
cfgname	Name of the driver configuration file	string

factor	Multiple of the EXEC block's <code>tick</code> parameter defining the driver's task execution period	$\downarrow 1 \odot 10$	long
stack	Stack size of the driver's task in bytes	$\downarrow 1024 \odot 10240$	long
pri	Logical priority of the driver's task	$\downarrow 1 \uparrow 31 \odot 3$	long
timer	Driver is a source of time		bool

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 and 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

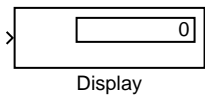
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Display – Numeric display of input values

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 `RexDraw` even without turning on *Watch* mode for the block, and the same in *Web Watch*. 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	unknown
---	--------------	---------

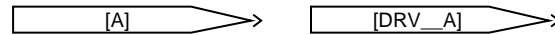
Parameters

Format	Format of displayed value	⊙1	long
	Best fit		
	short		
	long ..		
	short_e		
	long_e		
	bank ..		
	hex ...		
	bin ...		
	det ...		
Decimation	Value is evaluated in each Decimation period	↓1 ↑100000	⊙1 long
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.

The **From** block can be used in both the **REX** control system and the Matlab-Simulink environment, the **INSTD** block exists only in the **REX** control system.

The following rules define how the **RexComp** 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 of the parameter (substring) before the delimiter (**DRV** in the example above) is considered to be the name of an **IODRV** type block contained in the main file of the project. The **RexComp** 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, **A** 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 **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 **RexComp** 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.

There is no **INSTD** block in the Matlab-Simulink system, even the blocks whose **GotoTag** parameter contains the `__` delimiter are considered to be of the **From** type. This property is suitable for simulation of both the control system and the controlled system. The model can be connected via **From** and **Goto** blocks, whose **GotoTag** parameters include the `__` delimiter. Moreover it is possible to use one `.mdl` file for both simulation and real time control without any modifications if the controlled system model is "hidden" in a subsystem whose name starts with **Simulation**. The **RexComp** compiler ignores (omits) such subsystems. For further details see [2].

Output

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

Parameter

<code>GotoTag</code>	Reference to a <code>Goto</code> block with the same <code>GotoTag</code> parameter, which should be connected with the <code>From</code> block or a reference to input signal of the REX control system driver, which should provide data through the block's output.	<code>string</code>
----------------------	--	---------------------

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.

The **Goto** block can be used in both the **REX** control system and the Matlab-Simulink environment, the **OUTSTD** block exists only in the **REX** control system.

The following rules define how the **RexComp** 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 of the parameter (substring) before the delimiter (**DRV** in the example above) is considered to be the name of an **IODRV** type block contained in the main file of the project. The **RexComp** 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, **A** 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 **RexComp** 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.

There is no **OUTSTD** block in the Matlab-Simulink system, even the blocks whose **GotoTag** parameter contains the `__` delimiter are considered to be of the **Goto** type. This property is suitable for simulation of both the control system and the controlled system. The model can be connected via **From** and **Goto** blocks, whose **GotoTag** parameters

include the `__` delimiter. Moreover, it is possible to use one `.mdl` file for both simulation and real time control without any modifications if the controlled system model is "hidden" in a subsystem whose name starts with `Simulation`. The `RexComp` compiler ignores (omits) such subsystems. For further details see [2].

Input

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

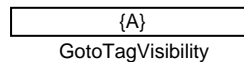
Parameters

GotoTag	Reference to a <code>From</code> block with the same <code>GotoTag</code> parameter, which should be connected with the <code>Goto</code> block or a reference to output signal of the REX control system driver, which should send the data from block input to the process.	string
TagVisibility	Visibility (availability) of the block within the <code>.mdl</code> file. Defines conditions under which the two corresponding <code>Goto</code> and <code>From</code> blocks are reciprocally available: <ul style="list-style-type: none"> local the two blocks must be in the same subsystem global blocks can be anywhere in the given <code>.mdl</code> file scoped the <code>From</code> block must be placed in the same subsystem or in any lower hierarchical level below the <code>GotoTagVisibility</code> block with the same <code>GotoTag</code> parameter 	string ⊙ local

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 configuration compilation by the **RexComp** compiler, it is not included in the final configuration as it does not perform any action in real-time.

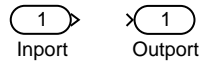
Parameter

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

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 **REX** control 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 connection of **Inport** and **Outport** blocks in various tasks is checked and created by the **RexComp** 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 both the **RexDraw** and the Matlab-Simulink system, 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!

There are other functionalities of the port blocks in the Matlab-Simulink environment, but these are not used in the **REX** control system. Detailed description of the blocks for Matlab-Simulink can be found in [3].

Input

value	Value going to the output pin or Inport	unknown
-------	--	---------

Output

value	Value coming from the input pin or Outport	unknown
-------	---	---------

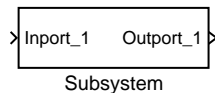
Parameter

Port	Ordering of the Inport or Outport pins	long
------	--	------

SubSystem – Subsystem block

Block Symbol

Licence: [STANDARD](#)



Function Description

The **Subsystem** block is a cornerstone of hierarchical control (and simulation) algorithm. It allows embedding a subsystem into another system (or subsystem). The subsystem contains blocks and their connections. The subsystem is executed as ordered sequence of blocks during real-time operation of the **REX** control system. Therefore it is sometimes referred to as sequence. All blocks from the surroundings of the subsystem are executed strictly before or after the whole subsystem is executed. This is called atomic subsystem in the Matlab-Simulink terminology, see [3].

There are two possible ways of creating a subsystem in both the **RexDraw** program and the Matlab-Simulink editor (only the **RexDraw** technique is described further):

- Copy the **Subsystem** block from the **INOUT** library to the given diagram (.mdl file). Blocks can be inserted into the subsystem upon its opening (including **Inport** and **Outport** blocks).
- Select a group of blocks and use the **Create subsystem** command (**Create subsystem** in the **Edit** menu). The selected blocks are then replaced by the subsystem block, which contains all the original blocks and **Inport** and **Outport** blocks for signals crossing the subsystem boundary. Ports for all unconnected inputs and outputs are created as well.

Inputs

The number and names of the inputs are given by the number and names of the **Inport** blocks contained within the subsystem.

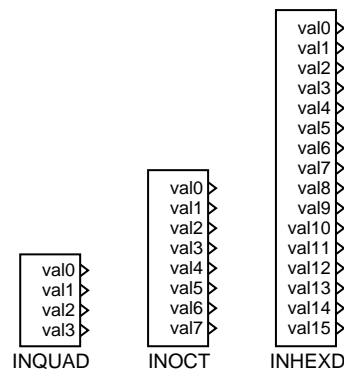
Outputs

The number and names of the outputs are given by the number and names of the **Outport** blocks contained within the subsystem.

INQUAD, INOCT, INHEXD – Multi-input blocks

Block Symbols

Licence: [STANDARD](#)



Function Description

The REX control 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). 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.

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.

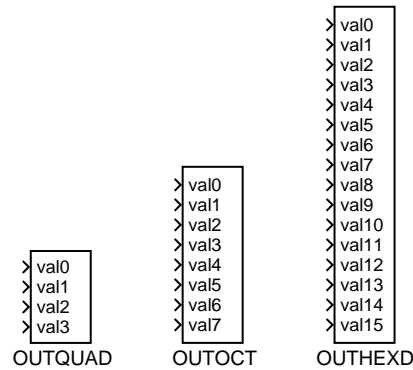
Outputs

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.	unknown
---------	--	---------

OUTQUAD, OUTOCT, OUTHEXD – Multi-output blocks

Block Symbols

Licence: [STANDARD](#)



Function Description

The REX control 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.

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.

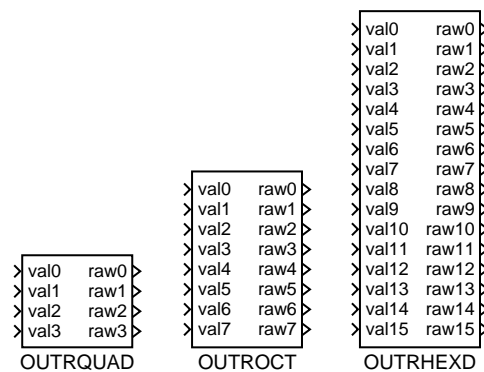
Inputs

vali	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.	unknown
--------------------------	--	----------------

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.

These blocks are not included in the RexLib function block library for Matlab-Simulink.

Inputs

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

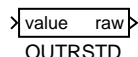
Outputs

<code>rawi</code>	Feedback information about the write operation result. The type and meaning of individual signals is described in the user manual for the given driver.	<code>unknown</code>
-------------------	---	----------------------

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.

This block is not included in the **RexLib** function block library for Matlab-Simulink.

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.	unknown
--------------	---	----------------

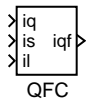
Output

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.	unknown
------------	---	----------------

QFC – Quality flags coding

Block Symbol

Licence: [ADVANCED](#)



Function Description

The **QFC** block creates the resulting signal **iqr** 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 REX control 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 15	long
is	Substatus flags, see [1]	long
il	Limits flags, see [1]	long

Output

iqr	Bit combination of the iq , is and il input signals	long
------------	--	------

QFD – Quality flags decoding

Block Symbol

Licence: [ADVANCED](#)



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 **REX** control 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
------------	--	-------------

Outputs

iq	Basic quality type flags, see table 1.2 , page 15	long
is	Substatus flags, see [1]	long
il	Limits flags, see [1]	long

VIN – Validation of the input signal

Block Symbol

Licence: [ADVANCED](#)



Function Description

The VIN block can be used for verification of the input signal quality in the REX control 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.

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 **on** if the quality is **GOOD** or **UNCERTAIN**. It is set to **QG = on** 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.	unknown
sv	Substitute value for an error case	unknown

Outputs

yg	Validated output signal (yg = u for QG = on or yg = sv for QG = off)	unknown
QG	Indicator of input signal acceptability	bool
iqf	Complete quality flag separated from the u input signal	long

Parameter

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

VOUT – Validation of the output signal

Block Symbol

Licence: [ADVANCED](#)



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. The **RexLib** function block library for Matlab-Simulink does not use any quality flags.

Inputs

u	Input signal whose quality flags are being replaced. The type of the signal is determined upon the connected signal.	unknown
iqf	Desired quality flags	long

Output

yq	Resulting signal composed from input u and quality flags given by the iqf input	unknown
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Chapter 4

MATH – Math blocks

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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.

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

Input

u	Analog input of the block	double
---	---------------------------	--------

Outputs

y	Absolute value of the input signal	double
sgn	Indication of the input signal sign	long

ADD – Addition of two signals

Block Symbol

Licence: [STANDARD](#)



Function Description

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

$$y = u1 + u2.$$

Consider using the [ADDOCT](#) block for addition or subtraction of multiple signals.

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double

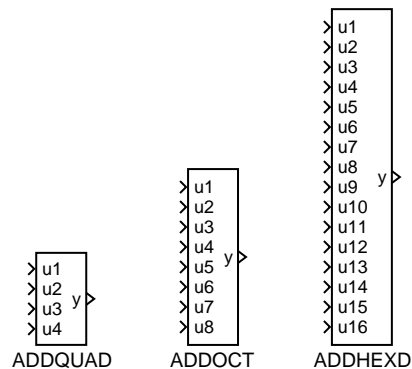
Output

y	Sum of the input signals	double
---	--------------------------	--------

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 **n1** parameter defines the inputs which are subtracted instead of adding. For an empty **n1** parameter the block output is given by $y = u1 + u2 + u3 + u4 + u5 + u6 + u7 + \dots + u16$. For e.g. **n1=2,5,7**, the block implements the function $y = u1 - u2 + u3 + u4 - u5 + u6 - u7 + \dots + u16$.

Note that the [ADD](#) and [SUB](#) blocks are available for simple addition and subtraction operations.

Inputs

u1..u16	Analog input signals	double
----------------	----------------------	---------------

Output

y	Resulting value	double
----------	-----------------	---------------

Parameter

n1	List of signals to subtract instead of adding. 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.	long
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CNB – Boolean (logic) constant

Block Symbol

Licence: [STANDARD](#)



Function Description

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

Output

Y	Logical output of the block	bool
---	-----------------------------	------

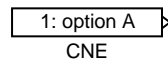
Parameter

YCN	Boolean constant	 on bool
	off ... Disabled	
	on Enabled	

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.

Parameters

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
-----------	-----------------------------	------

CNI – Integer constant

Block Symbol

Licence: [STANDARD](#)



Function Description

The CNI block stands for an integer constant.

Output

iy	Integer output of the block	long
----	-----------------------------	------

Parameter

icn	Integer constant	⊙1 long
-----	------------------	-----------

CNR – Real constant

Block Symbol

Licence: [STANDARD](#)



Function Description

The **CNR** block stands for a real constant.

Output

<code>y</code>	Analog output of the block	<code>double</code>
----------------	----------------------------	---------------------

Parameter

<code>ycn</code>	Real constant	<code>⊕1.0 double</code>
------------------	---------------	--------------------------

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).

Input

u	Analog input of the block	double
----------	---------------------------	---------------

Output

y	Difference of the input signal	double
----------	--------------------------------	---------------

Parameters

ISSF	Zero output at start-up	bool
	off ... In the first cycle the output will be $y = u$.	
	on ... Zero output in the first cycle, $y = 0$.	

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 **on** and the output **y** is substituted by $y = yerr$.

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double

Outputs

y	Quotient of the inputs	double
E	Error flag – division by zero	bool

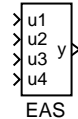
Parameter

yerr	Substitute value for an error case	⊙1.0 double
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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

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

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double
u3	Third analog input of the block	double
u4	Fourth analog input of the block	double

Output

y	Analog output of the block	double
----------	----------------------------	---------------

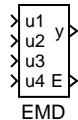
Parameters

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

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

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

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**.

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double
u3	Third analog input of the block	double
u4	Fourth analog input of the block	double

Outputs

y	Analog output of the block	double
E	Error flag – division by zero	bool

Parameters

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

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^u	–
8: exp10	exponential function 10^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	–

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**).

Input

u	Analog input of the block	double
---	---------------------------	--------

Outputs

y	Result of the selected function	double
E	Error flag	bool

Parameters

ifn	Function type (see table above)	⊙1 long
yerr	Substitute value for an error case	double

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** and **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**).

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double

Outputs

y	Result of the selected function	double
E	Error flag	bool
	off ... No error	
	on An error occurred	

Parameters

<code>ifn</code>	Function type (see the table above)	⊙1	<code>long</code>
	1 <code>atan2</code>		
	2 <code>fmod</code>		
	3 <code>pow</code>		
<code>yerr</code>	Substitute value for an error case		<code>double</code>

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

$$y = ku.$$

Input

u	Analog input of the block	double
----------	---------------------------	---------------

Output

y	Analog output of the block	double
----------	----------------------------	---------------

Parameter

k	Gain	⊙1.0 double
----------	------	--------------------

GRADS – Gradient search optimization

Block Symbol

Licence: [ADVANCED](#)



Function Description

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

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

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

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

Inputs

f	Value of the optimized $f(\cdot)$ for given variable \mathbf{x}	double
x0	Optimization starting point	double
START	Starting signal (rising edge)	bool
BRK	Termination signal	bool

Outputs

x	Current value of the optimized variable	double
xopt	Resulting optimal value of the \mathbf{x} variable	double
fopt	Resulting optimal value of the function $f(\mathbf{x}, v)$	double
BSY	Indicator of running optimization	bool
iter	Number of current iteration	long
E	Error flag	bool

iE	Error code	long
	1 $x \notin < \text{xmin}, \text{xmax} >$	
	2 $x = \text{xmin}$ or $x = \text{xmax}$	

Parameters

xmin	Lower limit for the x variable		double
xmax	Upper limit for the x variable	⊙10.0	double
gamma	Coefficient for determining the step size of the gradient optimization method	⊙0.3	double
d0	Initial step size	⊙0.05	double
dmin	Minimum step size	⊙0.01	double
dmax	Maximum step size	⊙1.0	double
n	Iteration period (in sampling periods T_S)	⊙100	long
itermax	Maximum number of iterations	⊙20	long

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 $-32768 \dots +32767$, 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 $30000 + 2770 = 32767$).

Inputs

i1	First integer input of the block	$\downarrow -9,22E+18 \uparrow 9,22E+18$	long
i2	Second integer input of the block	$\downarrow -9,22E+18 \uparrow 9,22E+18$	long

Outputs

n	Integer sum of the input signals	long
E	Error flag	bool
	off ... No error	
	on An error occurred	

Parameters

vtype	Numeric type	⊙4 long
	2 Byte (range 0 ... 255)	
	3 Short (range -32768 ... 32767)	
	4 Long (range -2147483648 ... 2147483647)	
	5 Word (range 0 ... 65536)	
	6 DWord (range 0 ... 4294967295)	
	10 Large (range -9223372036854775808...9223372036854775807)	

SAT	Saturation (overflow) checking	bool
	off ... Overflow is not checked	
	on Overflow is checked	

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 $-32768 \dots +32767$, 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 $30000 - -2770 = 32767$).

Inputs

i1	First integer input of the block	$\downarrow -9,22E+18$ $\uparrow 9,22E+18$	long
i2	Second integer input of the block	$\downarrow -9,22E+18$ $\uparrow 9,22E+18$	long

Parameters

vtype	Numeric type	⊙4	long
2	Byte (range 0 ... 255)		
3	Short (range -32768 ... 32767)		
4	Long (range -2147483648 ... 2147483647)		
5	Word (range 0 ... 65536)		
6	DWord (range 0 ... 4294967295)		
10	Large (range -9223372036854775808...9223372036854775807)		
SAT	Saturation (overflow) checking		bool
	off ... Overflow is not checked		
	on ... Overflow is checked		

Outputs

n	Integer difference between the input signals	long
---	--	------

E	Error flag	bool
	off ... No error	
	on An error occurred	

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 $-32768 \dots +32767$, 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 $2000 * 20 = 32767$).

Inputs

i1	First integer input of the block	$\downarrow -9,22E+18 \uparrow 9,22E+18$	long
i2	Second integer input of the block	$\downarrow -9,22E+18 \uparrow 9,22E+18$	long

Parameters

vtype	Numeric type	$\odot 4$	long
	2 Byte (range 0 ... 255)		
	3 Short (range -32768 ... 32767)		
	4 Long (range -2147483648 ... 2147483647)		
	5 Word (range 0 ... 65536)		
	6 DWord (range 0 ... 4294967295)		
	10 Large (range -9223372036854775808...9223372036854775807)		
SAT	Saturation (overflow) checking		bool
	off ... Overflow is not checked		
	on ... Overflow is checked		

Outputs

n	Integer product of the input signals	long
---	--------------------------------------	------

E	Error flag	bool
	off ... No error	
	on An error occurred	

IDIV – Integer division

Block Symbol

Licence: [STANDARD](#)



Function Description

The IDIV block performs an integer division of two integer input signals, $n = i1 \div i2$, where \div 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 **E** is set to **on** and the output **n** is substituted by $n = \mathbf{nerr}$.

Inputs

i1	First integer input of the block	$\downarrow -9,22E+18$ $\uparrow 9,22E+18$	long
i2	Second integer input of the block	$\downarrow -9,22E+18$ $\uparrow 9,22E+18$	long

Outputs

n	Integer quotient of the inputs	long
E	Error flag – division by zero	bool

Parameters

vtype	Numeric type	$\odot 4$	long
	2 Byte		
	3 Short		
	4 Long		
	5 Word		
	6 DWord		
	10 Large		
nerr	Substitute value for an error case	$\odot 1$	long

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 $n = \mathbf{nerr}$.

Inputs

i1	First integer input of the block	$\downarrow -9,22E+18 \uparrow 9,22E+18$	long
i2	Second integer input of the block	$\downarrow -9,22E+18 \uparrow 9,22E+18$	long

Outputs

n	Remainder after integer division	long
E	Error flag – division by zero	bool

Parameters

vtype	Numeric type	$\odot 4$	long
	2 Byte		
	3 Short		
	4 Long		
	5 Word		
	6 DWord		
	10 Large		
nerr	Substitute value for an error case	$\odot 1$	long

LIN – Linear interpolation

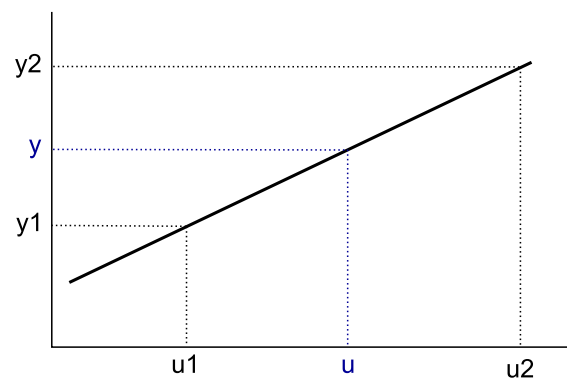
Block Symbol

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 .



Input

u	Analog input of the block	double
-----	---------------------------	--------

Output

y	Analog output of the block	double
-----	----------------------------	--------

Parameters

$u1$	x-coordinate of the 1st interpolation node	double
$y1$	y-coordinate of the 1st interpolation node	double
$u2$	x-coordinate of the 2nd interpolation node	⊙1.0 double
$y2$	y-coordinate of the 2nd interpolation node	⊙1.0 double

MUL – Multiplication of two signals

Block Symbol

Licence: [STANDARD](#)



Function Description

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

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double

Output

y	Product of the input signals	double
---	------------------------------	--------

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 improve the numerical robustness.

Input

u	Analog input of the block	double
---	---------------------------	--------

Output

y	Analog output of the block	double
---	----------------------------	--------

Parameters

a <i>i</i>	The <i>i</i> -th coefficient of the polynomial, $i = 0, 1, \dots, 8$	double
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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 substitut-
tional value **y** = **yerr**.

Input

u	Analog input of the block	double
----------	---------------------------	---------------

Outputs

y	Analog output of the block	double
E	Error flag – division by zero	bool

Parameter

yerr	Substitute value for an error case	1.0 double
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REL – Relational operator

Block Symbol

Licence: [STANDARD](#)



Function Description

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

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double

Output

Y	Logical output indicating whether the relation holds	bool
----------	--	-------------

Parameter

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

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:

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

where $\text{round}(r)$ 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. $\text{round}(1.5) = 2$, $\text{round}(-2.5) = -3$. 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).

Input

r	Analog input of the block	double
-----	---------------------------	--------

Output

i	Rounded and converted input signal	long
-----	------------------------------------	------

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

$$y = u^2.$$

Input

u	Analog input of the block	double
----------	---------------------------	---------------

Output

y	Square of the input signal	double
----------	----------------------------	---------------

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 ($E = \text{on}$) and the output `y` is set to the substitute value `y = yerr`.

Input

<code>u</code>	Analog input of the block	<code>double</code>
----------------	---------------------------	---------------------

Outputs

<code>y</code>	Square root of the input signal	<code>double</code>
<code>E</code>	Error flag	<code>bool</code>
	<code>off</code> ... No error	
	<code>on</code> Square root of negative number	

Parameter

<code>yerr</code>	Substitute value for an error case	$\odot 1.0$ <code>double</code>
-------------------	------------------------------------	---------------------------------

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.

Inputs

u1	Analog input of the block	double
u2	Analog input of the block	double

Output

y	Difference between the two input signals	double
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Chapter 5

ANALOG – Analog signal processing

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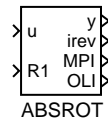
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ABSR0T – Processing data from absolute position sensor

Block Symbol

Licence: [ADVANCED](#)



Function Description

The **ABSR0T** 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 $+175^\circ$) 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.

Inputs

u	Signal from the absolute position sensor	double
R1	Block reset	bool

Outputs

y	Position output	double
irev	Number of finished revolutions	long
MPI	Mid-point indicator	bool
OLI	Off-limits indicator	bool

Parameters

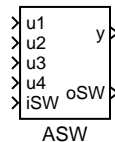
lolim	Lower limit of the sensor reading	$\odot -3.141592654$	double
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<code>hilim</code>	Upper limit of the sensor reading	$\odot 3.141592654$	<code>double</code>
<code>tol</code>	Tolerance for the mid-point indicator	$\odot 0.5$	<code>double</code>
<code>hys</code>	Hysteresis for the mid-point indicator		<code>double</code>
<code>RESR</code>	Flag for resetting the revolutions counter		<code>bool</code>
	<code>off ...</code> Reset only the estimated position <code>y</code>		
	<code>on</code> Reset also the <code>irev</code> revolutions counter		

ASW – Switch with automatic selection of input

Block Symbol

Licence: [ADVANCED](#)



Function Description

The **ASW** block copies one of the inputs $u1, \dots, u4$ or one of the parameters $p1, \dots, p4$ 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 $p1, \dots, p4$. 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 $u1, \dots, u4$ 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.

Inputs

$u1..u4$	Analog input signals to be selected from	double
iSW	Active signal or parameter selector	long

Outputs

y	The selected analog signal or parameter	double
oSW	Identifier of the selected signal or parameter	long

Parameters

<code>delta</code>	Threshold for detecting a change	$\odot 0.000001$	<code>double</code>
<code>p1..p4</code>	Parameters to be selected from		<code>double</code>

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.

Input

u	Input signal to be filtered	double
----------	-----------------------------	---------------

Output

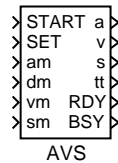
y	Filtered output signal	double
----------	------------------------	---------------

Parameter

n	Number of samples to compute the average from	↓1 ↑10000000 ⊕10	long
n	Limit value of parameter n (used for internal memory allocation)	↓1 ↑10000000 ⊕10	long

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 **off** before 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**.

Inputs

START	Starting signal (rising edge)	bool
SET	Initialize/compute the trajectory for the current inputs	bool
am	Maximal allowed acceleration [m/s ²]	double
dm	Maximal allowed deceleration [m/s ²]	double
vm	Maximum allowed velocity [m/s]	double
sm	Desired final position [m] (initial position is 0)	double

Outputs

a	Acceleration [m/s ²]	double
v	Velocity [m/s]	double
s	Position [m]	double
tt	Time [s]	double
RDY	Flag indicating that the block is ready to generate the trajectory	bool
BSY	Flag indicating that the trajectory is being generated	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 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**.

Input

u	Input signal to be filtered	double
----------	-----------------------------	--------

Output

y	Filtered output signal	double
----------	------------------------	--------

Parameters

fm	Peak frequency, middle of the frequency transmission band [Hz]	double
	$\odot 1.0$	
xi	Relative damping coefficient (recommended value 0.5 to 1)	double
	$\odot 0.707$	
ISSF	Steady state at start-up flag	bool
	off ... Zero initial state	
	on Initial steady state	

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:

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

where

$$e_k = u1_k - u2_k$$

and

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

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.

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double

Output

Y	Logical output of the block	bool
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Parameter

hys	Hysteresis	$\odot 0.5$ double
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CNDR – Nonlinear conditioner

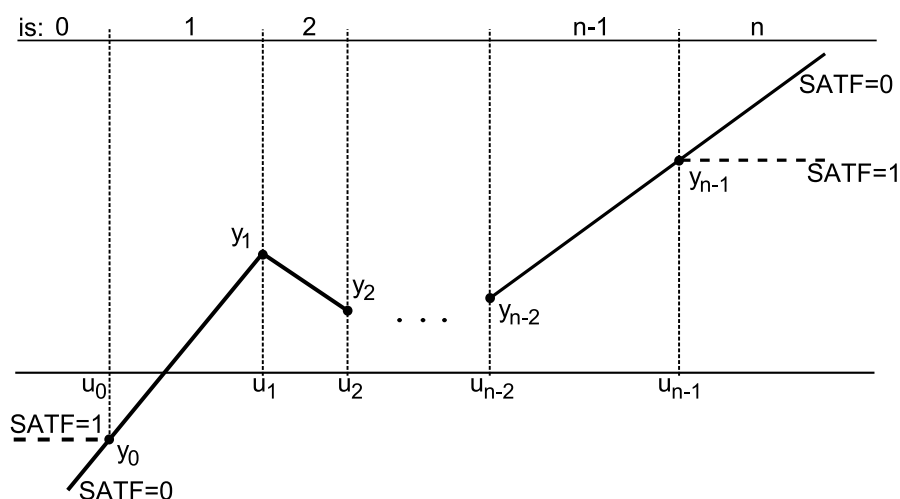
Block Symbol

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 $u < u_0$ or $u > u_{n-1}$ the output depends on the **SATF** parameter.

Input

u	Analog input of the block	double
----------	---------------------------	--------

Outputs

y	Analog output of the block	double
is	Active sector of nonlinearity (see the figure above)	long

Parameters

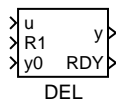
n	Number of (u, y) node pairs	$\odot 2$ long
----------	-------------------------------	----------------

SATF	Saturation flag	⊙on	bool
	off ... Signal not limited on Saturation limits active		
up	Vector of increasing u -coordinates	⊙[-1 1]	double
yp	Vector of y -coordinates	⊙[-1 1]	double

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.

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

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

$$y_k = y_0,$$

where **y₀** 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**.

Inputs

u	Analog input of the block	double
R1	Block reset	bool
y0	Initial output value	double

Outputs

y	Delayed input signal	double
RDY	Ready flag indicating that the buffer is filled with the input signal samples	bool

Parameter

n	Delay [samples] (the resulting time delay is $n \cdot T_S$, where T_S is the block execution period)	long ↓0 ↑10000000 ⊕10
nmax	Limit for parameter del (used for internal memory allocation)	long ↓1 ↑10000000 ⊕10

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.

Input

u	Analog input of the block	double
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Output

y	Delayed input signal	double
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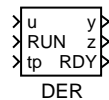
Parameter

del	Time delay [s]	$\odot 1.0$	double
nmax	Size (number of samples) of delay buffer (used for internal memory allocation)	$\downarrow 1 \uparrow 10000000 \odot 10$	long

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:

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

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

Inputs

u	Analog output of the block	double
RUN	Enable execution	bool
	off ... tracking ($z = u$)	
	on ... filtering (y – estimate of the derivative, z – estimate of u at time t_p)	
tp	Time instant for prediction/filtering ($tp = 0$ corresponds with the current sampling instant)	double

Outputs

y	Estimate of input signal derivative	double
z	Predicted/filtered input signal	double
RDY	Ready flag (all $n + 1$ samples are available)	bool

Parameter

n	Number of samples for interpolation ($n+1$ samples are used); $1 \leq n \leq$ <i>nmax</i> $\downarrow 1 \uparrow 10000000 \odot 10$	long
nmax	Limit value for parameter n (used for internal memory allocation) $\downarrow 1 \uparrow 10000000 \odot 10$	long

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

$$\mu_k = \frac{1}{n} \sum_{i=0}^{n-1} u_{k-i}$$

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

where k stands for the current sampling instant.

Input

u	Analog input of the block	double
----------	---------------------------	--------

Outputs

mu	Mean value of the input signal	double
si	Standard deviation of the input signal	double

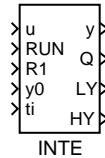
Parameter

n	Number of samples to estimate the statistical properties from	long
	↓2 ↑100000000 ⊙100	
nmax	Limit value of parameter n (used for internal memory allocation)	long
	↓1 ↑100000000 ⊙10	

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.

Consider using the [SINT](#) block, whose simpler structure and functionality might be sufficient for elementary tasks.

Inputs

u	Analog input of the block	double
RUN	Enable execution	bool
	off ... Integration stopped on ... Integration running	
R1	Block reset, initialization of the integrator output to y0	bool
y0	Initial output value	double
ti	Integral time constant	double

Outputs

y	Integrator output	double
Q	Running integration indicator	bool
LY	Lower level indicator (y < ymin)	bool
HY	Upper level indicator (y > ymax)	bool

Parameters

`ymin` Lower level definition
`ymax` Upper level definition

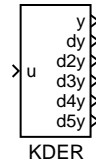
$\odot -1.0$ `double`

$\odot 1.0$ `double`

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 $\text{pbeta} \approx T_S \omega_0$ 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.

Input

u	Input signal to be filtered	double
----------	-----------------------------	---------------

Outputs

y	Filtered input signal	double
dy	Estimated 1st order derivative	double
d2y	Estimated 2nd order derivative	double
d3y	Estimated 3rd order derivative	double
d4y	Estimated 4th order derivative	double
d5y	Estimated 5th order derivative	double

Parameters

<code>norder</code>	Order of the derivative filter	$\downarrow 2 \uparrow 10 \odot 3$	<code>long</code>
<code>pbeta</code>	Bandwidth of the derivative filter	$\downarrow 0.0 \odot 0.1$	<code>double</code>

LPF – Low-pass filter

Block Symbol

Licence: [STANDARD](#)



Function Description

The LPF block implements a second order filter in the form

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

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 $\xi = \mathbf{xi}$ are the block parameters. The **fb** parameter defines the filter bandwidth and **xi** is the relative damping coefficient. 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**.

Input

u	Input signal to be filtered	double
----------	-----------------------------	--------

Output

y	Filtered output signal	double
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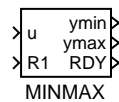
Parameters

fb	Filter bandwidth [Hz]; the frequencies in the range $\langle 0, \mathbf{fb} \rangle$ pass through the filter, the attenuation at the frequency fb is 3 dB and approximately 40 dB at $10 \cdot \mathbf{fb}$; it must hold $f_b < \frac{1}{10T_s}$ for proper function of the filter, where T_s is the block execution period $\odot 1.0$	double
xi	Relative damping coefficient (recommended value 0.5 to 1) $\odot 0.707$	double
ISSF	Steady state at start-up	bool
	off ... Zero initial state	
	on Initial steady state	

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.

Inputs

u	Analog input of the block	double
R1	Block reset	bool

Outputs

ymin	Minimal value found	double
ymax	Maximal value found	double
RDY	Ready flag (buffer filled)	bool

Parameter

n	Number of samples for analysis (buffer length)	↓1 ↑10000000 ⊕100	long
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NSCL – Nonlinear scaling factor

Block Symbol

Licence: [STANDARD](#)

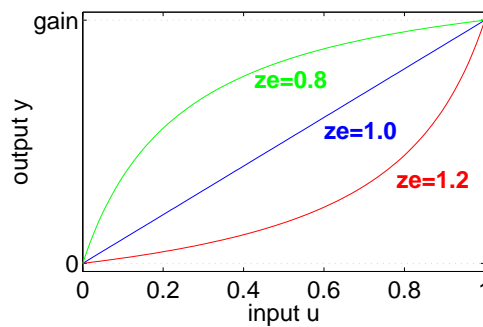


Function Description

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

$$y = \text{gain} \frac{u}{z\text{e} + (1 - z\text{e}) \cdot u},$$

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



Input

u	Analog input of the block	double
---	---------------------------	--------

Output

y	Analog output of the block	double
---	----------------------------	--------

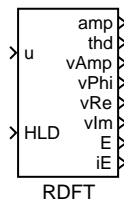
Parameters

gain	Signal gain	⊙1.0	double
ze	Shaping parameter	⊙1.0	double

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 $m = \text{nper}/\text{freq}/T_S$, 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.

Inputs

u	Analog input of the block	double
HLD	Hold	bool

Outputs

amp	Amplitude of the fundamental frequency	double
thd	Total harmonic distortion (only for nharm ≥ 1)	double
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 flag	bool
iE	Error code	error
i REX general error		

Parameters

<code>freq</code>	Fundamental frequency	$\downarrow 0.000000001 \uparrow 1000000000.0 \odot 1.0$	<code>double</code>
<code>nper</code>	Number of periods to calculate upon	$\downarrow 1 \uparrow 10000 \odot 10$	<code>long</code>
<code>nharm</code>	Number of monitored harmonic frequencies	$\downarrow 0 \uparrow 16 \odot 3$	<code>long</code>
<code>ifrunit</code>	Frequency units	$\downarrow 1 \uparrow 2 \odot 1$	<code>long</code>
	1 Hz		
	2 rad/s		
<code>iphunit</code>	Phase shift units	$\downarrow 0 \uparrow 2 \odot 1$	<code>long</code>
	1 degrees		
	2 radians		
<code>freq2</code>	Vector of user-defined monitored frequencies	$\odot [2.0 \ 3.0 \ 4.0]$	<code>double</code>

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

Input

u	Input signal to be filtered	double
----------	-----------------------------	---------------

Output

y	Filtered output signal	double
----------	------------------------	---------------

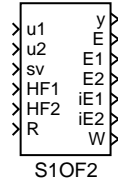
Parameters

tp	Time constant defining the maximum allowed rise	⊙2.0	double
tn	Time constant defining the maximum allowed descent (note that tn > 0)	⊙2.0	double

S10F2 – One of two analog signals selector

Block Symbol

Licence: [ADVANCED](#)



Function Description

The **S10F2** 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 **S10F2** block also evaluates the difference between the two input signals. The internal flag **D** is set to **on** if the differences $|u1 - u2|$ in the last **nd** samples exceed the given limit, which is given by the following inequation

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

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 **E1 = off** and **E2 = off** and **D = off** , then the output **y** depends on the **mode** parameter:

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

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

(ii) If **E1 = off** and **E2 = off** and **D = on** , then **y = sv** and **E = on**.

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

(iv) If **E1 = on** and **E2 = on** , then **y = sv** and **E = 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 $R = 0$, the output **E1** (**E2**) is set to **on** and remains true until the reset ($R: \text{off} \rightarrow \text{on}$). 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 ($D = \text{off} \rightarrow \text{on}$). On the other hand, for $R = 0$, the output **E** is set to **on** and remains true until the reset (rising edge $R: \text{off} \rightarrow \text{on}$). The output **W** is set to **on** only in the (iii) or (iv) cases, i.e. at least one input signal is invalid.

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double
sv	Substitute value for an error case, i.e. E = on	double
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 of the input signals u1 and u2	bool

Outputs

y	Analog output of the block	double
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, $y = u2$	bool
E2	Invalidity indicator for input u2 off ... Signal is valid on Signal is invalid, $y = u1$	bool
iE1	Reason of input u1 invalidity 0 Signal valid 1 Signal out of range 2 Signal varies too little 3 Signal varies too little and signal out of range 4 Signal varies too much 5 Signal varies too much 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
iE2	Reason of input u2 invalidity, see the iE1 output	long
W	Warning flag (invalid input signal) off ... Both input signals u1 and u2 are valid on At least one of the input signals is invalid	bool

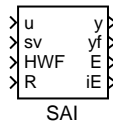
Parameters

nb	Number of samples which are not included in the validity assessment of the signals u1 and u2 after initialization of the block	⊙10	long
nc	Number of samples for invariability testing (see the SAI block, condition F2)	⊙10	long
nbits	Number of A/D converter bits (source of the signals u1 and u2)	⊙12	long
nr	Number of samples for variability testing (see the SAI block, condition F3)	⊙10	long
prate	Maximum allowed percentage change of the input u1 (u2) within the last nr samples (with respect to the overall range of the input signals vmax – vmin , see the SAI block)	⊙10.0	double
nv	Number of samples for out-of-range testing (see the SAI block, condition F4)	⊙1	long
vmin	Lower limit for the input signals u1 and u2	⊙-1.0	double
vmax	Upper limit for the input signals u1 and u2	⊙1.0	double
nd	Number of samples for deviation testing (inner flag D; D is always off for nd = 0)	⊙5	long
pdev	Maximum allowed percentage deviation of the inputs u1 and u2 with respect to the overall range of the input signals vmax – vmin	⊙10.0	double
mode	Defines how to compute the output signal y when both input signals are valid (E1 = off , E2 = off and D = off)	⊙1	long
	1 Average, $y = \frac{u1+u2}{2}$		
	2 Minimum, $y = \min(u1, u2)$		
	3 Maximum, $y = \max(u1, u2)$		

SAI – Safety analog input

Block Symbol

Licence: [ADVANCED](#)



Function Description

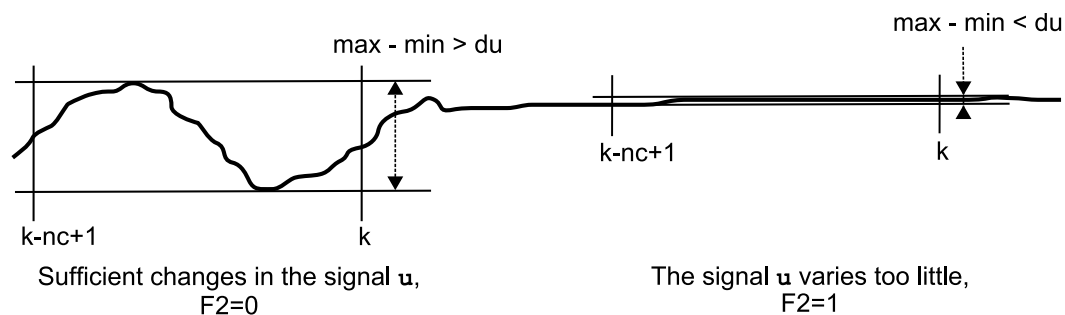
The SAI block tests the input signal u and assesses its validity. The input signal u is considered invalid (the output $E = \text{on}$) in the following cases:

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

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

$$du = \begin{cases} \frac{v_{\max} - v_{\min}}{2^{n_{\text{bits}}}}, & \text{for } n_{\text{bits}} \in \{8, 9, \dots, 16\} \\ 0, & \text{for } n_{\text{bits}} \notin \{8, 9, \dots, 16\}, \end{cases}$$

where v_{\min} and v_{\max} are the lower and upper limits of the input u , respectively, and n_{bits} is the number of A/D converter bits. The situation when the input signal u varies too little is shown in the following picture:

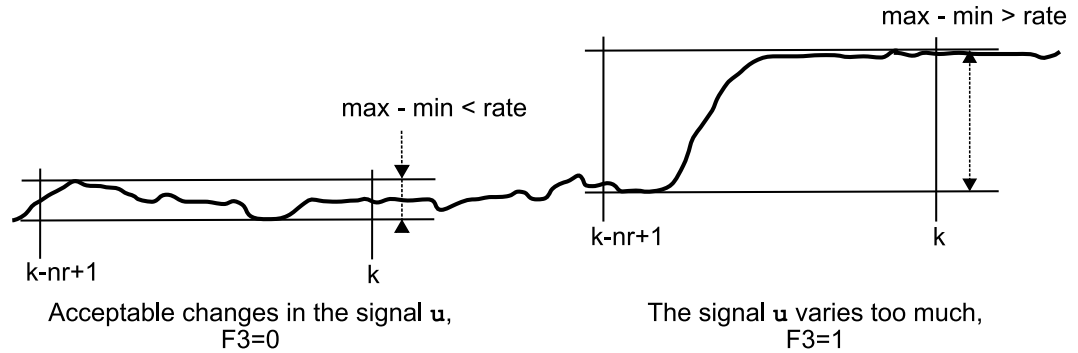


If the parameter nc is set to $nc = 0$, the condition F2 is never fulfilled.

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 ,

$$\text{rate} = \text{prate} \frac{v_{\max} - v_{\min}}{100},$$

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 $u \in \langle v_{\min}, v_{\max} \rangle$). The block includes a **SPIKE** filter with fixed parameters $\text{mingap} = \frac{v_{\max} - v_{\min}}{100}$ 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 $\langle v_{\min}, v_{\max} \rangle$.

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 $\text{nb} \geq 5$ to allow the **SPIKE** filter initial conditions to fade away.

Inputs

u	Analog input of the block	double
sv	Substitute value to be used when the signal u is marked as invalid	double
HWF	Hardware error indicator	bool
	off ... The input module of the signal works normally	
	on Hardware error of the input module occurred	
R	Reset inner error flags F1–F4	bool

Outputs

y	Analog output of the block	double
yf	Filtered analog output signal y , output of the SPIKE filter	double
E	Output signal invalidity indicator	bool
	off ... Signal is valid	sv
	on Signal is invalid, $y = yf =$	
iE	Reason of invalidity	long
	0 Signal valid	
	1 Signal out of range	
	2 Signal varies too little	
	3 Signal varies too little and signal out of range	
	4 Signal varies too much	
	5 Signal varies too much 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	

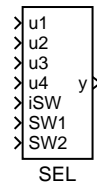
Parameters

nb	Number of samples which are not included in the validity assessment of the signal u after initialization of the block	$\odot 10$	long
nc	Number of samples for invariability testing (the F2 condition)	$\odot 10$	long
nbits	Number of A/D converter bits	$\odot 12$	long
nr	Number of samples for variability testing (the F3 condition)	$\odot 10$	long
prate	Maximum allowed percentage change of the input u within the last nr samples (with respect to the overall range of the input signal $v_{\max} - v_{\min}$)	$\odot 10.0$	double
nv	Number of samples for out-of-range testing (the F4 condition)	$\odot 1$	long
vmin	Lower limit for the input signal u	$\odot -1.0$	double
vmax	Upper limit for the input signal u	$\odot 1.0$	double

SEL – Analog signal selector

Block Symbol

Licence: [STANDARD](#)



Function Description

The **SEL** block is obsolete, replace it by the [SELQUAD](#) 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

Inputs

<i>u1</i>	First analog input of the block	double
<i>u2</i>	Second analog input of the block	double
<i>u3</i>	Third analog input of the block	double
<i>u4</i>	Fourth analog input of the block	double
<i>iSW</i>	Active signal selector, active when BINF = off	long
<i>SW1</i>	Binary signal selector, active when BINF = on	bool
<i>SW2</i>	Binary signal selector, active when BINF = on	bool

Output

<i>y</i>	The selected signal	double
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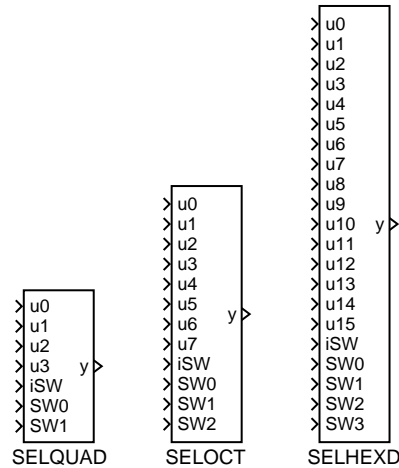
Parameter

BINF	Enable the binary selectors	bool
	off ... Disabled (analog selector)	
	on Enabled (binary selectors)	

SELQUAD, SELOCT, SELHEXD – Analog signal selectors

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**. 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

Please note that the only difference among the blocks is the number of inputs.

Inputs

<code>u0..15</code>	Analog inputs of the block	<code>double</code>
<code>iSW</code>	Active signal selector	<code>long</code>
<code>SW0..3</code>	Binary signal selectors	<code>bool</code>

Output

<code>y</code>	The selected input signal	<code>double</code>
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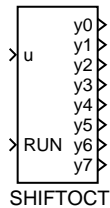
Parameter

<code>BINF</code>	Enable the binary selectors	<code>bool</code>
	<code>off ...</code> Disabled (analog selector)	
	<code>on</code> Enabled (binary selectors)	

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:

$$\begin{aligned} y_i &= y_{i-1}, \quad i = 1..7 \\ y_0 &= u \end{aligned}$$

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 **y8** then have the same data type.

If you need a triggered shift register, place the [EDGE_](#) block in front of the **RUN** input.

Inputs

u	Data input of the register	unknown
RUN	Enables outputs shift	bool

Outputs

y0	First output of the block	unknown
y1	Second output of the block	unknown
y2	Third output of the block	unknown
y3	Fourth output of the block	unknown
y4	Fifth output of the block	unknown
y5	Sixth output of the block	unknown
y6	Seventh output of the block	unknown

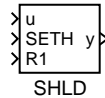
y7	Eighth output of the block	unknown
----	----------------------------	---------

Parameters

vtype	Output data type	⊙8	long
1 Bool		
2 Byte		
3 Short		
4 Long		
5 Word		
6 DWord		
7 Float		
8 Double		
--		
10 Large		

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 occurred. 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.

Inputs

u	Analog input of the block	double
SETH	Trigger for the set and hold operation	bool
R1	Block reset, R1 = on → y = y0	bool

Output

y	Analog output of the block	double
----------	----------------------------	--------

Parameter

y0	Initial output value	double
mode	Sampling mode	⊙3 long
	1 Triggered sampling	
	2 Hold last value	
	3 Hold current value	

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 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.

Input

u	Analog input of the block	double
---	---------------------------	--------

Output

y	Analog output of the block	double
---	----------------------------	--------

Parameters

ti	Integral time constant T_i	⊙1.0	double
y0	Initial output value		double
ymax	Upper limit of the output signal	⊙1.0	double
ymin	Lower limit of the output signal	⊙-1.0	double

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;
      if gap < mingap then gap:= mingap;
    end
  else
    begin
      if delta < 0
        then y := y + gap
        else y := y - gap;
      gap := gap * q;
    end
  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.

Input

u	Input signal to be filtered	double
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Output

y	Filtered output signal	double
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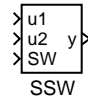
Parameters

mingap	Minimum size of the tolerance window	⊙0.01	double
q	Tolerance window adaptation speed	↓1.0 ⊙2.0	double

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**).

Inputs

u1	First analog input of the block	double
u2	Second analog input of the block	double
SW	Signal selector	bool
	off ... The u1 signal is selected, y = u1	
	on The u2 signal is selected, y = u2	

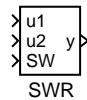
Output

y	Analog output of the block	double
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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.

Inputs

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

Parameters

t1	Rate limiter time constant for switching from u2 to u1	⊙1.0	double
t2	Rate limiter time constant for switching from u1 to u2	⊙1.0	double
y0	Initial output value to start the tracking from (before the first switching of signals occurs)		double

Output

y	Analog output of the block	double
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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.

Inputs

u	Analog input of the block	double
d	Time delay [s]	double

Output

y	Delayed input signal	double
----------	----------------------	---------------

Parameter

y0	Initial/substitute output value	double
nmax	Size (number of samples) of delay buffer (used for internal memory allocation)	long
↓1 ↑100000000 ⊙10		

ZV4IS – Zero vibration input shaper

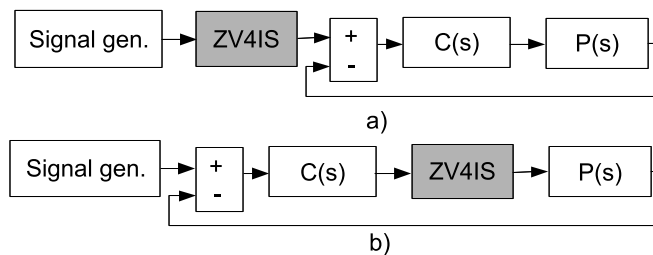
Block Symbol

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.

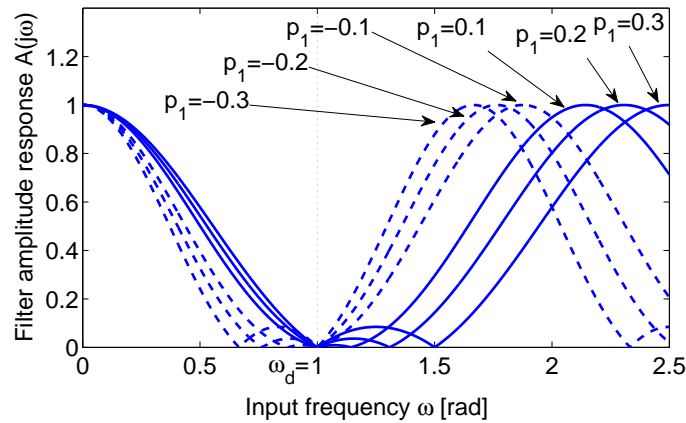
The algorithm of input shaper can be described in time domain

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

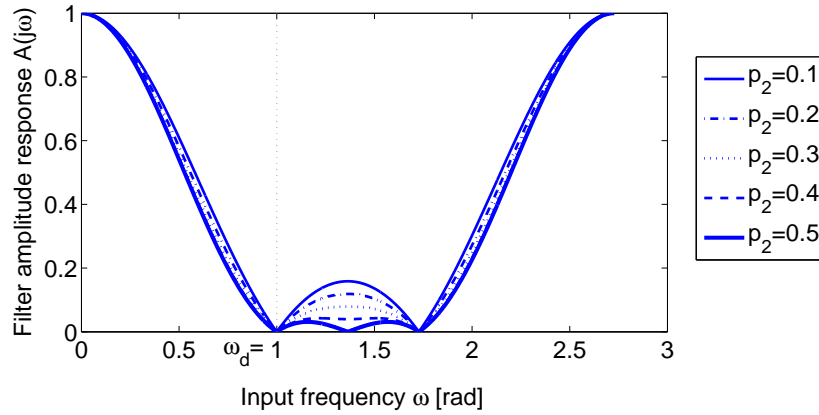
Thus, the filter has a structure of sum of weighted time delays of an input signal. The gains $A_1..A_4$ and time delay values $t_1..t_4$ depend on a choice of filter type, natural frequency and damping of controlled oscillatory mode of the system. The main advantage of this structure compared to commonly 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 ω and damping ξ of the oscillatory mode need to be set. The parameter ipar sets a filter type. For $\text{ipar} = 1$, 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 ω and ξ (one, two or five percent).

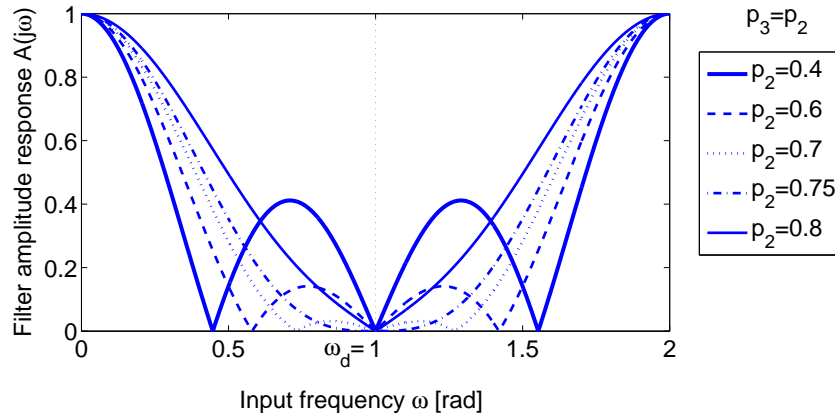
For precise tuning of the filter, complete parameterization $\text{ipar} = 2$ can be selected. For this choice, three parameters p_alpha , p_a2 and p_a3 which affect the shape of the filter frequency response can freely be assigned. These parameters can be used for finding of optimal compromise between 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.

Input

u

Input signal to be filtered

double

Outputs

y	Filtered output signal	double
E	Error flag	bool
	off ... No error on An error occurred	

Parameters

omega	Natural frequency	⊙1.0	double
xi	Relative damping coefficient		double
ipar	Specification	⊙1	long
	1 Basic types of IS		
	2 Complete parametrization		
istype	Type	⊙2	long
	1 ZV		
	2 ZVD		
	3 ZVDD		
	4 MISZV		
	5 UEI1		
	6 UEI2		
	7 UEI5		
	8 UTHEI1		
	9 UTHEI2		
	10 UTHEI5		
p_alpha	Shaper duration/assymetry parameter	⊙0.2	double
p_a2	Insensitivity parameter	⊙0.5	double
p_a3	Additional parameter (only for p_alpha = 0)	⊙0.5	double
nmax	Size (number of samples) of delay buffer (used for internal memory allocation)		long
		↓1 ↑10000000	⊙10

Chapter 6

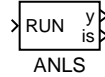
GEN – Signal generators

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ANLS – Controlled generator of piecewise linear function

Block Symbol

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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 $\langle t_i, t_{i+1} \rangle, i = 0, \dots, 3, t_0 = 0$.

To generate a step change in the output signal, it is necessary 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
is	Index of the active time interval	long

Parameters

y0	Initial output value		double
t1	Node 1 time	⊙1.0	double
y1	Node 1 value		double
t2	Node 2 time	⊙1.0	double

y2	Node 2 value	⊙1.0	double
t3	Node 3 time	⊙2.0	double
y3	Node 3 value	⊙1.0	double
t4	Node 4 time	⊙2.0	double
y4	Node 4 value		double
RPT	Repeating sequence		bool
	off ... Disabled		
	on Enabled		

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. The difference between **BINS** and **BIS** blocks is that the internal timer of the **BINS** block is set to 0 and the output **Y** is set to **Y0** whenever a rising edge occurs at the **START** input (even when a binary sequence is being generated). The output value is inverted at time instants **t1**, **t2**, ..., **t8** (**off**→**on**, **on**→**off**). The last switching of the output occurs at time t_i , where $t_{i+1} < t_i$ and the output holds its value afterwards. But for the **RPT** parameter set to **on**, instead of switching the output for the last time, the block returns to its initial state, the internal block timer is set to 0 and the binary sequence is generated repeatedly. On the contrary to the **BIS** block the changes in parameters **t1**...**t8** are accepted only when 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

Parameters

Y0	Initial output value	bool
	off ... Disabled/false on Enabled/true	
t1	Switching time 1 [s]	⊙1.0 double
t2	Switching time 2 [s]	⊙2.0 double
t3	Switching time 3 [s]	⊙3.0 double

t4	Switching time 4 [s]	⊙4.0	double
t5	Switching time 5 [s]	⊙5.0	double
t6	Switching time 6 [s]	⊙6.0	double
t7	Switching time 7 [s]	⊙7.0	double
t8	Switching time 8 [s]	⊙8.0	double
RPT	Repeating sequence		bool
	off ... Disabled	on Enabled	

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 output value is inverted at time instants **t1**, **t2**, ..., **t8** (**off**→**on**, **on**→**off**). The last switching of the output occurs at time t_i , where $t_{i+1} < t_i$ and the output then holds its value. But for the **RPT** parameter set to **on**, instead of switching the output for the last time, the block returns to its initial state, the internal block timer is set to 0 and the binary sequence is generated repeatedly.

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.

Outputs

Y	Logical output of the block	bool
is	Index of the active time interval	long

Parameters

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

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 REX Control System executive. Use the [BIS](#) block for such a purpose.

Output

Y	Logical output of the block	bool
---	-----------------------------	------

Parameters

pwidth	Pulse width [s]	⊙1.0	double
BSTATE	Output pulse activation		bool
	off ... No action		
	on Generate output pulse		
RPTF	Allow pulse extension		bool
	off ... Disabled		
	on Enabled		

PRBS – Pseudo-random binary sequence generator

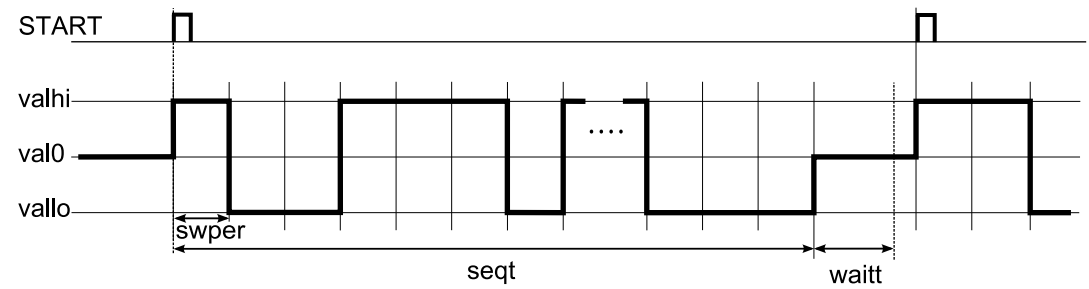
Block Symbol

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
BSY	Busy flag	bool

Parameters

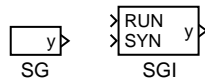
val0	Initial and final value	double
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valhi	Upper level of the y output	$\odot 1.0$	double
vallo	Lower level of the y output	$\odot -1.0$	double
swper	Period of random output switching [s]	$\odot 1.0$	double
swprob	Probability of switching	$\downarrow 0.0 \uparrow 1.0 \odot 0.2$	double
seqt	Length of the sequence [s]	$\odot 10.0$	double
waitt	Settling period [s]	$\odot 2.0$	double

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
----------	----------------------------	---------------

Parameters

isig	Generated signal type	$\odot 1$	long
	1 Sine wave		
	2 Symmetrical rectangular signal		
	3 Sawtooth signal		
	4 White noise with uniform distribution		
amp	Amplitude of the generated signal	$\odot 1.0$	double
freq	Frequency of the generated signal	$\odot 1.0$	double
phase	Phase shift of the generated signal		double
offset	Value added to the generated signal	$\odot 1.0$	double
ifrunit	Frequency units	$\odot 1$	long
	1 Hz		
	2 rad/s		

`iphunit` Phase shift units
 1 degrees
 2 radians

`⊙1` long

Chapter 7

REG – Function blocks for control

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ARLY – Advance relay

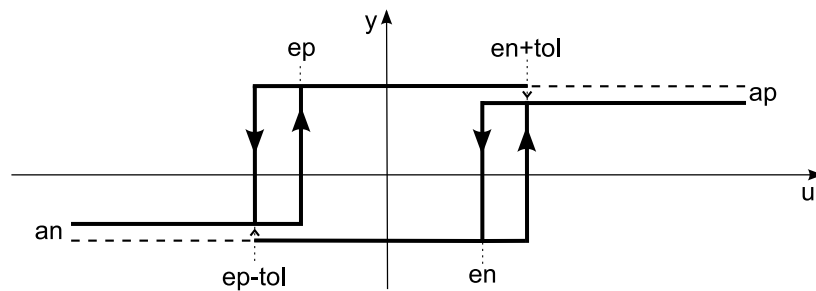
Block Symbol

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

Output

y Analog output of the block double

Parameters

ep	Value for switching the output to the "On" state	$\odot -1.0$	double
en	Value for switching the output to the "Off" state	$\odot 1.0$	double
tol	Tolerance limit for the superposed noise of the input signal u	$\downarrow 0.0 \odot 0.5$	double
ap	Value of the y output in the "On" state	$\odot 1.0$	double
an	Value of the y output in the "Off" state	$\odot -1.0$	double
$y0$	Initial output value		double

FLCU – Fuzzy logic controller unit

Block Symbol

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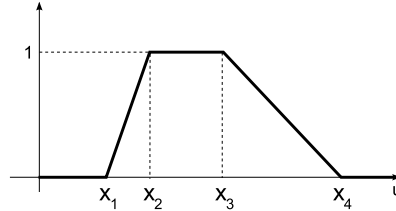
Function Description

The FLCU block implements a simple fuzzy logic controller with two inputs and one output. Introduction to fuzzy logic problems can be found in [4].

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

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

where $U_i, i = 1, \dots, nu$ are the linguistic terms of the u input; $V_j, j = 1, \dots, nv$ are the linguistic terms of the v input and $Y_k, k = 1, \dots, ny$ 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, \dots, 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 \mathbf{mfu} and \mathbf{mfv} are $(nu \times 4)$ and $(nv \times 4)$ respectively.

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

$$y_k, a_k, b_k,$$

where y_k is the value assigned to the linguistic term $Y_k, k = 1, \dots, ny$ 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 $y_k + a_k u + b_k v$. The output membership function matrix \mathbf{sty} has a dimension of $(ny \times 3)$ and contains the rows $[y_k, a_k, b_k], k = 1, \dots, ny$.

The set of inference rules is also a matrix whose rows are $[i_l, j_l, k_l, w_l], l = 1, \dots, nr$, 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 $w_l \in \{0, 1, \dots, 100\}$. It is possible to suppress or emphasize a particular inference rule if necessary.

Inputs

u	First analog input of the block	double
v	Second analog input of the block	double

Outputs

y	Analog output of the block	double
ir	Dominant rule	long
wr	Degree of truth of the dominant rule	double

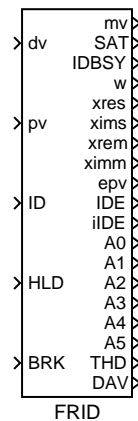
Parameters

umax	Upper limit of the u input	$\odot 1.0$	double
umin	Lower limit of the u input	$\odot -1.0$	double
nu	Number of membership functions of the input u	$\downarrow 1 \uparrow 25 \odot 3$	long
vmax	Upper limit of the v input	$\odot 1.0$	double
vmin	Lower limit of the v input	$\odot -1.0$	double
nv	Number of membership functions of the input v	$\downarrow 1 \uparrow 25 \odot 3$	long
ny	Number of membership functions of the output y	$\downarrow 1 \uparrow 100 \odot 3$	long
nr	Number of inference rules	$\downarrow 1 \uparrow 25 \odot 3$	long
mfu	Matrix of membership functions of the input u		double
		$\odot [-1 \ -1 \ -1 \ 0; \ -1 \ 0 \ 0 \ 1; \ 0 \ 1 \ 1 \ 1]$	
mfv	Matrix of membership functions of the input v		double
		$\odot [-1 \ -1 \ -1 \ 0; \ -1 \ 0 \ 0 \ 1; \ 0 \ 1 \ 1 \ 1]$	
sty	Matrix of membership functions of the output y		double
		$\odot [-1 \ 0 \ 0; \ 0 \ 0 \ 0; \ 1 \ 0 \ 0]$	
rls	Matrix of inference rules	$\odot [1 \ 2 \ 3 \ 100; \ 1 \ 1 \ 1 \ 100; \ 1 \ 0 \ 3 \ 100]$	byte

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
pv	Process variable	double
ID	Start the tuning experiment	bool
HLD	Hold	bool
BRK	Stop the tuning experiment	bool

Parameters

ubias	Static component of the exciting signal	double
uamp	Amplitude of the exciting signal	⊙1.0 double
wb	Frequency interval lower limit [rad/s]	⊙1.0 double
wf	Frequency interval higher limit [rad/s]	⊙10.0 double
isweep	Frequency sweeping mode	⊙1 long
	1 Logarithmic	
	2 Linear	
cp	Sweeping Rate	⊙0.995 double
iavg	Number of values for averaging	⊙10 long

obw	Observer bandwidth	⊙
	1 LOW	
	2 NORMAL	
	3 HIGH	
stime	Settling period [s]	⊙10.
umax	Maximum generator amplitude	⊙1.
thdmin	Minimum demanded THD threshold	⊙0.
adapt_rc	Maximum rate of amplitude variation	⊙0.00
pv_max	Maximum desired process value	⊙1.
pv_sat	Maximum allowed process value	⊙2.
ADAPT_EN	Enable automatic amplitude adaptation	⊙
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)	
nwm	Number of frequency response point for automatic mode	
wm	Frequency measurement points for manual meas. mode [array of rad/s]	double
	⊙[2.0 4.0 6.0 8.0]	

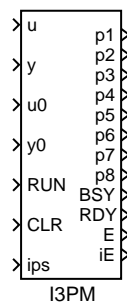
Outputs

mv	Manipulated variable (controller output)	double
SAT	Saturation flag	bool
IDBSY	Tuner busy flag	bool
w	Actual frequency [rad/s]	double
xres	real part of frequency response (sweeping)	double
xims	imaginary part of frequency response (sweeping)	double
xrem	real part of frequency response (measurement)	double
ximm	imaginary part of frequency response (measurement)	double
epv	Estimated process value	double
IDE	Error indicator	bool
iIDE	Error code	long
A0	Estimated DC value	double
A1	Estimated 1st harmonics amlitude	double
A2	Estimated 2nd harmonics amlitude	double
A3	Estimated 3rd harmonics amlitude	double
A4	Estimated 4th harmonics amlitude	double
A5	Estimated 5th harmonics amlitude	double
THD	Total harmonic distorsion	double
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
y	Output of the identified system	double
u0	Input steady state	double
y0	Output steady state	double
RUN	Execute identification	bool
CLR	Block reset	bool
ips	Meaning of the output signals	long
0 FOPDT model	
	p1 ... gain	
	p2 ... time delay	
	p3 ... time constant	
1 moments of input and output	
	p1 ... parameter <i>mu</i> 0	
	p2 ... parameter <i>mu</i> 1	
	p3 ... parameter <i>mu</i> 2	
	p4 ... parameter <i>my</i> 0	
	p5 ... parameter <i>my</i> 1	
	p6 ... parameter <i>my</i> 2	
2 process moments	
	p1 ... parameter <i>mp</i> 0	
	p2 ... parameter <i>mp</i> 1	
	p3 ... parameter <i>mp</i> 2	

3 characteristic numbers
 p1 ... parameter κ
 p2 ... parameter μ
 p3 ... parameter σ^2
 p4 ... parameter σ

Outputs

p <i>i</i>	Identified parameters with respect to ips , $i = 1, \dots, 8$	double
BSY	Busy flag	bool
RDY	Ready flag	bool
E	Error flag	bool
iE	Error code	long
	1 Premature termination (RUN = off)	
	2 $\mu_0 = 0$	
	3 $\mu_p = 0$	
	4 $\sigma^2 < 0$	

Parameters

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

LC – Lead compensator

Block Symbol

Licence: [STANDARD](#)



Function Description

The LC block is a discrete simulator of derivative element

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

where **td** is the derivative constant and **nd** determines the influence of parasite 1st order filter. It is recommended to use $2 \leq \mathbf{nd} \leq 10$. 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
----------	---------------------------	---------------

Output

y	Analog output of the block	double
----------	----------------------------	---------------

Parameters

td	Derivative time constant	⊙1.0	double
nd	Derivative filtering parameter	⊙10.0	double
ISSF	Steady state at start-up		bool
	off ... Zero initial state		
	on Initial steady state		

LLC – Lead-lag compensator

Block Symbol

Licence: [STANDARD](#)



Function Description

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

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

where **tau** is the denominator time constant and the time constant of numerator is an **a**-multiple of **tau** (**a * tau**). 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 is ideal for simulation of first order plus dead time systems (FOPDT). Just set the **a** parameter to zero.

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
----------	---------------------------	--------

Output

y	Analog output of the block	double
----------	----------------------------	--------

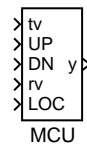
Parameters

tau	Time constant	⊙1.0 double
a	Numerator time constant coefficient	double
ISSF	Steady state at start-up	bool
	off ... Zero initial state	
	on Initial steady state	

MCU – Manual control unit

Block Symbol

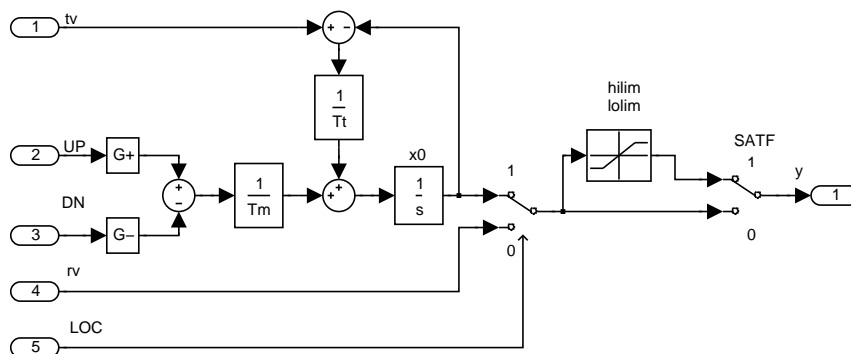
Licence: [STANDARD](#)



Function Description

The **MCU** block is suitable for manual setting of the numerical output value y , e.g. a setpoint. In the local mode ($LOC = \text{on}$) the value is set using the buttons **UP** and **DN**. The rate of increasing/decreasing of the output y from the initial value y_0 is determined by the integration time constant t_m and pushing time of the buttons. After elapsing t_a seconds while a button is pushed, the rate is always multiplied by the factor q until the time t_f is elapsed. Optionally, the output y range can be constrained ($SATF = \text{on}$) by saturation limits $lolim$ and $hilim$. If none of the buttons is pushed ($UP = \text{off}$ and $DN = \text{off}$), the output y tracks the input value tv . The tracking speed is controlled by the integration time constant t_t .

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



Inputs

tv	Tracking variable	double
UP	The "up" signal	bool
DN	The "down" signal	bool
rv	Remote output value in the mode $LOC = \text{off}$	double

L0C	Local or remote mode	bool
-----	----------------------	------

Output

y	Analog output of the block	double
---	----------------------------	--------

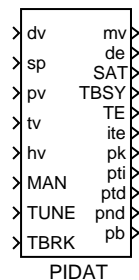
Parameters

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

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 **on** during 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
sp	Setpoint variable	double
pv	Process variable	double
tv	Tracking variable	double
hv	Manual value	double

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
de	Deviation error	double
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
pk	Proposed controller gain	double
pti	Proposed integral time constant	double
ptd	Proposed derivative time constant	double
pnd	Proposed derivative component filtering	double
pb	Proposed weighting factor – proportional component	double

Parameters

irtype	Controller type (control law) 1 D 4 P 7 PID 2 I 5 PD 3 ID 6 PI	⊙1.
RACT	Reverse action flag off ... Higher mv → higher pv on Higher mv → lower pv	
k	Controller gain K	⊙1.
ti	Integral time constant T_i	⊙4.
td	Derivative time constant T_d	⊙1.
nd	Derivative filtering parameter N	⊙10.
b	Setpoint weighting – proportional part	⊙1.
c	Setpoint weighting – derivative part	
tt	Tracking time constant. No meaning for controllers without integrator	⊙1.

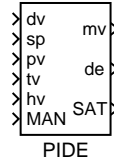
hilim	Upper limit of the controller output	⊙1.0	double
lolim	Lower limit of the controller output	⊙-1.0	double
iainf	Type of apriori information	⊙1	long
	1 No apriori information		
	2 Astatic process (process with integration)		
	3 Low order process		
	4 Static process + slow closed loop step response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

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
sp	Setpoint variable	double
pv	Process variable	double
tv	Tracking variable	double
hv	Manual value	double
MAN	Manual or automatic mode	bool
	off ... Automatic mode	
	on Manual mode	

Outputs

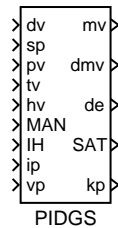
mv	Manipulated variable (controller output)	double
de	Deviation error	double
SAT	Saturation flag	bool
	off ... The controller implements a linear control law	
	on The controller output is saturated	

Parameters

irtype	Controller type (control law)	⊙6	long
	1 D 4 P 7 PID		
	2 I 5 PD		
	3 ID 6 PI		
RACT	Reverse action flag		bool
	off ... Higher mv → higher pv		
	on Higher mv → lower pv		
k	Controller gain K	⊙1.0	double
ti	Integral time constant T_i	⊙4.0	double
td	Derivative time constant T_d	⊙1.0	double
nd	Derivative filtering parameter N	⊙10.0	double
b	Setpoint weighting – proportional part	⊙1.0	double
c	Setpoint weighting – derivative part		double
tt	Tracking time constant. No meaning for controllers without integrator.	⊙1.0	double
bp	Static error coefficient		double
hilim	Upper limit of the controller output	⊙1.0	double
lolim	Lower limit of the controller output	⊙-1.0	double

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 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 **thrsha**. The following rules define the active parameter set: the set 0 is active for $vp < thrsha(0)$, the set 1 for $thrsha(1) < vp < thrsha(2)$ etc. till the set 5 for $thrsha(5) < vp$. The index of the active parameter set is available at the **kp** output.

Inputs

dv	Feedforward control variable	double
sp	Setpoint variable	double
pv	Process variable	double
tv	Tracking variable	double
hv	Manual value	double
MAN	Manual or automatic mode	bool
	off ... Automatic mode	
	on Manual mode	
IH	Integrator hold	bool
	off ... Integration enabled	
	on Integration disabled	
ip	Parameter set index	↓0 ↑5 long
vp	Switching analog signal	double

Outputs

mv	Manipulated variable (controller output)	double
dmv	Controller velocity output (difference)	double
de	Deviation error	double

SAT	Saturation flag	bool
	off ... The controller implements a linear control law	
	on ... The controller output is saturated	
kp	Active parameter set index	long

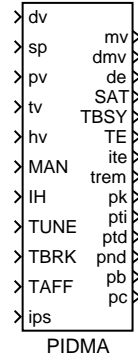
Parameters

hilim	Upper limit of the controller output	⊙1.0	double
lolim	Lower limit of the controller output	⊙-1.0	double
dz	Dead zone		double
icotype	Controller output type	⊙1	long
	1 Analog output		
	2 Pulse width modulation (PWM)		
	3 Step controller unit with position feedback (SCU)		
	4 Step controller unit without position feedback (SCUV)		
npars	Number of controller parameter sets	⊙6	long
GSCF	Switch parameters by analog signal vp		bool
	off ... Index-based switching		
	on ... Analog signal based switching		
hys	Hysteresis for controller parameters switching		double
irtypea	Vector of controller types (control laws)	⊙[6 6 6 6 6 6]	byte
	1 D 4 P 7 PID		
	2 I 5 PD		
	3 ID 6 PI		
RACTA	Vector of reverse action flags	⊙[0 0 0 0 0 0]	bool
	0 Higher mv → higher pv		
	1 Higher mv → lower pv		
ka	Vector of controller gains K	⊙[1.0 1.0 1.0 1.0 1.0 1.0]	double
tia	Vector of integral time constants T_i	⊙[4.0 4.0 4.0 4.0 4.0 4.0]	double
tda	Vector of derivative time constants T_d	⊙[1.0 1.0 1.0 1.0 1.0 1.0]	double
nda	Vector of derivative filtering parameters N	⊙[10.0 10.0 10.0 10.0 10.0 10.0]	double
ba	Setpoint weighting factors – proportional part	⊙[1.0 1.0 1.0 1.0 1.0 1.0]	double
ca	Setpoint weighting factors – derivative part	⊙[0.0 0.0 0.0 0.0 0.0 0.0]	double
tta	Vector of tracking time constants. No meaning for controllers without integrator.	⊙[1.0 1.0 1.0 1.0 1.0 1.0]	double
thrsha	Vector of thresholds for switching the parameters	double	
	⊙[0.1 0.2 0.3 0.4 0.5 0]		

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

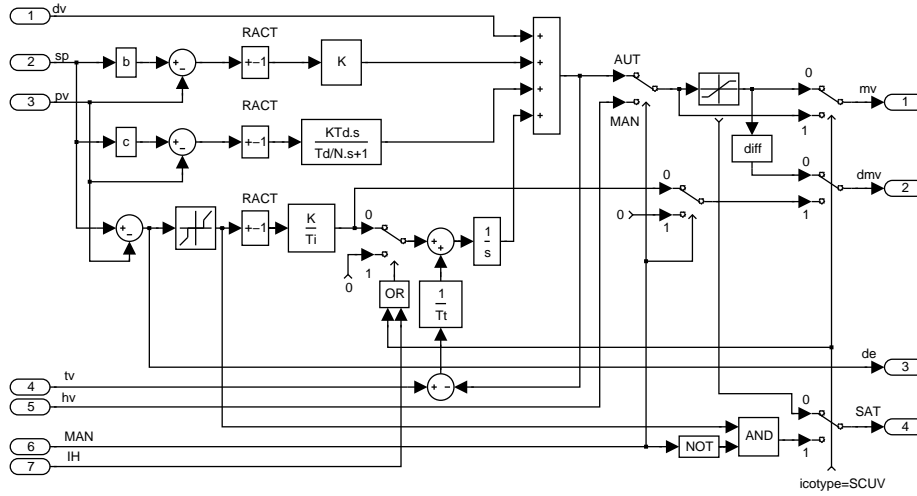
$$U(s) = \pm K \left\{ bW(s) - Y(s) + \frac{1}{T_i s} [W(s) - Y(s)] + \frac{T_d s}{\frac{T_d}{N}s + 1} [cW(s) - Y(s)] \right\} + Z(s)$$

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 is $tt \approx \sqrt{T_i T_d}$ or $tt \approx 2 \cdot \sqrt{T_i}$ in the case of a PI controller). 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 in the saturation of the output **mv** (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.

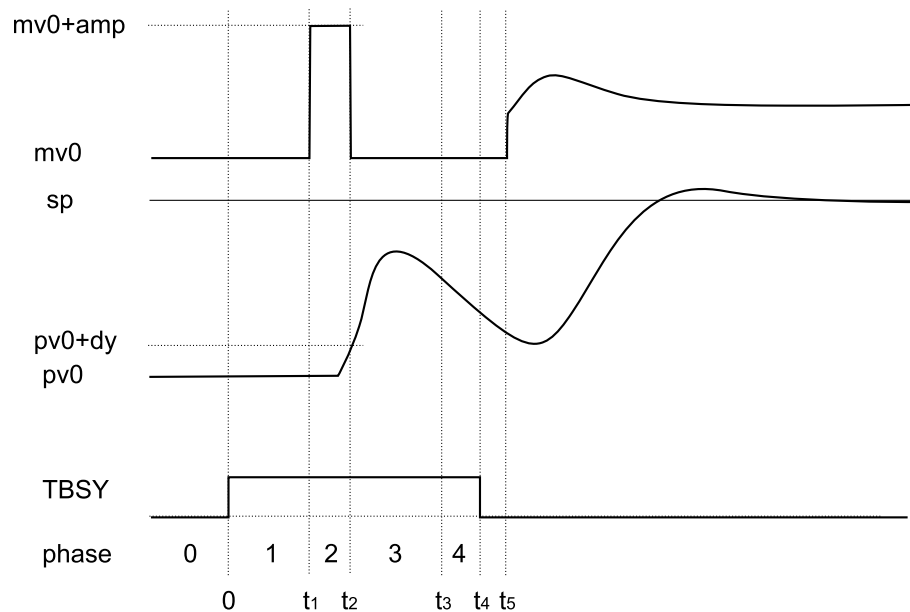
In the manual mode (**MAN** = **on**), the input **hv** is copied to the output **mv** unless saturated. The overall control function of the **PIDMA** block is quite clear from the following diagram:



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

<code>dv</code>	Feedforward control variable	double
<code>sp</code>	Setpoint variable	double
<code>pv</code>	Process variable	double
<code>tv</code>	Tracking variable	double
<code>hv</code>	Manual value	double
<code>MAN</code>	Manual or automatic mode	bool
	<code>off</code> ... Automatic mode	
	<code>on</code> Manual mode	
<code>IH</code>	Integrator hold	bool
	<code>off</code> ... Integration enabled	
	<code>on</code> Integration disabled	
<code>TUNE</code>	Start the tuning experiment (<code>off→on</code>) or force transition to the next tuning phase (see the description of the <code>ite</code> output)	bool
<code>TBRK</code>	Stop the tuning experiment	bool

TAFF	Tuning affirmation; determines the way the computed parameters are handled	bool
	<ul style="list-style-type: none"> off ... Parameters are only computed on Parameters are set into the control law 	
ips	Meaning of the output signals pk , pti , ptd , pnd , pb and pc	long
	<ul style="list-style-type: none"> 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
dmv	Controller velocity output (difference)	double
de	Deviation error	double
SAT	Saturation flag	bool
	<ul style="list-style-type: none"> off ... The controller implements a linear control law on The controller output is saturated 	
TBSY	Tuner busy flag	bool
TE	Tuning error	bool
	<ul style="list-style-type: none"> off ... Autotuning successful on An error occurred during the experiment 	
ite	Error code	long
	<i>Tuning error codes (after the experiment):</i>	
	<ul style="list-style-type: none"> 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 amplitude 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]
pk	Proposed controller gain K (ips = 0)
pti	Proposed integral time constant T_i (ips = 0)
ptd	Proposed derivative time constant T_d (ips = 0)
pnd	Proposed derivative component filtering N (ips = 0)
pb	Proposed weighting factor – proportional component (ips = 0) double
pc	Proposed weighting factor – derivative component (ips = 0) double

Parameters

irtype	Controller type (control law)	⊙
	1 D 4 P 7 PID	
	2 I 5 PD	
	3 ID 6 PI	
RACT	Reverse action flag	
	off ... Higher mv → higher pv	
	on ... Higher mv → lower pv	
k	Controller gain K	⊙1.
ti	Integral time constant T_i	⊙4.
td	Derivative time constant T_d	⊙1.
nd	Derivative filtering parameter N	⊙10.
b	Setpoint weighting – proportional part	⊙1.
c	Setpoint weighting – derivative part	
tt	Tracking time constant. No meaning for controllers without integrator	⊙1.
hilim	Upper limit of the controller output	⊙1.
lolim	Lower limit of the controller output	⊙-1.
dz	Dead zone	
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)	

itttype	Controller type to be designed	⊙6	long
	6 PI controller		
	7 PID controller		
iainf	Type of apriori information	⊙1	long
	1 Static process		
	2 Astatic process		
DGC	Drift gradient compensation	⊙on	bool
	off ... Disabled		
	on Enabled		
tdg	Drift gradient estimation time [s]	⊙60.0	double
tn	Length of noise estimation period [s]	⊙5.0	double
amp	Tuning pulse amplitude	⊙0.5	double
dy	Tuning pulse get down threshold (absolute difference from the steady pv value)	↓0.0 ⊙0.1	double
ispeed	Desired closed loop speed	⊙2	long
	1 Slow closed loop		
	2 Normal (middle fast) closed loop		
	3 Fast closed loop		
ipid	PID controller form	⊙1	long
	1 Parallel form		
	2 Series form		

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

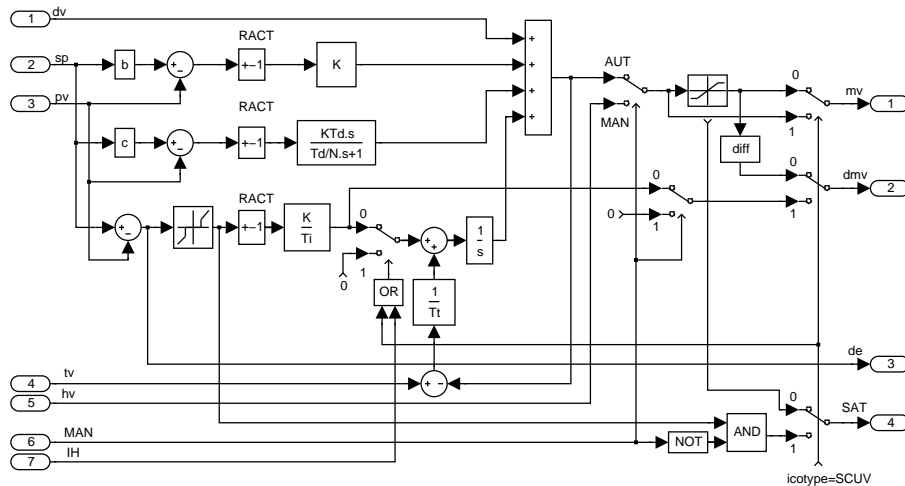
$$U(s) = \pm K \left\{ bW(s) - Y(s) + \frac{1}{T_i s} [W(s) - Y(s)] + \frac{T_d s}{\frac{T_d}{N}s + 1} [cW(s) - Y(s)] \right\} + Z(s)$$

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** (**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 is $tt \approx \sqrt{T_i T_d}$ or $tt \approx 2 \cdot \sqrt{T_i}$ in the case of a PI controller). 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 **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
sp	Setpoint variable	double
pv	Process variable	double
tv	Tracking variable	double
hv	Manual value	double
MAN	Manual or automatic mode	bool
	off ... Automatic mode	
	on Manual mode	
IH	Integrator hold	bool
	off ... Integration enabled	
	on Integration disabled	

Outputs

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

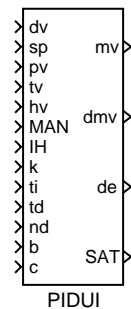
Parameters

irtype	Controller type (control law)	⊙6	long
	1 D 4 P 7 PID		
	2 I 5 PD		
	3 ID 6 PI		
RACT	Reverse action flag		bool
	off ... Higher mv → higher pv		
	on ... Higher mv → lower pv		
k	Controller gain K	⊙1.0	double
ti	Integral time constant T_i	⊙4.0	double
td	Derivative time constant T_d	⊙1.0	double
nd	Derivative filtering parameter N	⊙10.0	double
b	Setpoint weighting – proportional part	⊙1.0	double
c	Setpoint weighting – derivative part		double
tt	Tracking time constant. No meaning for controllers without integrator.	double	
		⊙1.0	
hilim	Upper limit of the controller output	⊙1.0	double
lolim	Lower limit of the controller output	⊙-1.0	double
dz	Dead zone		double
icotype	Controller output type	⊙1	long
	1 Analog output		
	2 Pulse width modulation (PWM)		
	3 Step controller unit with position feedback (SCU)		
	4 Step controller unit without position feedback (SCUV)		

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
sp	Setpoint variable	double
pv	Process variable	double
tv	Tracking variable	double
hv	Manual value	double
MAN	Manual or automatic mode	bool
	off ... Automatic mode	
	on Manual mode	
IH	Integrator hold	bool
	off ... Integration enabled	
	on Integration disabled	
k	Controller gain K	double
ti	Integral time constant T_i	double
td	Derivative time constant T_d	double
nd	Derivative filtering parameter N	double
b	Setpoint weighting – proportional part	double
c	Setpoint weighting – derivative part	double

Outputs

<code>mv</code>	Manipulated variable (controller output)	<code>double</code>
<code>dmv</code>	Controller velocity output (difference)	<code>double</code>
<code>de</code>	Deviation error	<code>double</code>
<code>SAT</code>	Saturation flag	<code>bool</code>
	<code>off ...</code> The controller implements a linear control law	
	<code>on</code> The controller output is saturated	

Parameters

<code>irtype</code>	Controller type (control law)	$\odot 6$	<code>long</code>
	1 D 4 P 7 PID		
	2 I 5 PD		
	3 ID 6 PI		
<code>RACT</code>	Reverse action flag		<code>bool</code>
	<code>off ...</code> Higher <code>mv</code> \rightarrow higher <code>pv</code>		
	<code>on</code> Higher <code>mv</code> \rightarrow lower <code>pv</code>		
<code>tt</code>	Tracking time constant. No meaning for controllers without integrator.	$\odot 1.0$	<code>double</code>
<code>hilim</code>	Upper limit of the controller output	$\odot 1.0$	<code>double</code>
<code>lolim</code>	Lower limit of the controller output	$\odot -1.0$	<code>double</code>
<code>dz</code>	Dead zone		<code>double</code>
<code>icotype</code>	Controller output type	$\odot 1$	<code>long</code>
	1 Analog output		
	2 Pulse width modulation (PWM)		
	3 Step controller unit with position feedback (SCU)		
	4 Step controller unit without position feedback (SCUV)		

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
----------	-----------------------------	-------------

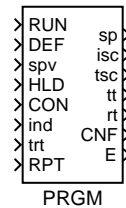
Parameters

dtime	Minimum width of the output pulse [s]	⊙1.0	double
btime	Minimum delay between two successive output pulses [s]	⊙1.0	double

PRGM – Setpoint programmer

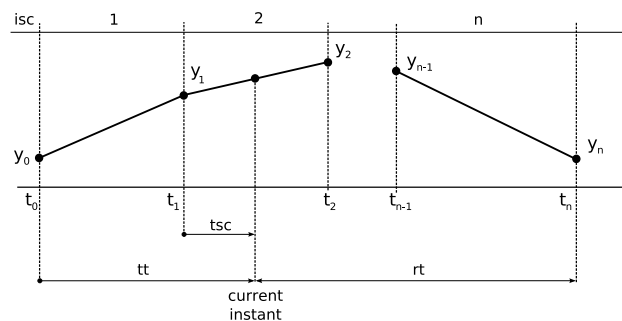
Block Symbol

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 ($\mathbf{tm} = [t_0, \dots, t_n]$) and output values ($\mathbf{y} = [y_0, \dots, y_n]$). 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

<code>spv</code>	Initializing constant	double
<code>HLD</code>	Output and timer freezing	bool
<code>CON</code>	Continue from defined node	bool
<code>ind</code>	Index of the node to continue from	long
<code>trt</code>	Time to reach the defined node with index <code>ind</code>	double
<code>RPT</code>	Repetition flag	bool

Outputs

<code>sp</code>	Setpoint variable (function value of the time function at given time)	double
<code>isc</code>	Current function sector	long
<code>tsc</code>	Time elapsed since the start of current sector	double
<code>tt</code>	Time elapsed since the start of program generation	double
<code>rt</code>	Remaining time till the end of program	double
<code>CNF</code>	Flag indicating that the configured curve is being followed	bool
<code>E</code>	Error flag – the node times are not ascending	bool

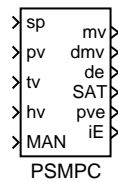
Parameters

<code>n</code>	Number of sectors	$\downarrow 1 \uparrow 10000000$	$\odot 2$	long
<code>tmunits</code>	Time units		$\odot 1$	long
	1 seconds			
	2 minutes			
	3 hours			
<code>tm</code>	$(n + 1)$ -dimensional vector of ascending node times		$\odot [0 \ 1 \ 2]$	double
<code>y</code>	$(n + 1)$ -dimensional vector of node values (values of the time function)		$\odot [0 \ 1 \ 0]$	double

PSMPC – Pulse-step model predictive controller

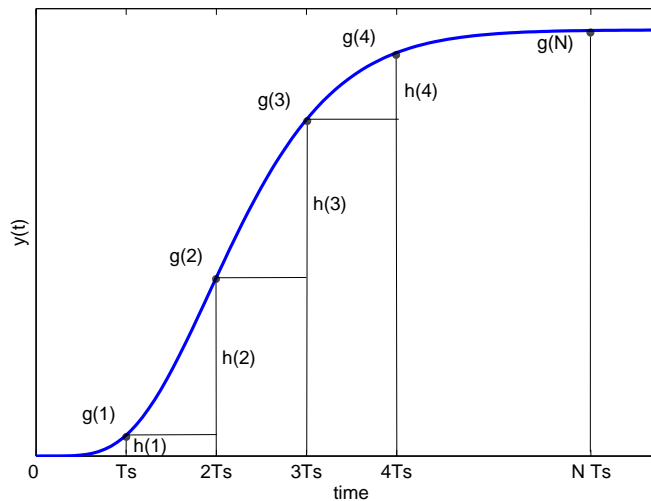
Block Symbol

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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 $g(j)$, $j = 1, \dots, N$ is used. The figure above shows how to obtain the discrete step response $g(j)$, $j = 0, 1, \dots, N$ and the discrete impulse response $h(j)$, $j = 0, 1, \dots, N$ 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 [5] 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

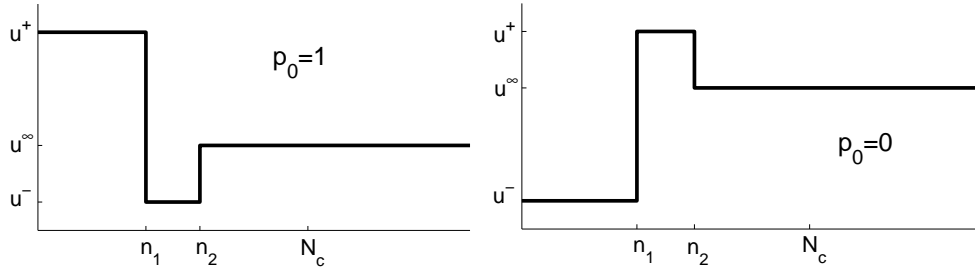
$$F_{FOPDT}(s) = \frac{K}{\tau s + 1} \cdot e^{-Ds}, \quad \kappa = K, \quad \mu = \tau + D, \quad \sigma^2 = \tau^2 \quad (7.1)$$

or second order plus dead-time system

$$F_{SOPDT}(s) = \frac{K}{(\tau s + 1)^2} \cdot e^{-Ds}, \quad \kappa = K, \quad \mu = 2\tau + D, \quad \sigma^2 = 2\tau^2 \quad (7.2)$$

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 $n_1, n_2 \in \{0, \dots, N_C\}$, p_0 and $u^\infty \in \langle u^-, u^+ \rangle$, where $N_C \in \{0, 1, \dots\}$ 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

$$I = \sum_{i=N_1}^{N_2} \hat{e}(k+i|k)^2 + \lambda \sum_{i=0}^{N_C} \Delta \hat{u}(k+i|k)^2 \rightarrow \min, \quad (7.3)$$

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 **nsr** parameter to sufficiently large number to avoid Matlab/Simulink crash when using the **PSMPC** block for simulation purposes. Especially when using FOPDT or SOPDT model, the **nsr** parameter must be greater than the length of the internally computed discrete step response.

Inputs

sp	Setpoint variable	double
pv	Process variable	double
tv	Tracking variable (applied control signal)	double
hv	Manual value	double
MAN	Manual or automatic mode	bool
	off ... Automatic mode	
	on Manual mode	

Outputs

mv	Manipulated variable (controller output)	double
dmv	Controller velocity output (difference)	double
de	Deviation error	double
SAT	Saturation flag	bool
	off ... The controller implements a linear control law	
	on The controller output is saturated	
pve	Predicted process variable based on the controlled process model	double
iE	Error code	long
	0 No error	
	1 Incorrect FOPDT model	
	2 Incorrect SOPDT model	
	3 Invalid step response sequence	

Parameters

nc	Control horizon length (N_C)	⊙5	long
np1	Start of coincidence interval (N_1)	⊙1	long
np2	End of coincidence interval (N_2)	⊙10	long
lambda	Control signal penalization coefficient (λ)	⊙0.05	double
umax	Upper limit of the controller output (u^+)	⊙1.0	double
umin	Lower limit of the controller output (u^-)	⊙-1.0	double

imtype	Controlled process model type	⊙3	long
	1 FOPDT model (7.1)		
	2 SOPDT model (7.2)		
	3 Discrete step response		
kappa	Static gain (κ)	⊙1.0	double
mu	Resident time constant (μ)	⊙20.0	double
sigma	Measure of the system response length ($\sqrt{\sigma^2}$)	⊙10.0	double
nsr	Length of the discrete step response (N), see the warning above		long
		↓10 ↑10000000 ⊙11	
sr	Discrete step response sequence ($[g(1), \dots, g(N)]$)		double
		⊙[0 0.2642 0.5940 0.8009 0.9084 0.9596 0.9826 0.9927 0.9970 0.9988 0.9995]	

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:

$$L = \text{pertm} * |u|,$$

where **pertm** is the modulation time period. If $u > 0$ ($u < 0$), 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:

$$\begin{aligned} \text{if } u > 0 \text{ then } L(\text{UP}) &:= \begin{cases} L & \text{for } \text{asyfac} \leq 1.0 \\ L/\text{asyfac} & \text{for } \text{asyfac} > 1.0 \end{cases} \\ \text{if } u < 0 \text{ then } L(\text{DN}) &:= \begin{cases} L * \text{asyfac} & \text{for } \text{asyfac} \leq 1.0 \\ L & \text{for } \text{asyfac} > 1.0 \end{cases} \end{aligned}$$

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
----------	---------------------------	---------------

Outputs

UP	The "up" signal	bool
DN	The "down" signal	bool

Parameters

<code>pertm</code>	Modulation period length [s]	⊙10.0	double
<code>dtime</code>	Minimum width of the output pulse [s]	⊙0.1	double
<code>btime</code>	Minimum delay between output pulses [s]	⊙0.1	double
<code>offtime</code>	Minimum delay when altering direction [s]	⊙1.0	double
<code>asyfac</code>	Asymmetry factor	⊙1.0	double
<code>SYNCH</code>	Synchronization flag of the period start		bool
	<code>off</code> ... Synchronization disabled		
	<code>on</code> Synchronization enabled		

RLY – Relay with hysteresis

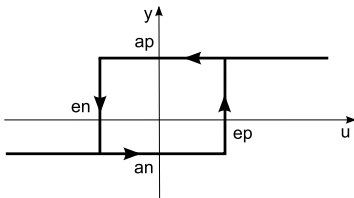
Block Symbol

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
-----	---------------------------	--------

Output

y	Analog output of the block	double
-----	----------------------------	--------

Parameters

ep	The value $u > ep$ causes $y = ap$ ("On")	$\odot 1.0$	double
en	The value $u < en$ causes $y = an$ ("Off")	$\odot -1.0$	double
ap	Output value y in the "On" state	$\odot 1.0$	double
an	Output value y in the "Off" state	$\odot -1.0$	double
$y0$	Initial output value at start-up		double

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 $\text{lolim} \leq u$ and $u \leq \text{hilim}$, where lolim and hilim are state variables of the block. If $u < \text{lolim}$ ($u > \text{hilim}$), then $y = \text{lolim}$ ($y = \text{hilim}$). The upper and lower limits are either constants ($\text{HLD} = \text{on}$) defined by parameters hilim0 and lolim0 respectively or input-driven variables ($\text{HLD} = \text{off}$, 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 ($\text{HLD} = \text{on}$) using the hilim0 and lolim0 parameters. To allow immediate changes of the saturation limits, set $\text{tp} = 0$ and $\text{tn} = 0$. 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
hi	Upper limit of the output signal (for the case $\text{HLD} = \text{off}$)	double
lo	Lower limit of the output signal (for the case $\text{HLD} = \text{off}$)	double

Outputs

y	Analog output of the block	double
HL	Upper limit saturation indicator	bool
LL	Lower limit saturation indicator	bool

Parameters

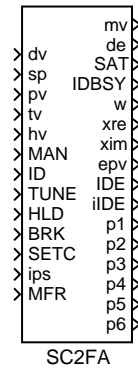
tp	Time constant defining the maximal positive slope of active limit changes	double	$\odot 1.0$
tn	Time constant defining the maximum negative slope of active limit changes	double	$\odot 1.0$
hilim0	Upper limit of the output (valid for $\text{HLD} = \text{on}$)	double	$\odot 1.0$
lolim0	Lower limit of the output (valid for $\text{HLD} = \text{on}$)	double	$\odot -1.0$

HLD Fixed saturation limits \odot on bool
 off ... Variable limits on Fixed limits

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

$$F(s) = \frac{b_1 s + b_0}{s^2 + 2\xi\Omega s + \Omega^2}, \quad (7.4)$$

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 $\langle \mathbf{wb}, \mathbf{wf} \rangle$, 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 $T_b = \frac{2\pi}{\mathbf{wb}}$ of the exciting sine wave in time T_b , thus

$$c_p = \frac{\mathbf{wb}}{\omega(T_b)} = \frac{\mathbf{wb}}{\mathbf{wbe}^{\gamma T_b}} = e^{-\gamma T_b}.$$

The **cp** parameter usually lies within the interval $\text{cp} \in (0,95; 1)$. 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 $\omega = \text{wb}$. 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 $(-360^\circ, 0^\circ)$, 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.

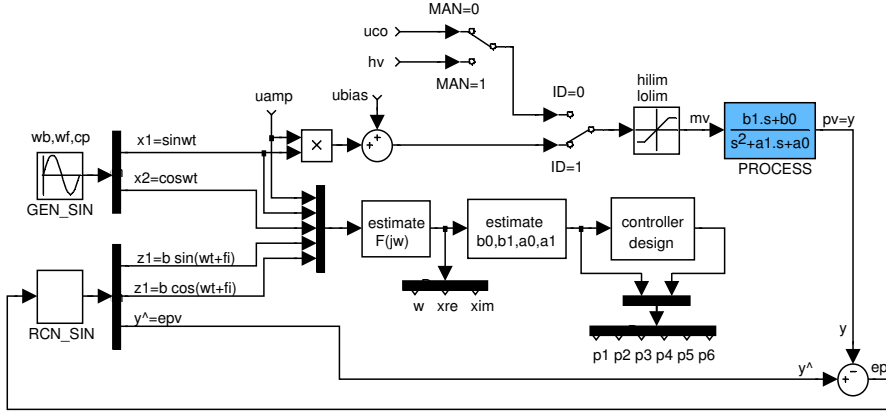
It is possible to terminate the identification experiment prematurely in case of necessity by the input **BRK** = **on**. If the two points of frequency response are already identified at that moment, the controller parameters are designed in a standard way. Otherwise the controller design cannot be 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.

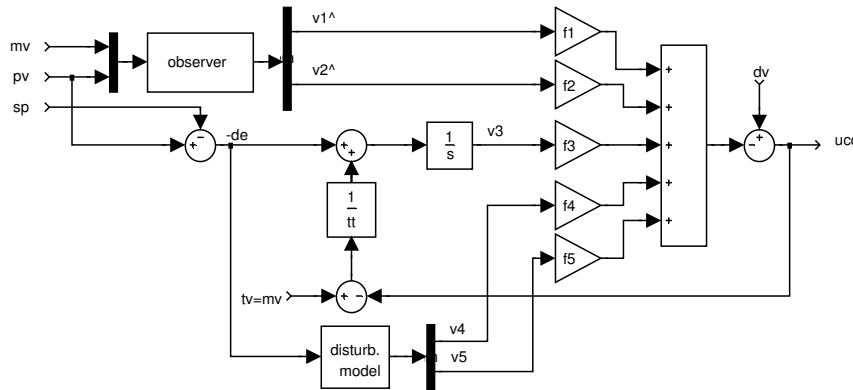
The computed state controller parameters are taken over by the control algorithm as soon as the **SETC** input is set to 1 (i.e. immediately if **SETC** is constantly set to **on**). The identified model and controller parameters can be obtained from the **p1**, **p2**, ..., **p6** outputs after setting 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 $f1, \dots, f5$ after identification experiment (and **SETC** = on).



The controlled system is assumed in the form of (7.4). Another forms of this transfer function are

$$F(s) = \frac{(b_1 s + b_0)}{s^2 + a_1 s + a_0} \quad (7.5)$$

and

$$F(s) = \frac{K_0 \Omega^2 (\tau s + 1)}{s^2 + 2\xi \Omega s + \Omega^2}. \quad (7.6)$$

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
sp	Setpoint variable	double
pv	Process variable	double
tv	Tracking variable	double
hv	Manual value	double
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

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
de	Deviation error	double
SAT	Saturation flag	bool
	off ... The controller implements a linear control law	
	on The controller output is saturated	
IDBSY	Identification running	bool
	off ... Identification not running	
	on Identification in progress	
w	Frequency response point estimate - frequency in rad/s	double
xre	Frequency response point estimate - real part	double
xim	Frequency response point estimate - imaginary part	double
epv	Reconstructed pv signal	double
IDE	Identification error indicator	bool
	off ... Successful identification experiment	
	on Identification error occurred	
iIDE	Error code	long
	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	
p1..p6	Results of identification and design phase	double

Parameters

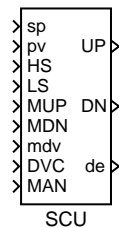
ubias	Static component of the exciting harmonic signal		double
uamp	Amplitude of the exciting harmonic signal	⊙1.0	double
wb	Frequency interval lower limit [rad/s]	⊙1.0	double
wf	Frequency interval upper limit [rad/s]	⊙10.0	double
isweep	Frequency sweeping mode	⊙1	long
	1 Logarithmic		
	2 Linear (not implemented yet)		
cp	Sweeping rate	↓0.5 ↑1.0 ⊙0.995	double
iavg	Number of values for averaging	⊙10	long
alpha	Relative positioning of the observer poles (in identification phase)	⊙2.0	double
xi	Observer damping coefficient (in identification phase)	⊙0.707	double
MANF	Manual frequency response points selection		bool
	off ... Disabled		
	on Enabled		
ph1	Phase delay of the 1st point in degrees	⊙-60.0	double

ph2	Phase delay of the 2nd point in degrees	⊙-120.
stime	Settling period [s]	⊙10.
ralpha	Relative positioning of the observer poles	⊙4.
rxl	Observer damping coefficient	⊙0.70
acl1	Relative positioning of the 1st closed-loop poles couple	⊙1.
xicl1	Damping of the 1st closed-loop poles couple	⊙0.70
INTGF	Integrator flag	⊙0.
	off ... State-space model without integrator	
	on Integrator included in the state-space model	
apcl	Relative position of the real pole	⊙1.0 double
DISF	Disturbance flag	bool
	off ... State space model without disturbance model	
	on Disturbance model is included in the state space model	
dom	Disturbance model natural frequency	⊙1.0 double
dxi	Disturbance model damping coefficient	double
acl2	Relative positioning of the 2nd closed-loop poles couple	⊙2.0 double
xicl2	Damping of the 2nd closed-loop poles couple	⊙0.707 double
tt	Tracking time constant	⊙1.0 double
hilim	Upper limit of the controller output	⊙1.0 double
lolim	Lower limit of the controller output	⊙-1.0 double
mb1p	Controlled system transfer function coefficient b_1	double
mb0p	Controlled system transfer function coefficient b_0	⊙1.0 double
ma1p	Controlled system transfer function coefficient a_1	⊙0.2 double
ma0p	Controlled system transfer function coefficient a_0	⊙1.0 double

SCU – Step controller with position feedback

Block Symbol

Licence: [STANDARD](#)



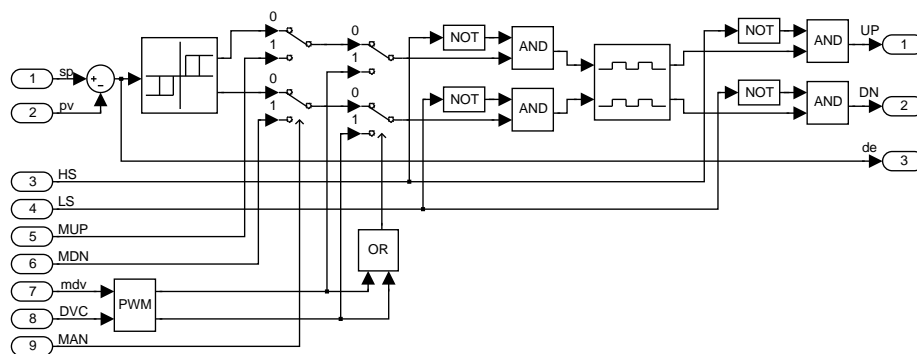
Function Description

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.

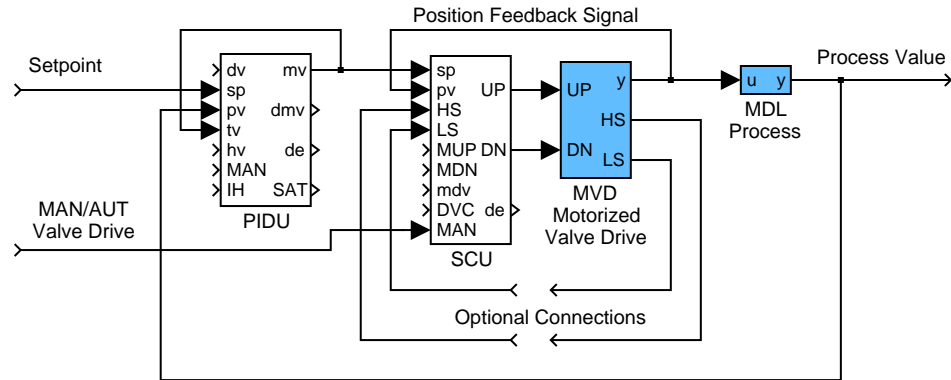
The **SCU** block processes the control deviation $sp - pv$ by a three state element with parameters (thresholds) **thron** and **throff** (see the **TSE** block, use parameters **ep** = **thron**, **epoff** = **throff**, **en** = **-thron** and **enoff** = **-throff**). The parameter **RACT** determines 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
pv	Controlled variable (position of the motorized valve drive)	double
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
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

Parameters

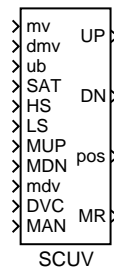
thron	Switch-on value	↓0.0 ⊕0.02	double
throff	Switch-off value	↓0.0 ⊕0.01	double
dtime	Minimum width of the output pulse [s]	↓0.0 ⊕0.1	double
btime	Minimum delay between two subsequent output pulses [s] to do	↓0.0 ⊕0.1	double
RACT	Reverse action flag off ... Higher mv → higher pv on Higher mv → lower pv		bool

<code>trun</code>	Motor time constant (determines the time during which the motor position changes by one unit)	<code>double</code>
		$\downarrow 0.0 \odot 10.0$

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 (**CW0I** = **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.

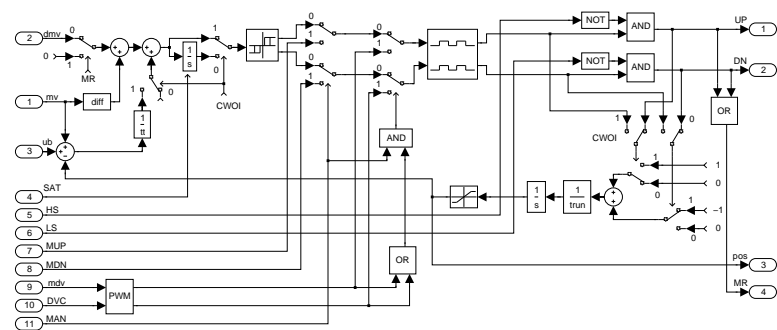
The position **pos** of the valve is estimated by an integrator with the time constant **trun**. If signals from high and low limit switches of the valve are available, they should be connected to the inputs **HS** and **LS**.

If the primary controller uses P or PD control law (**CW0I** = **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.

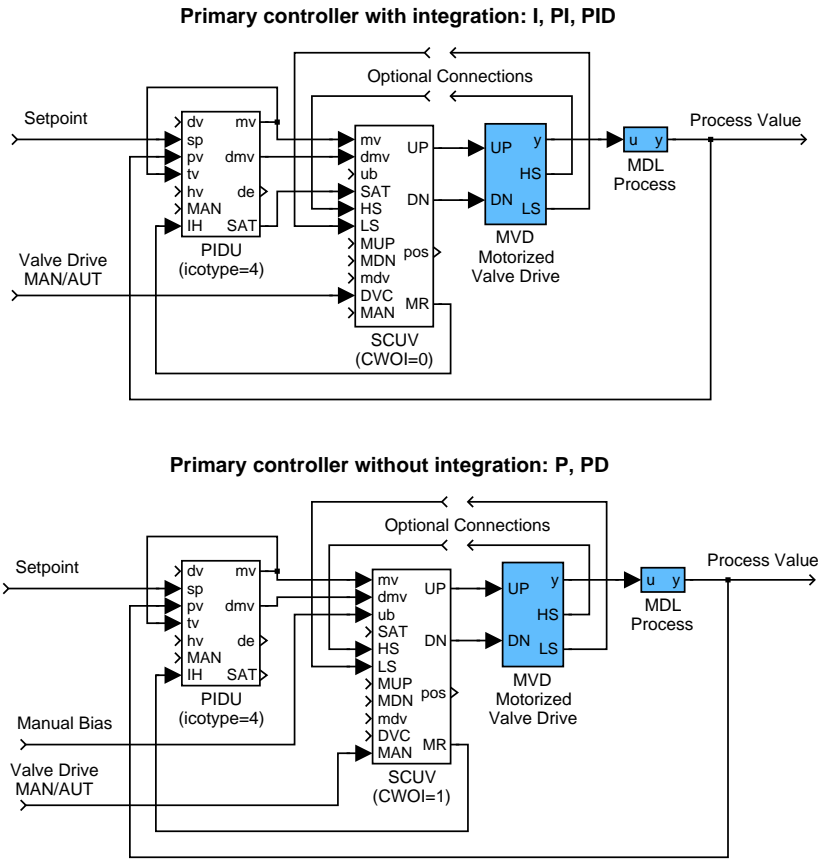
There is also a group of input signals for manual control available. The manual mode is activated by the **MAN** = **on** input signal. Then it is possible to move the motor back and forth by the **MUP** and **MDN** input signals. It is also possible to specify a position

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:



Inputs

mv	Manipulated variable (controller output)	double
dmv	Controller velocity output (difference)	double
ub	Bias (only for P or PD primary controller)	double

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
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
MR	Request to move the motor off ... Motor idle (UP = off and DN = off) on Request to move (UP = on or DN = on)	bool

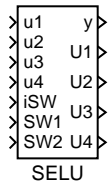
Parameters

thron	Switch-on value	↓0.0 ⊕0.02	double
throff	Switch-off value	↓0.0 ⊕0.01	double
dtime	Minimum width of the output pulse [s]	↓0.0 ⊕0.1	double
btime	Minimum delay between two subsequent output pulses [s]	↓0.0 ⊕0.1	double
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
CW0I	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

SELU – Controller selector unit

Block Symbol

Licence: [STANDARD](#)



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
iSW	Active signal selector in case of BINF = off	long
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
U1..U4	Binary output signal for selector control	bool

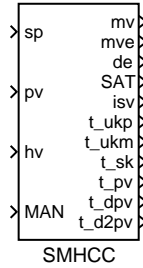
Parameter

BINF	Enable the binary selectors	bool
	off ... Disabled (analog selector)	
	on Enabled (binary selectors)	

SMHCC – Sliding mode heating/cooling controller

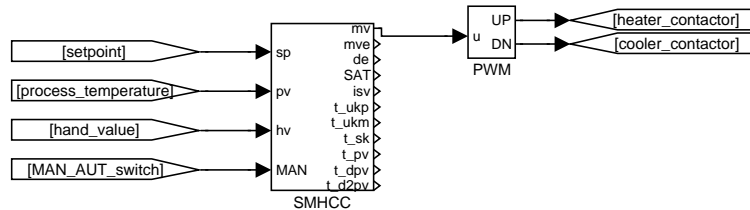
Block Symbol

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 $T_C = i_{pwm} T_S$ 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_{pwm} 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:

$$T_S = 0.1, \quad i_{pwmc} = 100, \quad T_C = 10s, \quad T_R = 0.01s.$$

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

$$s_k \triangleq \ddot{e}_k + 2\xi\Omega\dot{e}_k + \Omega^2 e_k$$

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

$$s \triangleq \ddot{e} + 2\xi\Omega\dot{e} + \Omega^2 e$$

is approximately equal to zero at any time. Therefore the control deviation behaves according to the second order differential equation

$$s \triangleq \ddot{e} + 2\xi\Omega\dot{e} + \Omega^2 e = 0$$

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

$$\text{if } (s_k < 0.0) \text{ then } mv = uk_p \text{ else } mv = -uk_m.$$

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
pv	process variable	double
hv	manual value	double
MAN	controller mode	bool
	0 automatic mode 1 manual mode	

Outputs

mv	manipulated variable (position controller output)	double
mve	equivalent manipulated variable	double
de	deviation error	double
SAT	saturation flag	bool
	0 the controller implements a linear control law	
	1 the controller output is saturated, $mv \geq hilim_p$ or $mv \leq -hilim_m$	
isv	number of the positive (+) or negative (–) sliding variable steps	long
t_ukp	current amplitude of heating	double
t_ukm	current amplitude of cooling	double
t_sk	discrete dynamic sliding variable s_k	double
t_pv	filtered control error -de	double
t_dpv	filtered first derivative of the control error t_ek	double
t_d2pv	filtered second derivative of the control error t_ek	double

Parameters

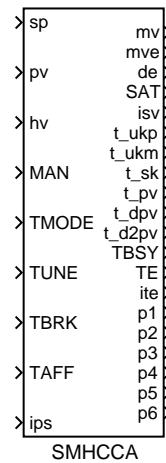
ipwmc	PWM cycle in the sampling periods of SMHCC (T_C/T_S)	long
xi	relative damping ξ of sliding zero dynamics $\xi \geq 0$	double

om	natural frequency Ω of sliding zero dynamics	$\downarrow(0.0)$	double
taup	time constant for adaptation of heating action amplitude in seconds		double
taum	time constant for adaptation of cooling action amplitude in seconds		double
beta	bandwidth parameter of the derivative filter	$\downarrow 0$	double
hilim_p	high limit of the heating action amplitude	$\downarrow 0.0 \uparrow 1.0$	double
hilim_m	high limit of the cooling action amplitude	$\downarrow 0.0 \uparrow 1.0$	double
u0_p	initial value of the heating action amplitude after setpoint change and start of the block		double
u0_m	initial value of the cooling action amplitude after setpoint change and start of the block		double
sp_dif	Setpoint difference threshold	$\odot 10.0$	double
tauf	Equivalent manipulated variable filter time constant	$\odot 400.0$	double

SMHCCA – Sliding mode heating/cooling controller with auto-tuner

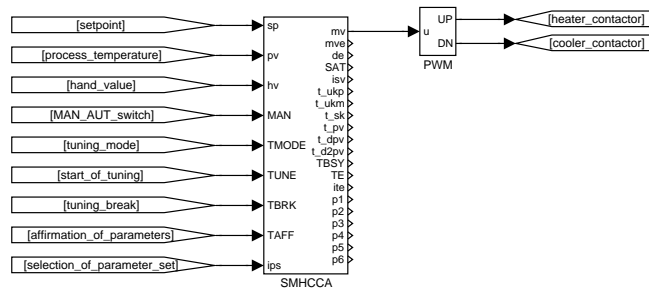
Block Symbol

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:

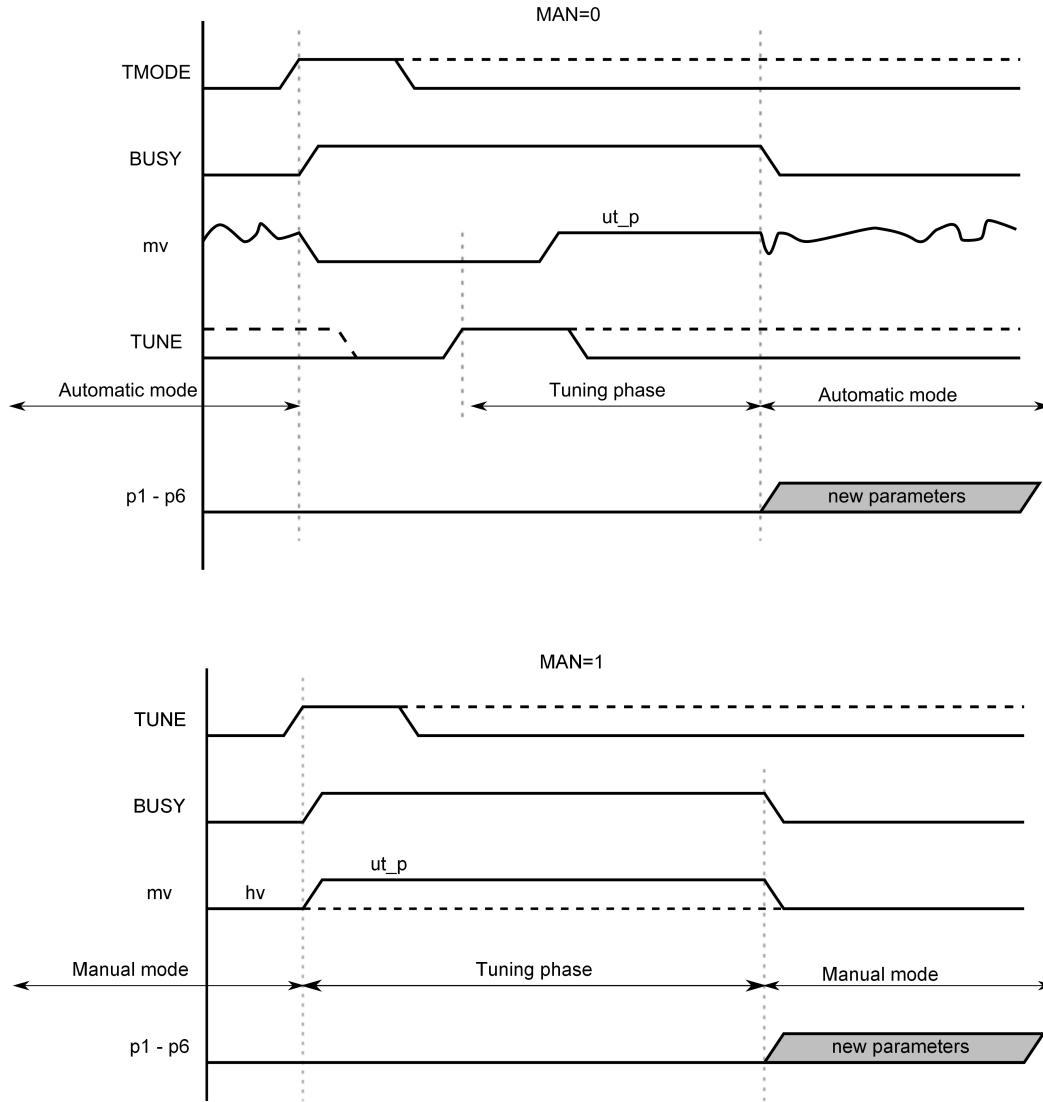
$$T_S = 0.1, \quad i_{pwmc} = 50, \quad T_C = 5s, \quad T_R = 0.1s.$$

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 ($MAN = \text{off}$) 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

$$s_k \triangleq \ddot{e}_k + 2\xi\Omega\dot{e}_k + \Omega^2 e_k$$

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 ($\mathbf{pv} - \mathbf{sp}$) 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

$$s \triangleq \ddot{e} + 2\xi\Omega\dot{e} + \Omega^2e$$

is approximately equal to zero at any time. Therefore the control deviation behaves according to the second order differential equation

$$s \triangleq \ddot{e} + 2\xi\Omega\dot{e} + \Omega^2e = 0$$

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

$$\text{if } (s_k < 0.0) \text{ then } \text{mv} = \text{uk_p} \text{ else } \text{mv} = -\text{uk_m}.$$

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 ($\text{MAN} = \text{on}$) the controller input h_v is (after limitation to the range $[-h_{lim_m}, h_{lim_p}]$) 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 τ_{auf} applied to mv .

Inputs

sp	Setpoint variable	double
pv	Process variable	double
h_v	Manual value	double
MAN	Manual or automatic mode	bool
	0 Automatic mode 1 Manual mode	
$TMODE$	Tuning mode	bool
$TUNE$	Start the tuning experiment: $TUNE \text{ off} \rightarrow \text{on}$	bool
$TBRK$	Stop the tuning experiment: $TBRK \text{ off} \rightarrow \text{on}$	bool
$TAFF$	Affirmation of the parameter set provided by the tuning procedure: $TAFF = \text{on}$	bool
ips	Meaning of the output signals p_1, \dots, p_6	long
	0 Controller parameters	
	$p_1 \dots$ recommended control period T_C	
	$p_2 \dots$ ξ	
	$p_3 \dots$ ω_m	
	$p_4 \dots$ τ_{aup}	
	$p_5 \dots$ τ_{aum}	
	$p_6 \dots$ τ_{auf}	
	1 Auxiliary parameters	
	$p_1 \dots$ h_{tp2} – time of the peak in the second derivative of pv	
	$p_2 \dots$ h_{peak2} – peak value in the second derivative of pv	
	$p_3 \dots$ d_2 – peak to peak amplitude of τ_{d2pv}	
	$p_4 \dots$ $tgain$	

Outputs

mv	Manipulated variable (controller output)	double
mve	Equivalent manipulated variable	double
de	Deviation error	double
SAT	Saturation flag	bool
	0 Signal not limited	
	1 Saturation limits active, $mv \geq h_{lim_p}$ or $mv \leq -h_{lim_m}$	
isv	Number of the positive (+) or negative (–) sliding variable steps	long
τ_{ukp}	Current amplitude of heating	double
τ_{ukm}	Current amplitude of cooling	double
τ_{sk}	Discrete dynamic sliding variable	double
τ_{pv}	Filtered process variable pv by 3rd order filter	double

t_dpv	Filtered first derivative of pv by 3rd order filter	double
t_d2pv	Filtered second derivative of pv by 3rd order filter	double
TBSY	Tuner busy flag (TBSY = on)	bool
TE	Tuning error	bool
	off ... Autotuning successful	
	on An error occurred during the experiment	
ite	Error code	long
	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)	
pi	Identified parameters with respect to ips , $i = 1, \dots, 6$	double

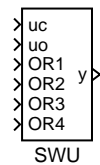
Parameters

ipwmc	PWM cycle (in sampling periods of the block, T_C/T_S)	⊙100	long
xi	Relative damping of sliding zero dynamics	↓0.5↑8.0⊙1.0	double
om	Natural frequency ω of sliding zero dynamics	↓0.0⊙0.01	double
taup	Time constant for adaptation of heating action amplitude [s]	⊙700.0	double
taum	Time constant for adaptation of cooling action amplitude [s]	⊙400.0	double
beta	Bandwidth parameter of the derivative filter	⊙0.01	double
hilim_p	Upper limit of the heating action amplitude	↓0.0↑1.0⊙1.0	double
hilim_m	Upper limit of the cooling action amplitude	↓0.0↑1.0⊙1.0	double
u0_p	Initial amplitude of the heating action	⊙1.0	double
u0_m	Initial amplitude of the cooling action	⊙1.0	double
sp_dif	Setpoint difference threshold for blocking of heating/cooling amplitudes reset	⊙10.0	double
tauf	Time constant of the filter for obtaining the equivalent manipulated variable	⊙400.0	double
itm	Tuning method	⊙1	long
	1 Restricted to symmetrical processes		
	2 Asymmetrical processes (not implemented yet)		
ut_p	Amplitude of heating for tuning experiment	↓0.0↑1.0⊙1.0	double
ut_m	Amplitude of cooling for tuning experiment	↓0.0↑1.0⊙1.0	double

SWU – Switch unit

Block Symbol

Licence: [STANDARD](#)



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**, **OR2**, **OR3** and **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
uo	This input is copied to output y when any of the binary inputs OR1 , OR2 , OR3 , OR4 is on	double
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
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TSE – **Three-state element**

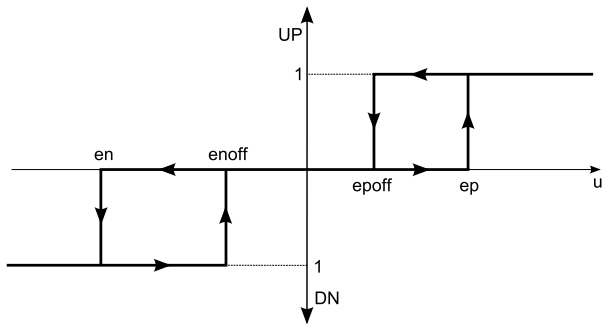
Block Symbol

Licence: [STANDARD](#)



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
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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
en	The input value u < en results in UP = off and DN = off	⊙-1.0	double
epoff	UP switch off value; if UP = on and u < epoff then UP = off	⊙0.5	double
enoff	DN switch off value; if DN = on and u > enoff then DN = off	⊙-0.5	double

Chapter 8

LOGIC – Logic control

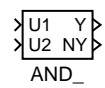
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AND_ – Logical product of two signals

Block Symbol

Licence: [STANDARD](#)



Function Description

The `AND_` block computes the logical product of two input signals `U1` and `U2`.
If you need to work with more input signals, use the [ANDOCT](#) block.

Inputs

<code>U1</code>	First logical input of the block	<code>bool</code>
<code>U2</code>	Second logical input of the block	<code>bool</code>

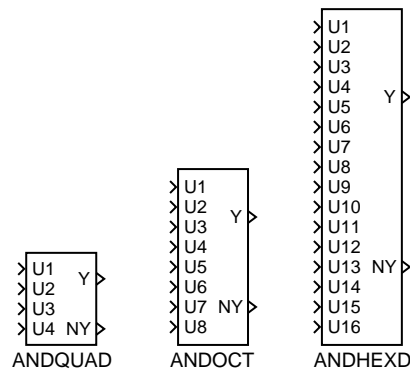
Outputs

<code>Y</code>	Output signal, logical product ($U1 \wedge U2$)	<code>bool</code>
<code>NY</code>	Boolean complementation of <code>Y</code> ($NY = \neg Y$)	<code>bool</code>

ANDQUAD, ANDOCT, ANDHEXD – Logical product of multiple signals

Block Symbols

Licence: [STANDARD](#)



Function Description

The **ANDQUAD**, **ANDOCT** and **ANDHEXD** blocks compute the logical product of up to sixteen input signals $U1, U2, \dots, U16$. The signals listed in the **n1** parameter are negated prior to computing the logical product.

For an empty **n1** parameter a simple logical product $Y = U1 \wedge U2 \wedge U3 \wedge U4 \wedge U5 \wedge U6 \wedge U7 \wedge U8$ is computed. For e.g. **n1=1,3..5,8**, the logical function is $Y = \neg U1 \wedge U2 \wedge \neg U3 \wedge \neg U4 \wedge \neg U5 \wedge U6 \wedge \dots U16$.

If you have less than 4/8/16 signals, use the **n1** parameter to handle the unconnected inputs. If you have only two input signals, consider using the [AND_](#) block.

Inputs

U1..U16	Logical inputs of the block	bool
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Outputs

Y	Result of the logical operation	bool
NY	Boolean complementation of Y	bool

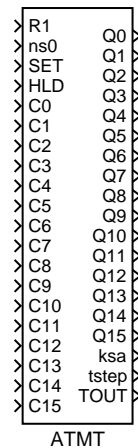
Parameter

n1	List of signals to negate. 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.	long
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ATMT – Finite-state automaton

Block Symbol

Licence: [STANDARD](#)



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 , $i = 0, 1, \dots, 15$ is indicated by the binary outputs $Q0, Q1, \dots, Q15$. If the state i is active, the corresponding output is set to $Qi=on$. The current state is also indicated by the **ksa** output ($ksa \in \{0, 1, \dots, 15\}$).

The transition conditions C_k , $k = 0, 1, \dots, 15$ are activated by the binary inputs $C0, C1, \dots, C15$. If $Ck = on$ the k -th transition condition is fulfilled. The transition cannot happen when $Ck = off$.

The automat function is defined by the following table of transitions:

$S1$	$C1$	$FS1$
$S2$	$C2$	$FS2$
		\dots
Sn	Cn	FSn

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 **moresteps** 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 REX Control System include also the **SFC**Editor program. You can create SFC schemes graphically using this tool. Run this editor from **RexDraw** by clicking the *Configure* button in the parameter dialog of the **ATMT** block.

Inputs

R1	Reset signal, R1 = on brings the automat to the initial state <i>S0</i> ; the R1 input overpowers the SET input	bool
ns0	This state is reached when rising edge occurs at the the SET input	long
SET	The rising edge of this signal forces the transition to the ns0 state	bool
HLD	The HLD = on freezes the automat, no transitions occur regardless of the input signals, tstep is not increasing	bool
C0...C15	The transition conditions; Ci = on means that the <i>i</i> -th condition was fulfilled and the corresponding transition rule can be executed	bool

Outputs

Q0...Q15	Output signals indicating the current state of the automat; the current state <i>i</i> is indicated by Qi = on	bool
ksa	Integer code of the active state	long
tstep	Time elapsed since the current state was reached; the timer is set to 0 whenever a state transition occurs	double
TOUT	Flag indicating that the time limit for the current state was exceeded	bool

Parameters

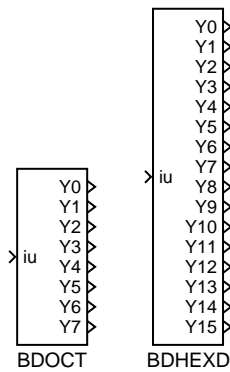
moresteps	Allow multiple transitions in one cycle of the automat off ... Disabled on Enabled	bool
ntr	Number of state transition table rows	↓0 ↑64 ⊙4 long

sfcname	Filename of block configurator data file (filename is generated by system if parameter is empty)	string
STT	State transition table (matrix) $\odot[0\ 0\ 1;\ 1\ 1\ 2;\ 2\ 2\ 3;\ 3\ 3\ 0]$	byte
touts	Vector of timeouts $TO0, TO1, \dots, TO15$ for the states $S0, S1, \dots, S15$ $\odot[1\ 2\ 3\ 4\ 5\ 6\ 7\ 8\ 9\ 10\ 11\ 12\ 13\ 14\ 15\ 16]$	double

BDOCT, BDHEXD – Bitwise demultiplexers

Block Symbols

Licence: [STANDARD](#)



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 Y_i correspond with the individual bits of the input signal i_u , the Y_0 output is the least significant bit.

Input

<code>iu</code>	Input signal to be decomposed	<code>long</code>
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Outputs

<code>Y0...Y15</code>	Individual bits of the input signal	<code>bool</code>
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Parameter

<code>shift</code>	Bit shift of the input signal	<code>↓0 ↑31</code> <code>long</code>
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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).

Inputs

i1	First integer input of the block	long
i2	Second integer input of the block	long

Output

n	Result of the bitwise operation iop	long
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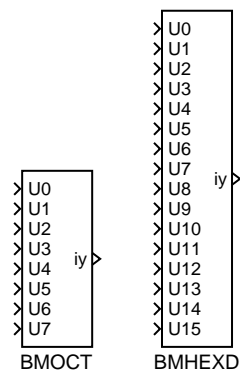
Parameter

iop	Bitwise operation	⊙1	long
1 Bitwise negation (Bit NOT)		
2 Bitwise logical sum (Bit OR)		
3 Bitwise logical product (Bit AND)		
4 Bitwise logical exclusive sum (Bit XOR)		
5 Shift of the i1 signal by i2 bits to the left (Shift Left)		
6 Shift of the i1 signal by i2 bits to the right (Shift Right)		
7 2's complement of the i1 signal on 8 bits (2's Complement - Byte)		
8 2's complement of the i1 signal on 16 bits (2's Complement - Word)		
9 2's complement of the i1 signal on 32 bits (2's Complement - Long)		

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. The input signals U_i correspond with the individual bits of the output signal iy , the **U0** input is the least significant bit.

Inputs

$U0 \dots U15$	Individual bits of the output signal	bool
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Output

iy	Composed output signal	long
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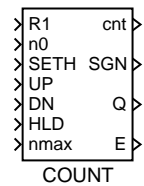
Parameter

shift	Bit shift of the output signal	$\downarrow 0 \uparrow 31$ long
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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 $\text{cnt} \geq \text{nmax}$, the **Q** output is set to **on**.

Inputs

R1	Block reset (R1 = on)	bool
n0	Value to set the counter to (using the SETH input)	long
SETH	Set the counter value to n0 (SETH = on)	bool
UP	Incrementing input signal	bool
DN	Decrementing input signal	bool
HLD	Counter freeze	bool
	off ... Counter is running	
	on Counter is locked	
nmax	Counter target value	long

Outputs

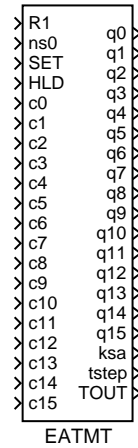
cnt	Total number of pulses	long
SGN	Sign of the cnt output	bool
	off ... for $\text{cnt} \leq 0$	
	on for $\text{cnt} > 0$	

Q	Target value indicator	bool
	off ... for cnt < nmax	
	on for cnt ≥ nmax	
E	Indicator of simultaneous occurrence of rising edges at both inputs UP and DN	bool

EATMT – Extended finite-state automaton

Block Symbol

Licence: [ADVANCED](#)



Function Description

The **EATMT** block implements a finite automaton with at most 256 states and 256 transition rules, thus it extends the possibilities of the **ATMT** block.

The current state of the automaton i , $i = 0, 1, \dots, 255$ is indicated by individual bits of the integer outputs $q0, q1, \dots, q15$. Only a single bit with index $i \text{ MOD } 16$ of the $q(i \text{ DIV } 16)$ 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 $ksa \in \{0, 1, \dots, 255\}$ output.

The transition conditions C_k , $k = 0, 1, \dots, 255$ are activated by individual bits of the inputs $c0, c1, \dots, c15$. The k -th transition condition is fulfilled when the $(k \text{ MOD } 16)$ -th bit of the input $c(k \text{ DIV } 16)$ is equal to 1. The transition cannot happen otherwise.

The **BMHEXD** or **BMOCT** bitwise multiplexers can be used for composition of the input signals $c0, c1, \dots, c15$ from individual Boolean signals. Similarly the output signals $q0, q1, \dots, q15$ can be decomposed using the **BDHEXD** or **BDOCT** bitwise demultiplexers.

The automaton function is defined by the following table of transitions:

$S1$	$C1$	$FS1$
$S2$	$C2$	$FS2$
		\dots
Sn	Cn	FSn

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 **moresteps** 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 REX Control System include also the **SFCEditor** program. You can create SFC schemes graphically using this tool. Run this editor from **RexDraw** by clicking the *Configure* button in the parameter dialog of the **EATMT** block.

Inputs

R1	Reset signal, R1 = on brings the automat to the initial state $S0$; the R1 input overpowers the SET input	bool
ns0	This state is reached when rising edge occurs at the the SET input	long
SET	The rising edge of this signal forces the transition to the ns0 state	bool
HLD	The HLD = on freezes the automat, no transitions occur regardless of the input signals, tstep is not increasing	bool
c0...c15	Transition conditions, each input signal contains 16 transition conditions, see details above	

Outputs

q0...q15	Output signals indicating the current state of the automat, see details above	long
ksa	Integer code of the active state	long
tstep	Time elapsed since the current state was reached; the timer is set to 0 whenever a state transition occurs	double
TOUT	Flag indicating that the time limit for the current state was exceeded	bool

Parameters

moresteps	Allow multiple transitions in one cycle of the automat off ... Disabled on Enabled	bool
ntr	Number of state transition table rows	$\downarrow 0 \uparrow 1024 \odot 4$ long
sfcname	Filename of block configurator data file (filename is generated by system if parameter is empty)	string
STT	State transition table (matrix)	$\odot [0 \ 0 \ 1; \ 1 \ 1 \ 2; \ 2 \ 2 \ 3; \ 3 \ 3 \ 0]$ short
touts	Vector of timeouts T00, T01, ..., T0255 for the states S_0, S_1, \dots, S_{255}	$\odot [1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ 9 \ 10 \ 11 \ 12 \ 13 \ 14 \ 15 \ 16]$ double

EDGE_ – Falling/rising edge detection in a binary signal

Block Symbol

Licence: [STANDARD](#)



Function Description

The **EDGE_** block detects rising (**off**→**on**) and/or falling (**on**→**off**) edges in the binary input signal **U**. The type of edges to detect is determined by the **iedge** parameter. As long as the input signal remains constant, the output **Y** is **off**. In the case when an edge corresponding with the **iedge** parameter is detected, the output **Y** is set to **on** for one sampling period.

Input

U	Logical input of the block	bool
----------	----------------------------	------

Output

Y	Logical output of the block	bool
----------	-----------------------------	------

Parameter

iedge	Type of edges to detect	⊙1 long
	1 Rising edge	
	2 Falling edge	
	3 Both edges	

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.

Input

<code>i</code>	Integer value to shift and mask	<code>long</code>
----------------	---------------------------------	-------------------

Parameters

<code>shift</code>	Bit shift (negative=left, positive=right)	<code>↓-31 ↑31</code>	<code>long</code>
<code>mask</code>	Bit mask (applied after bit shift)	<code>↓XXX ↑XXX ⊙XXX</code>	<code>dword</code>

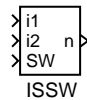
Output

<code>n</code>	Resulting integer value	<code>long</code>
----------------	-------------------------	-------------------

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.

Inputs

i1	First integer input of the block	long
i2	Second integer input of the block	long
SW	Signal selector	bool
	off ... The i1 signal is selected	
	on The i2 signal is selected	

Output

n	Integer output of the block	long
----------	-----------------------------	------

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.

Input

i	Integer value to shift and mask	long
----------	---------------------------------	------

Parameters

shift	Bit shift (negative=left, positive=right)	↓-31 ↑31	long
mask	Bit mask (applied after bit shift)	↓XXX ↑XXX ⊙XXX	dword

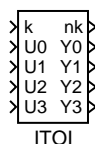
Output

n	Resulting integer value	long
----------	-------------------------	------

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 $\{0, 1, 2, \dots, 15\}$ 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 $n0, \dots, n15$ 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 $(U3\ U2\ U1\ U0)_2$.

Inputs

k	Integer input of the block	long
$U0$	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

Outputs

nk	Integer output of the block	long
$Y0$	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

Parameters

BINF	Enable the binary selectors	on bool
	off ... Disabled (integer input k)	
	on Enabled (binary input signals $U3 \dots U0$)	

<code>fktab</code>	Vector of mapping table target values	<code>byte</code>
	\odot [0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15]	

NOT_ – Boolean complementation

Block Symbol

Licence: [STANDARD](#)



Function Description

The NOT block negates the input signal.

Input

U	Logical input of the block	bool
---	----------------------------	------

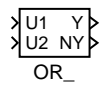
Output

Y	Logical output of the block ($Y = \neg U$)	bool
---	--	------

OR_ – Logical sum of two signals

Block Symbol

Licence: [STANDARD](#)



Function Description

The **OR** block computes the logical sum of two input signals **U1** and **U2**.
If you need to work with more input signals, use the [OROCT](#) block.

Inputs

U1	First logical input of the block	bool
U2	Second logical input of the block	bool

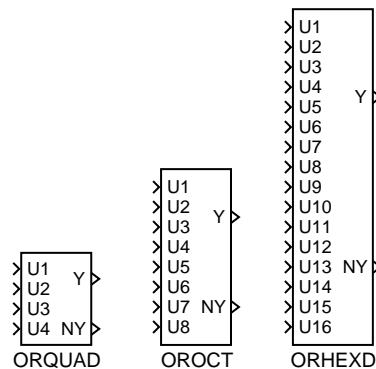
Outputs

Y	Logical output of the block ($U1 \vee U2$)	bool
NY	Boolean complementation of Y ($NY = \neg Y$)	bool

ORQUAD, OROCT, ORHEXD – Logical sum of multiple signals

Block Symbols

Licence: [STANDARD](#)



Function Description

The **ORQUAD**, **OROCT** and **ORHEXD** blocks compute the logical sum of up to sixteen input signals $U1, U2, \dots, U16$. The signals listed in the **n1** parameter are negated prior to computing the logical sum.

For an empty **n1** parameter a simple logical sum $Y = U1 \vee U2 \vee U3 \vee U4 \vee U5 \vee U6 \vee U7 \vee \dots \vee U16$ is computed. For e.g. **n1**=1,3..5, the logical function is $Y = \neg U1 \vee U2 \vee \neg U3 \vee \neg U4 \vee \neg U5 \vee U6 \vee \dots \vee U16$.

If you have only two input signals, consider using the [OR_](#) block.

Inputs

U1..U16	Logical inputs of the block	bool
----------------	-----------------------------	-------------

Outputs

Y	Result of the logical operation	bool
NY	Boolean complementation of Y	bool

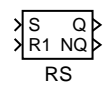
Parameter

n1	List of signals to negate. 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.	long
-----------	--	-------------

RS – Reset-set flip-flop circuit

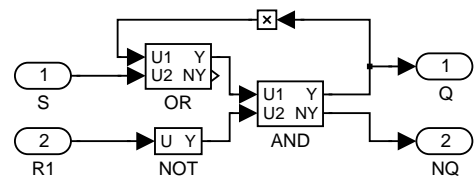
Block Symbol

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.



Inputs

S	Flip-flop set, sets the Q output to on	bool
R1	Priority flip-flop reset, sets the Q output to off, overpowers the S input	bool

Outputs

Q	Flip-flop circuit state	bool
NQ	Boolean complementation of Q	bool

SR – Set-reset flip-flop circuit

Block Symbol

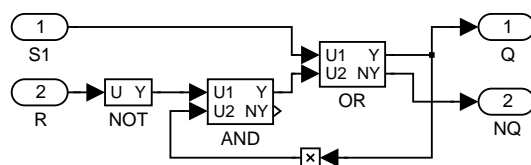
Licence: [STANDARD](#)



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.



Inputs

S1	Priority flip-flop set, sets the Q output to on , overpowers the R input	bool
R	Flip-flop reset, sets the Q output to off	bool

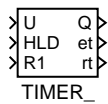
Outputs

Q	Flip-flop circuit state	bool
NQ	Boolean complementation of Q	bool

TIMER_ – Multipurpose timer

Block Symbol

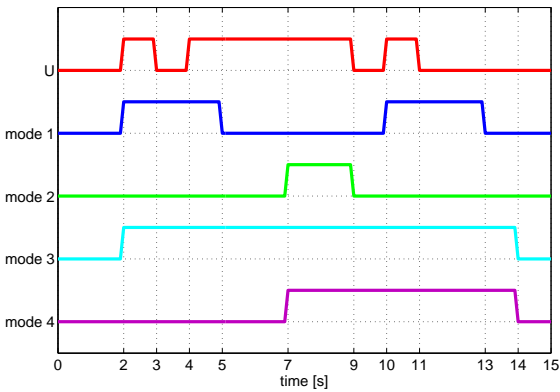
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Function Description

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. The timer can be paused by the `HLD` input.

The graph illustrates the behaviour of the block in individual modes for `pt = 3`:



Inputs

U	Trigger of the timer	bool
HLD	Timer hold	bool

Outputs

Q	Timer output	bool
et	Elapsed time [s]	double

Parameters

<code>mode</code>	Timer mode	⊙1	<code>long</code>
1 Pulse – an output pulse of the length <code>pt</code> is generated upon rising edge at the <code>U</code> input. All input pulses during the generation of the output pulse are ignored.		
2 Delayed ON – the input signal <code>U</code> is copied to the <code>Q</code> output, but the start of the pulse is delayed by <code>pt</code> seconds. Any pulse shorter than <code>pt</code> is does not pass through the block.		
3 Delayed OFF – the input signal <code>U</code> is copied to the <code>Q</code> output, but the end of the pulse is delayed by <code>pt</code> seconds. If the break between two pulses is shorter than <code>pt</code> , the output remains <code>on</code> for the whole time.		
4 Delayed change – the <code>Q</code> output is set to the value of the <code>U</code> input no sooner than the input remains unchanged for <code>pt</code> seconds		
<code>pt</code>	Timer interval [s]	⊙1.0	<code>double</code>

Chapter 9

TIME – Blocks for handling time

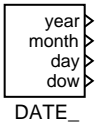
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DATE_ – Current date

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

<code>year</code>	Year	<code>long</code>
<code>month</code>	Month	<code>long</code>
<code>day</code>	Day	<code>long</code>
<code>dow</code>	Day of week, first day of week is Sunday (1)	<code>long</code>

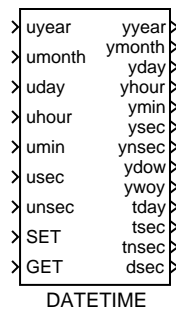
Parameter

<code>tz</code>	Timezone	<code>⊙1</code>	<code>long</code>
	1 Local time		
	2 UTC		

DATETIME – Get, set and convert time

Block Symbol

Licence: [STANDARD](#)



Function Description

The **DATETIME** block is intended for advanced date/time operations in the REX control system.

It allows synchronization of the operating system clock and the clock of the REX control system. When the executive of the REX control 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 REX control system according to the block inputs and parameters.

It is highly recommended not to adjust the REX control 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 REX control system is not adjusted at once, a gradual synchronization is used instead. In such a case, the timing of the REX control system executive is negligibly altered and the clocks synchronization is achieved after some time. Afterwards the timing of the REX 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
umonth	Input for setting month	long

<code>u day</code>	Input for setting day		long
<code>u hour</code>	Input for setting hours		long
<code>u min</code>	Input for setting minutes		long
<code>u sec</code>	Input for setting seconds		long
<code>u nsec</code>	Input for setting nanoseconds	$\downarrow -9,22\text{E}+18$ $\uparrow 9,22\text{E}+18$	large
<code>SET</code>	Trigger for setting time		bool
<code>GET</code>	Trigger for getting time		bool

Outputs

<code>y year</code>	Year		long
<code>y month</code>	Month		long
<code>y day</code>	Day		long
<code>y hour</code>	Hours		long
<code>y min</code>	Minutes		long
<code>y sec</code>	Seconds		long
<code>y nsec</code>	Nanoseconds		long
<code>y dow</code>	Day of week		long
<code>y woy</code>	Week of year		long
<code>t day</code>	Total number of days		long
<code>t sec</code>	Total number of seconds		long
<code>t nsec</code>	Total number of nanoseconds		large
<code>d sec</code>	Number of seconds since midnight		long

Parameters

<code>isetmode</code>	Source for setting time	$\odot 1$	long
	1 OS clock		
	2 Block inputs		
	3 The <code>u nsec</code> input		
	4 The <code>u sec</code> input		
	5 The <code>u nsec</code> input, relative		
<code>igetmode</code>	Source for getting or converting time	$\odot 6$	long
	1 OS clock		
	2 Block inputs		
	3 The <code>u nsec</code> input		
	4 The <code>u sec</code> input		
	5 The <code>u day</code> input		
	6 REX clock		
<code>settol</code>	Tolerance for setting the REX clock [s]	$\odot 1.0$	double
<code>setper</code>	Period for setting time [s] (0=not periodic)		double
<code>getper</code>	Period for getting time [s] (0=not periodic)	$\odot 0.001$	double
<code>FDOW</code>	First day of week is Sunday		bool
	off Week starts on Monday		
	on Week starts on Sunday		

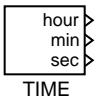
tz Timezone
 1 Local time
 2 UTC

⊙1 long

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
min	Minutes	long
sec	Seconds	long

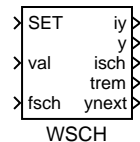
Parameter

tz	Timezone	⊕1	long
	1		Local time
	2		UTC

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

<code>SET</code>	Trigger for setting the <code>y</code> and <code>iy</code> outputs	<code>bool</code>
<code>val</code>	Temporary value to set the <code>y</code> and <code>iy</code> outputs to	<code>double</code>
<code>fsch</code>	Forced schedule	<code>long</code>
	0 standard weekly schedule	
	1 Monday	
	2 Tuesday	
	
	7 Sunday	
	8 and above additional daily programs as defined by the <code>wst</code> table	

Outputs

<code>iy</code>	Integer output value	<code>long</code>
<code>y</code>	Output value	<code>double</code>
<code>isch</code>	Daily schedule identifier	<code>long</code>
<code>trem</code>	Time remaining in the current section (in seconds)	<code>double</code>
<code>ynext</code>	Output in the next section	<code>double</code>

Parameters

<code>tz</code>	Timezone	⊙1	<code>long</code>
	1 Local time		
	2 UTC		
<code>nmax</code>	Allocated size of arrays	↓10 ↑1000000 ⊙100	<code>long</code>
<code>wst</code>	Weekly schedule table (list of triplets <i>day-hour-value</i>)		<code>double</code>
	⊙[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		
<code>specdays</code>	List of special days (list of pairs <i>date-daily program</i>)		<code>long</code>
	⊙[20150406 1; 20151224 1; 20151225 1; 20151226 1; 20160101 1; 20160328 1; 20170		

Chapter 10

ARC – Data archiving

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The RexCore executive of the REX Control 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 REX Control 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 REX Control 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).

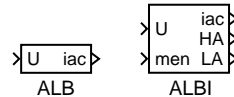
Disk archive The disk archives are files in a proprietary binary format. The files are easily transferrable among individual platforms and the main advantage is the size, which is limited only by the capacity of the storage medium. On the other hand, the drawback is the relatively slow data access.

Not all hardware platforms support all types of archives. The individual types which are supported by the platform can be displayed in the **RexDraw** program after clicking on the name (IP address) of the target device in the tree view panel. 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 **lv1** parameter in the REX Control System. The range $1 \leq lv1 \leq 127$ is reserved for alarms. All starts, ends and acknowledgements of the alarms are stored in the archive. On the contrary, the range $128 \leq lv1 \leq 255$ indicates events. Only the start (the time instant) of the event is stored in the archive.

Inputs

U	Logical input of the block whose changes are watched	bool
men	Enable alarms	long
	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	
iACK	Acknowledge alarm	byte
	1 Low-alarm acknowledge	
	2 High-alarm acknowledge	
	3 Both alarms acknowledge	
	Alarm is acknowledged on rising edge	

Outputs

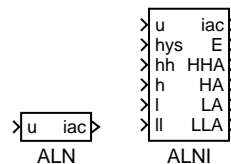
<code>iac</code>	Current alarm code	<code>long</code>
	0 All alarms inactive	
	1 Low-alarm active (LA)	
	2 High-alarm active (HA)	
	256 ... Low-alarm not acknowledged (NACK)	
	512 ... High-alarm not acknowledged (NACK)	
<code>HA</code>	High-alarm indicator	<code>bool</code>
<code>LA</code>	Low-alarm indicator	<code>bool</code>
<code>NACK</code>	Alarm-not-acknowledged indicator	<code>bool</code>

Parameters

<code>arc</code>	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.	<code>word</code>
<code>id</code>	Identification code of the alarm in the archive. This identifier must be unique in the whole target device with the REX control system (i.e. in all archiving blocks). $\odot 1$	<code>word</code>
<code>lvl</code>	The level of the alarms (HA and LA) which differentiates alarms from events and defines the severity of the alarm/event $\downarrow 1 \odot 1$	<code>byte</code>
<code>Desc</code>	Extended description of the alarm which is displayed by the diagnostic tools of the REX control system \odot Alarm Description	<code>string</code>

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 *lv1* parameter in the REX Control System. The range $1 \leq lv1 \leq 127$ is reserved for alarms. All starts, ends and acknowledgements of the alarms are stored in the archive. On the contrary, the range $128 \leq lv1 \leq 255$ indicates events. Only the start (the time instant) of the event is stored in the archive.

Inputs

<i>u</i>	Analog input of the block which is checked to remain within the given limits	double
<i>hys</i>	Alarm hysteresis for switching the alarm off	$\downarrow 0.0 \uparrow 10000000000.0$ double
<i>hh</i>	The second high-alarm limit, must be greater than <i>h</i>	double
<i>h</i>	High-alarm limit, must be greater than <i>l</i>	double
<i>l</i>	Low-alarm limit, must be greater than <i>ll</i>	double
<i>ll</i>	The second low-alarm limit	double
<i>iACK</i>	Alarm is acknowledged on rising edge of the individual bits of this input/parameter. E.g. value 15 acknowledges all alarms.	
byte		
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 `lv12=0` or set the `hh` and `ll` limits to extreme values which can never be reached by the input signal.

Outputs

<code>iac</code>	Current alarm code. Additional bitwise combinations of the codes may appear. E.g. 12 means both high alarms.	<code>long</code>
	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	
<code>E</code>	Error flag	<code>bool</code>
	off ... No error	
	on ... An error occurred, alarm limits disordered	
<code>HHA</code>	The second high-alarm indicator	<code>bool</code>
<code>HA</code>	High-alarm indicator	<code>bool</code>
<code>LA</code>	Low-alarm indicator	<code>bool</code>
<code>LLA</code>	The second low-alarm indicator	<code>bool</code>
<code>NACK</code>	Alarm-not-acknowledged indicator	<code>bool</code>

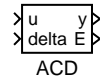
Parameters

<code>acIs</code>	Alarm class (data type to store)	$\odot 8$ <code>byte</code>
	1 Bool 4 Long 7 Float	
	2 Byte 5 Word 8 Double	
	3 Short 6 DWord 9 Time	
<code>arc</code>	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.	<code>word</code>
<code>id</code>	Identification code of the alarm in the archive. This identifier must be unique in the whole target device with the REX control system (i.e. in all archiving blocks).	<code>word</code>
<code>lv11</code>	The level of first high- and low-alarms (<code>HA</code> and <code>LA</code>) which differentiates alarms from events and defines the severity of the alarm/event	<code>byte</code>
	$\downarrow 1 \odot 1$	
<code>lv12</code>	The level of second high- and low-alarms (<code>HHA</code> and <code>LLA</code>) which differentiates alarms from events and defines the severity of the alarm/event	<code>byte</code>
	$\downarrow 1 \odot 10$	
<code>Desc</code>	Extended description of the alarm which is displayed by the diagnostic tools of the REX control system	<code>string</code>
	\odot Alarm Description	

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.

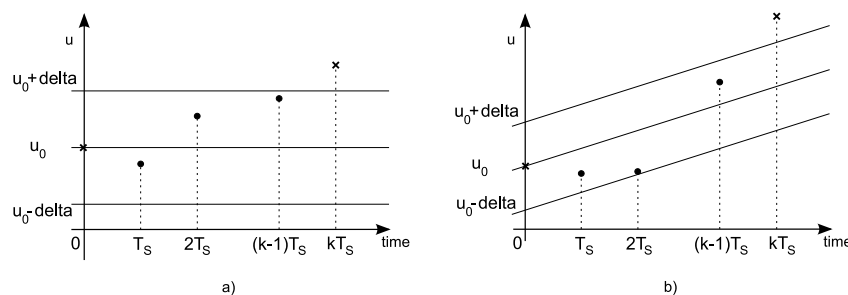
The main idea is to store the input signal **u** only when it changes significantly. The interval between two samples is in the range $\langle \mathbf{tmin}, \mathbf{tmax} \rangle$ seconds (rounded to the nearest multiple of the sampling period). A constant input signal is stored every **tmax** seconds 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 $|u - u_0| > \mathbf{delta}$ 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 \times .



Inputs

u	Signal to compress and store	double
delta	Threshold for storing the signal	↓0.0 ↑10000000000.0 double

Outputs

y	The last value stored in the archive	double
E	Error flag – indicates that a significant change in the input signal occurred sooner than the tmin interval passes	bool
	off ... No error	
	on An error occurred	

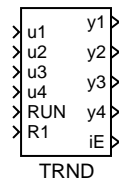
Parameters

acls	Archive class determining the variable type to store	⊙8	byte
	1 Bool 4 Long 7 Float		
	2 Byte 5 Word 8 Double		
	3 Short 6 DWord 9 Time		
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
id	Identification code of the event in the archive. This identifier must be unique in the whole target device with the REX control system (i.e. in all archiving blocks).	⊙1	word
tmin	The shortest interval between two samples of the u input signal stored in the archive [s]	↓0.001 ↑1000000.0 ⊙1.0	double
tmax	The longest interval between two samples of the u input signal stored in the archive [s]	↓1.0 ↑1000000.0 ⊙1000.0	double
TR	Trend evaluation flag	⊙on	bool
	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		
Desc	Extended description of the event which is displayed by the diagnostic tools of the REX control 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 1 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 **p1type** to **p4type** 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 $s \cdot n \cdot l$, where s is the size of the corresponding variable in bytes. The default type **Double** consumes 8 bytes per sample, thus for storing $n = 4$ trends of this type and length $l = 1000$, $8 \cdot 4 \cdot 1000 = 32000$ 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 14 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 RexView diagnostic program.

Inputs

u1..u4	Analog inputs to be processed and stored in the trend	double
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
iE	Error code, see the table above	long

Parameters

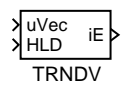
n	Number of signals to process and store in the trend buffers	long ↓1 ↑4 ⊙4
l	Number of samples reserved in memory for each trend buffer	long ↓0 ↑268435000 ⊙1000
btype	Type of all n trend buffers	⊙8 long
	1 Bool 4 Long 7 Float 2 Byte 5 Word 8 Double 3 Short 6 DWord 10 Large	
pptypei	The way the signal u_i , $i = 1 \dots 4$, is processed. The last pfac samples are processed as selected and the result is stored in the i -th trend buffer.	long ⊙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	
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 $\text{pfac} \cdot T_S$ unless RUN = off , where T_S is the block execution period in seconds.	long ↓1 ↑1000000 ⊙1
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 $\text{afac} \cdot \text{pfac} \cdot T_S$, where T_S is the block execution period in seconds.	long ↓0 ↑1000000

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
id	Identification code of the trend block. This identifier must be unique in the whole target device with the REX control system (i.e. in all archiving blocks). ☉1	word
Title	Title of the trend to be displayed in the diagnostic tools of the REX Control System, e.g. in the RexView program ☉Trend Title	string
timesrc	Source of timestamps. Each data sample in 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 – REX internal technological time which is incremented by nominal period each base tick. For long running trends where you are interested mostly in absolute time shared with operating system (and possibly synchronized by NTP), choose RTC . Other values are intended for debug or special purposes. ☉1 <ul style="list-style-type: none"> 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) 	long

TRNDV – Real-time trend recording with vector input

Block Symbol

Licence: [STANDARD](#)



Function Description

The **TRND** 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 1 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 $s \cdot n \cdot 1$, 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. **n** = 4 trends of this type and length 1 = 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 14 of this reference guide.

It is possible to read, display and export the stored data by the **RexView** diagnostic program.

Inputs

uVec	Vector signal to record	reference
HLD	Input for freezing the cyclic buffers, no data is appended when HLD = on	bool

Output

iE	Error code	error
	i REX general error	

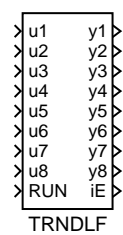
Parameters

n	Number of signals (trend buffers)	$\downarrow 1 \uparrow 64 \odot 8$	long
l	Number of samples per trend buffer	$\downarrow 2 \uparrow 268435000 \odot 1000$	long
btype	Type of all trend buffers	$\odot 8$	long
	1 Bool 4 Long 7 Float		
	2 Byte 5 Word 8 Double		
	3 Short 6 DWord 10 Large		
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 $\text{pfac} \cdot T_S$ unless <code>RUN = off</code> , where T_S is the block execution period in seconds.	$\downarrow 1 \uparrow 1000000 \odot 1$	long
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 $\text{afac} \cdot \text{pfac} \cdot T_S$, where T_S is the block execution period in seconds.	$\downarrow 0 \uparrow 1000000$	long
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
id	Identification code of the trend block. This identifier must be unique in the whole target device with the REX control system (i.e. in all archiving blocks).	$\odot 1$	word
Title	Title of the trend to be displayed in the diagnostic tools of the REX Control System, e.g. in the RexView program	$\odot \text{Trend Title}$	string

TRNDLF – * **Real-time trend recording (lock-free)**

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

u1	First analog input of the block	double
u2	Second analog input of the block	double
u3	Third analog input of the block	double
u4	Fourth analog input of the block	double
u5	Fifth analog input of the block	double
u6	Sixth analog input of the block	double
u7	Seventh analog input of the block	double
u8	Eighth analog input of the block	double
RUN	Enable execution	bool

Parameters

n	Number of signals (trend buffers)	↓1 ↑8 ⊙8	long
1	Number of samples per trend buffer	↓0 ↑268435000 ⊙1024	long

btype	Type of all trend buffers	⊙8	long
	1 Bool		
	2 Byte		
	3 Short		
	4 Long		
	5 Word		
	6 DWord		
	7 Float		
	8 Double		
	--		
	10 Large		
Title	Trend title string	⊙Trend Title	string
timesrc	Source of timestamps	⊙1	long

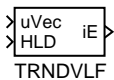
Outputs

y1	First analog output of the block	double
y2	Second analog output of the block	double
y3	Third analog output of the block	double
y4	Fourth analog output of the block	double
y5	Fifth analog output of the block	double
y6	Sixth analog output of the block	double
y7	Seventh analog output of the block	double
y8	Eighth analog output of the block	double
iE	Error code (bitwise multiplexed)	long

TRNDVLF – * Real-time trend recording (for vector signals, lock-free)

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

uVec	Vector signal to record	reference
HLD	Hold	bool

Parameters

n	Number of signals (trend buffers)	↓1 ↑64 ⊙8	long
l	Number of samples per trend buffer	↓2 ↑268435000 ⊙1024	long
btype	Type of all trend buffers	⊙8	long
	1 Bool		
	2 Byte		
	3 Short		
	4 Long		
	5 Word		
	6 DWord		
	7 Float		
	8 Double		
	--		
	10 Large		
Title	Trend title string	⊙Trend Title	string
timesrc	Source of timestamps	⊙1	long

Output

iE	Error code	error
	i REX general error	

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
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Chapter 11

STRING – Blocks for string operations

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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

<code>scv</code>	String (constant) value	<code>string</code>
<code>nmax</code>	Allocated size of string [bytes]	$\downarrow 0 \uparrow 65520$ <code>long</code>

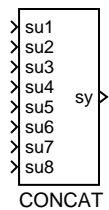
Output

<code>sy</code>	String output value	<code>string</code>
-----------------	---------------------	---------------------

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

<code>su1..8</code>	String input value	<code>string</code>
---------------------	--------------------	---------------------

Parameters

<code>ptrn</code>	Concatenation pattern	<code>⊙%1%2%3%4</code>	<code>string</code>
<code>nmax</code>	Allocated size of string [bytes]	<code>↓0 ↑65520</code>	<code>long</code>

Output

<code>sy</code>	String output value	<code>string</code>
-----------------	---------------------	---------------------

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
-------------	----------------------------------	-----------	-------------

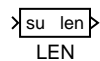
Output

pos	Position of substring	long
------------	-----------------------	-------------

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

<code>su</code>	String input value	<code>string</code>
-----------------	--------------------	---------------------

Parameter

<code>nmax</code>	Allocated size of string [bytes]	↓0 ↑65520	<code>long</code>
-------------------	----------------------------------	-----------	-------------------

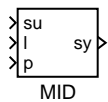
Output

<code>len</code>	Length of input string	<code>long</code>
------------------	------------------------	-------------------

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
p	Position of output string (one-based)	long

Parameter

nmax	Allocated size of string [bytes]	↓0 ↑65520	long
-------------	----------------------------------	-----------	-------------

Output

sy	String output value	string
-----------	---------------------	---------------

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.

Inputs

<code>jtxt</code>	JSON formatted string	<code>string</code>
<code>RUN</code>	Enable execution	<code>bool</code>

Parameters

<code>name1..8</code>	Name of JSON object	<code>string</code>
<code>nmax</code>	Allocated size of string [bytes]	<code>long</code>
<code>yerr</code>	Substitute value for an error case	<code>double</code>

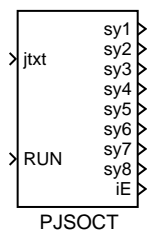
Outputs

<code>y1..8</code>	Block output signal	<code>double</code>
<code>iE</code>	Error code	<code>error</code>

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.

Inputs

<code>jtxt</code>	JSON formatted string	<code>string</code>
<code>RUN</code>	Enable execution	<code>bool</code>

Parameters

<code>name1..8</code>	Name of JSON object	<code>string</code>
<code>nmax</code>	Allocated size of string [bytes]	<code>↓0 ↑65520 long</code>

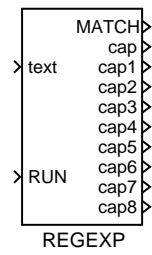
Outputs

<code>sy1..8</code>	String output value	<code>string</code>
<code>iE</code>	Error code	<code>error</code>

REGEXP – Regular expression parser

Block Symbol

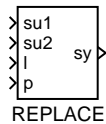
Licence: [ADVANCED](#)



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
p	Position of origin text (one-based)	long

Parameter

nmax	Allocated size of string [bytes]	↓0 ↑65520	long
------	----------------------------------	-----------	------

Output

sy	String output value	string
----	---------------------	--------

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

<code>u</code>	Analog input of the block	<code>double</code>
----------------	---------------------------	---------------------

Parameters

<code>prec</code>	Precision (number of digits)	<code>↓0 ↑20</code>	<code>long</code>
<code>mode</code>	Output string format	<code>⊙1</code>	<code>long</code>
	<code>1</code> best fit		
	<code>2</code> normal		
	<code>3</code> exponencial		

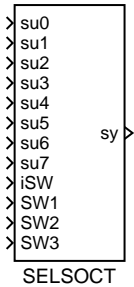
Output

<code>sy</code>	String output value	<code>string</code>
-----------------	---------------------	---------------------

SELSOCT – * String selector

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
SW1...3	Binary signal selector	bool

Parameters

BINF	Enable the binary selectors	bool
nmax	Allocated size of string [bytes]	↓0 ↑65520 long

Output

`sy`

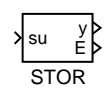
The selected input signal

`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
-------------	------------------------------------	---------------

Outputs

y	Analog output of the block	double
E	Error indicator	bool

Chapter 12

PARAM – Blocks for parameter handling

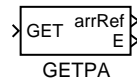
Contents

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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"**.
- 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 displayed in a tree structure in the **RexView** program.

Input

GET	Input for initiating one-shot parameter read	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	bool
	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)	
nmax	Maximum size of array	⊙256 long

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"`.
- 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 **RexView** program.

Input

GET	Input for initiating one-shot parameter read (off → on)	bool
------------	---	------

Outputs

y	Parameter value, output of the GETPR block	double
k	Parameter value, output of the GETPI block	long
Y	Parameter value, output of the GETPB block	bool
E	Error flag	bool
	off ... No error	
	on An error occurred	

Parameters

sc	String connection to the remote parameter respecting the above mentioned notation	string
GETF	Continuous or one-shot mode	bool
	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)	

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	bool
	off ... Remote parameter is continuously read	
	on One-shot mode	
nmax	Allocated size of string	long

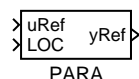
Outputs

sy	Parameter value	string
E	Error indicator	bool
	off ... No error	
	on An error occurred	

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 the value of the parameter (**yRef** = **apar**).

Inputs

uRef	Array reference	reference
LOC	Activation of local mode	bool
	off ... The parameter follows the input	
	on Local mode active	

Output

yRef	Array reference	reference
-------------	-----------------	------------------

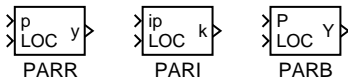
Parameters

SETS	Set array size flag. Use this flag to adjust the size of array when setting the parameter.	bool
apar	Initial value of the parameter	\odot [0.0 1.0 2.0 3.0 4.0 5.0] double

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**.

The output value is equivalent 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**.

Inputs

p	Parameter value (the PARR block)	double
ip	Parameter value (the PARI block)	long
P	Parameter value (the PARB block)	bool
LOC	Activation of local mode	bool
	off ... The parameter follows the input	
	on Local mode active	

Output

y	Logical output of the PARR block	double
k	Logical output of the PARI block	long
Y	Logical output of the PARB block	bool

Parameter

par	Initial value of the parameter (the PARR block)	⊙1.0	double
ipar	Initial value of the parameter (the PARI block)	⊙1	long
PAR	Initial value of the parameter (the PARB block)	⊙on	bool

SATF	Activation of the saturation limits for the PARR and PARI blocks		bool
	off ... Signal not limited		
	on Saturation limits active		
hilim	Upper limit of the output signal (the PARR and PARI blocks)	⊙1.0	double
lolim	Lower limit of the output signal (the PARR and PARI blocks)	⊙-1.0	double

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	Initial value of the parameter	string
nmax	Allocated size of string	long

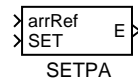
Output

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"**.
- 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 displayed in a tree structure in the **RexView** program.

Inputs

arrRef	Array reference	reference
SET	Input for initiating one-shot parameter write	bool

Output

E	Error flag	bool
----------	------------	-------------

Parameters

<code>sc</code>	String connection to the parameter	<code>string</code>
<code>SETF</code>	Continuous or one-shot mode	<code>bool</code>
	<code>off</code> ... Remote parameter is continuously updated	
	<code>on</code> One-shot mode, the remote parameter is updated only when forced to by the <code>SET</code> input (rising edge)	
<code>SETS</code>	Set array size flag. Use this flag to adjust the size of array when setting the parameter.	<code>bool</code>

SETPR, SETPI, SETPB – Blocks for remote parameter setting

Block Symbols

Licence: [STANDARD](#)



Function Description

The **SETPR**, **SETPI** and **SETPB** 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 and the **SETPB** block for Boolean 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**) is located. The string has to be prefixed with **'.'** in this case. Examples of relative 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 **RexView** program.

Inputs

<code>p</code>	Desired parameter value at the <code>SETPR</code> block input	<code>double</code>
<code>ip</code>	Desired parameter value at the <code>SETPI</code> block input	<code>long</code>
<code>P</code>	Desired parameter value at the <code>SETPB</code> block input	<code>bool</code>
<code>SET</code>	Input for initiating one-shot parameter write (<code>off</code> → <code>on</code>)	<code>bool</code>

Outputs

<code>y</code>	Parameter value (the <code>SETPR</code> block)	<code>double</code>
<code>k</code>	Parameter value (the <code>SETPI</code> block)	<code>long</code>
<code>Y</code>	Parameter value (the <code>SETPB</code> block)	<code>bool</code>
<code>E</code>	Error flag	<code>bool</code>
	<code>off</code> ... No error	
	<code>on</code> An error occurred	

Parameters

<code>sc</code>	String connection to the remote parameter respecting the above mentioned notation	<code>string</code>
<code>SETF</code>	Continuous or one-shot mode	<code>bool</code>
	<code>off</code> ... Remote parameter is continuously updated	
	<code>on</code> One-shot mode, the remote parameter is updated only when forced to by the <code>SET</code> input (rising edge)	

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

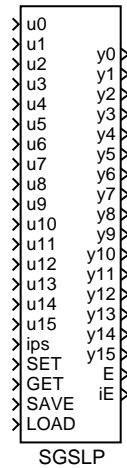
Outputs

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 REX control 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 REX control system. An empty **sci** 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 **sci** string can contain up to 16 items in the form **<block>:<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 **sci** 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 **sci** 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 **sci** 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 **REX** control 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 REX Control 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 **sci**, $i = 0, \dots, m$, where $m < 16$ defines the nonempty **scm** 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 **sci** 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 **sci** 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, $i = 0, \dots, 15$	double
ips	Parameter set index (numbered from zero)	long
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, $i = 0, \dots, 15$	double
E	Error flag	bool
	off ... No error	
	on An error occurred (see iE)	

iE	Error or warning code of the last operation	long
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	

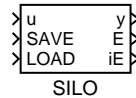
Parameters

nps	Number of parameter sets	$\downarrow 1 \uparrow 16 \odot 1$	long
ips0	Index of parameter set to load and set during the block initialization. No set is read for $\text{ips0} < 0$ or $\text{ips0} \geq \text{nps}$	$\downarrow -1 \uparrow 15$	long
iprec	Precision (number of digits) for storing the values of double type in a file	$\downarrow 2 \uparrow 15 \odot 12$	long
icolw	Requested column width in the status file. Spaces are appended to the parameter value when necessary.	$\downarrow 0 \uparrow 22$	long
fname	Name of the file the SAVE and LOAD operations work with	$\odot \text{status}$	string
broot	Root block in hierarchy, inserted at the beginning of all sci parameters, see the description above	$\odot .$	string
sci	Strings defining the connection of ui inputs and yi outputs to the parameters, $i = 0, \dots, 15$, 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. If an error occurs, 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 folder where the archives of the REX Control System are stored.

Use the [SGSLP](#) function block for advanced and complex operations.

Inputs

u	Input signal	double
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

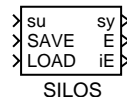
Outputs

y	Output signal	double
E	Error flag	bool
iE	Error code of the operating system	long

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.

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 folder where the archives of the REX Control System are stored.

Inputs

su	String input of the block	⊙0	string
SAVE	Save string to file		bool
LOAD	Load string from file		bool

Parameters

fname	Name of persistent storage file	string
CSF	Continuous saving	bool
CLF	Continuous loading	bool

Outputs

sy	String output of the block	string
E	Error indicator	bool
	off ... No error	
	on ... An error occurred	
iE	Error code of the operating system	long

Chapter 13

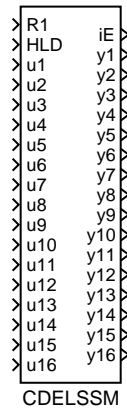
MODEL – Dynamic systems simulation

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CDELSSM – Continuous state space model of a linear system with time delay

Block Symbol

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Function Description

The **CDELSSM** block (Continuous State Space Model with time DELay) simulates behavior of a linear system with time delay del

$$\begin{aligned}\frac{dx(t)}{dt} &= A_c x(t) + B_c u(t - del), \quad x(0) = x_0 \\ y(t) &= C_c x(t) + D_c u(t),\end{aligned}$$

where $x(t) \in \mathbb{R}^n$ is the state vector, $x_0 \in \mathbb{R}^n$ 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 x_0 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

$$\begin{aligned}x((k+1)T) &= A_d x(kT) + B_{d1} u((k-d)T) + B_{d2} u((k-d+1)T), \quad x(0) = x_0 \\ y(kT) &= C_c x(kT) + D_c u(kT),\end{aligned}$$

where $k \in \{1, 2, \dots\}$ 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 [6], 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 \mathbf{x} is set to its initial value \mathbf{x}_0 . 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 B_c .	double

Outputs

iE	Block error code	error
	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 REX, see appendix B for details	
y1..y16	Simulated system outputs. First p simulation outputs are used where p is the number of rows of the matrix C_c .	double

Parameters

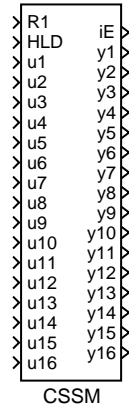
UD	Matrix D_c usage flag. If UD=off then the D_c matrix is not used for simulation (simulation behaves as if the D_c matrix is zero).	bool
del	Model time delay [s].	↓0.0 double
is	Order of the Padé approximation of the matrix exponential for the computation of the discretized system matrices.	long ↓0 ↑4 ⊙2

eps	Required accuracy of the Padé approximation. $\downarrow 0.0 \uparrow 1.0 \odot 0.0$	double
Ac	Matrix ($n \times n$) of the continuous linear system dynamics.	double
Bc	Input matrix ($n \times m$) of the continuous linear system.	double
Cc	Output matrix ($p \times n$) of the continuous linear system.	double
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
x0	Initial value of the state vector (of dimension n) of the continuous linear system.	double

CSSM – Continuous state space model of a linear system

Block Symbol

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Function Description

The **CSSM** block (Continuous State Space Model) simulates behavior of a linear system

$$\begin{aligned}\frac{dx(t)}{dt} &= A_c x(t) + B_c u(t), \quad x(0) = x_0 \\ y(t) &= C_c x(t) + D_c u(t),\end{aligned}$$

where $x(t) \in \mathbb{R}^n$ is the state vector, $x_0 \in \mathbb{R}^n$ 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 x_0 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

$$\begin{aligned}x((k+1)T) &= A_d x(kT) + B_d u(kT), \quad x(0) = x_0 \\ y(kT) &= C_c x(kT) + D_c u(kT),\end{aligned}$$

where $k \in \{1, 2, \dots\}$ 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 [6], 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

Outputs

iE	Block error code	error
	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 REX , see appendix B for details	
y1..y16	Simulated system outputs. First p simulation outputs are used where p is the number of rows of the matrix Cc .	double

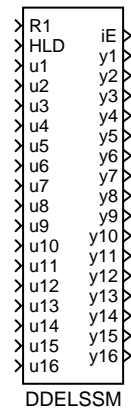
Parameters

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. $\downarrow 0 \uparrow 4 \odot 2$	long
eps	Required accuracy of the Padé approximation. $\downarrow 0.0 \uparrow 1.0 \odot 0.0$	double
Ac	Matrix ($n \times n$) of the continuous linear system dynamics.	double
Bc	Input matrix ($n \times m$) of the continuous linear system.	double
Cc	Output matrix ($p \times n$) of the continuous linear system.	double
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
x0	Initial value of the state vector (of dimension n) of the continuous linear system.	double

DDELSSM – Discrete state space model of a linear system with time delay

Block Symbol

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Function Description

The **DDELSSM** block (Discrete State Space Model with time DELay) simulates behavior of a linear system with time delay *del*

$$\begin{aligned} x(k+1) &= A_d x(k) + B_d u(k-d), \quad x(0) = x_0 \\ y(k) &= C_d x(k) + D_d u(k), \end{aligned}$$

where k is the simulation step, $x(k) \in \mathbb{R}^n$ is the state vector, $x_0 \in \mathbb{R}^n$ 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 x_0 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

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 REX, see appendix B 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

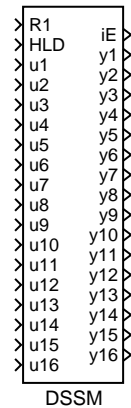
Parameters

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].	$\downarrow 0.0$ double
Ad	Matrix $(n \times n)$ of the discrete linear system dynamics.	double
Bd	Input matrix $(n \times m)$ of the discrete linear system.	double
Cd	Output matrix $(p \times n)$ of the discrete linear system.	double
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
x0	Initial value of the state vector (of dimension n) of the discrete linear system.	double

DSSM – Discrete state space model of a linear system

Block Symbol

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Function Description

The **DSSM** block (Discrete State Space Model) simulates behavior of a linear system

$$\begin{aligned} x(k+1) &= A_d x(k) + B_d u(k), \quad x(0) = x_0 \\ y(k) &= C_d x(k) + D_d u(k), \end{aligned}$$

where k is the simulation step, $x(k) \in \mathbb{R}^n$ is the state vector, $x_0 \in \mathbb{R}^n$ 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 x_0 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 x_0 . 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 B_d .	double

Outputs

iE	Block error code	error
	0 O.K., the simulation runs correctly	
	-213 .. incompatibility of the state space model matrices dimensions	
	xxx ... error code xxx of REX, see appendix B for details	
y1..y16	Simulated system outputs. First p simulation outputs are used where p is the number of rows of the matrix Cd.	double

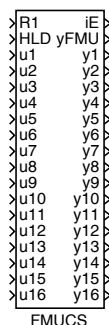
Parameters

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
Bd	Input matrix $(n \times m)$ of the discrete linear system.	double
Cd	Output matrix $(p \times n)$ of the discrete linear system.	double
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
x0	Initial value of the state vector (of dimension n) of the discrete linear system.	double

FMUCS — * Import modelu FMU CS (pro Co-Simulation)

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

R1	Reset bloku	bool
HLD	Podržení aktuálního stavu modelu	bool
u1	Analogový vstupní signál	double
u2	Analogový vstupní signál	double
u3	Analogový vstupní signál	double
u4	Analogový vstupní signál	double
u5	Analogový vstupní signál	double
u6	Analogový vstupní signál	double
u7	Analogový vstupní signál	double
u8	Analogový vstupní signál	double
u9	Analogový vstupní signál	double
u10	Analogový vstupní signál	double
u11	Analogový vstupní signál	double
u12	Analogový vstupní signál	double
u13	Analogový vstupní signál	double
u14	Analogový vstupní signál	double
u15	Analogový vstupní signál	double
u16	Analogový vstupní signál	double

Parameters

tstop	Koncový čas simulace	↓0.000001 ⊙1.
eps	Přesnost aproximace	↓0.0 ↑1.0 ⊙0.00000
loglevel	Úroveň protokolování knihovny FMI do systémového logu	↓0 ↑7 ⊙
	0 Nic	
	1 Fatální	
	2 Chyba	
	3 Varování	
	4 Info	
	5 Podrobný	
	6 Ladění	
	7 Všechno	
SelPars	Seznam vybraných parametrů FMU	
TUNEALLP	Považuj všechny vybrané parametry za laditelné parametry	
p1	Analogový parametr bloku	
p2	Analogový parametr bloku	
p3	Analogový parametr bloku	
p4	Analogový parametr bloku	
p5	Analogový parametr bloku	
p6	Analogový parametr bloku	
p7	Analogový parametr bloku	
p8	Analogový parametr bloku	
p9	Analogový parametr bloku	
p10	Analogový parametr bloku	
p11	Analogový parametr bloku	
p12	Analogový parametr bloku	
p13	Analogový parametr bloku	
p14	Analogový parametr bloku	
p15	Analogový parametr bloku	double
p16	Analogový parametr bloku	double

Outputs

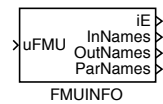
iE	Kód chyby	error
yFMU	Výstupní odkaz na instanci FMU	reference
y1	Analogový výstupní signál	double
y2	Analogový výstupní signál	double
y3	Analogový výstupní signál	double
y4	Analogový výstupní signál	double
y5	Analogový výstupní signál	double
y6	Analogový výstupní signál	double
y7	Analogový výstupní signál	double
y8	Analogový výstupní signál	double
y9	Analogový výstupní signál	double

y10	Analogový výstupní signál	double
y11	Analogový výstupní signál	double
y12	Analogový výstupní signál	double
y13	Analogový výstupní signál	double
y14	Analogový výstupní signál	double
y15	Analogový výstupní signál	double
y16	Analogový výstupní signál	double

FMUINFO – * **Informace o importovaném modelu FMU**

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.

Vstup

uFMU	Vstupní odkaz na instanci FMU	reference
------	-------------------------------	-----------

Parameters

SelPars	Seznam vybraných parametrů FMU	string
Separ	Oddělovač jmen v řetězcových výstupech	⊙, string

Outputs

iE	Kód chyby	error
InNames	Seznam jmen vstupů FMU	string
OutNames	Seznam jmen výstupů FMU	string
ParNames	Seznam jmen vybraných parametrů FMU	string

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:

$$P(s) = \frac{k0}{(\tau \cdot s + 1)} \cdot e^{-del \cdot s}$$

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
---	---------------------------	--------

Output

y	Analog output of the block	double
---	----------------------------	--------

Parameters

k0	Static gain	⊙1.0	double
del	Dead time [s]		double
tau	Time constant	⊙1.0	double
nmax	Size (number of samples) of delay buffer (used for internal memory allocation)	↓1 ↑10000000 ⊙10	long

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

<code>u</code>	Analog input of the block	<code>double</code>
----------------	---------------------------	---------------------

Output

<code>y</code>	Analog output of the block	<code>double</code>
----------------	----------------------------	---------------------

Parameters

<code>k0</code>	Static gain	<code>⊙1.0</code>	<code>double</code>
<code>del</code>	Dead time [s]		<code>double</code>
<code>tau1</code>	The first time constant	<code>⊙1.0</code>	<code>double</code>
<code>tau2</code>	The second time constant	<code>⊙2.0</code>	<code>double</code>
<code>nmax</code>	Size (number of samples) of delay buffer (used for internal memory allocation)	<code>↓1 ↑10000000 ⊙10</code>	<code>long</code>

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
k0	Static gain	double
del	Dead time [s]	double
tau1	The first time constant	double
tau2	The second time constant	double

Output

y	Analog output of the block	double
----------	----------------------------	--------

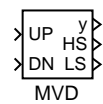
Parameters

nmax	Size (number of samples) of delay buffer (used for internal memory allocation)	long
		↓1 ↑10000000 Ⓢ10

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 signaled 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
HS	Upper end switch	bool
LS	Lower end switch	bool

Parameters

y0	Initial valve position	double
tv	Time required for transition between $y = 0$ and $y = 1$ [s]	⊙10.0 double
hilim	Upper limit position (open)	⊙1.0 double
lolim	Lower limit position (closed)	double

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.

$$\begin{aligned} \text{itf} = 1: \quad P(s) &= \frac{\text{pb1} \cdot s + \text{pb0}}{s^2 + \text{pa1} \cdot s + \text{pa0}} \cdot e^{-\text{del} \cdot s} \\ \text{itf} = 2: \quad P(s) &= \frac{k0 (\tau \cdot s + 1)}{(\tau_1 \cdot s + 1)(\tau_2 \cdot s + 1)} \cdot e^{-\text{del} \cdot s} \\ \text{itf} = 3: \quad P(s) &= \frac{k0 \cdot \omega^2 \cdot (\tau / \omega \cdot s + 1)}{(s^2 + 2 \cdot \xi \cdot \omega \cdot s + \omega^2)} \cdot e^{-\text{del} \cdot s} \\ \text{itf} = 4: \quad P(s) &= \frac{k0 (\tau \cdot s + 1)}{(\tau_1 \cdot s + 1)s} \cdot e^{-\text{del} \cdot s} \end{aligned}$$

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
----------	---------------------------	--------

Output

y	Analog output of the block	double
----------	----------------------------	--------

Parameters

itf	Transfer function form	⊙1	long
	1 A general form		
	2 A form with real poles		
	3 A form with complex poles		
	4 A form with integrator		
k0	Static gain	⊙1.0	double
tau	Numerator time constant		double
tau1	The first time constant	⊙1.0	double
tau2	The second time constant	⊙1.0	double
om	Natural frequency	⊙1.0	double
xi	Relative damping coefficient	⊙1.0	double
pb0	Numerator coefficient: s^0	⊙1.0	double
pb1	Numerator coefficient: s^1	⊙1.0	double
pa0	Denominator coefficient: s^0	⊙1.0	double
pa1	Denominator coefficient: s^1	⊙1.0	double
del	Dead time [s]		double
nmax	Size (number of samples) of delay buffer (used for internal memory allocation)		long
		↓1 ↑10000000	⊙10

Chapter 14

MATRIX – Blocks for matrix and vector operations

Contents

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CNA – * **Array (vector/matrix) constant**

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

filename	CSV data file		string
TRN	Transpose loaded matrix		bool
nmax	Allocated size of array	↓2 ↑100000000 ⊙100	long
etype	Type of elements		⊙8 long
	1 Bool		
	2 Byte		
	3 Short		
	4 Long		
	5 Word		
	6 DWord		
	7 Float		
	8 Double		
	--		
	10 Large		
acn	Initial array value	⊙[0 1 2 3]	double

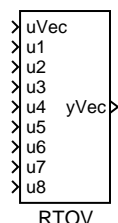
Output

vec	Reference to vector/matrix data	reference
-----	---------------------------------	-----------

RTOV – Vector multiplexer

Block Symbol

Licence: [STANDARD](#)



Function Description

The **RTOV** block can be used to create vector signals in the **REX** Control 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.

Inputs

uVec	Vector signal	reference
u1	Analog input of the block	double
u2	Analog input of the block	double
u3	Analog input of the block	double
u4	Analog input of the block	double
u5	Analog input of the block	double
u6	Analog input of the block	double
u7	Analog input of the block	double
u8	Analog input of the block	double

Parameters

nmax	Allocated size of vector	↓0 ↻8	long
offset	Index of the first input in vector	↓0	long
n	Number of valid inputs	↓1 ↑8 ↻8	long

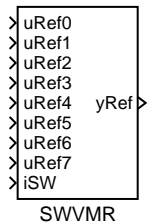
Output

yVec	Vector signal	reference
-------------	---------------	------------------

SWVMR – Vector/matrix/reference signal switch

Block Symbol

Licence: [STANDARD](#)



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

<code>uRef0</code>	Vector signal	reference
<code>uRef1</code>	Vector signal	reference
<code>uRef2</code>	Vector signal	reference
<code>uRef3</code>	Vector signal	reference
<code>uRef4</code>	Vector signal	reference
<code>uRef5</code>	Vector signal	reference
<code>uRef6</code>	Vector signal	reference
<code>uRef7</code>	Vector signal	reference
<code>iSW</code>	Active signal selector	long

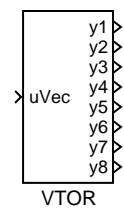
Output

<code>yRef</code>	Vector signal	reference
-------------------	---------------	-----------

VTOR – Vector demultiplexer

Block Symbol

Licence: [STANDARD](#)



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	↓1 ↑8 ⊖8	long
offset	Index of the first output	↓0	long

Outputs

y1	Analog output of the block	double
y2	Analog output of the block	double
y3	Analog output of the block	double
y4	Analog output of the block	double
y5	Analog output of the block	double
y6	Analog output of the block	double
y7	Analog output of the block	double
y8	Analog output of the block	double

Chapter 15

SPEC – Special blocks

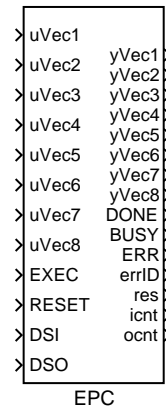
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EPC – External program call

Block Symbol

Licence: [ADVANCED](#)



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 REX Control 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 REX Control 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	error
i REX general error	
res	External program return code	long
icnt	Current input sample	long
ocnt	Current output sample	long

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
s1	List of inputs working in the <i>sampling mode</i> . 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.	long
ifm	Maximum number of input samples	⊙10000 long
format	Format of input and output files	⊙1 long
	1 Space-delimited values	
	2 CSV (decimal point and commas)	
	3 CSV (decimal comma and semicolons)	
nmax	Maximum output vectors length	⊙10000 long

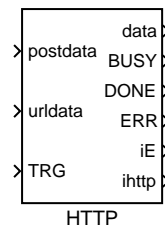
Notes

- 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 REX Control 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

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 REX Control 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

<code>postdata</code>	Data to put in HTTP POST request	<code>string</code>
<code>urldata</code>	Data to append to URL address	<code>string</code>
<code>TRG</code>	Trigger of the selected action	<code>bool</code>

Parameters

<code>url</code>	URL address to send the HTTP request to		<code>string</code>
<code>method</code>	HTTP request type	⊙1	<code>long</code>
	1 GET		
	2 POST		
<code>user</code>	User name		<code>string</code>
<code>password</code>	Password		<code>string</code>
<code>certificate</code>	Authentication certificate		<code>string</code>
<code>VERIFY</code>	Enable server verification (valid certificate)		<code>bool</code>
<code>postmime</code>	MIME encoding for POST request	⊙application/json	<code>string</code>
<code>acceptmime</code>	MIME encoding of HTTP response	⊙application/json	<code>string</code>
<code>timeout</code>	Timeout interval	⊙5.0	<code>double</code>
<code>BLOCKING</code>	Wait for the operation to finish		<code>bool</code>
<code>nmax</code>	Allocated size of string	↓0 ↑65520	<code>long</code>
<code>postmax</code>	Allocated memory for POST request data	↓128 ↑65520 ⊙256	<code>long</code>
<code>datamax</code>	Allocated memory for HTTP response	↓128 ↑10000000 ⊙1024	<code>long</code>

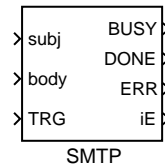
Outputs

<code>data</code>	Response data	<code>string</code>
<code>BUSY</code>	Sending HTTP request	<code>bool</code>
<code>DONE</code>	HTTP request processed	<code>bool</code>
<code>ERROR</code>	Error indicator	<code>bool</code>
<code>errId</code>	Error code	<code>error</code>
<code>hterror</code>	HTTP response	<code>long</code>

SMTP – Send email message via SMTP

Block Symbol

Licence: [ADVANCED](#)



Function Description

The **SMTP** block sends a single email message via standard SMTP protocol. The block acts as a simple email client. It does not implement a mail server.

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 last error identified by REX Control System error code. The **domain** parameter must always be set to identify the target device. A default value should work in most cases.

The block may be run in blocking or non-blocking mode which is specified by the **BLOCKING** parameter. In a blocking mode, the execution of a task is suspended until a request is finished. In a non-blocking mode, the block performs only a single operation depending on available data and the execution of a task is not blocked. It is advised to always run the **SMTP** block in a non-blocking mode. It is however necessary to mention that on various operating systems some operations may not be performed in a 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. A maximal duration of a request performed by the **SMTP** block is specified by the **timeout** parameter.

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. An 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.

Parameters **nmax** and **datamax** specify maximum sizes of buffers allocated by the block. The **nmax** parameter is maximal size of any string parameter. The **datamax** parameter specifies a maximal size of a **data**.

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 long
	1 None	
	2 StartTLS	
	3 TLS	
user	User name	string
password	Password	string
domain	Domain name or identification of the target device	string
auth	Authentication method	⊙1 long
	1 Login	
	2 Plain	
certificate	Authentication certificate	string
VERIFY	Enable server verification (valid certificate)	bool
timeout	Timeout interval	double
BLOCKING	Wait for the operation to finish	bool
nmax	Allocated size of string	↓0 ↑65520 ⊙512 long
datamax	Allocated memory for HTTP response	↓128 ↑65520 long

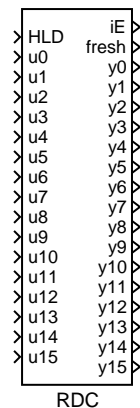
Outputs

BUSY	Sending e-mail	bool
DONE	E-mail has been sent	bool
ERROR	Error indicator	bool
errId	Error code	error

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 **REX** control 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 greater 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

<code>HLD</code>	Input for disabling the execution of the block. No packets are received nor transmitted when <code>HLD = on</code> .	<code>bool</code>
<code>u0..u15</code>	Values which are sent/written to the output values <code>y0</code> to <code>y15</code> of the paired block	<code>double</code>

Outputs

<code>iE</code>	Displays the code of the last error. The error codes are listed below:	<code>long</code>
	0 No error	

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)

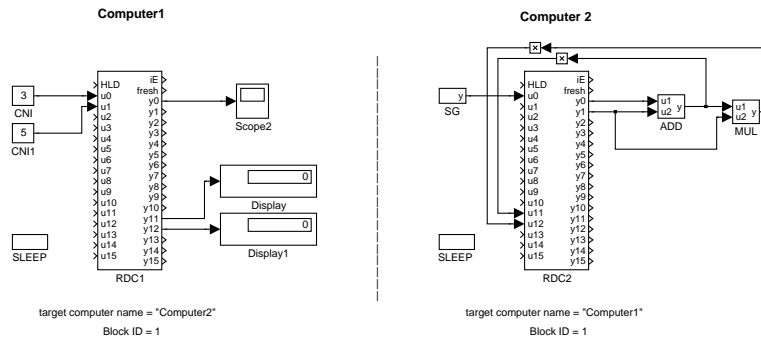
<code>fresh</code>	Elapsed time (in seconds) since the last received packet. Can be used for detection of an error in the paired block.	double
<code>y0..y15</code>	Values transmitted from the input ports <code>u0</code> to <code>u15</code> of the paired RDC block – data from the last packet received	double

Parameters

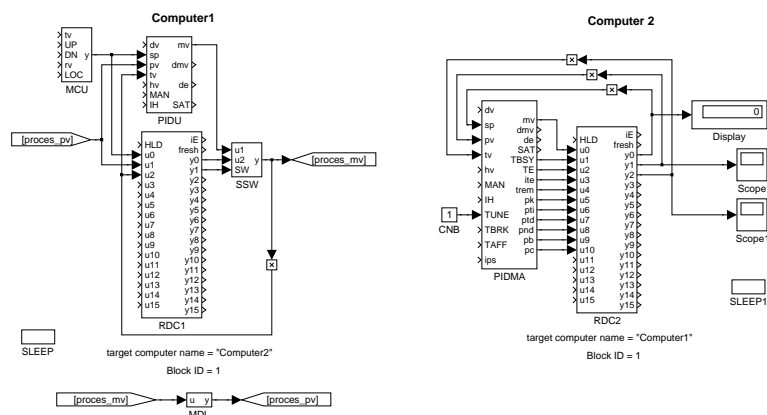
<code>target</code>	Name or IP address running the paired RDC block. Broadcast address is allowed.	string
<code>rport</code>	Remote port – address of the UDP/IP protocol service, it is recommended to keep the default value unless necessary (service/application conflict) $\odot 1288$	word
<code>lport</code>	Local port – similar meaning as the <code>rport</code> parameter; remote port applies to the receiving machine, local port applies to the machine sending the packet $\odot 1288$	word
<code>id</code>	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 <code>id</code> decomposes it and uses the data contained to update its outputs) $\downarrow 1 \uparrow 32767 \odot 1$	long
<code>period</code>	The shortest time interval between transmitting/receiving packets (in seconds). The packets are transmitted/received during each execution of the block for <code>period</code> ≤ 0 while the positive values of this parameter are extremely useful when sending data out of the Simulink continuous models based on a <code>Variable step</code> solver.	double

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 view the data in the REX control system, the **RexView** diagnostic program and the **TRND** block must be used.



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.



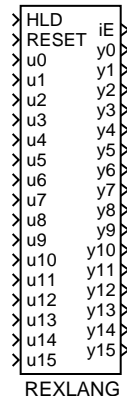
OPC server of the RDC block

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 standard function blocks of the REX control 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. It implements an user-defined algorithm written in a scripting language very similar to the C language (or Java).

Scripting language

As mentioned, the scripting language is similar to the C language. Nevertheless, there are some differences and limitations:

- Only the **double** and **long** data types are supported (it is possible to use **int**, **short**, **bool** as well, but these are internally converted to **long**. The **float** type can be used but it is converted internally to **double**. The **typedef** type is not defined.
- Pointers and structures are not implemented. However, it is possible to define arrays and use the indexes (the **[]** operator).
- The **' , '** operator is not implemented.
- The preprocessor supports the following commands: **#include**, **#define**, **#ifdef .. [#else ..] #endif**, **#ifndef .. [#else ..] #endif** (i.e. **#pragma** and **#if .. [#else ..] #endif** are not supported).

- The standard ANSI C libraries are not implemented, however the majority of mathematic functions from `math.h` and some other functions are implemented (see the text below).
- The `input`, `output` and `parameter` keywords are defined for referencing the `REXLANG` block inputs, outputs and parameters. System functions for controlling the execution and diagnostics are implemented (see the text below).
- The `main()` function is executed periodically during runtime. Alongside the `main()` function the `init()` (executed once at startup), `exit()` (executed once when the control algorithm is stopped) and the `parchange()` (executed on parameters change in the REX system, executed in each step in Simulink).
- The functions and procedures without parameters must be explicitly declared `void`.
- The identifiers cannot be overloaded, i.e. the keywords and built-in functions cannot share the name with an identifier. The local and global variables cannot share the same name.
- Array initializers are not supported. Neither in local arrays nor the global ones.

Scripting language syntax

The scripting language syntax is based on the C language, but pointers are not supported and the data types are limited to `long` and `double`. Moreover the `input`, `output` and `parameter` keywords are defined for referencing the `REXLANG` block inputs, outputs and parameters. The syntax is as follows:

- `<type> input(<input number>) <variable name>;`
- `<type> output(<outpt number>) <variable name>;`
- `<type> parameter(<parameter number>) <variable name>;`

The `input` and `parameter` variables are read-only while the `output` variables are write-only. For 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 following functions are available in the scripting language:

- **Mathematic functions** (see ANSI C, `math.h`):
`atan`, `sin`, `cos`, `exp`, `log`, `sqrt`, `tan`, `asin`, `acos`, `fabs`, `fmod`, `sinh`, `cosh`, `tanh`,
`pow`, `atan2`, `ceil`, `floor` and `abs` Please note that the `abs` function works with
integer numbers. All the other functions work with variables of type `double`.
- **Vector functions** (not part of ANSI C)
 - `double max([n,] val1, ..., valn)`
Returns the maximum value. The first parameter defining the number of
items is optional.
 - `double max(n, vec)`
Returns the value of maximal item in the `vec` vector.
 - `double min([n,] val1, ..., valn)`
Returns the minimum value. The first parameter defining the number of
items is optional.
 - `double min(n, vec)`
Returns the value of minimal item in the `vec` vector.
 - `double poly([n,] x, an, ..., a1, a0)`
Evaluates the polynomial $y = an \cdot x^n + \dots + a1 \cdot x + a0$. The first parameter
defining the number of items is optional.
 - `double poly(n, x, vec)`
Evaluates the polynomial $y = vec[n] \cdot x^n + \dots + vec[1] \cdot x + vec[0]$.
 - `double scal(n, vec1, vec2)`
Evaluates the scalar product $y = vec1[0] \cdot vec2[0] + \dots + vec1[n-1] \cdot$
 $vec2[n-1]$.
 - `double scal(n, vec1, vec2, skip1, skip2)`
Evaluates the scalar product $y = vec1[0] \cdot vec2[0] + vec1[skip1] \cdot$
 $vec2[skip2] + \dots + vec1[(n-1) \cdot skip1] \cdot vec2[(n-1) \cdot skip2]$. 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)`
Evaluates the convolutive product $y = vec1[0] \cdot vec2[n-1] + vec1[1] \cdot$
 $vec2[n-1] + \dots + vec1[n-1] \cdot vec2[0]$.
 - `double sum(n, vec)`
Sums the items in a vector, i.e. $y = vec[0] + vec[1] + \dots + vec[n-1]$.
 - `double sum([n,] val1, ..., valn)`
Sums the items, i.e. $y = val1 + val2 + \dots + valn$. The first parameter
defining the number of items is optional.
 - `[] array([n,] an-1, ..., a1, a0)`
Returns an array/vector with the given values. The first parameter defin-
ing the number of items 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/subvector of the `vec` array, starting at the `idx` index. 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).

- **String functions** (ANSI C contains analogous functions in the `string.h` file)

`string strstr(str,idx,len)`

Returns a substring of length `len` starting at index `idx`.

`long strlen(str)`

Returns string length (number of characters).

`long strfind(str,substr)`

Returns the position of a substring (starting at 0).

`long strrfind(str,substr)`

Returns the position of a substring relative to the end of the string.

`strreplace(str,pattern,substr)`

Find all occurrences of `pattern` in `str` and replace it with `substr` (in-place replacement, so new string is stored into `str`).

`string strupr(str)`

Converts a string to uppercase.

`long str2long(str)`

Converts string to integer number. The first non-numerical character is considered the end of the input string and the remaining characters are ignored.

`double str2double(str)`

Converts string to a decimal number. The first non-numerical character is considered the end of the input string and the remaining characters are ignored.

`string long2str(num)`

Converts an integer number `num` to text.

`string double2str(num)`

Converts a decimal number `num` to text.

`strcpy(dest,src)`

Function copies the `src` string to the `dest` string. Implemented for compatibility with ANSI C. The construction `dest=src` yields the same result.

`strcat(dest,src)`

Function appends a copy of the `src` string to the `dest` string. Implemented for compatibility with ANSI C. The construction `dest=dest+src` yields the same result.

strcmp(str1, str2)

Function compares strings **str1** and **str2**. Implemented for compatibility with ANSI C. The construction **str1==str2** yields the same result.

long RegExp(str, regexp, capture[])

Compares the **str** string with regular expression **regexp**. When the string matches the pattern, the **capture** array contains individual sections of the regular expression. **capture[0]** is always the complete regular expression. The function return the number of captured strings or a negative value in case of an error. The regular expression may contain the following:

(?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.

long ParseJson(json, cnt, names[], values[])

The **json** string is supposed to contain text in JSON format. The **names** array contain the requested objects (subitems are accessed via ., index of the array via []). The **values** array then contains values of the requested objects. The **cnt** parameter defines the number of requested objects (length of both the **names** and **values** arrays). The function returns the number of values, negative numbers indicate errors.

Note: String variable is declared just like in ANSI C, i.e. `char <variable name>[<maximum number of characters>];`. For passing the strings to functions use `char <variable name>[]` or `string <variable name>`.

- **System functions** (not part of ANSI C)

Trace(id, val)

Displays the `id` value and the `val` value. The function is intended for debugging. The `id` is a user-defined constant (from 0 to 9999) for easy identification of the displayed message. The `val` can be of any data type including text string. The output can be found in the system log of the REX Control System. In Simulink the output is displayed directly in the command window of Matlab.

In order to view these debugging messages in the `RexView` program 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 have to be also enabled for the particular block by checking item "Logging" in the "Runtime" section in 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** tab.

TraceError(id, val) TraceWarning(id, val) TraceVerbose(id, val)

On the contrary to the **Trace** command, the output is routed to the corresponding logging group. To view the messages, enable the corresponding group. See the **Trace** command for details. Messages with the "Error" level are written to the log allways, regardless the "Logging" item is checked for the block.

Suspend(sec)

The script is suspended if its execution within the given sampling period takes more seconds than specified by the `sec` parameter. At the next start of the block the script continues from the point where it was suspended. Use **Suspend(0)** to suspend the code immediately.

double GetPeriod()

Returns the sampling period of the block in seconds.

double CurrentTime()

Returns the current time (in internal format). Intended for use with the **ElapsedTime()** function.

double ElapsedTime(new_time, old_time)

Returns the elapsed time in seconds (decimal number), i.e. the difference between the two time values `new_time` and `old_time`. The **CurrentTime()** function is typically used in place of the `new_time` parameter.

double Random()

Returns a pseudo-random number from the $(0,1)$ interval. The pseudo-random number generator is initialized prior to calling the **init()** function so the sequence is always the same.

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 REX 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. A binary file with **double** values or a text file with values on individual lines is supposed. The **idx** index (binary file) or line number (text file) starts at 0. The file is identified by **fileid**. 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 the **value** to a file. The meaning of parameters is the same as in the **LoadValue** function.

void GetSystemTime(time)

Returns the system time. The time is usually returned as UTC but this can be altered by the operating system settings. The **time** parameter must be an array of at least 8 items of type **long**. 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)

Stop execution of the block's algorithm (and whole task) for defined time. Shortest possible time is about 0.01s, but depend on platform.

`long GetExtInt(ItemID)`

Returns the value of input/output/parameter of arbitrary block in REX algorithm. The data item is defined 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.

`long GetExtLong(ItemID)`

See `GetExtLong(ItemID)`.

`double GetExtReal(ItemID)`

Similar to `GetExtInt(ItemID)` but for decimal numbers.

`double GetExtDouble(ItemID)`

See `GetExtReal(ItemID)`.

`double GetExtString(ItemID)`

Similar to `GetExtInt(ItemID)` but for strings.

`void SetExt(ItemID, value)`

Sets the input/output/parameter of arbitrary block in REX algorithm to `value`. The data item is defined 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 item (long/double/string) is defined by the type of the `value` parameter.

`long memrd32(hMem, offset)`

Reading physical memory. Get the handle by `Open(72, "/dev/mem", <physical address>, <area size>)`.

`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 set of functions is intended for communication over TCP/IP, UDP/IP or serial line (RS-232 or RS-485). Only a brief list of available functions is given below, see the example projects of the REX Control System for more details.

`long Open(long type, long lclIP, long lclPort, long rmtIP, long rmtPort)`

Opens a socket or COM port according to the `type` parameter. Connect is performed for TCP client. Identification number (the so-called handle) of socket or COM port is returned. If a negative value is returned, the opening/connection was not successful.

`long Open(long type, string comname, long baudrate, long parity)`

Modification of the `Open()` function for opening a serial line.

`long Open(long type, string filename)`

Modification of the `Open()` function for opening a file.

`long Open(long type, string localname, long locPort, string remotename, long remPort)`

Modification of the `Open()` function for opening a TCP or UDP socket.

```

long OpenFile(string filename)
    Modification of the Open() function for opening a file.
long OpenCom(string comname, long baudrate, long parity)
    Modification of the Open() function for opening a serial line.
long OpenUDP(string localname, long lolPort, string remotename, long remPort)
    Modification of the Open() function for opening a UDP socket.
long OpenTCPSvr(string localname, long lolPort)
    Modification of the Open() function for opening a TCP socket - server,
    listening.
long OpenTCPcli(string remotename, long remPort)
    Modification of the Open() function for opening a TCP socket - client.
long OpenI2C(string devicename)
    Modification of the Open() function for opening an I2C bus.
long OpenMemory(string devicename, long baseaddr, long size)
    Modification of the Open() function for mapping physical memory.
long OpenSPI(string devicename)
    Modification of the Open() function for opening a SPI bus.
long Close(long handle)
    Closes the socket, serial line, file or any device opened by the Open function
    or its modifications.
void GetOptions(long handle, long params[])
    Reads parameters to the params array. The array size must be big enough,
    at least 2 for files, 2 for a socket and 22 for serial line (see SetOptions).
void SetOptions(long handle, long params[])
    Sets the parameters of a socket or serial line. The array size must be at
    least:
        - 22 for serial line,
        - 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 nuber of retries,
          5th item is timeout)
long Accept(long hListen)
    Accepts the connection to listening socket hListen invoked by the client.
    A communication socket handle or an error is returned.
long Read(long handle, long buffer[], long count)
    Receives data from a serial line or socket. The count parameter defines
    the maximum number of bytes to read. The count of bytes read or an error
    code is returned. Each byte of incoming data is put to the buffer array
    of type long in the corresponding order.

```

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)`

Sends the data to a serial line or socket. The `count` parameter defines the number of bytes to send. The count of bytes or an error code sent is returned. Each byte of outgoing data is read from the `buffer` array of type `long` in the corresponding order.

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 WriteRead(long handle, long addr, long bufW[], long cntW, long bufR[], long cntR)`

Communication over the I2C or SPI bus. Works only in Linux operating system on devices with the I2C or SPI bus (e.g. Raspberry Pi or ALIX). Sends and receives data to/from the slave device with address `addr`. The parameter `handle` is returned by the `OpenI2C` or `OpenSPI` functions, whose parameter defines the device name (according to the operating system). The function returns 0 or an error code.

`long ReadLine(long handle, string data)`

Read one line from (text) file, serial line or socket; read characters are in the variable `data` up to allocated size of the string; the function returns real size (number of bytes) of line or error code.

`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 DeleteFile(string filename)`

Delete file. Return 0 if success; negative value is error code.

`long RenameFile(string filename, string newfilename)`

Rename file. Return 0 if success; negative value is error code.

Remarks

- The data type of inputs `u0..u15`, outputs `y0..y15` and parameters `p0..p15` is determined during compilation of the source code according to the `input`, `output` and `parameter` definitions.
- All error codes < 0 require restarting of the REX control system executive. Of course it is necessary to remove the cause of the error first.
- WARNING! – The inputs and outputs of the block cannot be accessed within the `init()` function (the values of inputs are 0, outputs are not set).
- It is possible to include path in the `srcname` parameter. Otherwise the file is expected directly in the project directory or in the directories specified by the `-I` command line option of the RexComp compiler.
- All parameters of the vector functions are of type `double` (or array of type `double`). The only exception is the `n` parameter 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` 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.

- 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.
- In all case it is important to keep in mind that the vectors start at index 0 and that the array limits are not checked (just like in the C language). E.g. if `double vec[10], x;` is defined, the elements have indexes 0 to 9. The expression `x=vec[10];` is neither a syntax nor runtime error, the value is not defined. More importantly, it is possible to write `vec[11]=x;`, which poses a threat, because some other variable might be overwritten and the program works unexpectedly or even crashes.

- Only the **parser error** and line number are reported during compilation. This means a syntax error. If everything seems fine, the problem can be caused by identifier/keyword/function name conflict.
- 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 temporary results are stored in the stack, namely:
 - Global variables and local **static** variables (permanently at the beginning of the stack)
 - Return addresses of functions
 - Parameters of functions
 - Local function variables
 - Return value of function
 - Temporary results of operations (i.e. the expression **a=b+c**; is evaluated in the following manner: **b** is stored in the stack, **c** is stored in the stack (it follows after **b**), the sum is evaluated, both values are removed from the stack and the result is stored in the stack)

Each simple variable (**long** or **double**) thus counts as one item in the stack. For arrays, only the size is important, not the type.

- The arrays are passed to the functions as a reference. This means that the parameter counts as one item in the stack and that the function works directly with the referenced array, not its local copy.
- If the stack size is not sufficient (less than space required for global variables plus 10), the stack size is automatically set to twice the size of the space required for the global variables plus 100 (for computations, function parameters and local variables in the case that only a few global variables are present).
- If basic debug level is selected, several checks are performed during the execution of the script, namely initialization of the values which are read and array index limits. Also a couple of uninitialized values are inserted in front of and at the back of each declared array. The **NOP** instructions with line number of the source file are added to the ***.ill** file.
- If full debug is selected, additional check is engaged – the attempts to access invalid data range are monitored (e.g. stack overflow).
- The program size and stack size are set to a fixed value of 16384 in Simulink (for implementation reasons). If this size is exceeded, an error is reported.
- The term instruction in the context of this block refers to an instruction of a processor-independent mnemocode. The mnemocode is stored in the ***.ill** file.

- The `Open()` function set serial line always 19200Bd, no parity, 8 bit per character, 1 stopbit, binary mode, no timeout. Optional 2nd (bitrate) and 3th (parity) parametrs can be used in the `Open()` function.
- Accessing text file is significantly slower that binary file. A advantage of the text file is possibility view/edit data in file without special editor.
- This block does not call the `parchange()` function. It is necessary to call it in `init()` function (if it is required).
- The block's inputs are available in the `init()` function, but all are equal to zero. It is possible (but not common) to set block's outputs.
- The `Open()` function also allows opening of a regular file. Same codes like in the `LoadValue()` function are used.

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 <code>Init()</code> function is called).	bool
u0..u15	Input signals which are accessible from the script	unknown

Outputs

iE	Runtime error code. Unless <code>iE = 0</code> or <code>iE = -1</code> the algorithm is stopped until it is reinitialized by the <code>RESET</code> input or by restarting the executive) 0 No error occurred, the whole <code>main()</code> function was executed (also the <code>init()</code> function). -1 The execution was suspended using the <code>Suspend()</code> command, i.e. the execution will resume as soon as the <code>REXLANG</code> block is executed again xxx ... Error code of the REX Control System, see Appendix B	error
y0..y15	Output signals which can be set from within the script	unknown

Parameters

srcname	Source file name	⊙srcfile.c	string
---------	------------------	------------	--------

srctype	Coding of source file	⊙1	long
	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.		
stack	Stack size defined as number of variables. Default and recommended value is 0, which enables automatic estimation of the necessary stack size.		long
debug	Debug level – checking is safer but slows down the execution of the algorithm. Option No check can crash REXapplication on target platform if code is incorrect.	⊙3	long
	1 No check		
	2 Basic check		
	3 Full check		
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
p0..p15	Parameters which are accessible from the script		unknown

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
```


Chapter 16

MC_SINGLE – Motion control - single axis blocks

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This library includes functional blocks for single axis motion control as it is defined in the PLCopen specification. It is recommended to study the PLCopen specification prior to using the blocks from this library. The knowledge of PLCopen is necessary for advanced use of the blocks included in this library.

PLCopen defines all blocks with the MC_ prefix. This notation is kept within this library. Nevertheless, there are also function blocks, which are not described by PLCopen or are described as *vendor specific*. These blocks can be recognized by the RM_ prefix. Note that PLCopen (and also IEC 61131-3 which is the base for PLCopen) does not use block parameters, all the parameters are specified by input signals. In the REX control system, block parameters are used to simplify usage of the blocks. To keep compatibility with PLCopen and improve usability of the blocks, almost all of them are implemented twice: with prefix MC_ without parameters (parameters are inputs) and with prefix MCP_ with parameters. Some blocks require additional *vendor specific* parameters. In such a case even the MC_-prefixed blocks contain parameters.

PLCopen specifies that all inputs/parameters are sampled at rising-edge of the Execute input. In the REX control system block parameters are usually changed very rare. Therefore the parameters of the activated block have not be changed until block is finished (e.g. while output Busy is on).

The REX control system does not allow input-output signals and all signals must have different name. For these reasons the Axis input-output signal, which is used in all blocks, is divided into input uAxis and output yAxis. The block algorithm copies the input uAxis to the output yAxis. The yAxis output is not necessary for the function of motion control blocks, but "chaining" the axis references makes it possible to order the blocks and define priorities. Other reference signals are either defined as input-only or use this mechanism as well.

PLCopen defines the outputs Busy, Active, CommandAborted as optional in almost all blocks. In the REX control system, some of them are never set, but the outputs are defined to simplify future extensions and/or changes in the implementation.

Units used for position and distance of axis are implementation specific. It can be meters, millimeters, encoder ticks, angular degrees (for rotational axis) or any others,

but all blocks connected to one axis must use the same position units. Time is always defined in seconds. Velocity unit is thus "position units per second" and acceleration unit is "position units per square second".

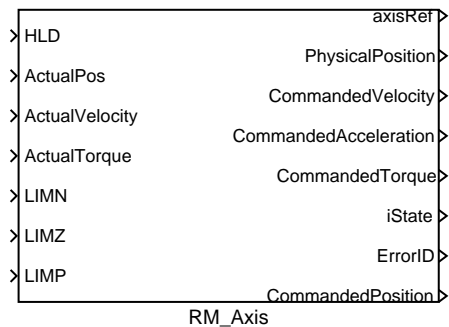
The REX control system uses more threads for execution of the function blocks. In standard function blocks the synchronization is provided by the system and the user does not need to care about it. But using the **reference** references could violate the synchronization mechanisms. However, there is no problem if all referenced blocks are located in the same task and therefore e.g. the [RM_Axis](#) block must be in the same task as all other blocks connected to this axis.

Some inputs/parameters are of enumeration type (for example **BufferMode** or **Direction**). It is possible to choose any of the defined values for this type in the **MCP_** version of the blocks, although not all of them are valid for all blocks (for example the block [MC_MoveVelocity](#) does not support **Direction = shortest_way**). Valid values for each block are listed in this manual.

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 **REX** control 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 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 the -720 error code (general failure).

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

HLD	Hold	bool
	off ... Motion is allowed	
	on Axis is halted and no motion is possible	
ActualPos	Current position of the axis (feedback)	double
ActualVelocity	Current velocity of the axis (feedback)	double

ActualTorque	Current torque in the axis (feedback)	double
LIMN	Limit switch in negative direction	bool
LIMZ	Absolute switch or reference pulse for homing	bool
LIMP	Limit switch in positive direction	bool

Outputs

axisRef	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
CommandedPosition	Requested (commanded) position of the axis	double
CommandedVelocity	Requested (commanded) velocity of the axis	double
CommandedAcceleration	Requested (commanded) acceleration of the axis	double
CommandedTorque	Requested (commanded) torque in the axis	double
iState	State of the axis	long
	0 Disabled	
	1 Stand still	
	2 Homing	
	3 Discrete motion	
	4 Continuous motion	
	5 Synchronized motion	
	6 Coordinated motion	
	7 Stopping	
	8 Error stop	
ErrorID	Error code	error
	i REX general error	

Parameters

AxisType	Type of the axis	⊙1 long
	1 Linear axis	
	2 Cyclic axis with cyclic position sensor	
	3 Cyclic axis with linear position sensor	
EnableLimitPos	Enable positive position limit checking	bool
SWLimitPos	Positive position limit for application (MC blocks)	double
MaxPosSystem	Positive position limit for system	double
EnableLimitNeg	Enable negative position limit checking	bool
SWLimitNeg	Negative position limit for application (MC blocks)	double
MinPosSystem	Negative position limit for system	double
EnablePosLagMonitor	Enable monitoring of position lag	bool
MaxPositionLag	Maximal position lag	double
MaxVelocitySystem	Maximal allowed velocity for system	double
MaxVelocityAppl	Maximal allowed velocity for application (MC blocks)	double
MaxAccelerationSystem	Maximal allowed acceleration for system	double
MaxAccelerationAppl	Maximal allowed acceleration for application (MC blocks)	double
MaxDecelerationSystem	Maximal allowed deceleration for system	double

MaxDecelerationAppl

Maximal allowed deceleration for application (MC blocks)

MaxJerk

Maximal allowed jerk [unit/ s^3]

MaxTorque

Maximal motor torque/force (0=not used)

kta

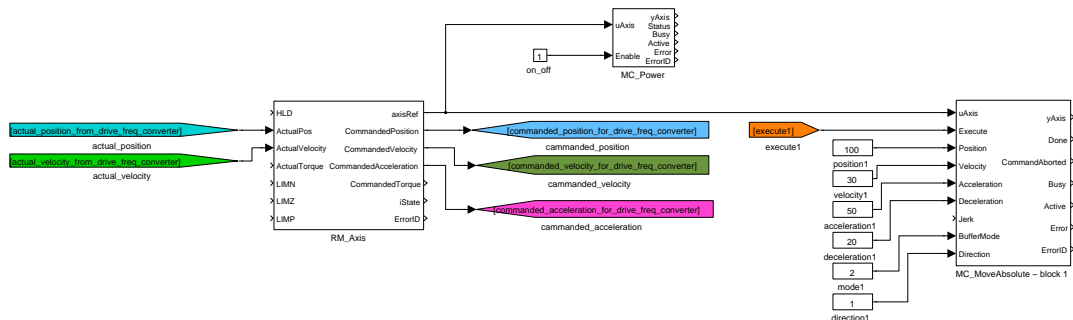
Torque-Acceleration ratio

ReverseLimit

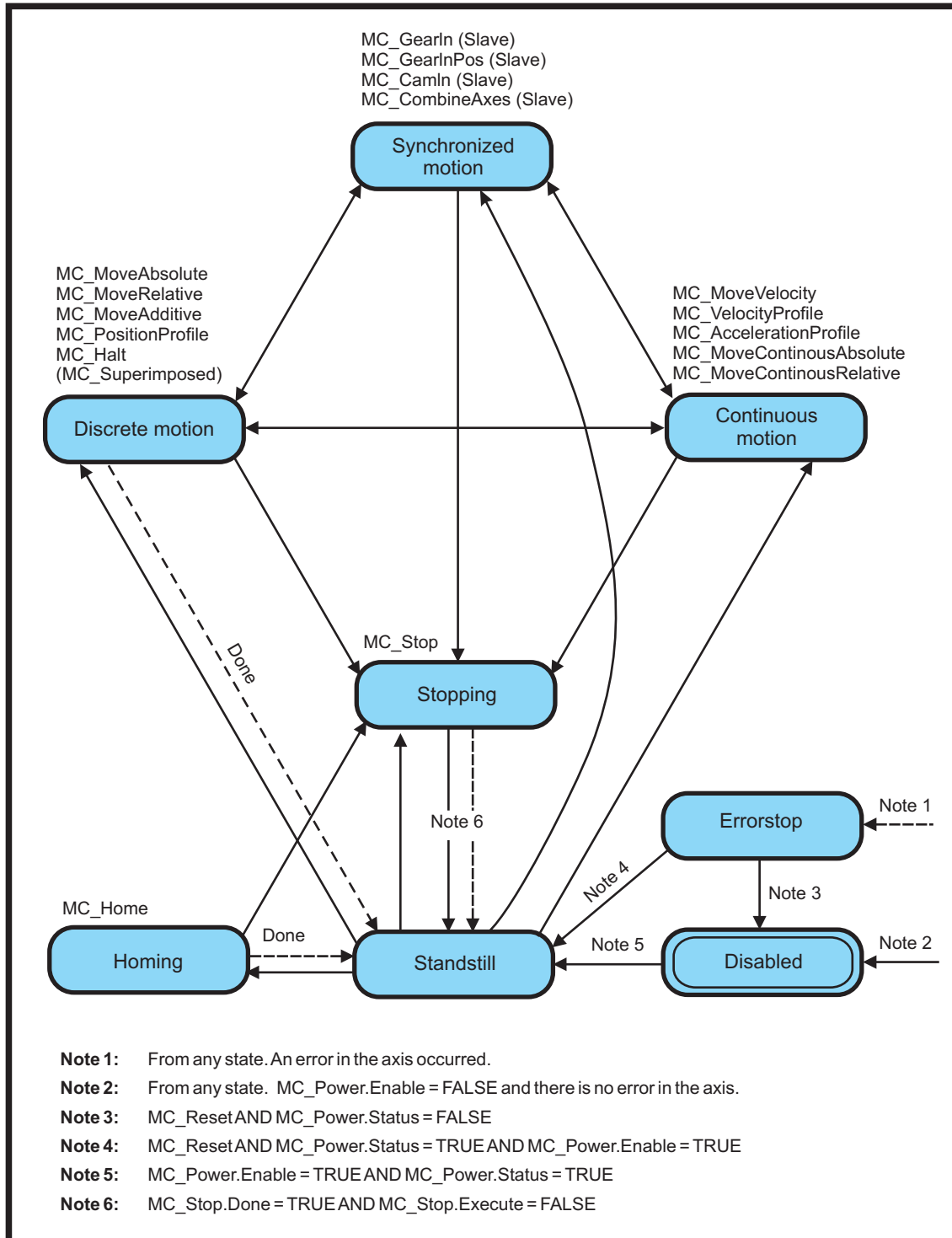
Invert meaning of LIMN, LIMZ and LIMP inputs

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 **REX** control 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

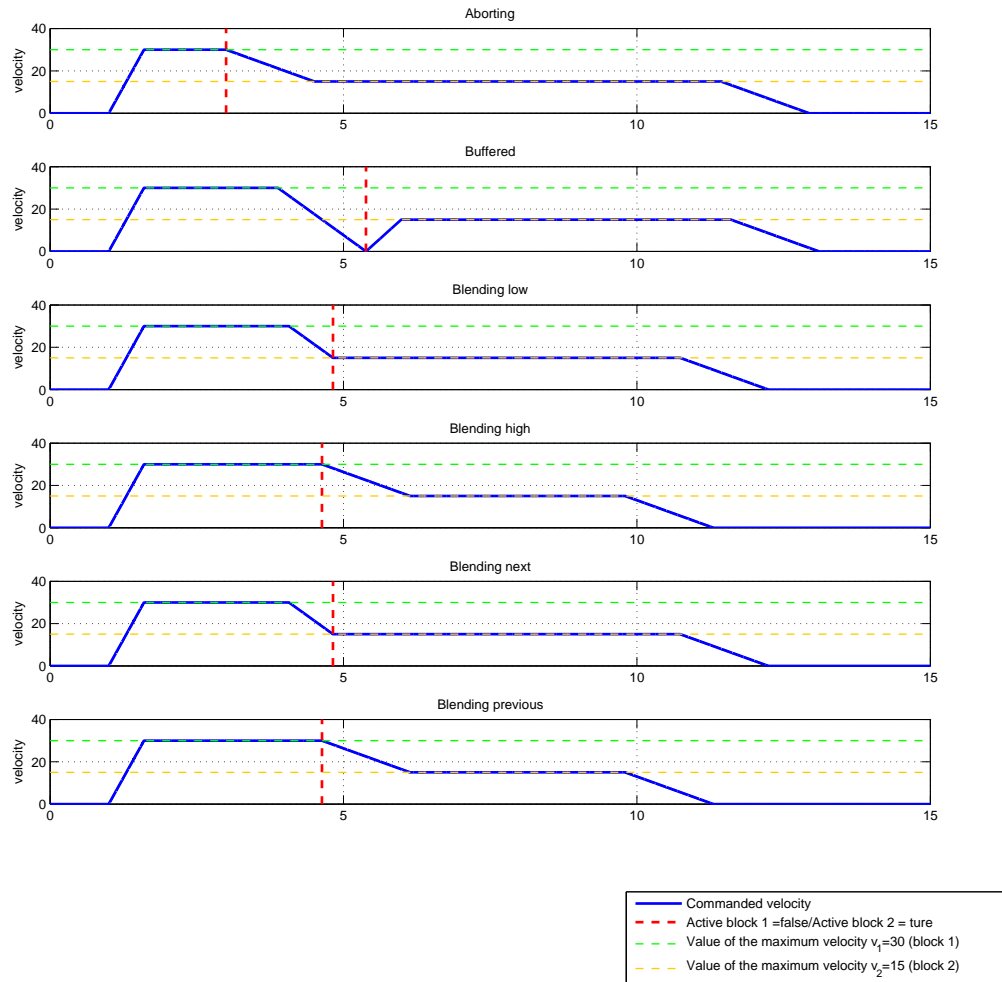


Motion blending

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.

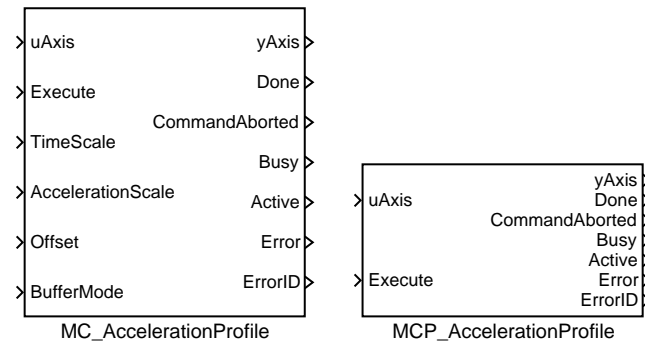
Aborting	The new motion is executed immediately
Buffered	the new motion is executed immediately after finishing the previous one, there is no blending
Blending low	the new motion is executed immediately after finishing the previous one, but the axis will not stop between the movements, the first motion 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



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 reference connections are allowed)	
Execute	The block is activated on rising edge	bool
TimeScale	Overall scale factor in time	double
AccelerationScale	Overall scale factor in value	double
Offset	Overall profile offset in value	double
BufferMode	Buffering mode	long
	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)	

Outputs

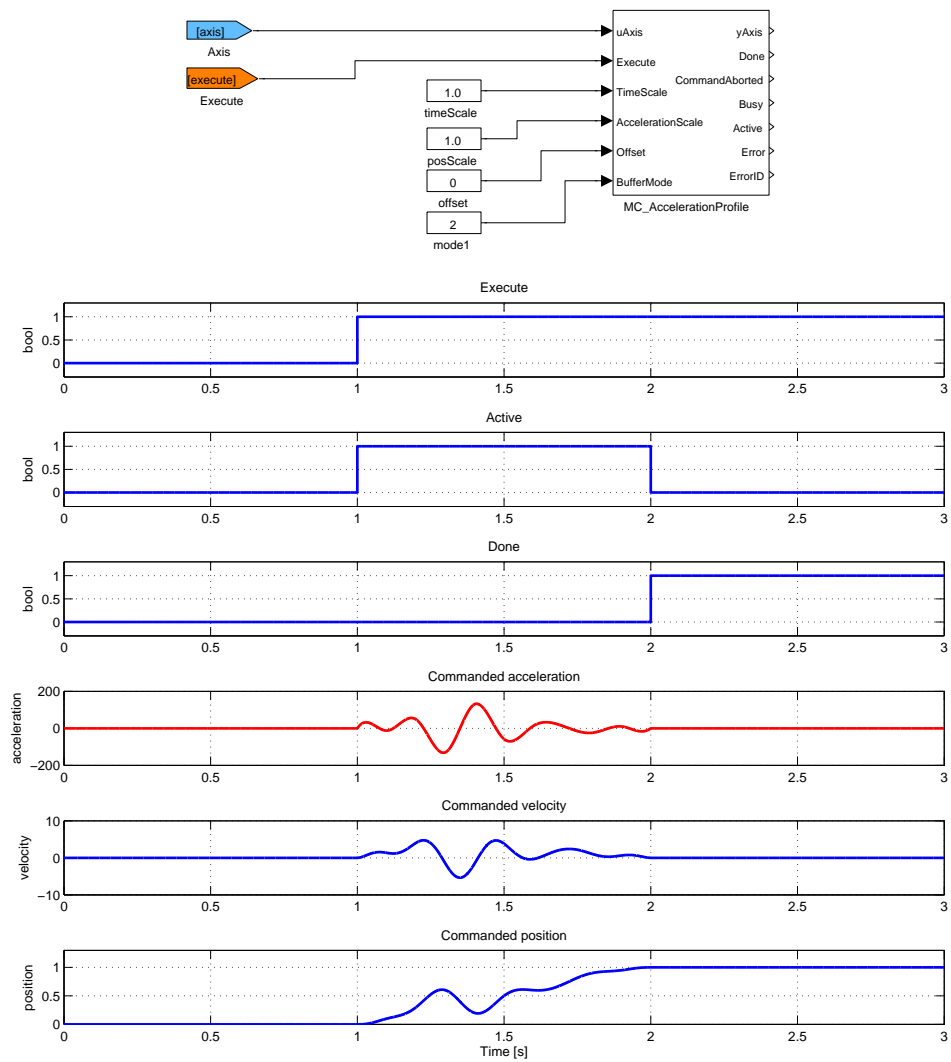
yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Done	Algorithm finished	bool
CommandAborted	Algorithm was aborted	bool
Busy	Algorithm not finished yet	bool
Active	The block is controlling the axis	bool
Error	Error occurred	bool

ErrorID	Error code	error
i REX general error	

Parameters

alg	Algorithm for interpolation	⊙2	long
	1 Sequence of time/value pairs		
	2 Sequence of equidistant values		
	3 Spline		
	4 Equidistant spline		
cSeg	Number of profile segments	⊙3	long
times	Times when segments are switched	⊙[0 30]	double
values	Values or interpolating polynomial coefficients (a0, a1, a2, ...)		double
		⊙[0 100 100 50]	

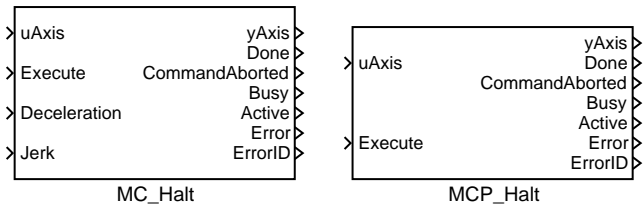
Example



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

<code>uAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Execute</code>	The block is activated on rising edge	<code>bool</code>
<code>Deceleration</code>	Maximal allowed deceleration [<code>unit/s²</code>]	<code>double</code>
<code>Jerk</code>	Maximal allowed jerk [<code>unit/s³</code>]	<code>double</code>

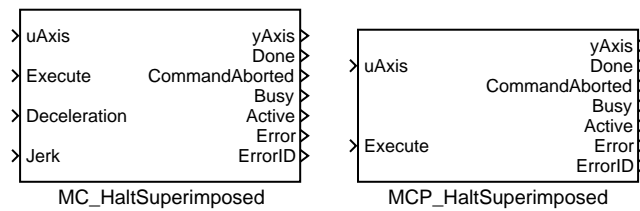
Outputs

<code>yAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Done</code>	Algorithm finished	<code>bool</code>
<code>CommandAborted</code>	Algorithm was aborted	<code>bool</code>
<code>Busy</code>	Algorithm not finished yet	<code>bool</code>
<code>Active</code>	The block is controlling the axis	<code>bool</code>
<code>Error</code>	Error occurred	<code>bool</code>
<code>ErrorID</code>	Error code	<code>error</code>
	i REX general 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

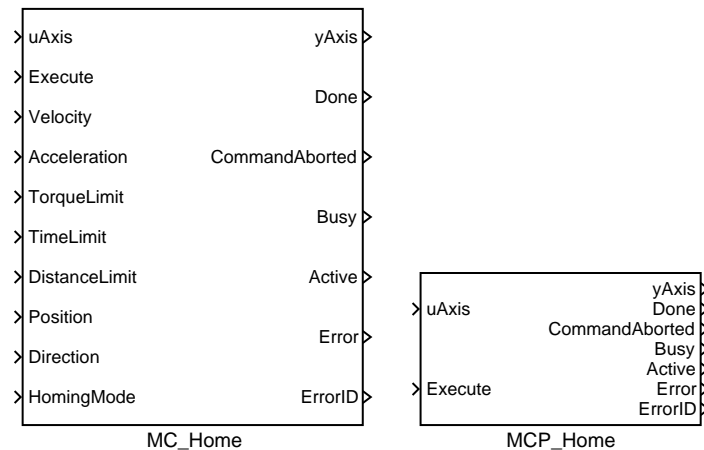
uAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Execute	The block is activated on rising edge	bool
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double

Outputs

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
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	Error code	error
	i REX general error	

MC_Home, MCP_Home – Homing

Block Symbols

Licence: [MOTION CONTROL](#)

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 Block 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 reference connections are allowed)	
Execute	The block is activated on rising edge	bool
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
TorqueLimit	Maximal allowed torque/force	double
TimeLimit	Maximal allowed time for the whole algorithm [s]	double
DistanceLimit	Maximal allowed distance for the whole algorithm [unit]	double
Position	Requested target position (absolute) [unit]	double
Direction	Direction of movement (cyclic axis or special case only)	long
	1 Positive	
	2 Shortest	
	3 Negative	
	4 Current	
HomingMode	Homing mode algorithm	long
	1 Absolute switch	
	2 Limit switch	
	3 Reference pulse	
	4 Direct (user reference)	
	5 Absolute encoder	
	6 Block	

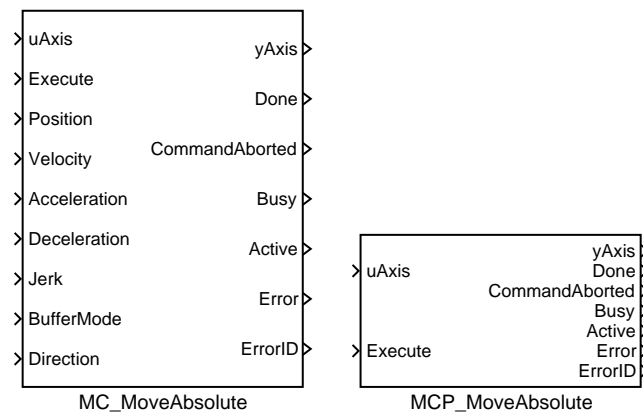
Outputs

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
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	Error code	error
	i REX general error	

MC_MoveAbsolute, MCP_MoveAbsolute – Move to position (absolute coordinate)

Block Symbols

Licence: [MOTION CONTROL](#)



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

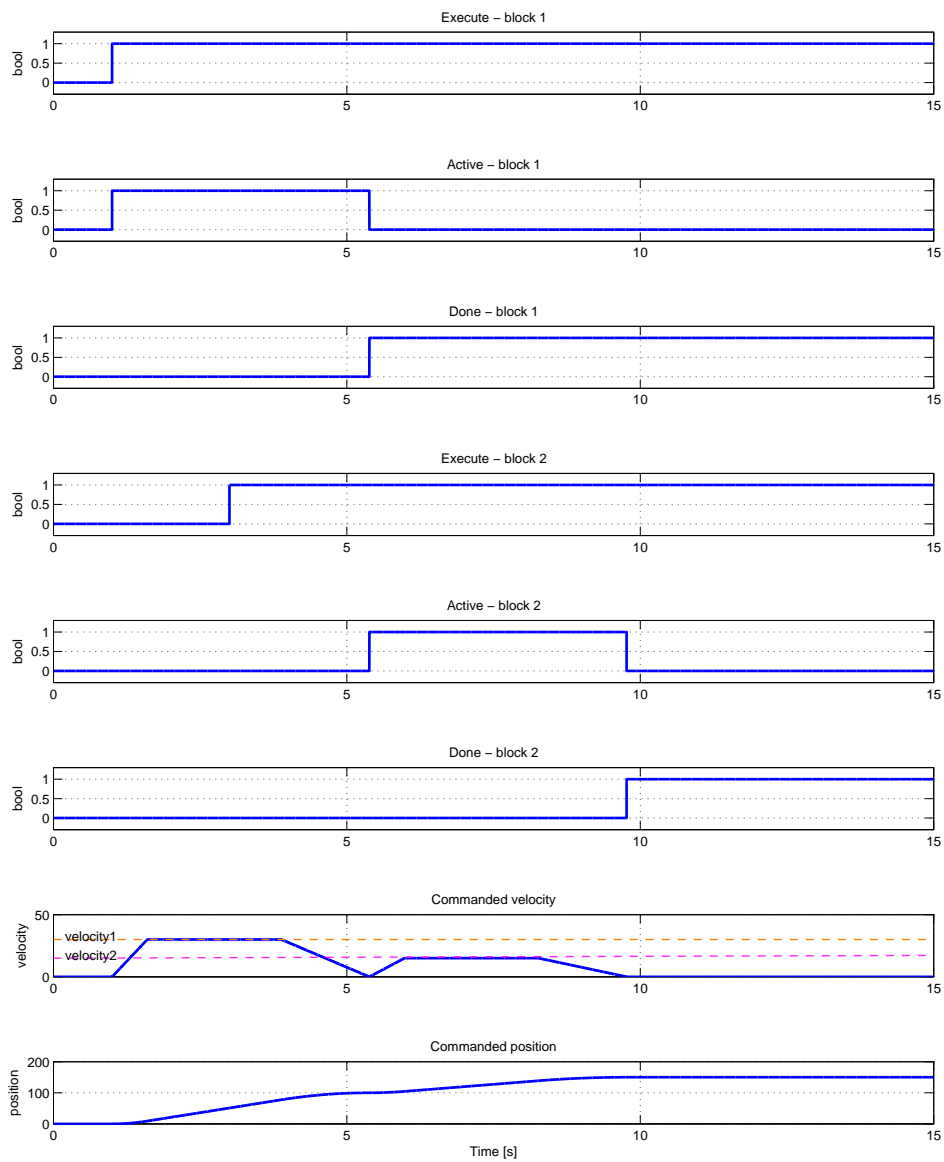
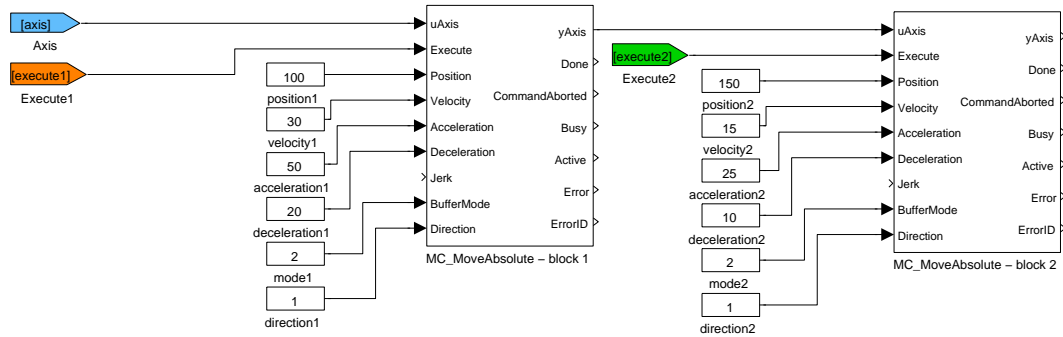
<code>uAxis</code>	AAxis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Execute</code>	The block is activated on rising edge	bool
<code>Position</code>	Requested target position (absolute) [unit]	double
<code>Velocity</code>	Maximal allowed velocity [unit/s]	double
<code>Acceleration</code>	Maximal allowed acceleration [unit/s ²]	double
<code>Deceleration</code>	Maximal allowed deceleration [unit/s ²]	double
<code>Jerk</code>	Maximal allowed jerk [unit/s ³]	double
<code>BufferMode</code>	Buffering mode	long
	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)	
<code>Direction</code>	Direction of movement (cyclic axis or special case only)	long
	1 Positive	
	2 Shortest	
	3 Negative	
	4 Current	

Outputs

<code>yAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Done</code>	Algorithm finished	bool
<code>CommandAborted</code>	Algorithm was aborted	bool
<code>Busy</code>	Algorithm not finished yet	bool

Active	The block is controlling the axis	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	

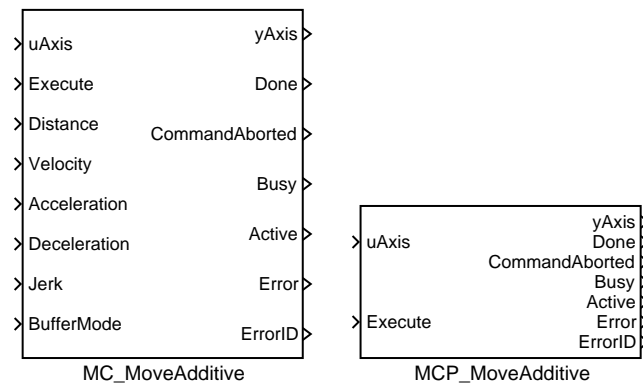
Example



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.

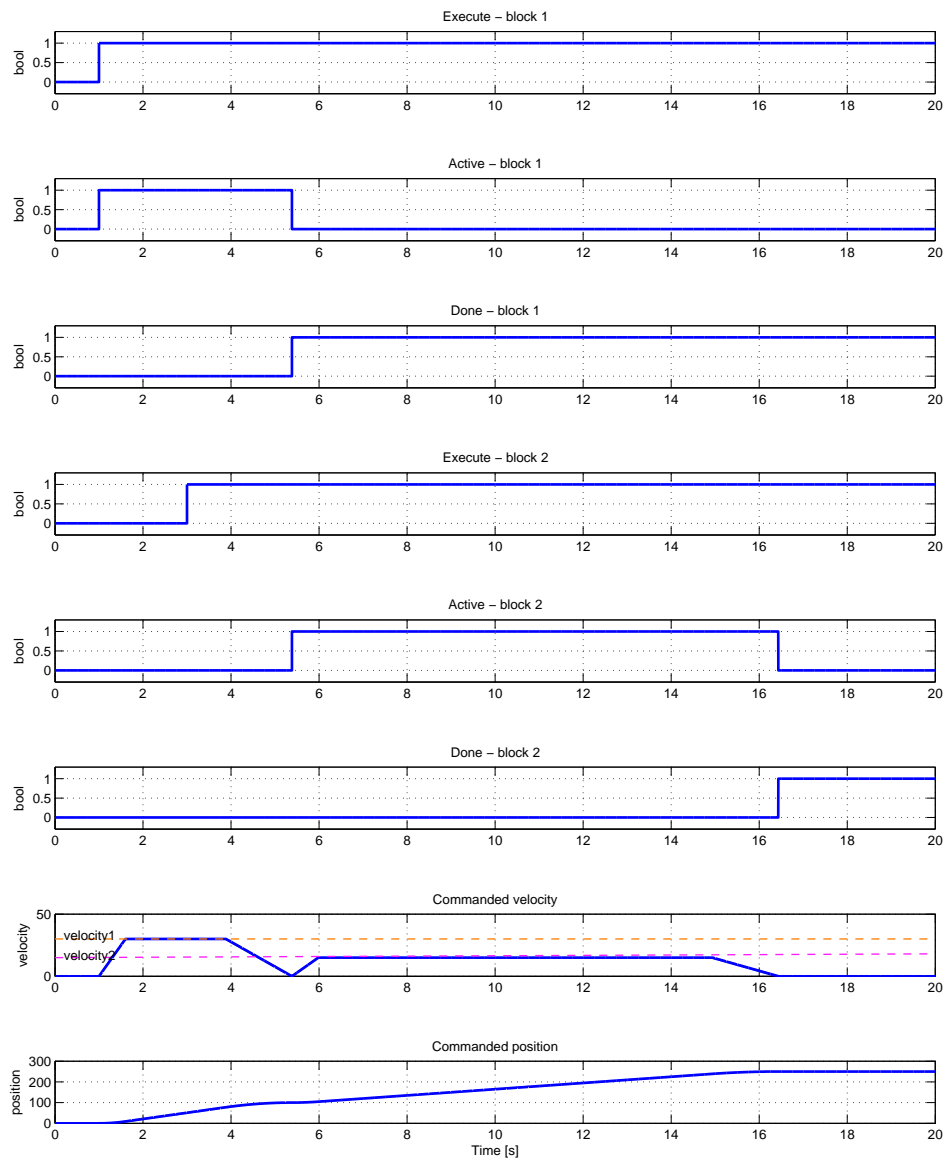
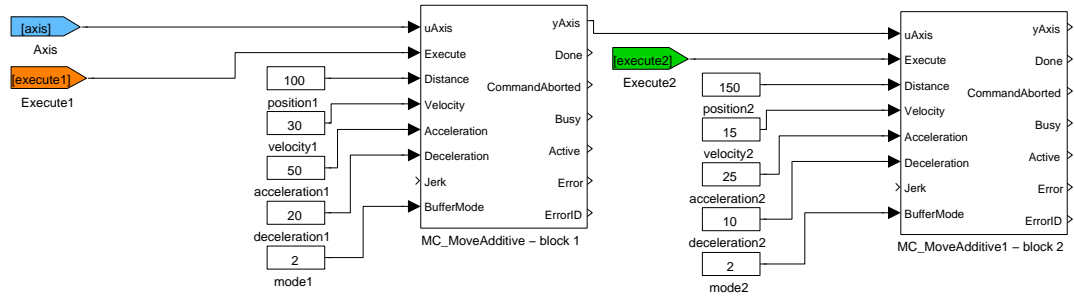
Inputs

uAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> connections are allowed)	reference
Execute	The block is activated on rising edge	bool
Distance	Requested target distance (relative to start point) [unit]	double
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
BufferMode	Buffering mode	long
	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)	

Outputs

yAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> 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	Error code	error
	i REX general error	

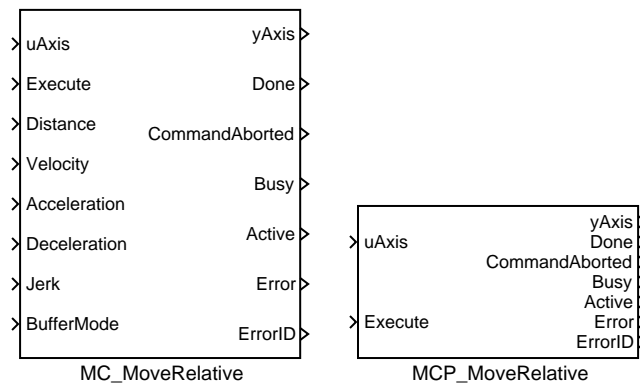
Example



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.

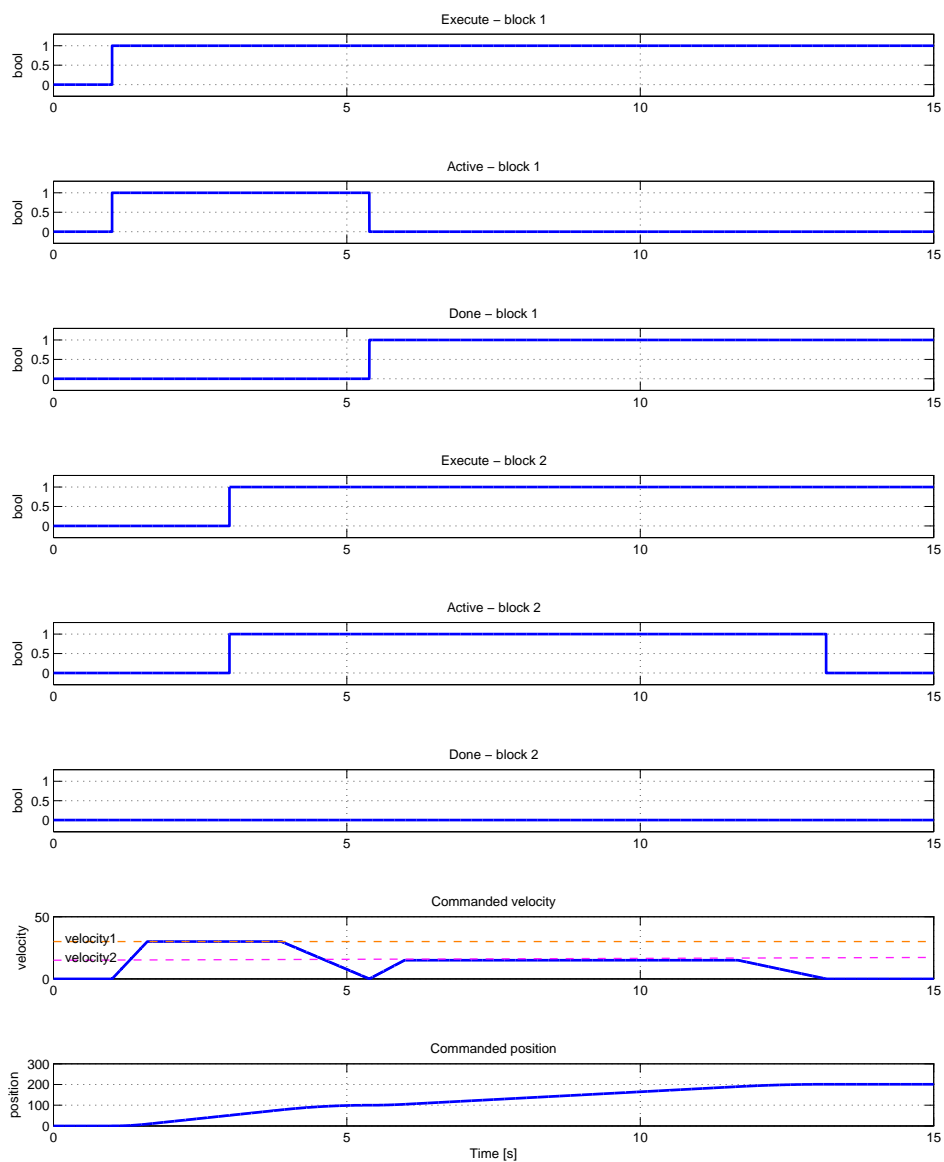
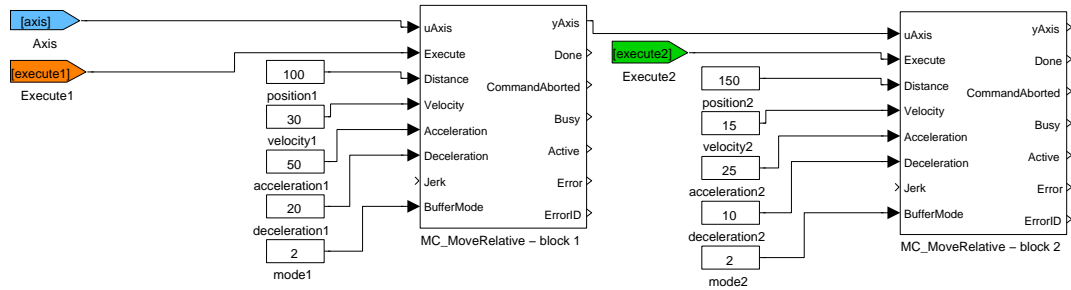
Inputs

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
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [[unit/s ²]	double
Deceleration	Maximal allowed deceleration [[unit/s ²]	double
Jerk	Maximal allowed jerk [[unit/s ³]	double
BufferMode	Buffering mode	long
	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)	

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	Error code	error
	i REX general error	

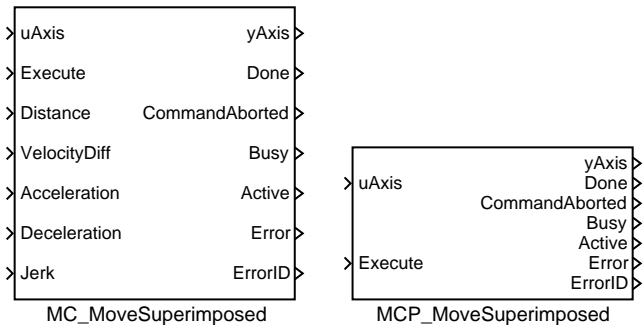
Example



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).

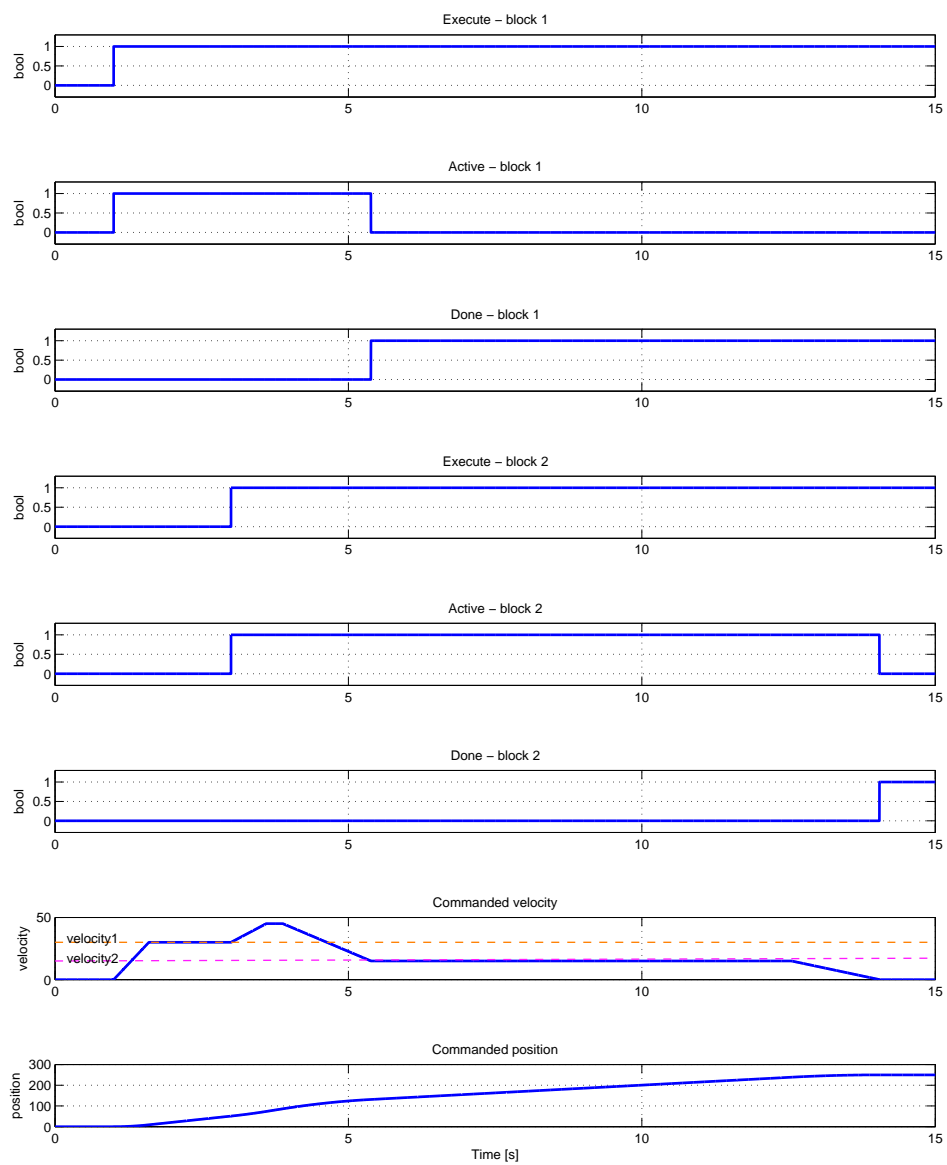
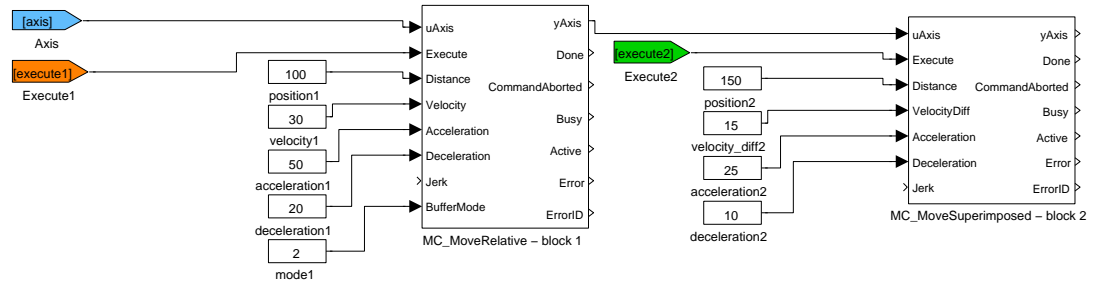
Inputs

uAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Execute	The block is activated on rising edge	bool
Distance	Requested target distance (relative to execution point) [unit]	double
VelocityDiff	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double

Outputs

yAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
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	Error code	error
	i REX general error	

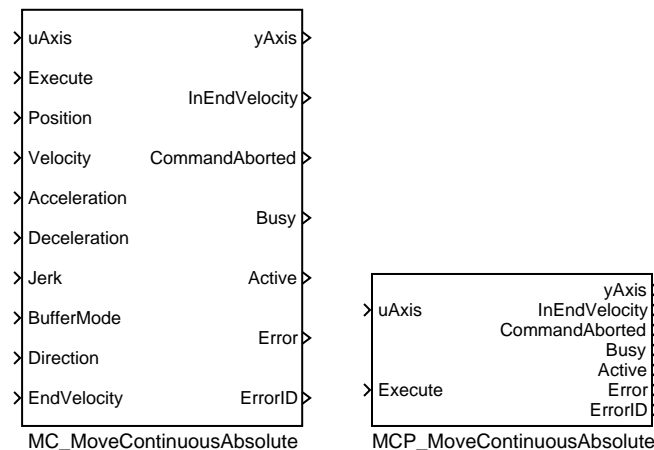
Example



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](#).

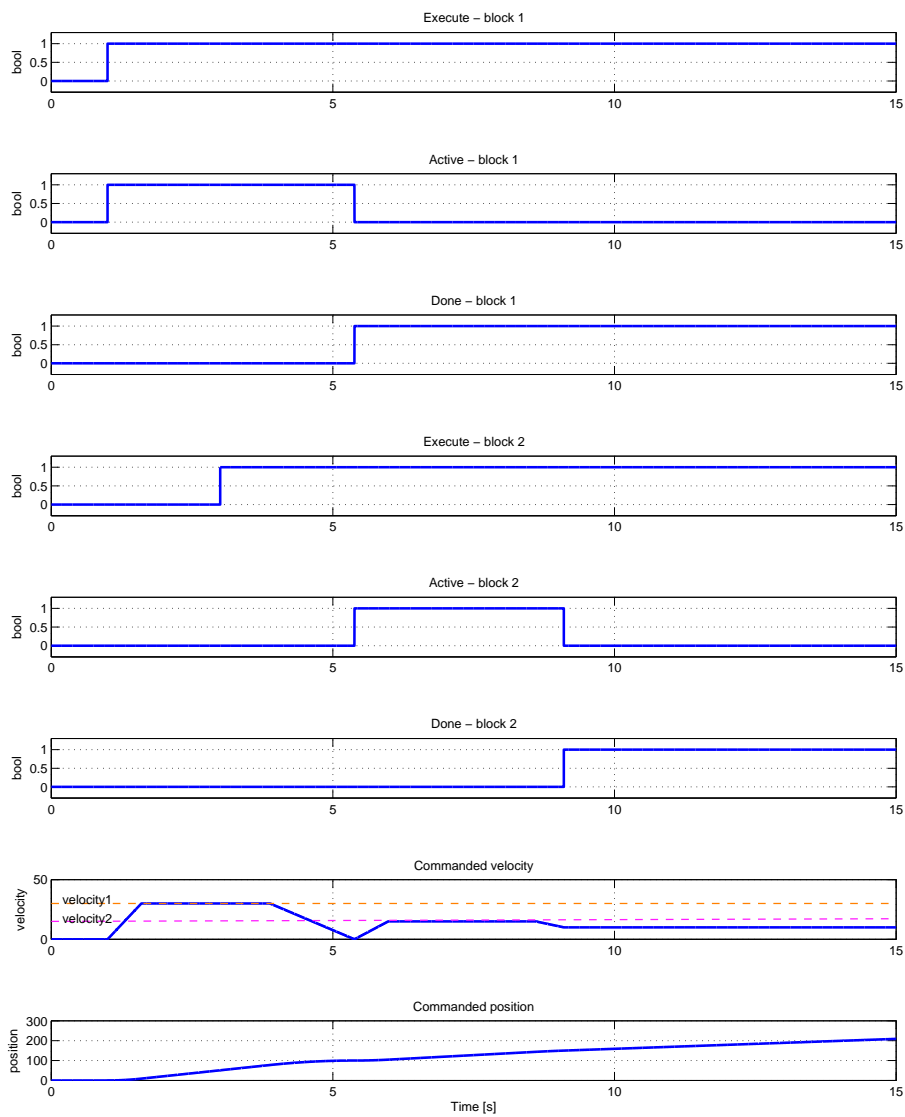
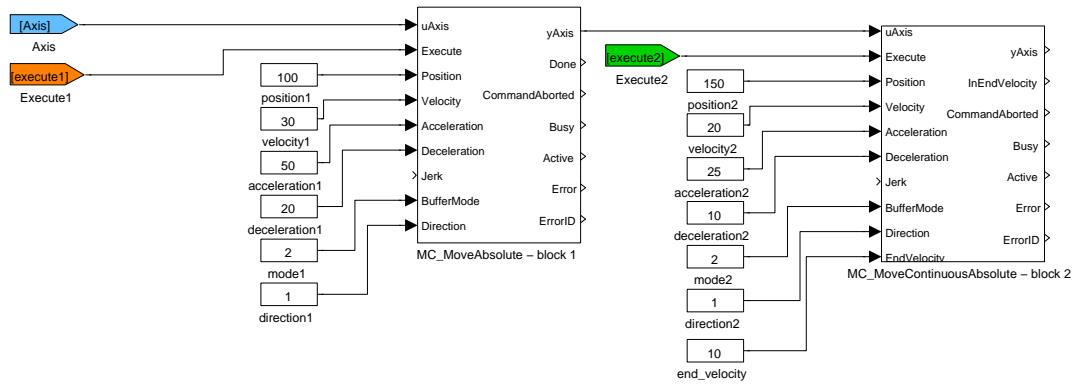
Inputs

uAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> connections are allowed)	reference
Execute	The block is activated on rising edge	bool
Position	Requested target position (absolute) [unit]	double
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
BufferMode	Buffering mode	long
	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)	
Direction	Direction of movement (cyclic axis or special case only)	long
	1 Positive	
	2 Shortest	
	3 Negative	
	4 Current	
EndVelocity	End velocity	double

Outputs

yAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> 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	Error code	error
	i REX general error	

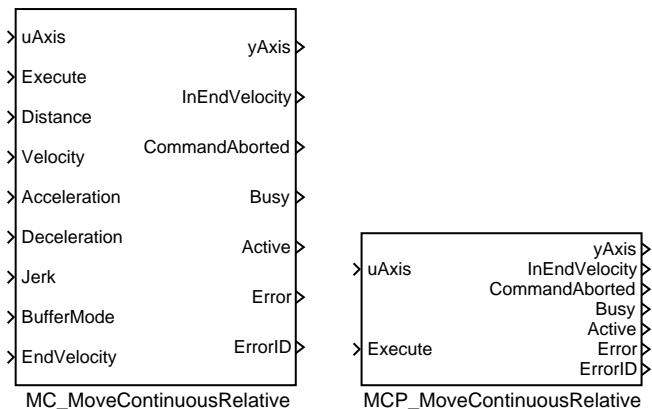
Example



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

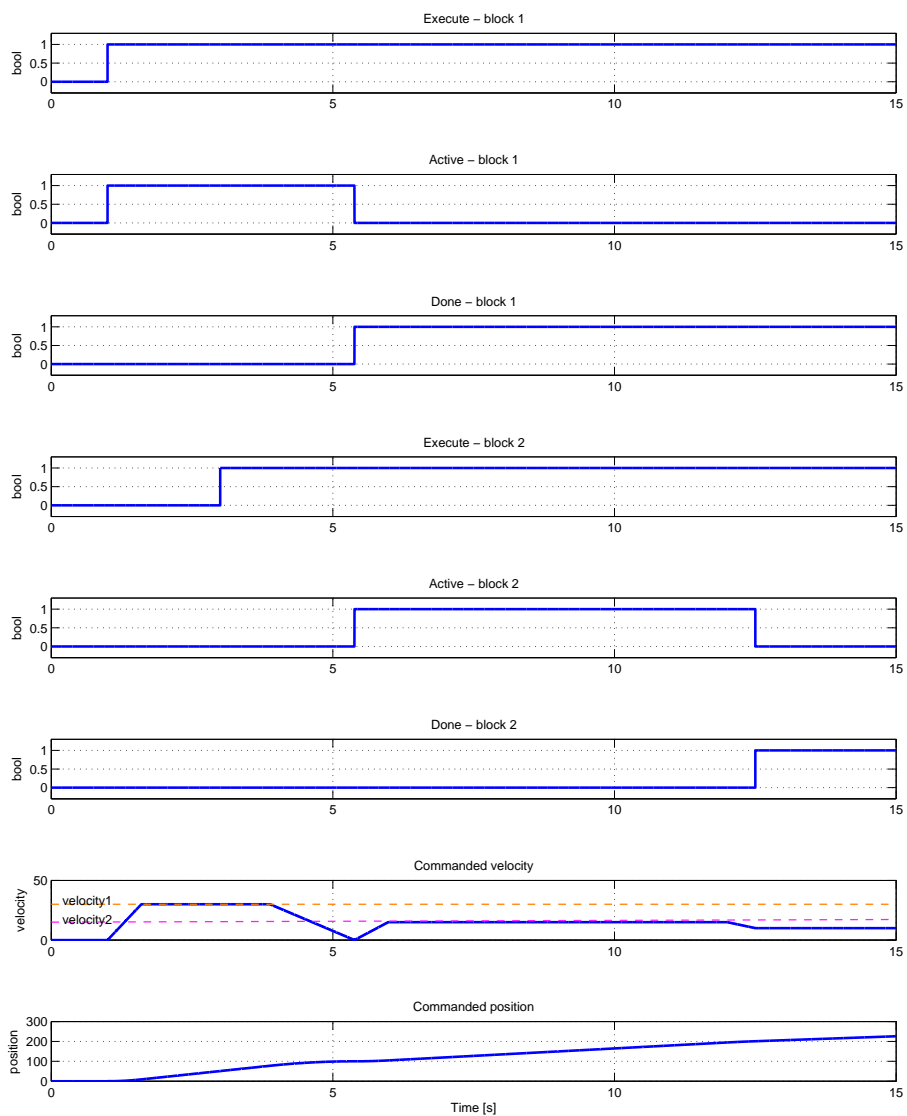
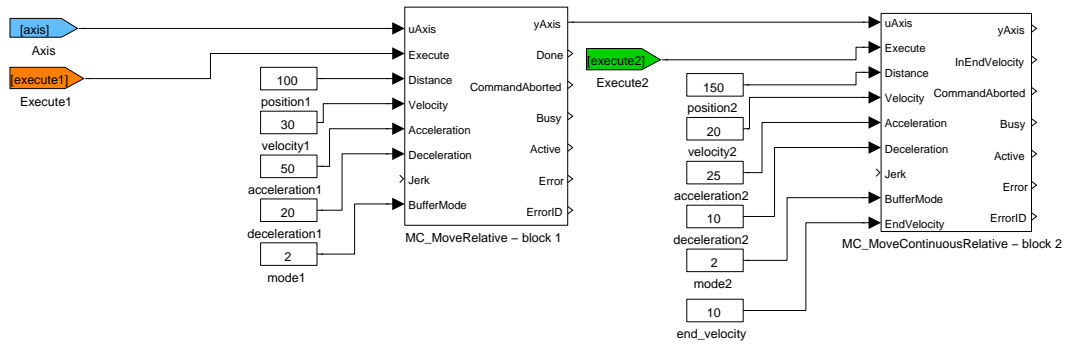
uAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
Execute	The block is activated on rising edge	bool
Distance	Requested target distance (relative to execution point) [unit]	double
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double

BufferMode	Buffering mode	long
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)	
EndVelocity	End velocity	long

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	Error code	error
	i REX general error

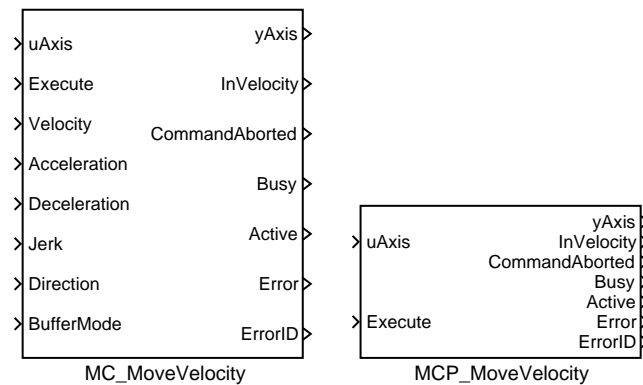
Example



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

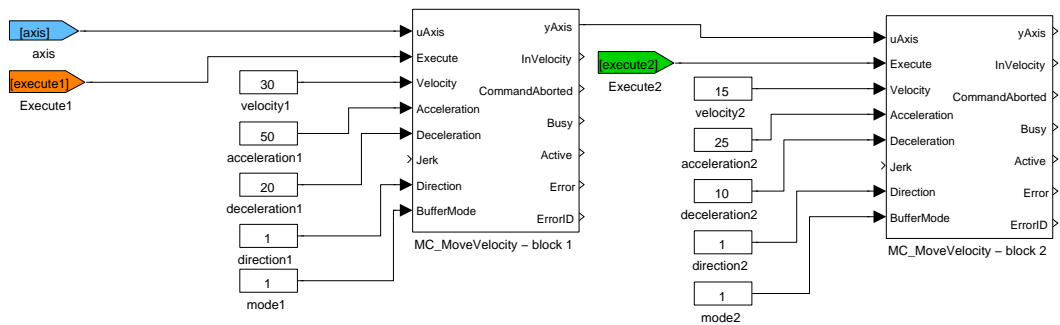
<code>uAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Execute</code>	The block is activated on rising edge	<code>bool</code>
<code>Velocity</code>	Maximal allowed velocity [unit/s]	<code>double</code>
<code>Acceleration</code>	Maximal allowed acceleration [unit/s ²]	<code>double</code>
<code>Deceleration</code>	Maximal allowed deceleration [unit/s ²]	<code>double</code>
<code>Jerk</code>	Maximal allowed jerk [unit/s ³]	<code>double</code>
<code>Direction</code>	Direction of movement (cyclic axis or special case only)	<code>long</code>
	1 Positive	
	2 Shortest	
	3 Negative	
	4 Current	

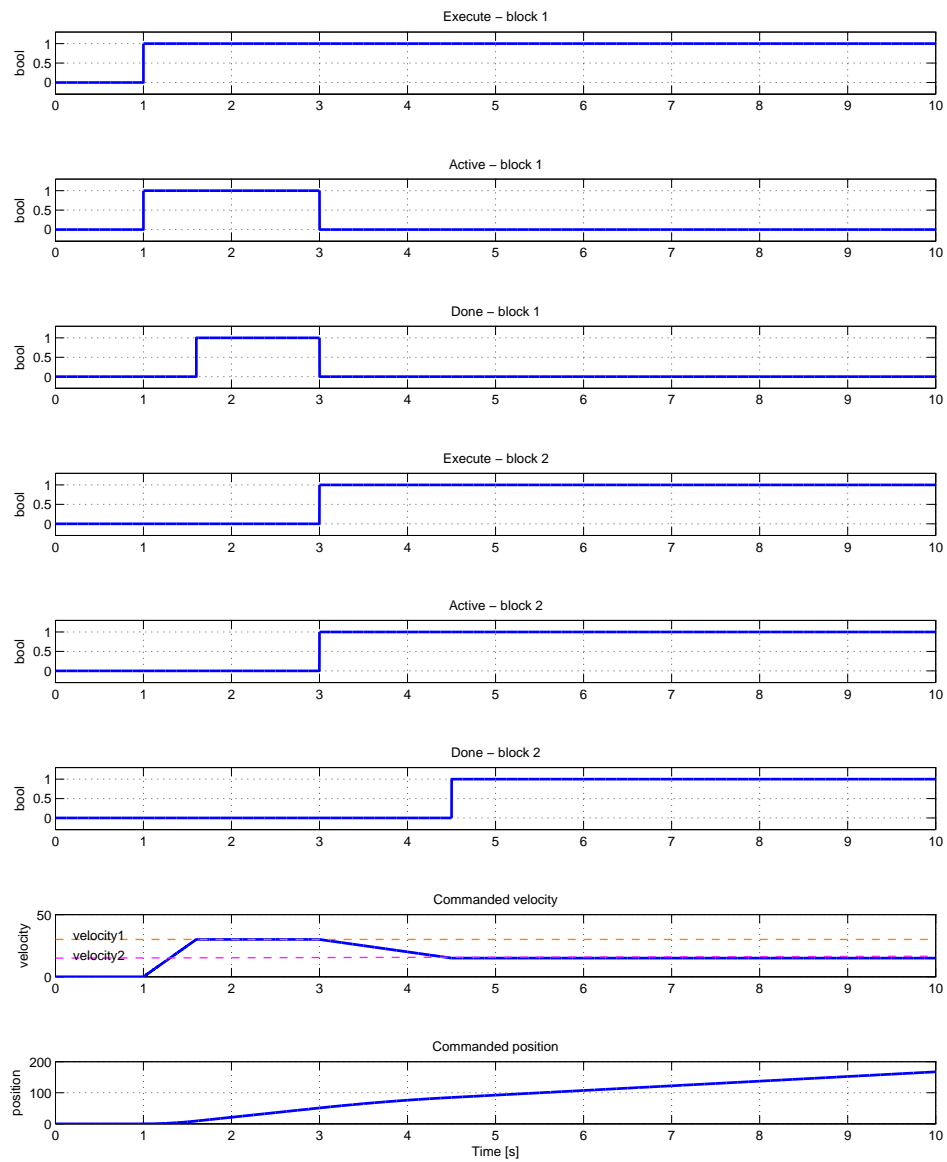
BufferMode	Buffering mode	long
1 Aborting (start immediately)	
2 Buffered (start after finish of previous motion)	
3 Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands)	
4 Blending high (start after finishing the previous motion, 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)	

Outputs

yAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> 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	Error code	error
	i REX general error	

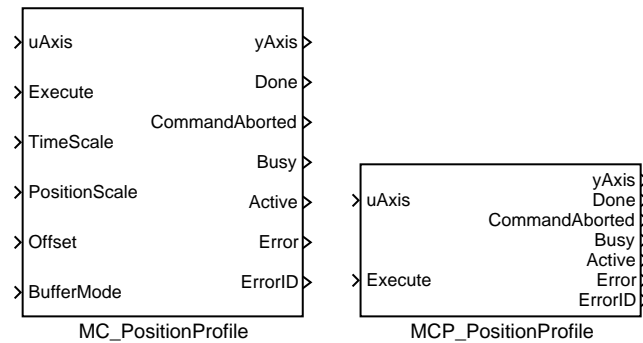
Example





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 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_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 reference connections are allowed)	
Execute	The block is activated on rising edge	bool
TimeScale	Overall scale factor in time	double
PositionScale	Overall scale factor in value	double
Offset	Overall profile offset in value	double
BufferMode	Buffering mode	long
	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)	

Outputs

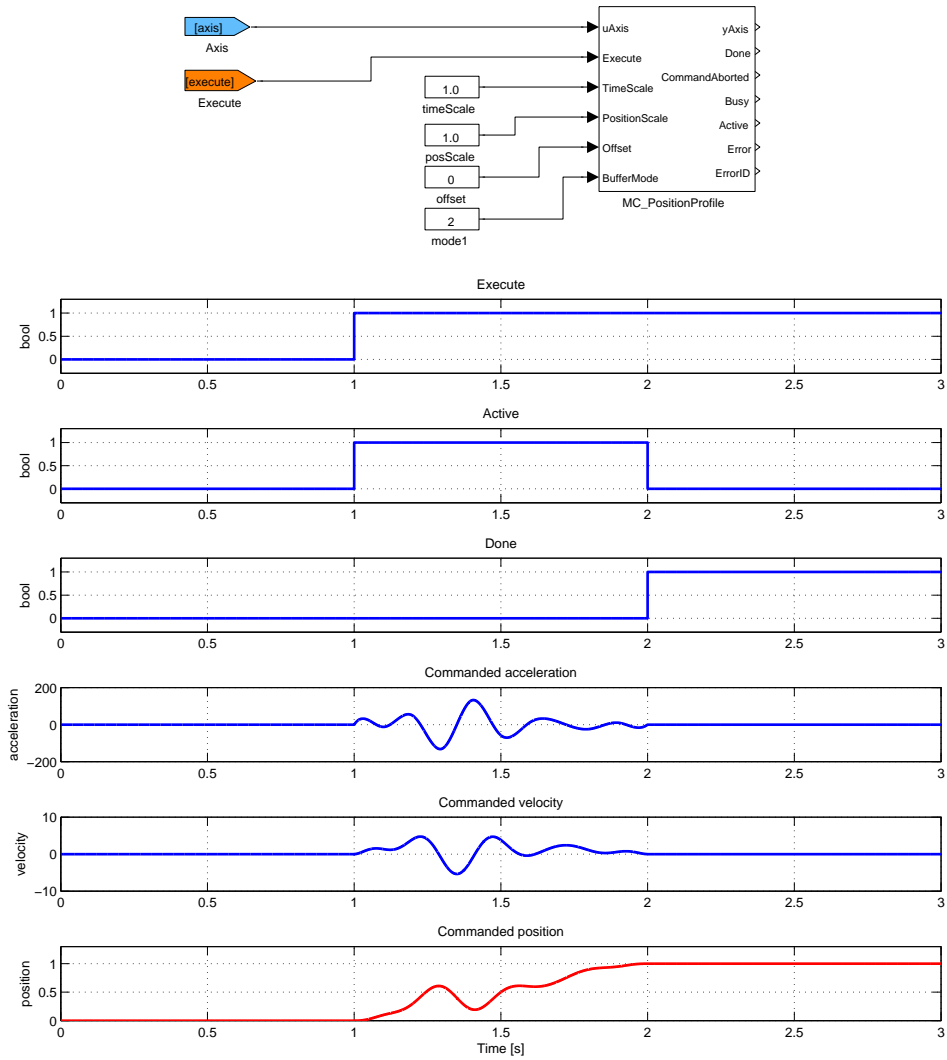
yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Done	Algorithm finished	bool
CommandAborted	Algorithm was aborted	bool
Busy	Algorithm not finished yet	bool
Active	The block is controlling the axis	bool
Error	Error occurred	bool

ErrorID	Error code	error
i REX general error	

Parameters

alg	Algorithm for interpolation	⊙2	long
	1 Sequence of time/value pairs		
	2 Sequence of equidistant values		
	3 Spline		
	4 Equidistant spline		
cSeg	Number of profile segments	⊙3	long
times	Times when segments are switched	⊙[0 30]	double
values	Values or interpolating polynomial coefficients (a0, a1, a2, ...)		double
		⊙[0 100 100 50]	

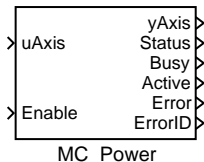
Example



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 <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
Enable	Block function is enabled	bool

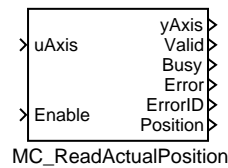
Outputs

yAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
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	Error code	error
	i REX general error	

MC_ReadActualPosition – Read actual position

Block Symbol

Licence: [MOTION CONTROL](#)



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

<code>uAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Enable</code>	Block function is enabled	<code>bool</code>

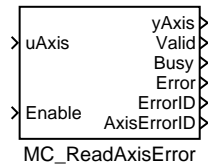
Outputs

<code>yAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Valid</code>	Output value is valid	<code>bool</code>
<code>Busy</code>	Algorithm not finished yet	<code>bool</code>
<code>Error</code>	Error occurred	<code>bool</code>
<code>ErrorID</code>	Error code	<code>error</code>
	i REX general error	
<code>Position</code>	Actual absolute position	<code>double</code>

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 reference connections are allowed)	
Enable	Block function is enabled	bool

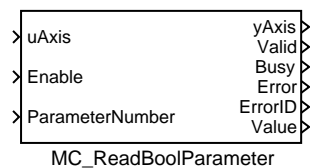
Outputs

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Valid	Output value is valid	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	
AxisErrorID	Error code read from axis	error
	i REX general 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 reference connections are allowed)	
Enable	Block function is enabled	bool
ParameterNumber	Parameter ID	long
	4 Enable sw positive limit	
	5 Enable sw negative limit	
	6 Enable position lag monitoring	

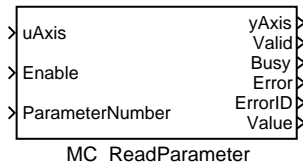
Outputs

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Valid	Output value is valid	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	
Value	Parameter value	bool

MC_ReadParameter – Read axis parameter

Block Symbol

Licence: MOTION CONTROL



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 reference connections are allowed)	
Enable	Block function is enabled	bool
ParameterNumber	Parameter ID	long
	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	

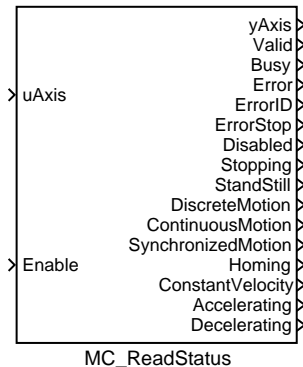
Outputs

<code>yAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Valid</code>	Output value is valid	<code>bool</code>
<code>Busy</code>	Algorithm not finished yet	<code>bool</code>
<code>Error</code>	Error occurred	<code>bool</code>
<code>ErrorID</code>	Error code	<code>error</code>
	<code>i</code> REX general error	
<code>Value</code>	Parameter value	<code>double</code>

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 <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
Enable	Block function is enabled	bool

Outputs

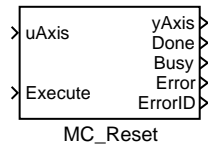
yAxis	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
Valid	Output value is valid	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	
ErrorStop	Axis is in the ErrorStop state	bool
Disabled	Axis is in the Disabled state	bool
Stopping	Axis is in the Stopping 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 reference connections are allowed)	
Execute	The block is activated on rising edge	bool

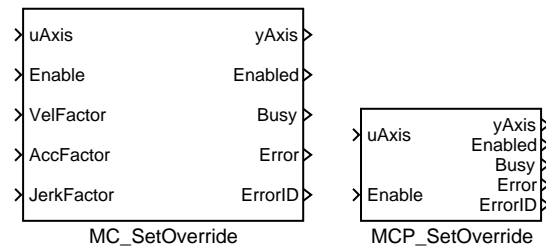
Outputs

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general 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 recalculation 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 reference connections are allowed)	
Enable	Block function is enabled	bool
VelFactor	Velocity multiplication factor	double
AccFactor	Acceleration/deceleration multiplication factor	double

JerkFactor Jerk multiplication factor double

Outputs

yAxis Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)

Enabled Block function is enabled bool

Busy Algorithm not finished yet bool

Error Error occurred bool

ErrorID Error code error

i REX general error

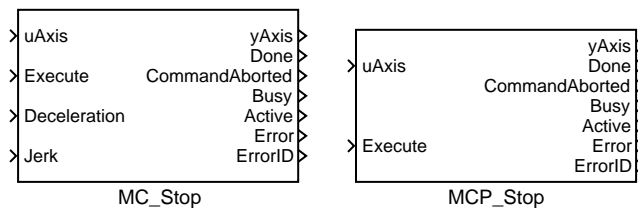
Parameter

diff Deadband (difference for recalculation) ↓0.0 ↑1.0 ⊙0.1 double

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 reference connections are allowed)	
Execute	The block is activated on rising edge	bool
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double

Outputs

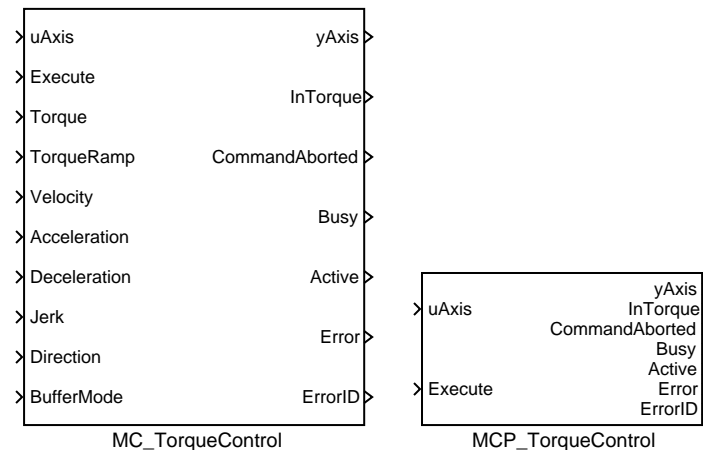
yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Done	Algorithm finished	bool
CommandAborted	Algorithm was aborted	bool
Busy	Algorithm not finished yet	bool

Active	The block is controlling the axis	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general 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 <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
Execute	The block is activated on rising edge	bool
Torque	Maximal allowed torque/force	double
TorqueRamp	Maximal allowed torque/force ramp	double
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double

Direction	Direction of movement (cyclic axis or special case only)	long
	1 Positive	
	2 Shortest	
	3 Negative	
	4 Current	
BufferMode	Buffering mode	long
	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)	

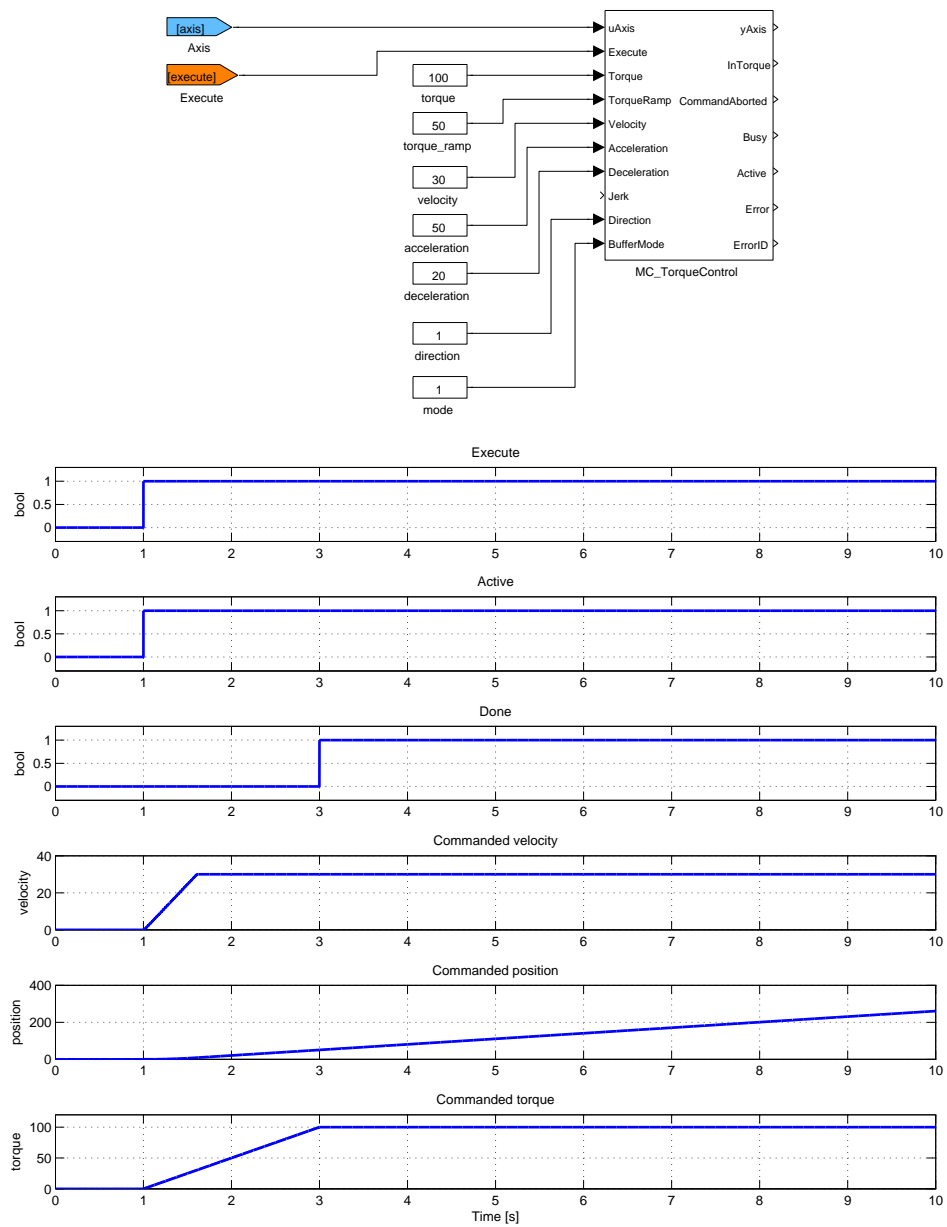
Outputs

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	Error code	error
	i REX general error	

Parameter

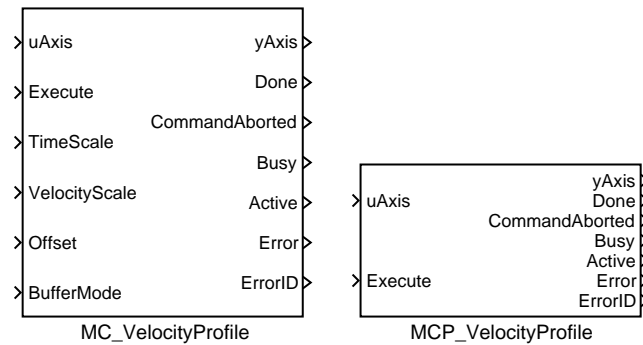
kma	Torque/force to acceleration ratio	double
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Example



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

<code>uAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Execute</code>	The block is activated on rising edge	bool
<code>TimeScale</code>	Overall scale factor in time	double
<code>VelocityScale</code>	Overall scale factor in value	double
<code>Offset</code>	Overall profile offset in value	double
<code>BufferMode</code>	Buffering mode	long
	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)	

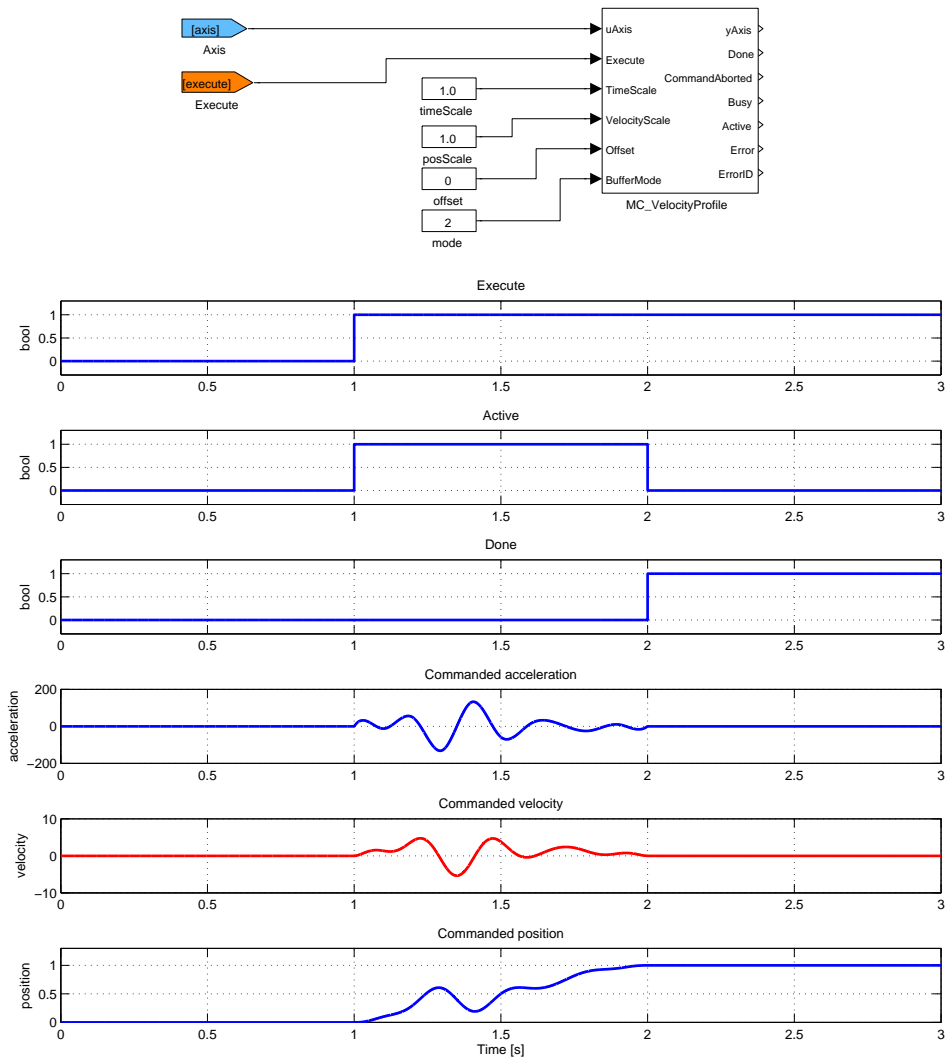
Outputs

<code>yAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> reference connections are allowed)	
<code>Done</code>	Algorithm finished	bool
<code>CommandAborted</code>	Algorithm was aborted	bool
<code>Busy</code>	Algorithm not finished yet	bool
<code>Active</code>	The block is controlling the axis	bool
<code>Error</code>	Error occurred	bool
<code>ErrorID</code>	Error code	error
	i REX general error	

Parameters

alg	Algorithm for interpolation	⊙1	long
	1 Sequence of time/value pairs		
	2 Sequence of equidistant values		
	3 Spline		
	4 Equidistant spline		
cSeg	Number of profile segments	⊙3	long
times	Times when segments are switched	⊙[0 15 25 30]	double
values	Values or interpolating polynomial coefficients (a0, a1, a2, ...)		double
		⊙[0 100 100 50]	

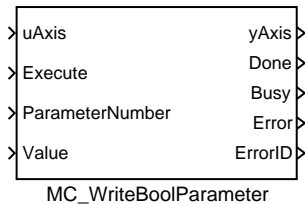
Example



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 reference connections are allowed)	
Execute	The block is activated on rising edge	bool
ParameterNumber	Parameter ID	long
	4 Enable sw positive limit	
	5 Enable sw negative limit	
	6 Enable position lag monitoring	
Value	Parameter value	bool

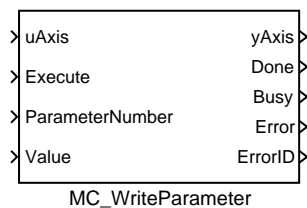
Outputs

yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	

MC_WriteParameter — Write axis parameter

Block Symbol

Licence: [MOTION CONTROL](#)



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 reference connections are allowed)	
Execute	The block is activated on rising edge	bool
ParameterNumber	Parameter ID	long
	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	
Value	Parameter value	double

Outputs

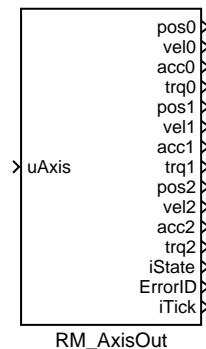
yAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)	
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool

ErrorID	Error code	error
i	REX general error	

RM_AxisOut – Axis output

Block Symbol

Licence: [MOTION CONTROL](#)



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 1: Control system REX orders blocks primary by flow of signal, secondarily by name of block (ascendent in alphabetical order), so name like "zzz" is good choice. For checking the order, you can use `RexView` tool where the blocks are sorted by execution order.

Note 2: 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

<code>uAxis</code>	axis reference that must be connected to <code>axisRef</code> of the <code>RM_Axis</code> block (direct or indirect throw output <code>yAxis</code> of some other block)	reference
--------------------	---	-----------

Input

<code>uAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> connections are allowed)	reference
--------------------	--	-----------

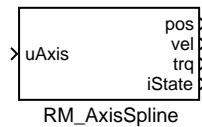
Outputs

pos0	Current commanded position [unit]	double
vel0	Current commanded velocity [unit/s]	double
acc0	Current commanded acceleration [unit/s ²]	double
trq0	Current commanded torque/force (if generated)	double
pos1	Next step commanded position [unit]	double
vel1	Next step commanded velocity [unit/s]	double
acc1	Next step commanded acceleration/deceleration [unit/s ²]	double
trq1	Next step commanded torque/force (if generated)	double
pos2	2nd next step commanded position [unit]	double
vel2	2nd next step commanded velocity [unit/s]	double
acc2	2nd next step commanded acceleration/deceleration [unit/s ²]	double
trq2	2nd next step commanded torque/force (if generated)	double
iState	State of the axis	long
	0 Disabled	
	1 Stand still	
	2 Homing	
	3 Discrete motion	
	4 Continuous motion	
	5 Synchronized motion	
	6 Coordinated motion	
	7 Stopping	
	8 Error stop	
ErrorID	Error code	error
	i REX general error	
iTick	Current tick	long

RM_AxisSpline – Commanded values interpolation

Block Symbol

Licence: [MOTION CONTROL](#)



Function Description

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 200ms). 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 different task than other motion control blocks with highest sampling period possible. It interpolates commanded position, velocity and torque and generates smooth curve which is more suited for motor driver controllers.

There are two possibilities of connection to **RM_Axis** block: connect all necessary values (outputs of the block **RM_AxisOut**) as input of interpolating block or use only axis reference and read the state directly. This block uses axis reference. For correct synchronization between two tasks, the block **RM_Axis** must be executed first followed by all axis related motion control blocks and finally by block **RM_AxisOut** at the end.

Note 1: For interpolation of position signal, 3rd order polynomial $p(t)$ is used, where $p_s(0) = pos0, p_s(t_S) = pos1, \frac{dp_s(t)}{dt}_{t=0} = vel0, \frac{dp_s(t)}{dt}_{t=t_S} = vel1$. To interpolate velocity, also a 3rd order polynomial $p_v(t)$ is used, where $p_v(0) = vel0, p_v(t_S) = vel1, \frac{dp_v(t)}{dt}_{t=0} = acc0, \frac{dp_v(t)}{dt}_{t=t_S} = acc1$. Torque is interpolated by linear function.

Note 2: Because the time of execution 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 **RUN0**, **RUN1**, **RUN2**.

Note 3: Control system **REX** orders the blocks primarily by flow of signal, secondarily by name of block (ascendent in alphabetical order), so name like "zzz" is good choice for the block **RM_AxisOut**. For checking the order, you can use **RexView** tool where the blocks are sorted by execution order.

Input

uAxis	Axis reference (only RM_Axis.axisRef-uAxis or yAxis-uAxis reference connections are allowed)
--------------	--

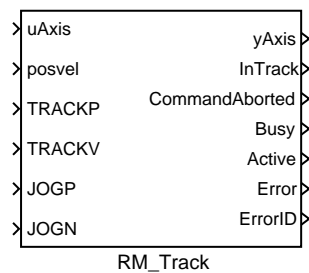
Outputs

pos	Commanded interpolated position [unit]	double
vel	Commanded interpolated velocity [unit/s]	double
trq	Commanded interpolated torque/force	double
iState	Interpolator state/error	long
	0 Off	
	1 Run0	
	2 Run1	
	3 Run2	
	5 Change1	
	-1 Change0	
	-2 Late	
	-3 Busy	
	-4 Slow	

RM_Track – Tracking and inching

Block Symbol

Licence: [MOTION CONTROL](#)



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/deceleration 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 though 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 reference connections are allowed)	
posvel	Requested target position or velocity [unit]	double
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
pa	Maximal allowed acceleration [unit/s ²]	double
pd	Maximal allowed deceleration [unit/s ²]	double
pj	Maximal allowed jerk [unit/s ³]	double
iLen	Length of buffer for estimation	⊙10 long

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	Error code	error
	i REX general error	

Chapter 17

MC_MULTI – Motion control - multi axis blocks

Contents

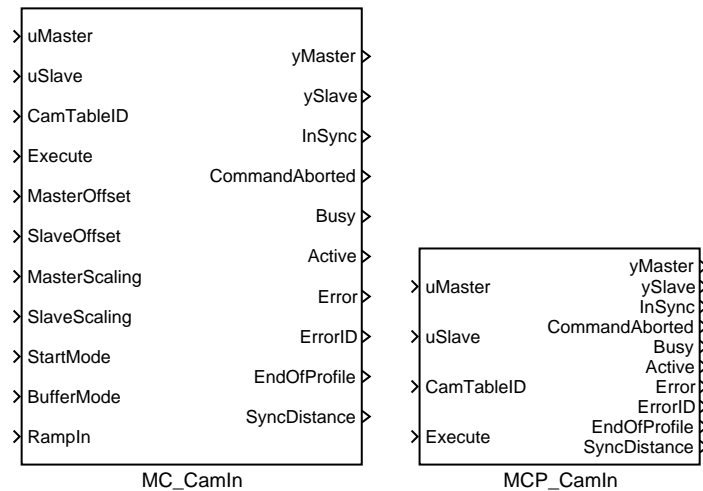
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This block set is the second part of motion control blocks library according to the PLCopen standard for multi axis control. General vendor specific rules are the same as described in chapter 16 (the MC_SINGLE library, blocks for single axis motion control).

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 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 parameter 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** parameter 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

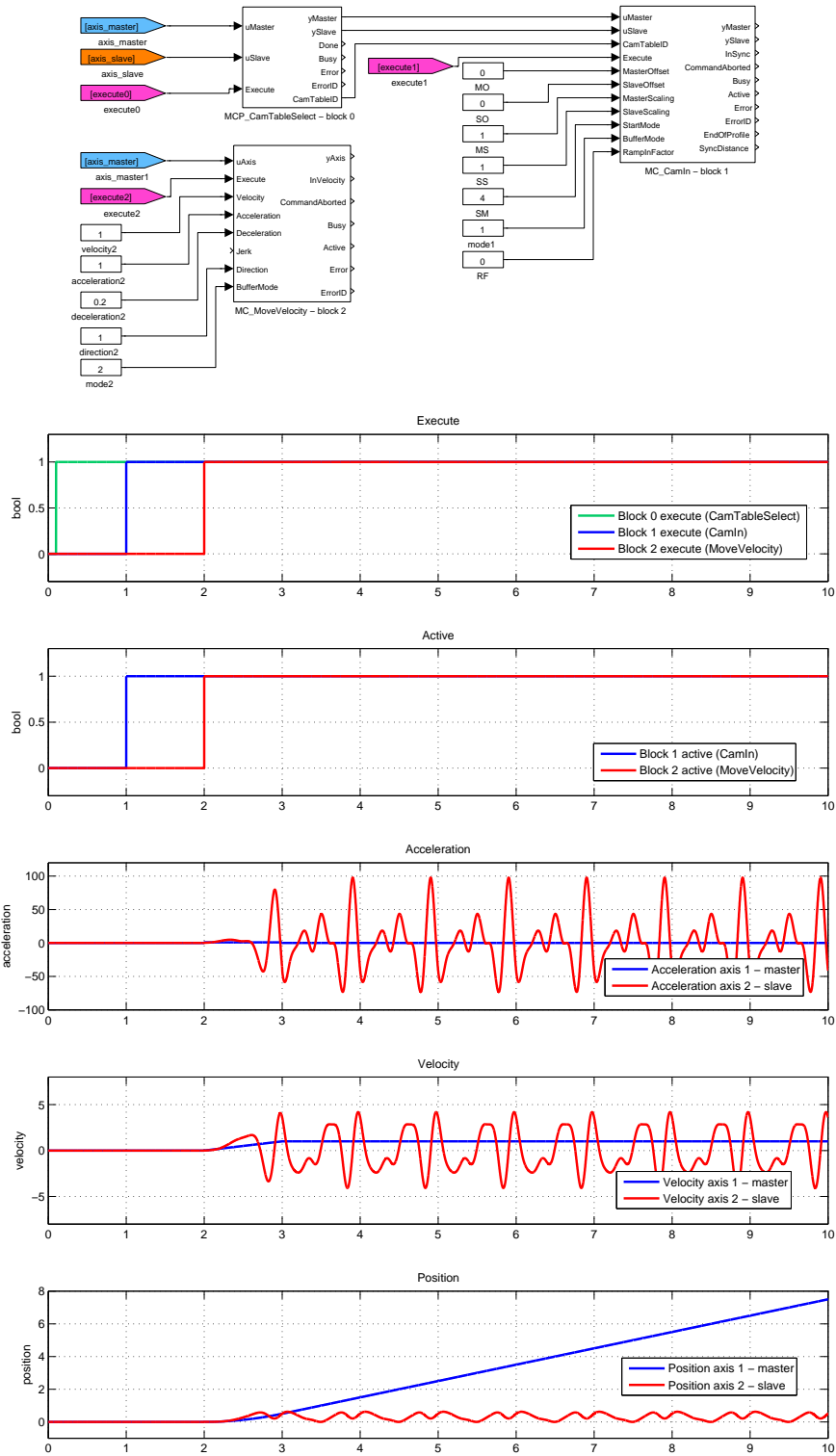
uMaster	Master axis reference	reference
uSlave	Slave axis reference	reference
CamTableID	Cam table reference (connect to MCP_CamTableSelect.CamTableID)	reference
Execute	The block is activated on rising edge	bool
MasterOffset	Offset in cam table on master side [unit]	double
SlaveOffset	Offset in cam table on slave side [unit]	double
MasterScaling	Overall scaling factor in cam table on master side	double
SlaveScaling	Overall scaling factor in cam table on slave side	double
StartMode	Select relative or absolute cam table	long
	1 Master relative	
	2 Slave relative	
	3 Both relative	
	4 Both absolute	
BufferMode	Buffering mode	long
	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)	
RampIn	RampIn factor (0 = RampIn mode not used); average additive velocity (absolute value) during ramp-in process	double

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	Error code	error
	i REX general error	

EndOfProfile	Indicate end of cam profile (not periodic cam only)	bool
SyncDistance	Position deviation of the slave axis from synchronized position	double

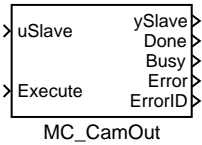
Example



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).

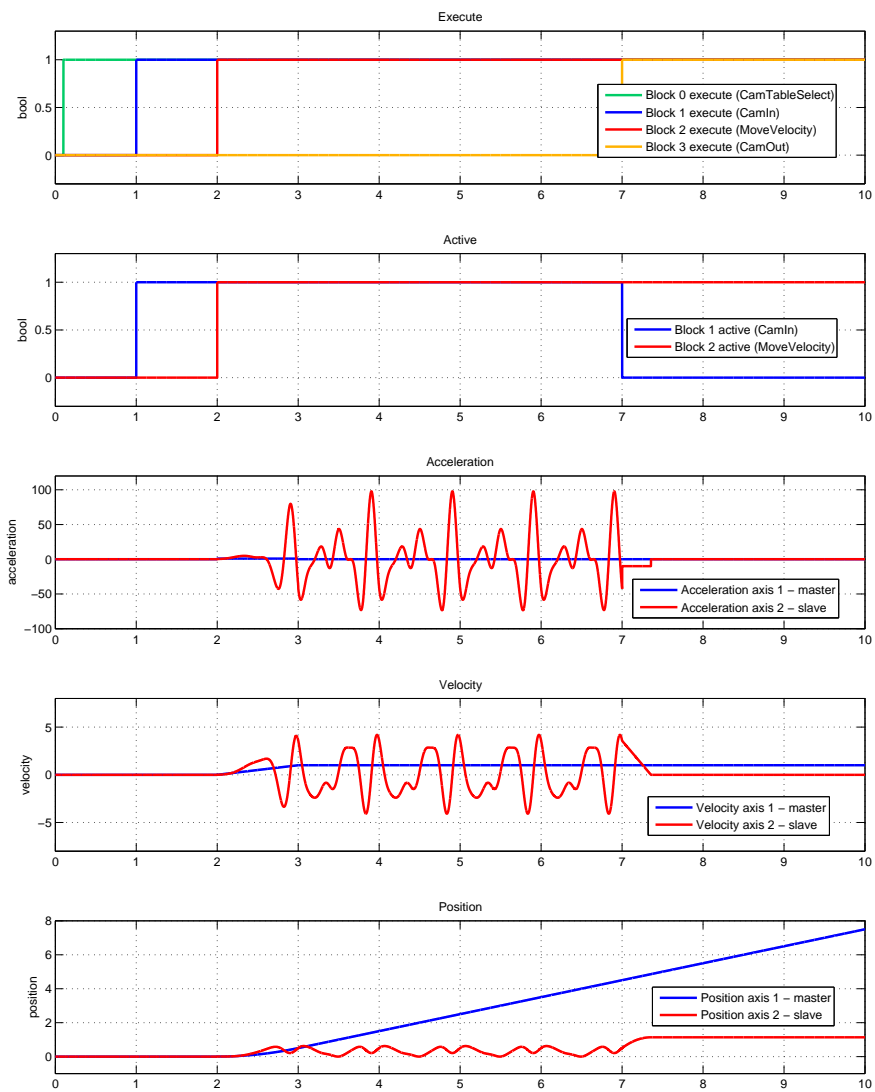
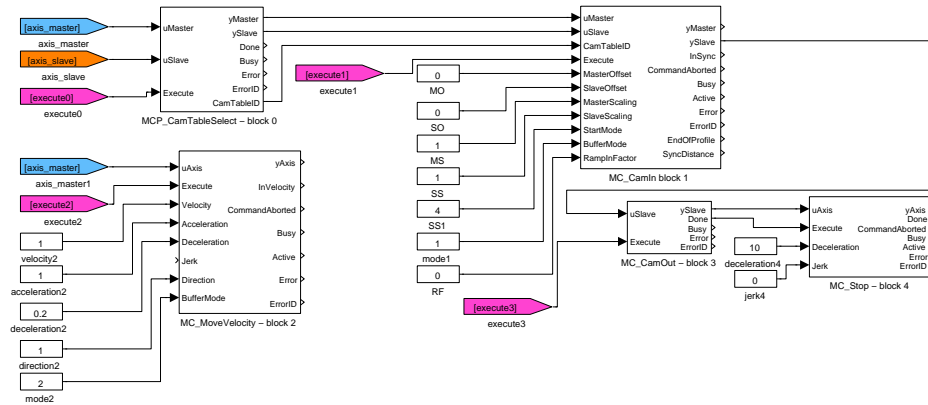
Inputs

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	Error code	error
	i REX general error	

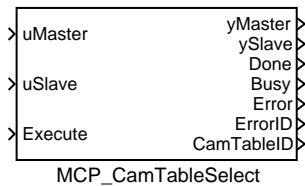
Example



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

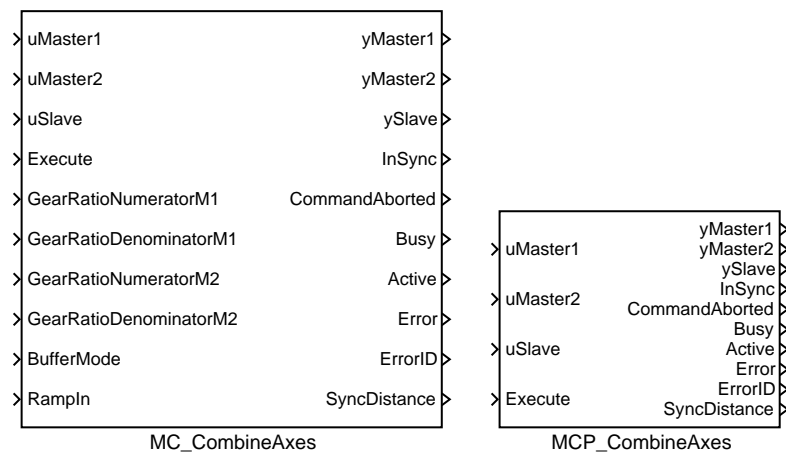
yMaster	Master axis reference	reference
ySlave	Slave axis reference	reference
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	
CamTableID	Cam table reference (connect to MC_CamIn.CamTableID)	reference

Parameters

alg	Algorithm for interpolation	⊙2	long
	1 Sequence of time/value pairs		
	2 Sequence of equidistant values		
	3 Spline		
	4 Equidistant spline		
cSeg	Number of profile segments	⊙3	long
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
svalues	Slave positions or interpolating polynomial coefficients (a0, a1, a2, ...)	⊙[0 100 100 0]	double

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:

$$\text{SlavePosition} = \text{Master1Position} \cdot \frac{\text{GearRatioNumeratorM1}}{\text{GearRatioDenominatorM1}} + \text{Master2Position} \cdot \frac{\text{GearRatioNumeratorM2}}{\text{GearRatioDenominatorM2}}$$

Negative number can be set in `GearRatio...` parameter to obtain the resulting slave movement in form of difference of master axes positions.

Inputs

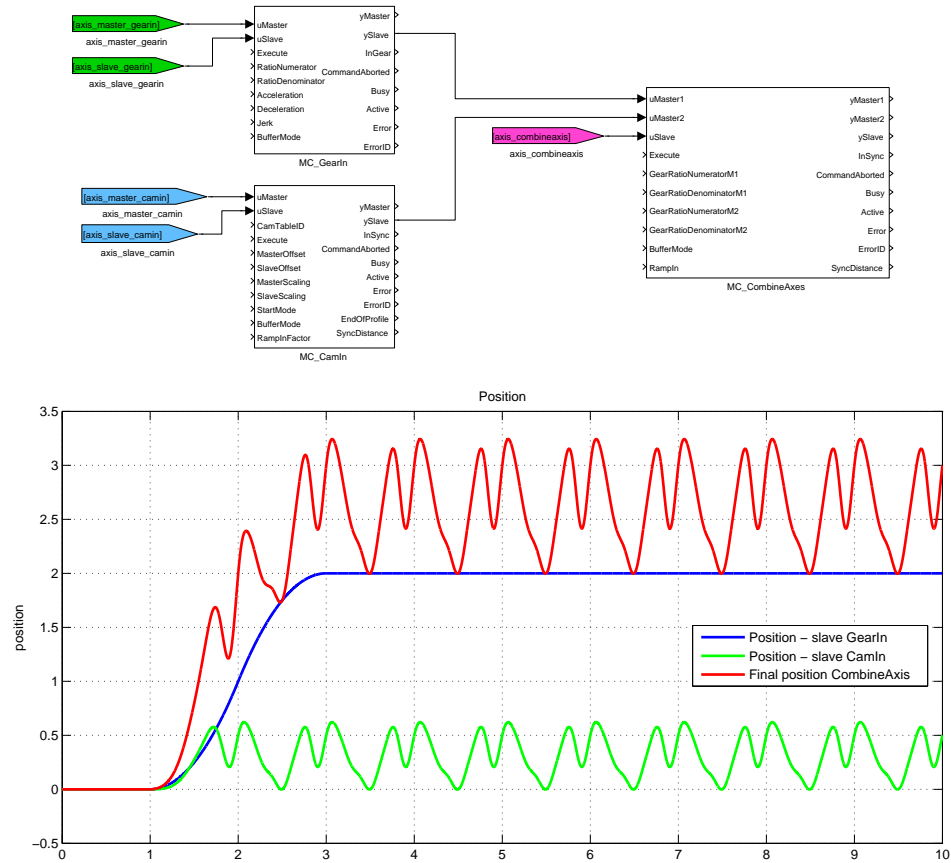
<code>uMaster1</code>	First master axis reference	reference
<code>uMaster2</code>	Second master axis reference	reference
<code>uSlave</code>	Slave axis reference	reference
<code>Execute</code>	The block is activated on rising edge	bool
<code>GearRatioNumeratorM1</code>	Numerator for the gear factor for master axis 1	long
<code>GearRatioDenominatorM1</code>	Denominator for the gear factor for master axis 1	long
<code>GearRatioNumeratorM2</code>	Numerator for the gear factor for master axis 2	long
<code>GearRatioDenominatorM2</code>	Denominator for the gear factor for master axis 2	long

BufferMode	Buffering mode	long
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)	
RampIn	RampIn factor (0 = RampIn mode not used)	double

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	Error code	error
i	REX general error	
SyncDistance	Position deviation of the slave axis from synchronized position	double

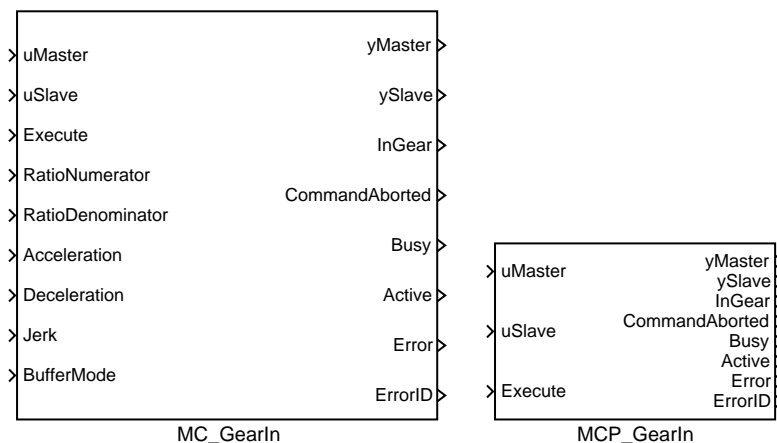
Example



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 pre-set 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

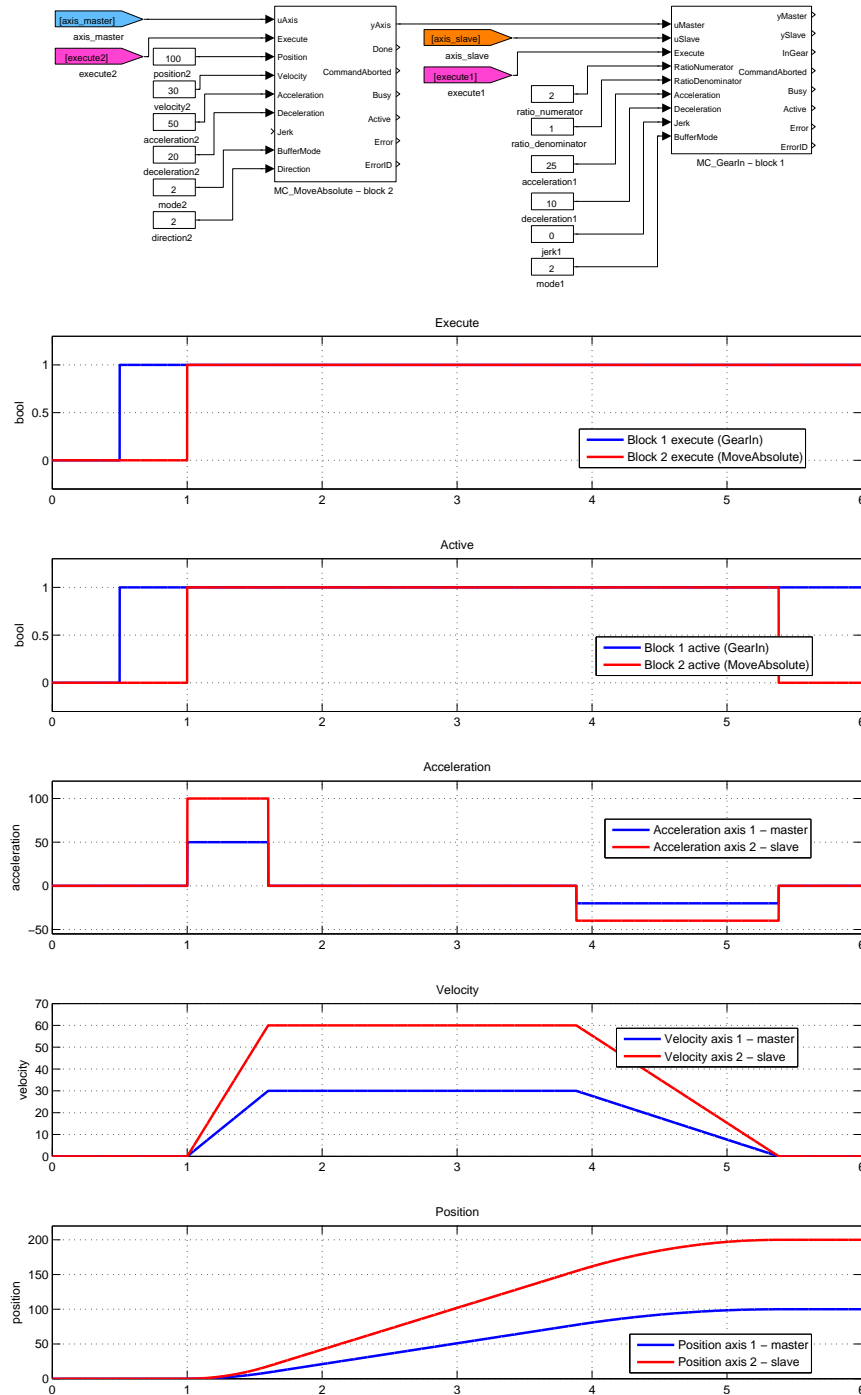
uMaster	Master axis reference	reference
uSlave	Slave axis reference	reference
Execute	The block is activated on rising edge	bool
RatioNumerator	Gear ratio Numerator	long

RatioDenominator	Gear ratio Denominator	long
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
BufferMode	Buffering mode	long
	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)	

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	Error code	error
	i REX general error	

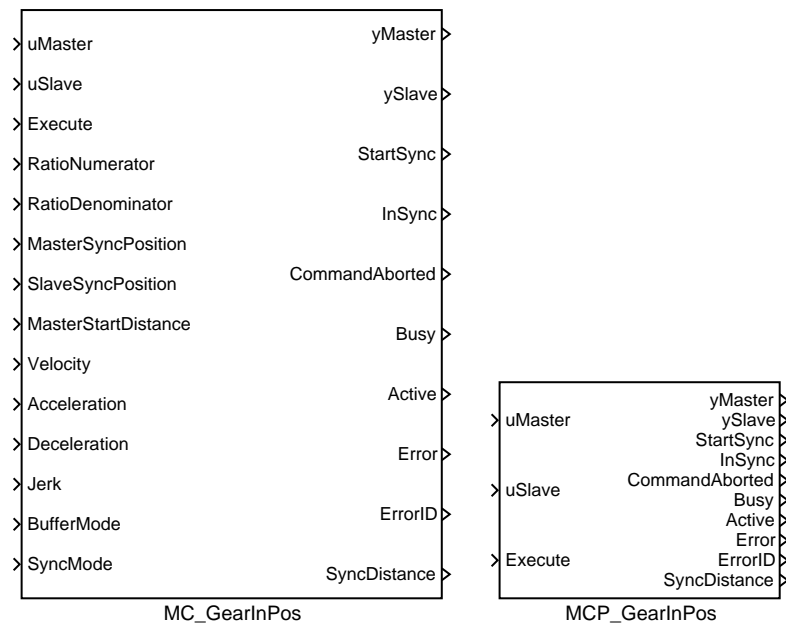
Example



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:

$$\frac{SlavePosition - SlaveSyncPosition}{MasterPosition - MasterSyncPosition} = \frac{RatioNumerator}{RatioDenominator}.$$

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** \pm **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

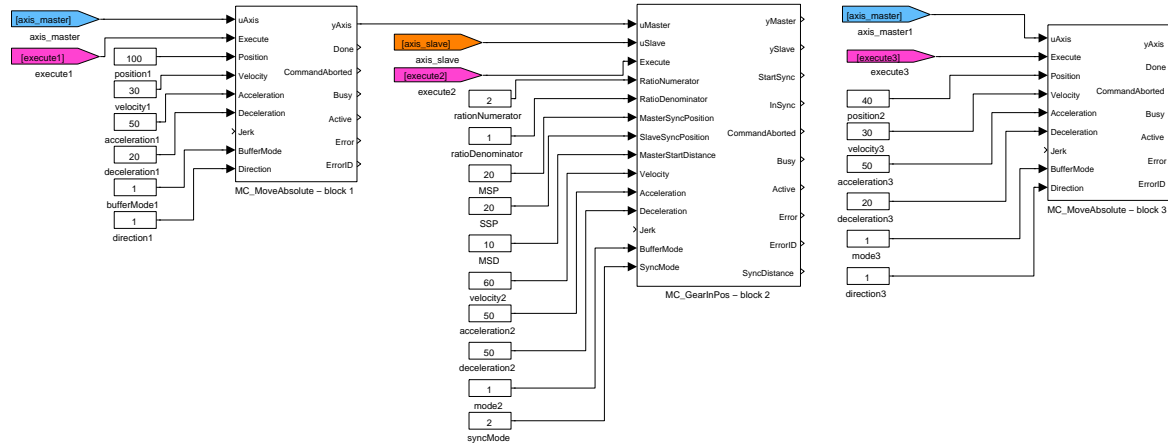
uMaster	Master axis reference	reference
uSlave	Slave axis reference	reference
Execute	The block is activated on rising edge	bool
RatioNumerator	Gear ratio Numerator	long
RatioDenominator	Gear ratio Denominator	long
MasterSyncPosition	Master position for synchronization	double
SlaveSyncPosition	Slave position for synchronization	double
MasterStartDistance	Master distance for starting gear in procedure	double
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double

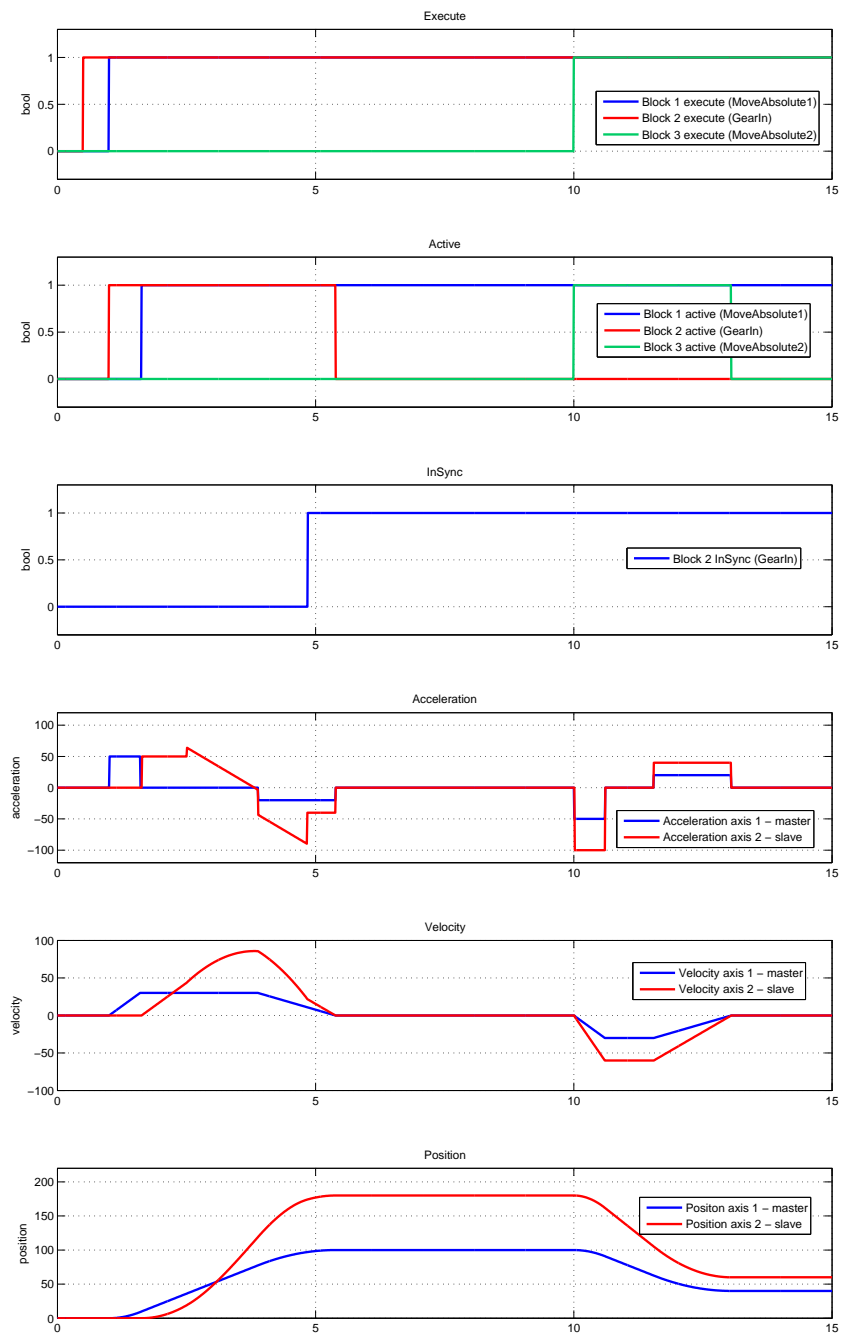
BufferMode	Buffering mode	long
1 Aborting (start immediately)	
2 Buffered (start after finish of previous motion)	
3 Blending low (start after finishing the previous motion, previous motion finishes with the lowest velocity of both commands)	
4 Blending high (start after finishing the previous motion, 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)	
SyncMode	Synchronization mode (cyclic axes only)	long
1 CatchUp	
2 Shortest	
3 SlowDown	

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	Error code	error
i REX general error	
SyncDistance	Position deviation of the slave axis from synchronized position	double

Example

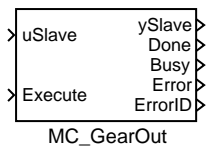




MC_GearOut – Disengage the master/slave velocity ratio

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).

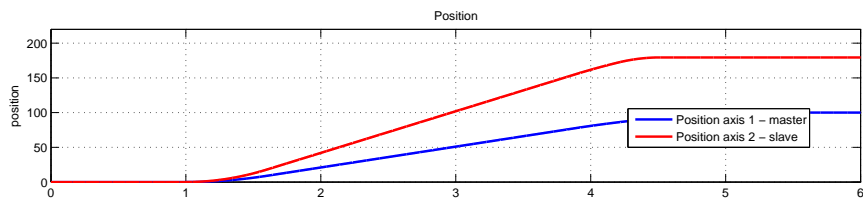
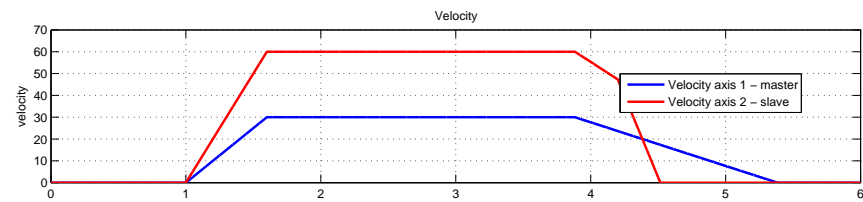
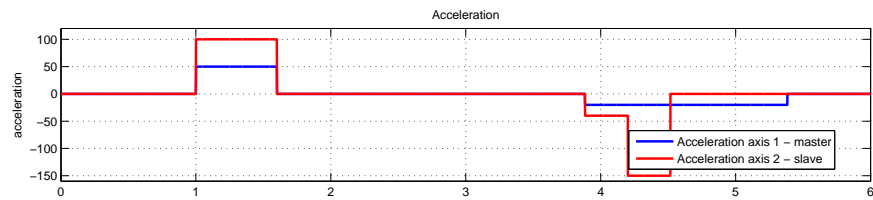
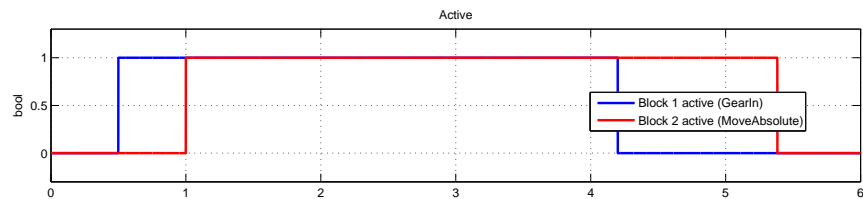
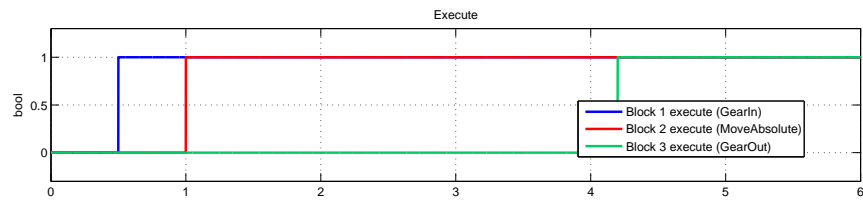
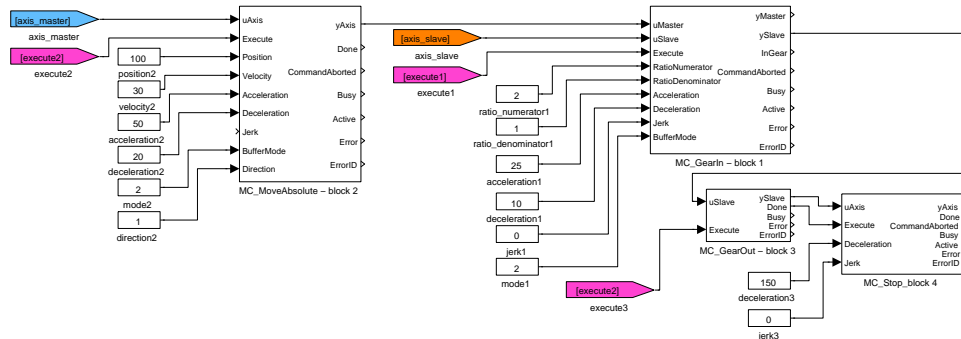
Inputs

<code>uSlave</code>	Slave axis reference	<code>reference</code>
<code>Execute</code>	The block is activated on rising edge	<code>bool</code>

Outputs

<code>ySlave</code>	Slave axis reference	<code>reference</code>
<code>Done</code>	Algorithm finished	<code>bool</code>
<code>Busy</code>	Algorithm not finished yet	<code>bool</code>
<code>Error</code>	Error occurred	<code>bool</code>
<code>ErrorID</code>	Error code	<code>error</code>
	i REX general error	

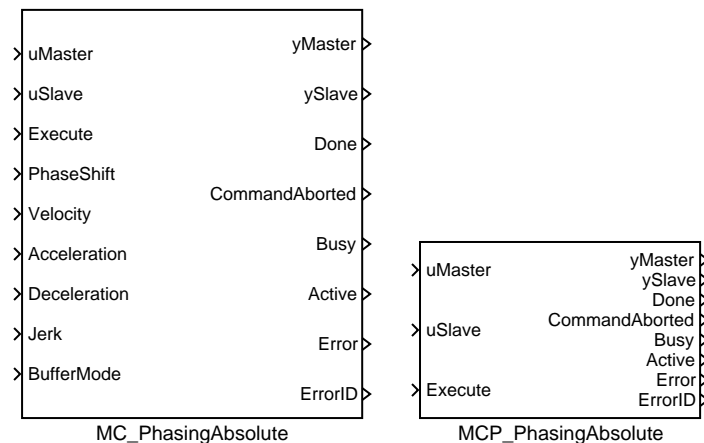
Example



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

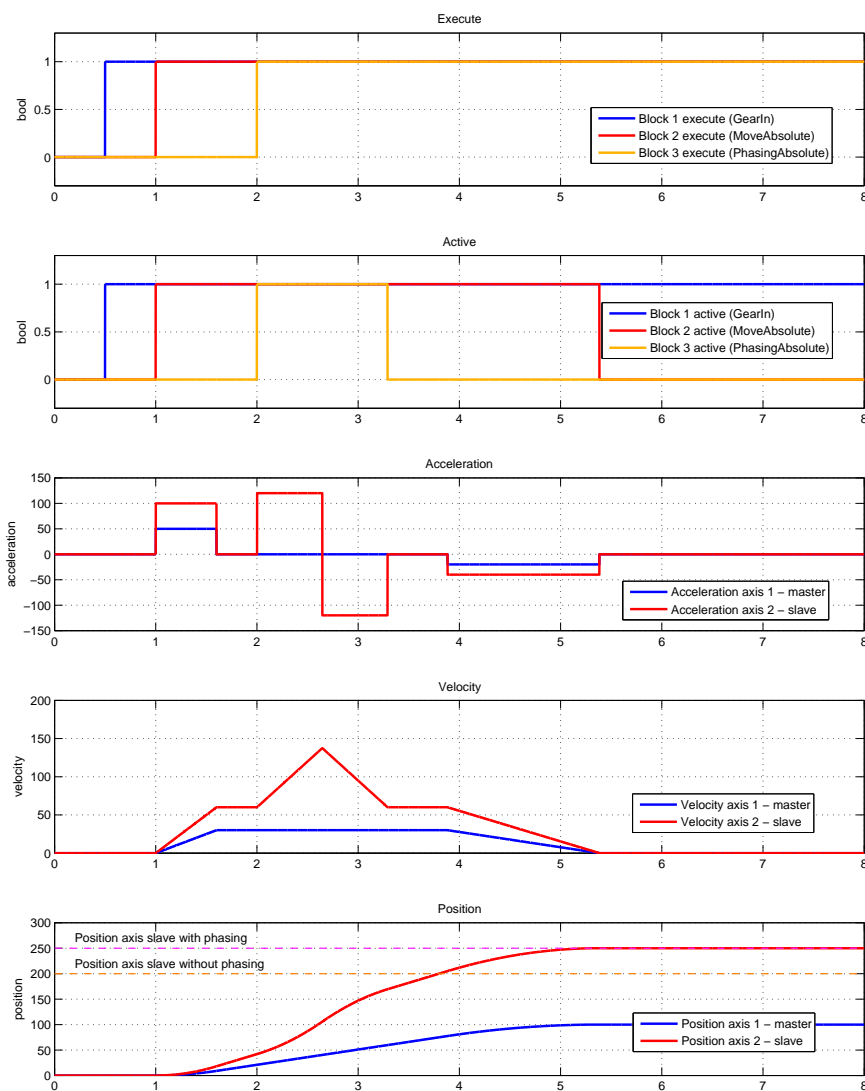
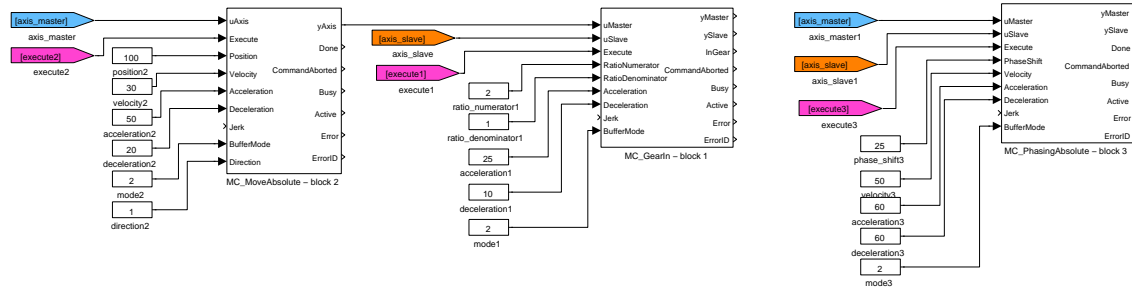
uMaster	Master axis reference	reference
uSlave	Slave axis reference	reference
Execute	The block is activated on rising edge	bool
PhaseShift	Requested phase shift (distance on master axis) for cam	double

Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
BufferMode	Buffering mode	long
	1 Aborting	
	2 Buffered	

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	Error code	error
	i REX general error	

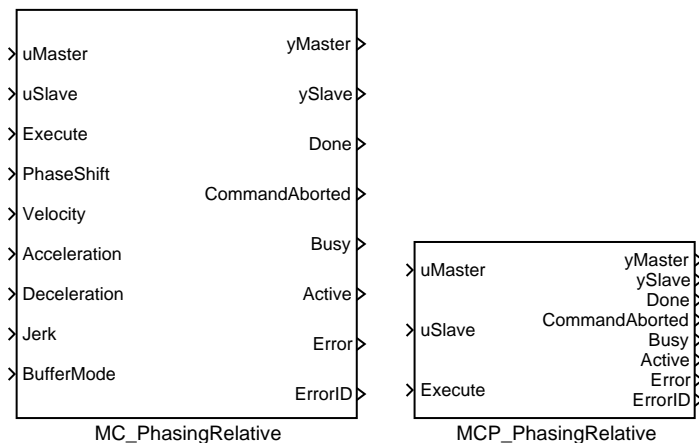
Example



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

<code>uMaster</code>	Master axis reference	reference
<code>uSlave</code>	Slave axis reference	reference
<code>Execute</code>	The block is activated on rising edge	bool
<code>PhaseShift</code>	Requested phase shift (distance on master axis) for cam	double

Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
BufferMode	Buffering mode	long
	1 Aborting	
	2 Buffered	

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	Error code	error
	i REX general error	

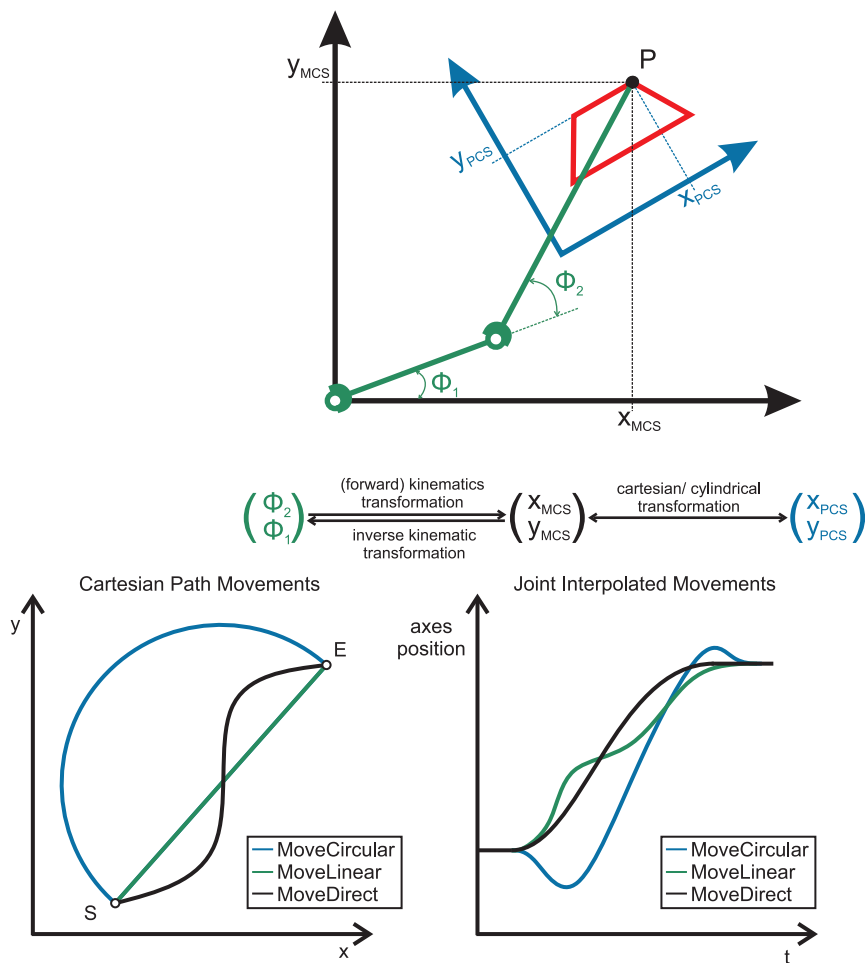
Chapter 18

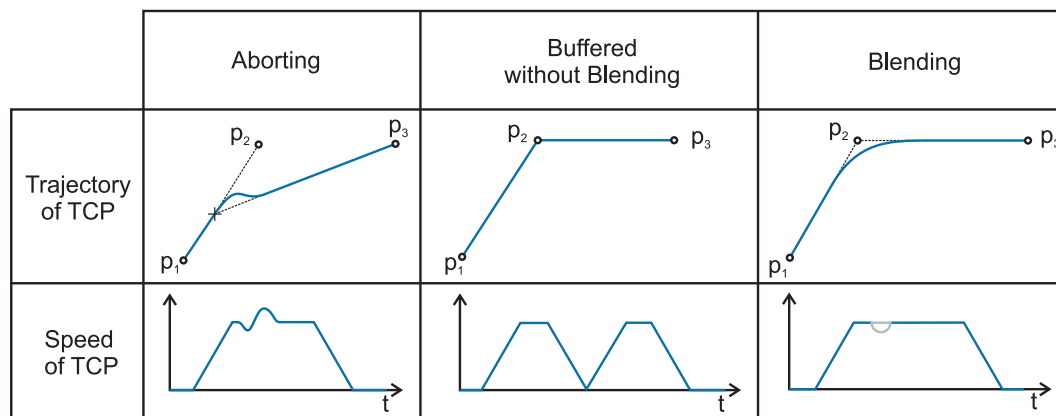
MC_COORD – Motion control - coordinated movement blocks

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RM_AxesGroup – Axes group for coordinated motion control

Block Symbol

Licence: [COORDINATED MOTION CONTROL](#)



Function Description

- Note 1: Applicable for all non-administrative (moving) function blocks.
- Note 2: In the states GroupErrorStop or GroupStopping, all Function Blocks can be 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
AcsCount	Number of axis in ACS	↓1 ↑16 ⊙6	long
PosCount	Number of position axis	↓1 ↑6 ⊙3	long
Velocity	Maximal allowed velocity [unit/s]		double
Acceleration	Maximal allowed acceleration [unit/s ²]		double
Jerk	Maximal allowed jerk [unit/s ³]		double

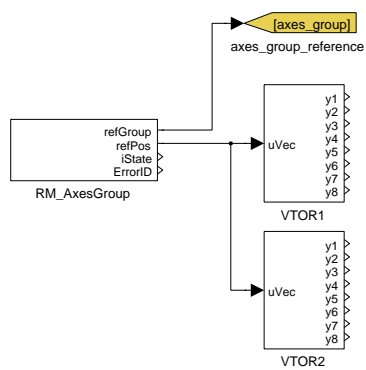
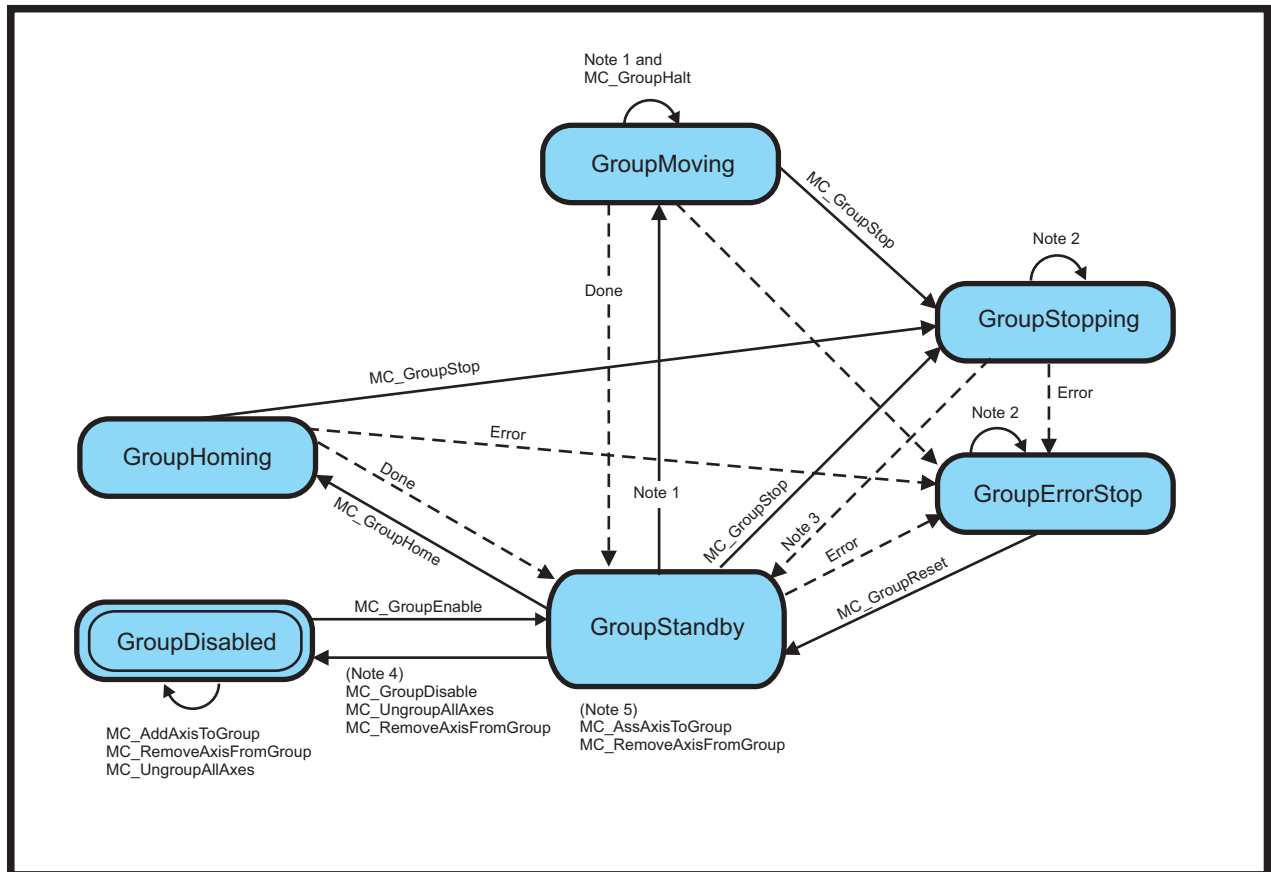
Outputs

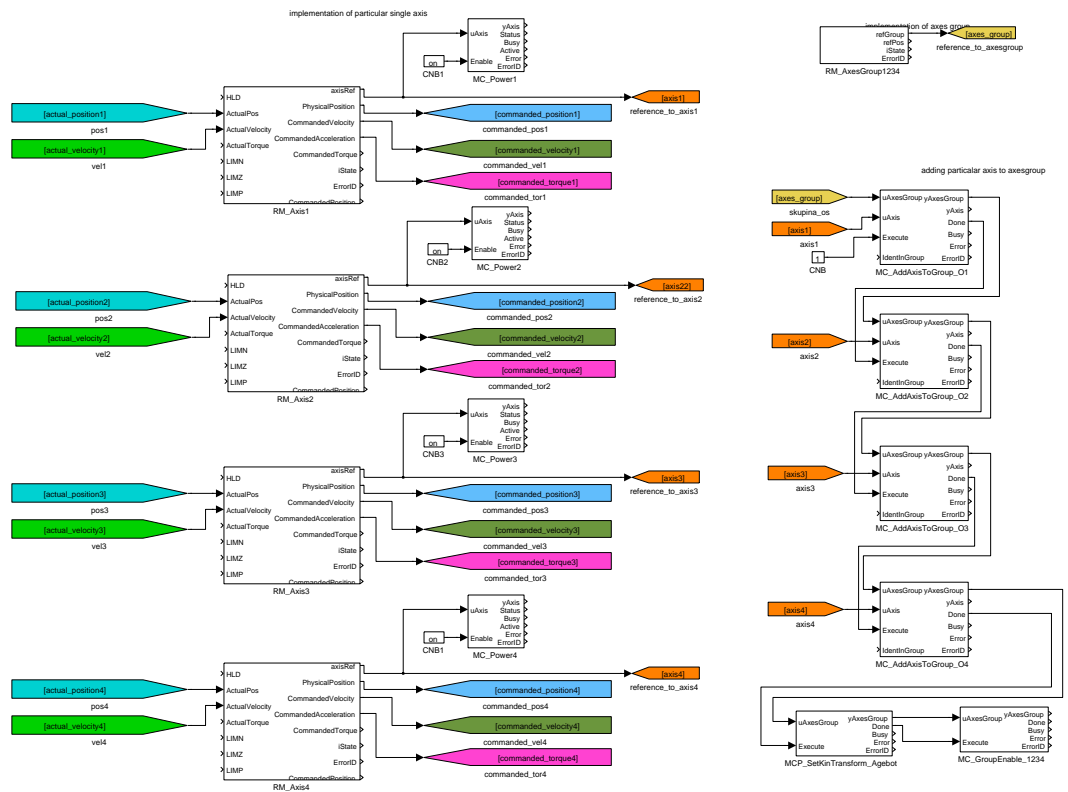
refGroup	Axes group reference	reference
refPos	Position, velocity and acceleration vector	reference
iState	Group status	long
	0 Disabled	
	1 Standby	
	2 Homing	
	6 Moving	
	7 Stopping	
	8 Error stop	

ErrorID Error code
 i REX general error

error

The State Diagram of AxesGroup

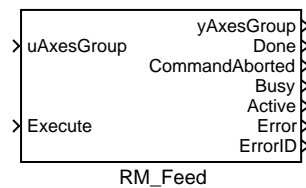




RM_Feed — * MC Feeder ???

Block Symbol

Licence: [COORDINATED 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.

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
Relative	0		bool
CoordSystem	0	↓1 ↑3 ⊙2	long
BufferMode	0	↓1 ↑6 ⊙1	long
TransitionMode	0	↓0 ↑15 ⊙1	long
TransitionParameter	0		double

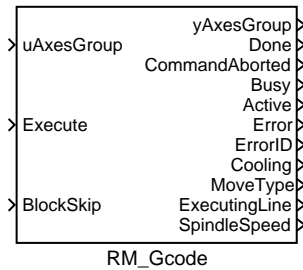
Outputs

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	Error code	error
Aux	0	double

RM_Gcode – * CNC motion control

Block Symbol

Licence: [COORDINATED 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.

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
CoordSystem	0	↓1 ↑3 ⊙3 long
BufferMode	Buffering mode	⊙1 long
	1 Aborting	
	2 Buffered	
	3 Blending low	
	4 Blending high	
	5 Blending previous	
	6 Blending next	
TransitionMode	Transition mode in blending mode	⊙1 long
	1 TMNone	
	2 TMStartVelocity	
	3 TMConstantVelocity	
	4 TMCornerDistance	
	5 TMMaxCornerDeviation	
	11 Smooth	

TransitionParameter	Parametr for transition (depends on transition mode)	double
workOffsets	Sets with initial coordinate	double
	$\odot[0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0]$	
toolOffsets	Sets of tool offset	$\odot[0\ 0\ 0]$ double
cutterOffsets	Tool radii	$\odot[0\ 0\ 0]$ double

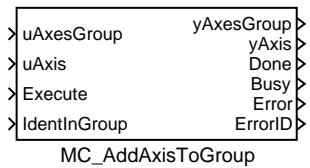
Outputs

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	Error code	error
	i REX general error	
Cooling	Cooling	bool
MoveType	Command execution	long
ExecutingLine	Current line of G-code	long
SpindleSpeed	Spindle speed	long

MC_AddAxisToGroup – Adds one axis to a group

Block Symbol

Licence: COORDINATED MOTION CONTROL



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

<code>uAxesGroup</code>	Axes group reference	reference
<code>uAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> connections are allowed)	reference
<code>Execute</code>	The block is activated on rising edge	bool
<code>IdentInGroup</code>	The order of axes in the group (0 = first unassigned)	long

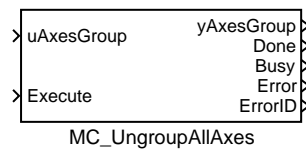
Outputs

<code>yAxesGroup</code>	Axes group reference	reference
<code>yAxis</code>	Axis reference (only <code>RM_Axis.axisRef-uAxis</code> or <code>yAxis-uAxis</code> connections are allowed)	reference
<code>Done</code>	Algorithm finished	bool
<code>Busy</code>	Algorithm not finished yet	bool
<code>Error</code>	Error occurred	bool
<code>ErrorID</code>	Error code	error
	i REX general error	

MC_UngroupAllAxes – Removes all axes from the group

Block Symbol

Licence: [COORDINATED MOTION CONTROL](#)



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

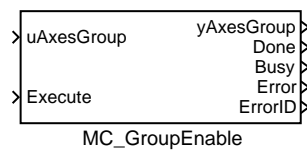
Outputs

yAxesGroup	Axes group reference	reference
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	

MC_GroupEnable – Changes the state of a group to **GroupEnabled**

Block Symbol

Licence: COORDINATED MOTION CONTROL



Function Description

The function block **MC_GroupEnable** changes the state for the group **uAxesGroup** from "GroupDisabled" to "GroupStandby".

Inputs

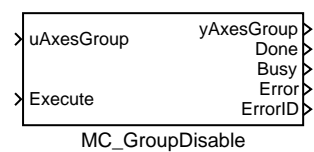
<code>uAxesGroup</code>	Axes group reference	reference
<code>Execute</code>	The block is activated on rising edge	bool

Outputs

yAxesGroup	Axes group reference	reference
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	

MC_GroupDisable – Changes the state of a group to GroupDisabled

Block Symbol Licence: COORDINATED MOTION CONTROL



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

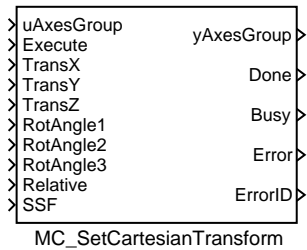
uAxesGroup	Axes group reference	reference
Execute	The block is activated on rising edge	bool

Outputs

yAxesGroup	Axes group reference	reference
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	

MC_SetCartesianTransform – Sets Cartesian transformation

Block Symbol Licence: [COORDINATED MOTION CONTROL](#)



Function Description

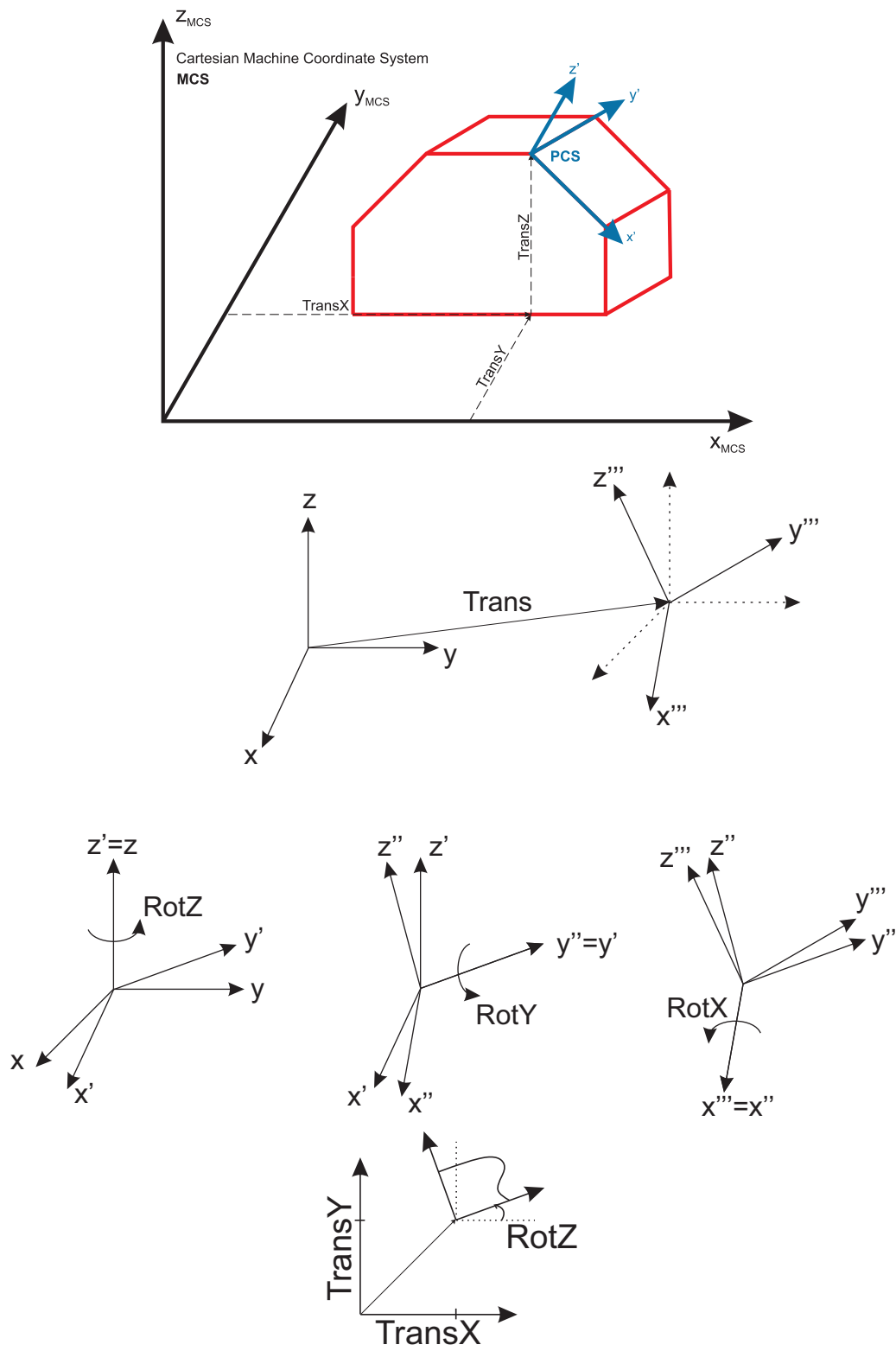
The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

Inputs

uAxesGroup	Axes group reference	reference
Execute	The block is activated on rising edge	bool
TransX	X-component of translation vector	double
TransY	Y-component of translation vector	double
TransZ	Z-component of translation vector	double
RotAngle1	Rotation angle component	double
RotAngle2	Rotation angle component	double
RotAngle3	Rotation angle component	double
Relative	Mode of position inputs	bool

Outputs

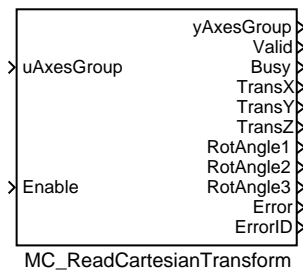
yAxesGroup	Axes group reference	reference
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	



MC_ReadCartesianTransform – Reads the parameter of the cartesian transformation

Block Symbol

Licence: COORDINATED MOTION CONTROL



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

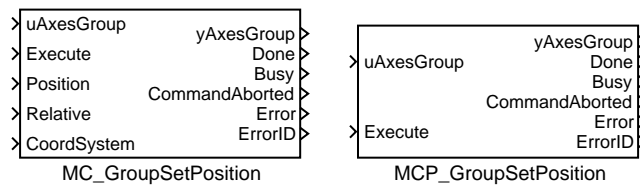
Outputs

yAxesGroup	Axes group reference	reference
Valid	Output value is valid	bool
Busy	Algorithm not finished yet	bool
TransX	X-component of translation vector	double
TransY	Y-component of translation vector	double
TransZ	Z-component of translation vector	double
RotAngle1	Rotation angle component	double
RotAngle2	Rotation angle component	double
RotAngle3	Rotation angle component	double
Error	Error occurred	bool
ErrorID	Error code	error
i REX general error		

MC_GroupSetPosition, MCP_GroupSetPosition – Sets the position of all axes in a group

Block Symbols

Licence: [COORDINATED MOTION CONTROL](#)



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

<code>uAxesGroup</code>	Axes group reference	reference
<code>Execute</code>	The block is activated on rising edge	bool
<code>Position</code>	Array of coordinates (positions and orientations)	reference
<code>Relative</code>	Mode of position inputs	bool
	off ... absolute	
	on relative	
<code>CoordSystem</code>	Reference to the coordinate system used	long
	1 ACS	
	2 MCS	
	3 PCS	

Outputs

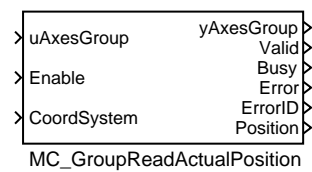
<code>yAxesGroup</code>	Axes group reference	reference
<code>Done</code>	Algorithm finished	bool
<code>Busy</code>	Algorithm not finished yet	bool

CommandAborted	Algorithm was aborted	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	

MC_GroupReadActualPosition – Read actual position in the selected coordinate system

Block Symbol

Licence: [COORDINATED MOTION CONTROL](#)



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	long
	1 ACS	
	2 MCS	
	3 PCS	

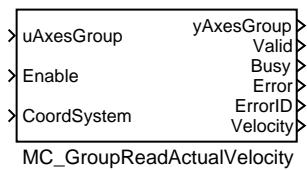
Outputs

yAxesGroup	Axes group reference	reference
Valid	Output value is valid	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	
Position	xxx	reference

MC_GroupReadActualVelocity – Read actual velocity in the selected coordinate system

Block Symbol

Licence: COORDINATED MOTION CONTROL



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

<code>uAxesGroup</code>	Axes group reference	reference
<code>Enable</code>	Block function is enabled	bool
<code>CoordSystem</code>	Reference to the coordinate system used	long
	1 ACS	
	2 MCS	
	3 PCS	

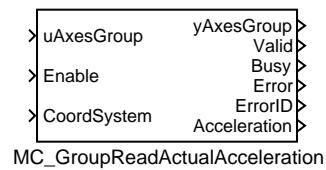
Outputs

<code>yAxesGroup</code>	Axes group reference	reference
<code>Valid</code>	Output value is valid	bool
<code>Busy</code>	Algorithm not finished yet	bool
<code>Error</code>	Error occurred	bool
<code>ErrorID</code>	Error code	error
	i REX general error	
<code>Velocity</code>	xxx	reference

MC_GroupReadActualAcceleration – Read actual acceleration in the selected coordinate system

Block Symbol

Licence: [COORDINATED MOTION CONTROL](#)



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

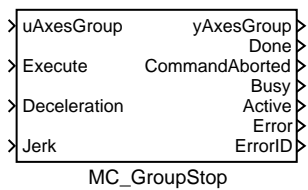
uAxesGroup	Axes group reference	reference
Enable	Block function is enabled	bool
CoordSystem	Reference to the coordinate system used	long
	1 ACS	
	2 MCS	
	3 PCS	

Outputs

yAxesGroup	Axes group reference	reference
Valid	Output value is valid	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	
Acceleration	xxx	reference

MC_GroupStop – Stopping a group movement

Block Symbol Licence: [COORDINATED MOTION CONTROL](#)



Function Description

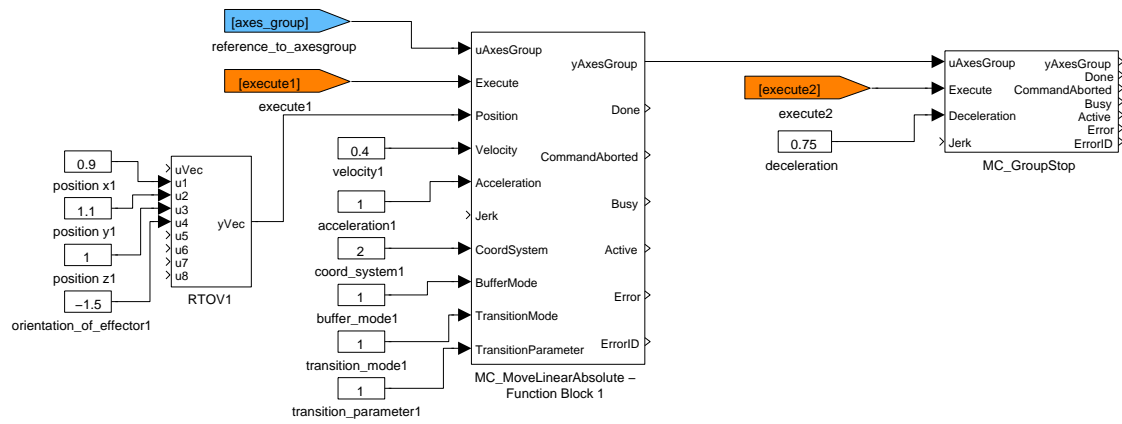
The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

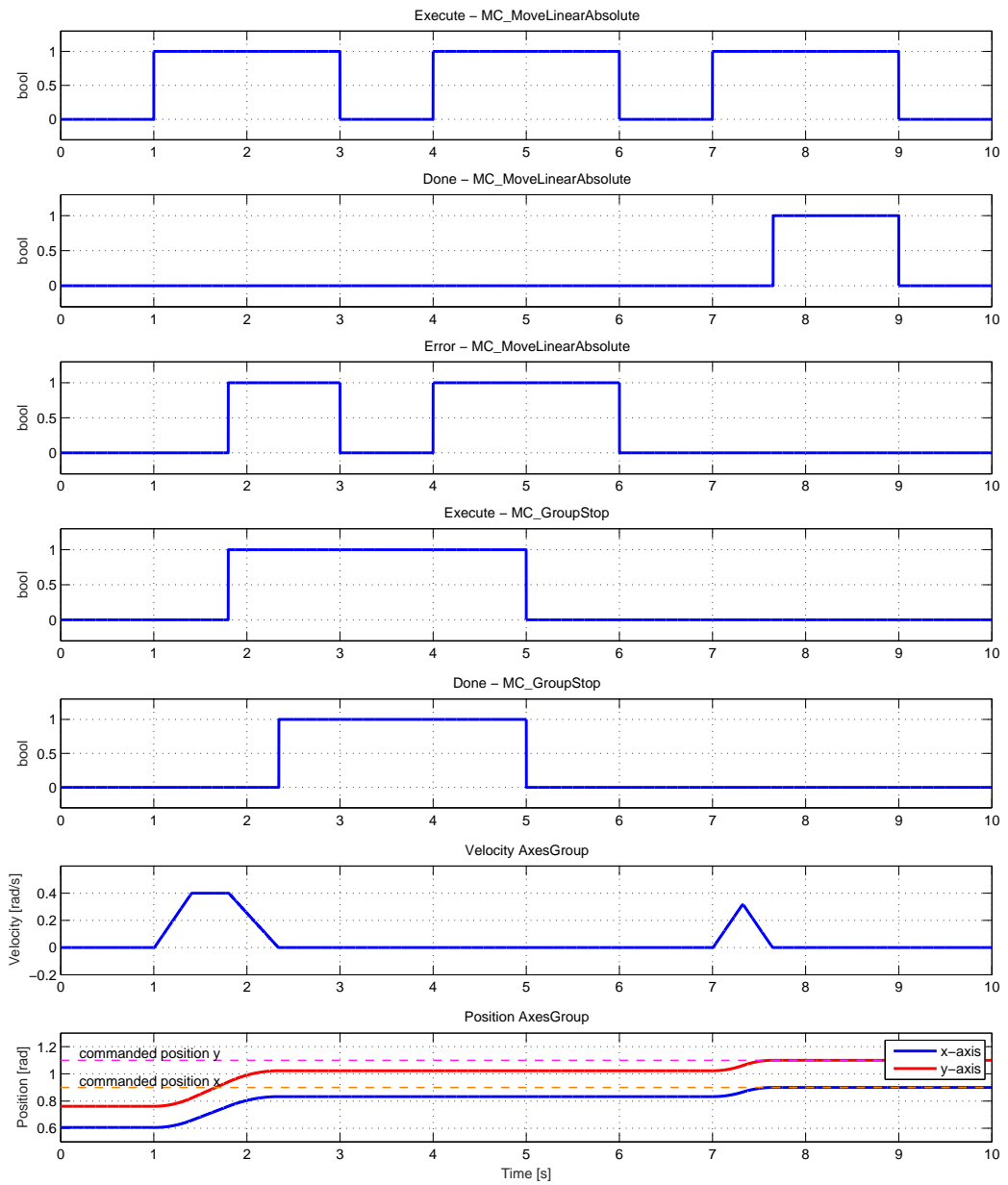
Inputs

uAxesGroup	Axes group reference	reference
Execute	The block is activated on rising edge	bool
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double

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	Error code	error
	i REX general error	

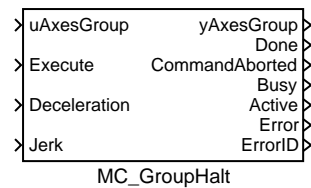




MC_GroupHalt – Stopping a group movement (interruptible)

Block Symbol

Licence: [COORDINATED MOTION CONTROL](#)



Function Description

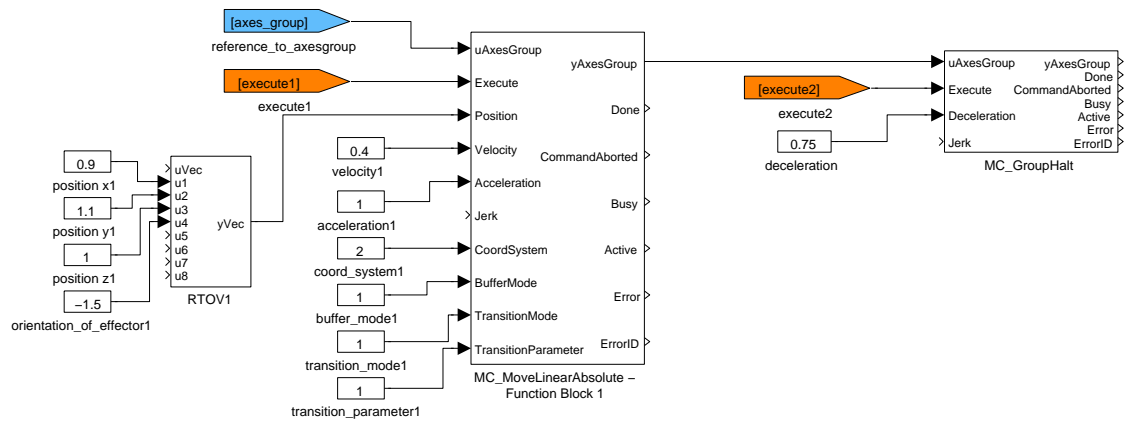
The function block description is not yet available. Below you can find partial description of the inputs, outputs and parameters of the block. Complete documentation will be available in future revisions.

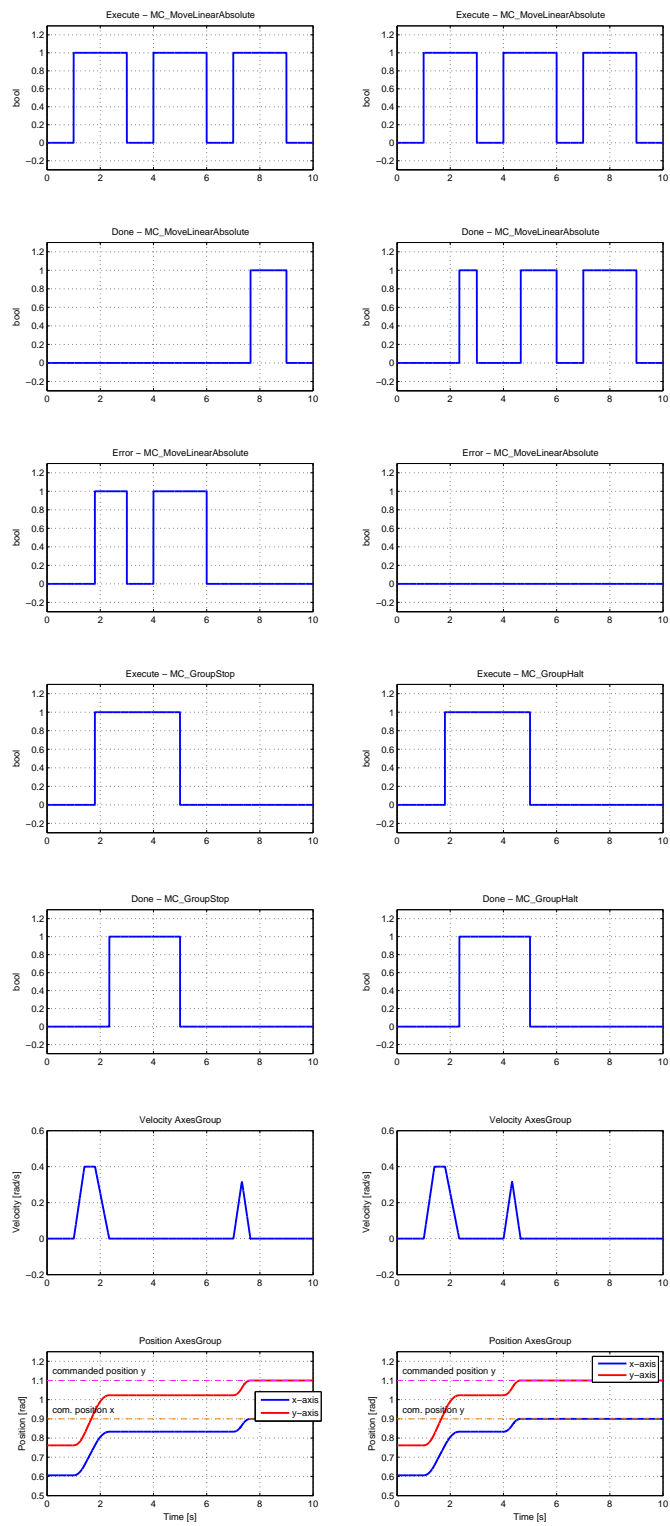
Inputs

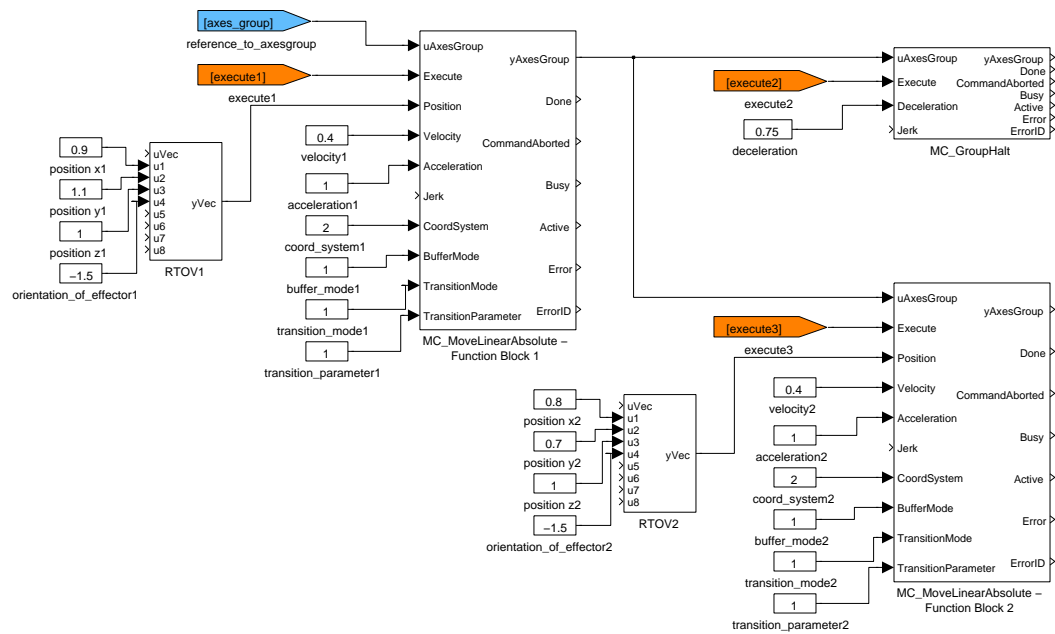
uAxesGroup	Axes group reference	reference
Execute	The block is activated on rising edge	bool
Deceleration	Maximal allowed deceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double

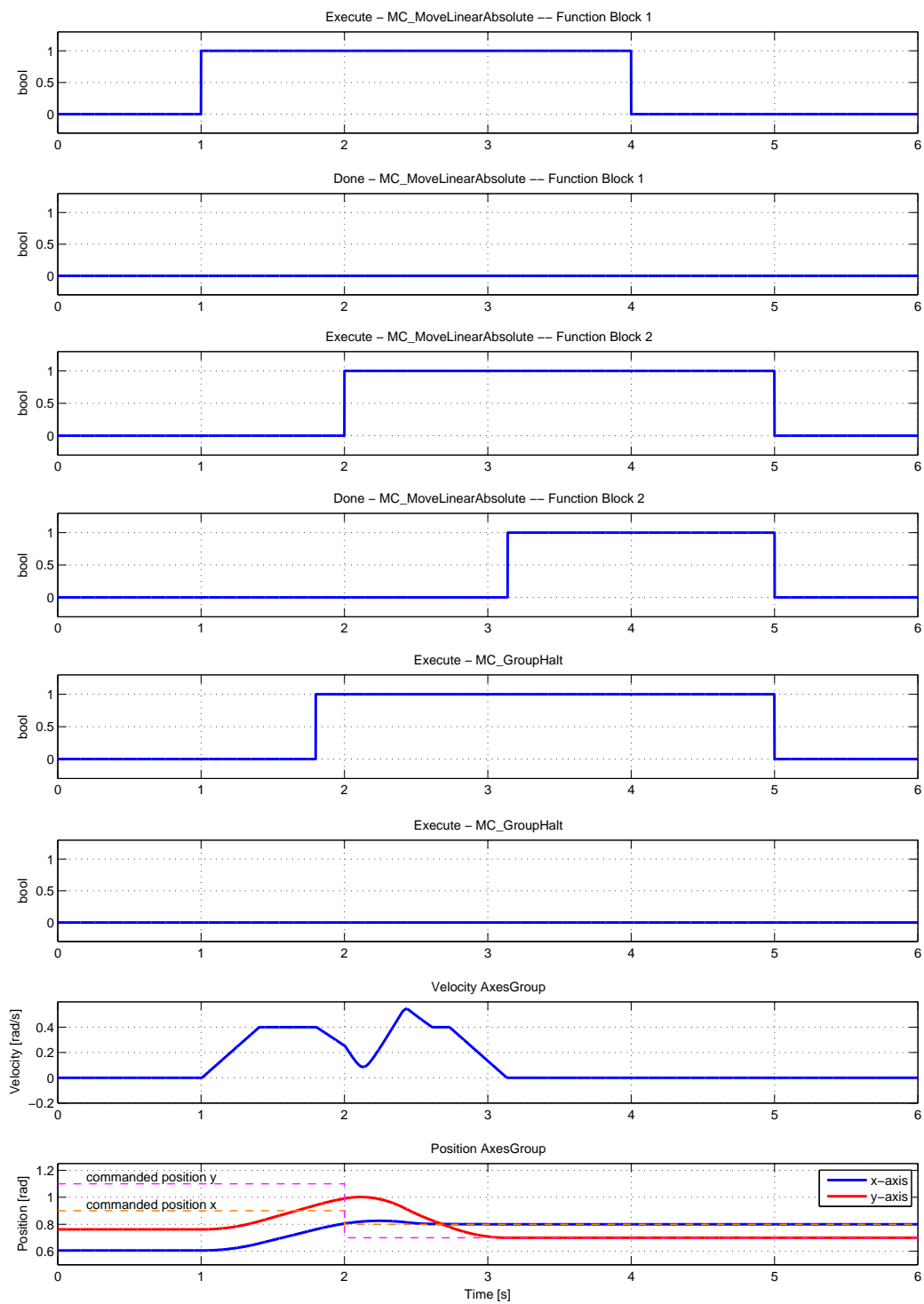
Outputs

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	Error code	error
	i REX general error	





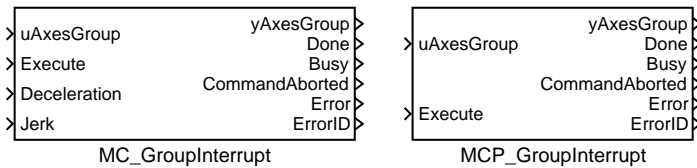




MC_GroupInterrupt, MCP_GroupInterrupt – Read a group interrupt

Block Symbols

Licence: [COORDINATED MOTION CONTROL](#)



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
Jerk	Maximal allowed jerk [unit/s ³]	double

Outputs

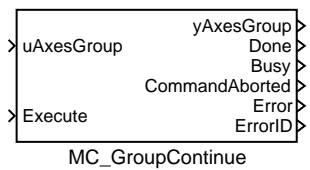
yAxesGroup	Axes group reference	reference
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
CommandAborted	Algorithm was aborted	bool
Error	Error occurred	bool

ErrorID	Error code
i	REX general error

error

MC_GroupContinue – Continuation of interrupted movement

Block Symbol Licence: COORDINATED MOTION CONTROL



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

<code>uAxesGroup</code>	Axes group reference	reference
<code>Execute</code>	The block is activated on rising edge	bool

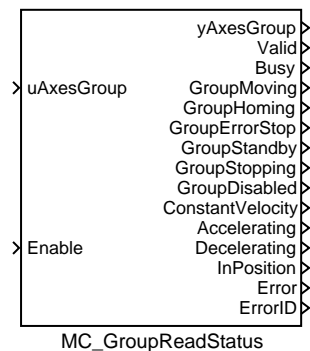
Outputs

<code>yAxesGroup</code>	Axes group reference	reference
<code>Done</code>	Algorithm finished	bool
<code>Busy</code>	Algorithm not finished yet	bool
<code>CommandAborted</code>	Algorithm was aborted	bool
<code>Error</code>	Error occurred	bool
<code>ErrorID</code>	Error code	error
	i REX general error	

MC_GroupReadStatus – Read a group status

Block Symbol

Licence: [COORDINATED MOTION CONTROL](#)



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

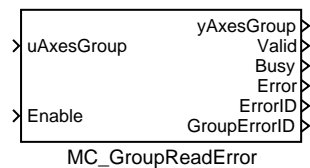
yAxesGroup	Axes group reference	reference
Valid	Output value is valid	bool
Busy	Algorithm not finished yet	bool
GroupMoving	State GroupMoving	bool
GroupHoming	State GroupHoming	bool
GroupErrorStop	State ErrorStop	bool
GroupStandby	State Standby	bool
GroupStopping	State Stopping	bool
GroupDisabled	State 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	Error code	error
i	REX general error	

MC_GroupReadError – Read a group error

Block Symbol

Licence: [COORDINATED MOTION CONTROL](#)



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

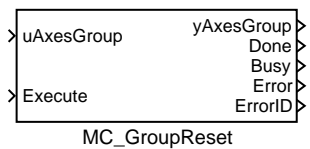
uAxesGroup	Axes group reference	reference
Enable	Block function is enabled	bool

Outputs

yAxesGroup	Axes group reference	reference
Valid	Output value is valid	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	
GroupErrorID	Error code	error
	i REX general error	

MC_GroupReset – Reset axes errors

Block Symbol Licence: [COORDINATED MOTION CONTROL](#)



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

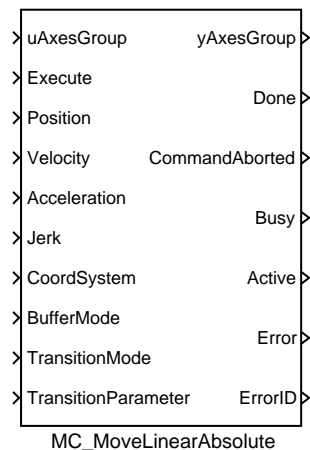
Outputs

yAxesGroup	Axes group reference	reference
Done	Algorithm finished	bool
Busy	Algorithm not finished yet	bool
Error	Error occurred	bool
ErrorID	Error code	error
	i REX general error	

MC_MoveLinearAbsolute – Linear move to position (absolute coordinates)

Block Symbol

Licence: [COORDINATED 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.

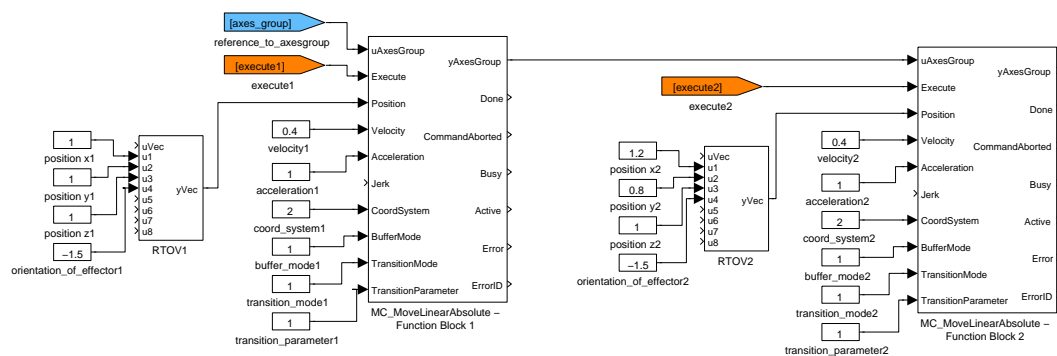
Inputs

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
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
CoordSystem	Reference to the coordinate system used	long
	1 ACS	
	2 MCS	
	3 PCS	

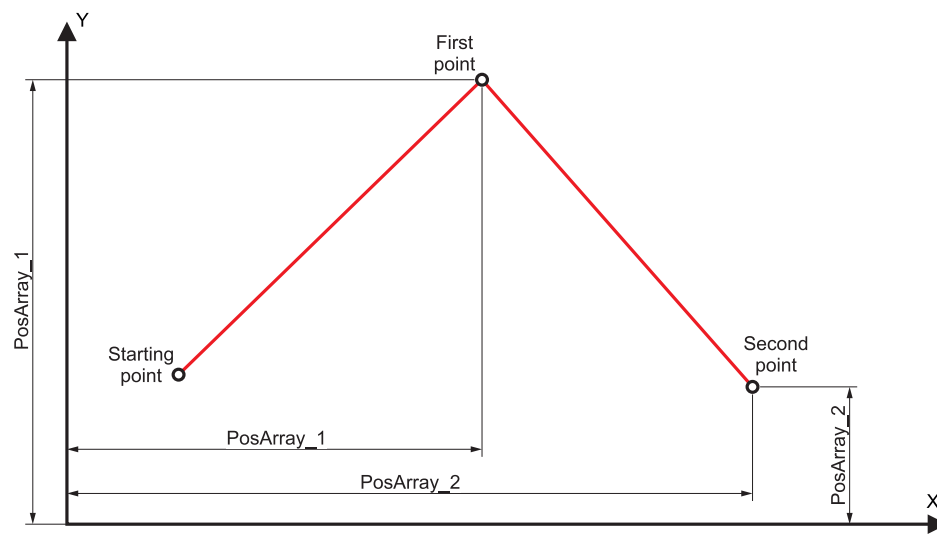
BufferMode	Buffering mode	long
1 Aborting	
2 Buffered	
3 Blending low	
4 Blending high	
5 Blending previous	
6 Blending next	
TransitionMode	Transition mode in blending mode	long
1 TMNone	
2 TMStartVelocity	
3 TMConstantVelocity	
4 TMCornerDistance	
5 TMMaxCornerDeviation	
11 Smooth	
TransitionParameter	Parametr for transition (depends on transition mode)	double

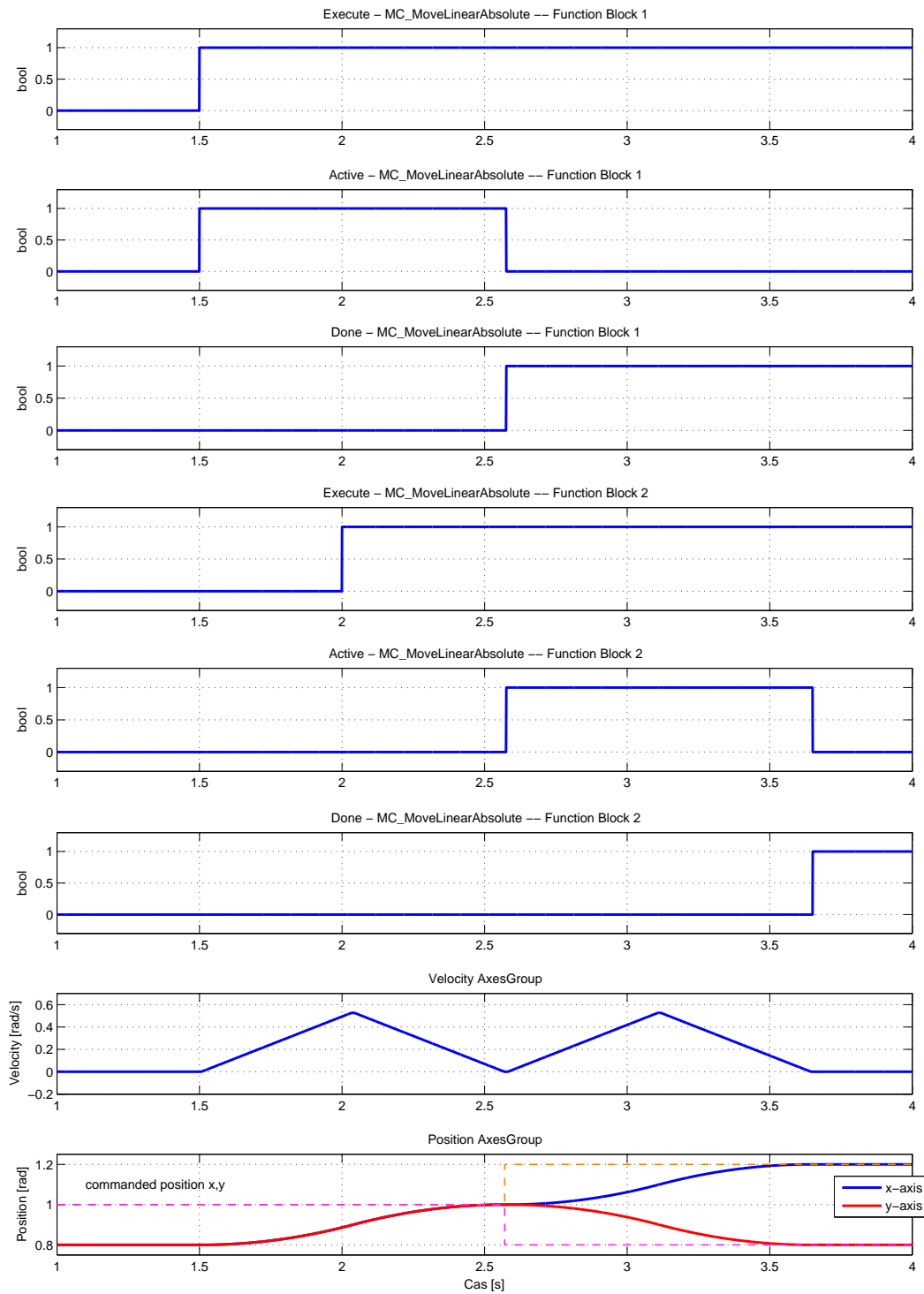
Outputs

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	Error code	error
i REX general error	



Sequence of two complete motions (Done>Execute)

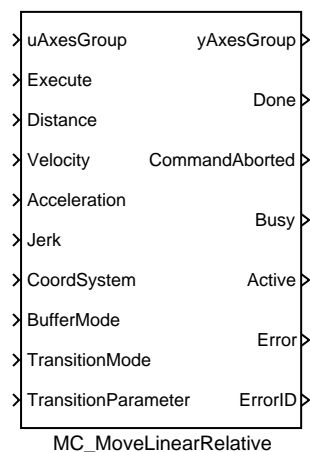




MC_MoveLinearRelative – Linear move to position (relative to execution point)

Block Symbol

Licence: [COORDINATED 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.

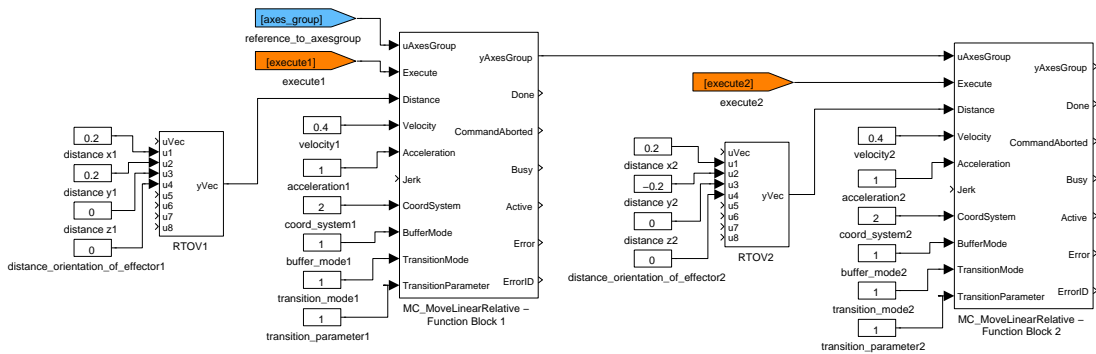
Inputs

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
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
CoordSystem	Reference to the coordinate system used	long
	1 ACS	
	2 MCS	
	3 PCS	
BufferMode	Buffering mode	long
	1 Aborting	
	2 Buffered	
	3 Blending low	
	4 Blending high	
	5 Blending previous	
	6 Blending next	

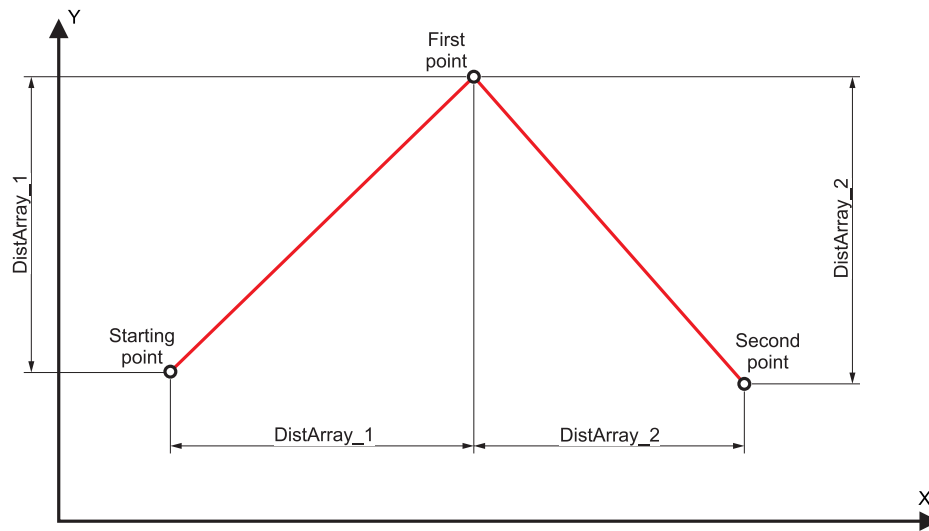
TransitionMode	Transition mode in blending mode	long
1	TMNone	
2	TMStartVelocity	
3	TMConstantVelocity	
4	TMCornerDistance	
5	TMMaxCornerDeviation	
11	Smooth	
TransitionParameter	Parametr for transition (depends on transition mode)	double

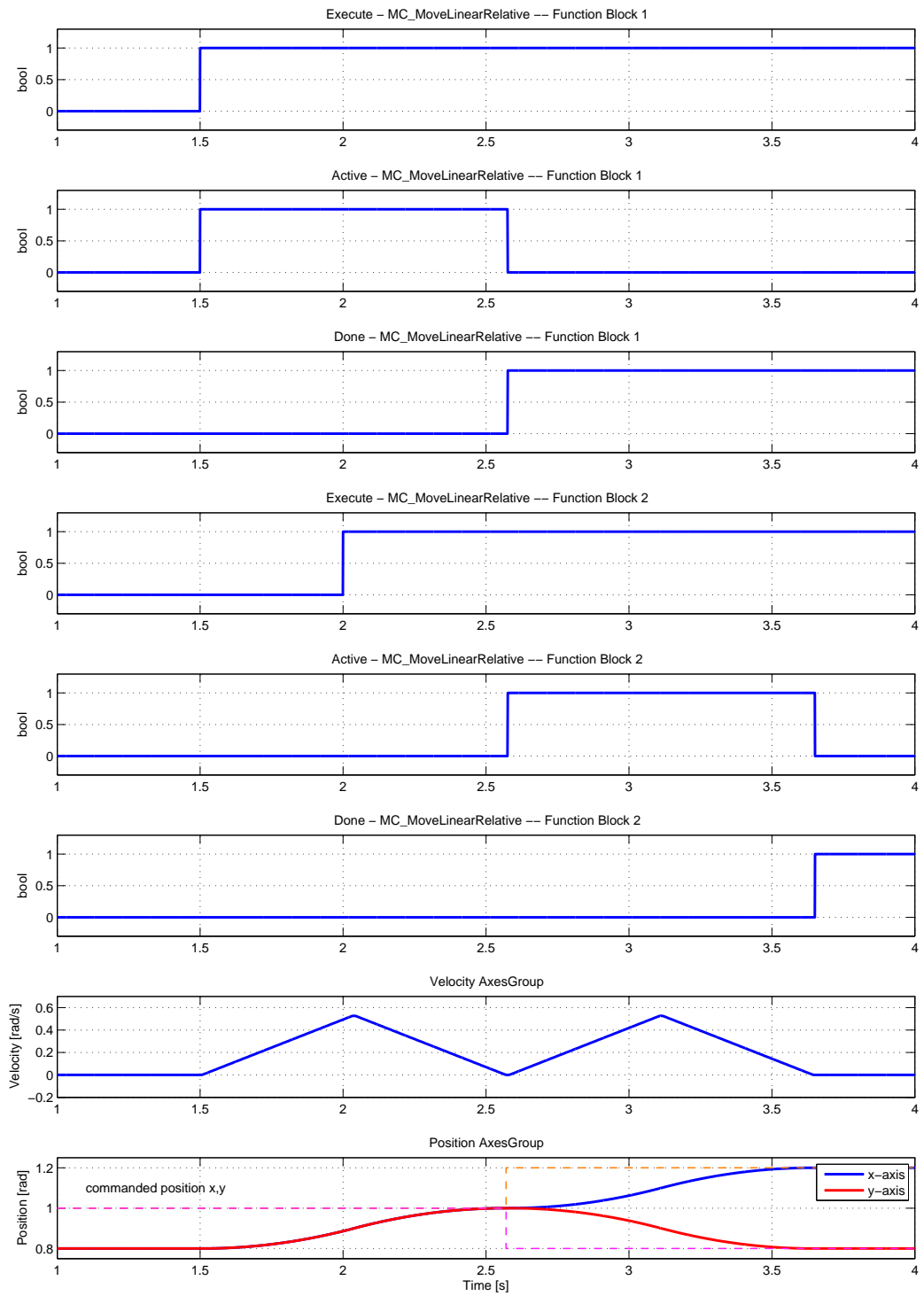
Outputs

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	Error code	error
i	REX general error	



Sequence of two complete motions (Done>Execute)

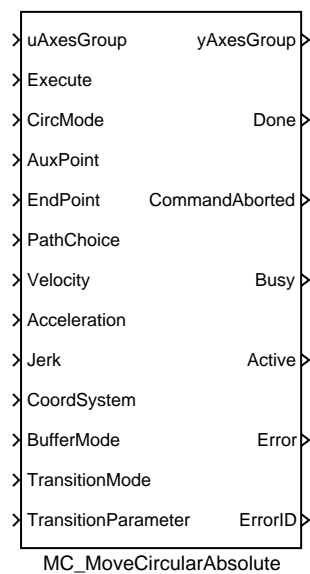




MC_MoveCircularAbsolute – Circular move to position (absolute coordinates)

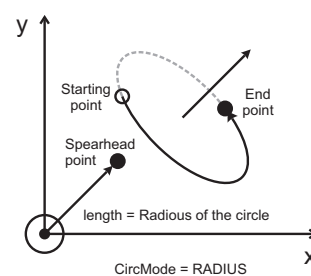
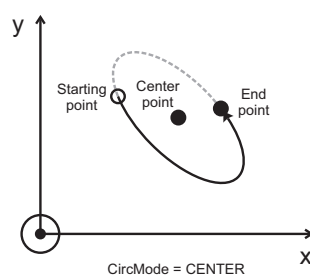
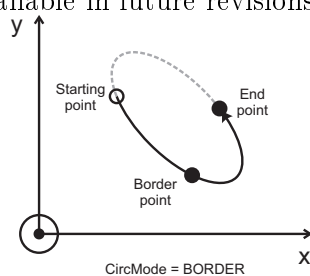
Block Symbol

Licence: [COORDINATED 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.



Inputs

uAxesGroup Axes group reference

reference

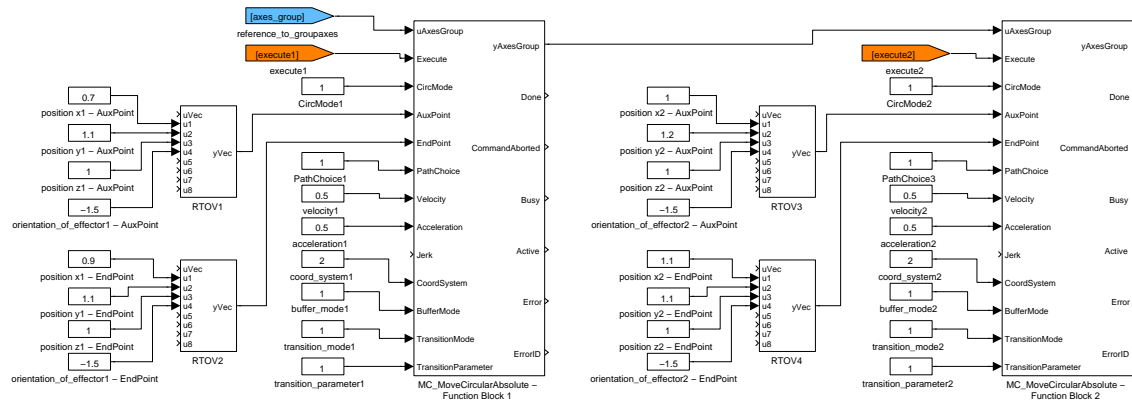
Execute The block is activated on rising edge

bool

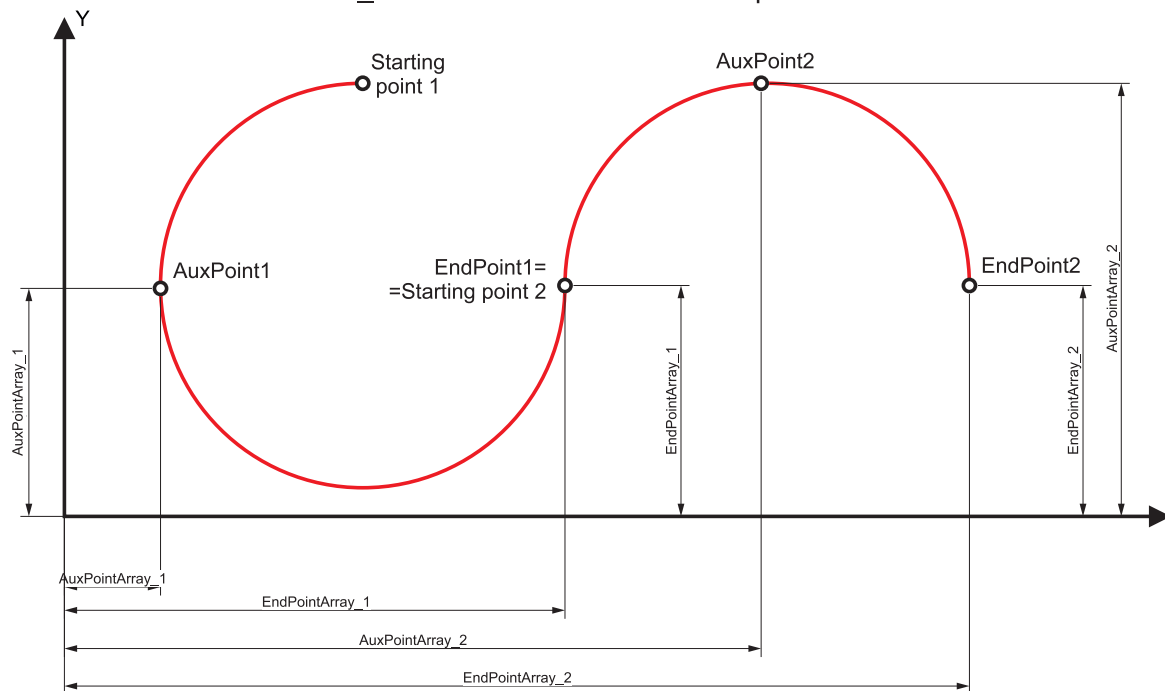
CircMode	Specifies the meaning of the input signals AuxPoint and CircDirection	long
1	BORDER	
2	CENTER	
3	RADIUS	
AuxPoint	Next coordinates to define circle (depend on CircMode)	reference
EndPoint	Target axes coordinates position	reference
PathChoice	Choice of path	long
1	Clockwise	
2	CounterClockwise	
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
CoordSystem	Reference to the coordinate system used	long
1	ACS	
2	MCS	
3	PCS	
BufferMode	Buffering mode	long
1	Aborting	
2	Buffered	
3	Blending low	
4	Blending high	
5	Blending previous	
6	Blending next	
TransitionMode	Transition mode in blending mode	long
1	TMNone	
2	TMStartVelocity	
3	TMConstantVelocity	
4	TMCornerDistance	
5	TMMaxCornerDeviation	
11	Smooth	
TransitionParameter	Parametr for transition (depends on transition mode)	double

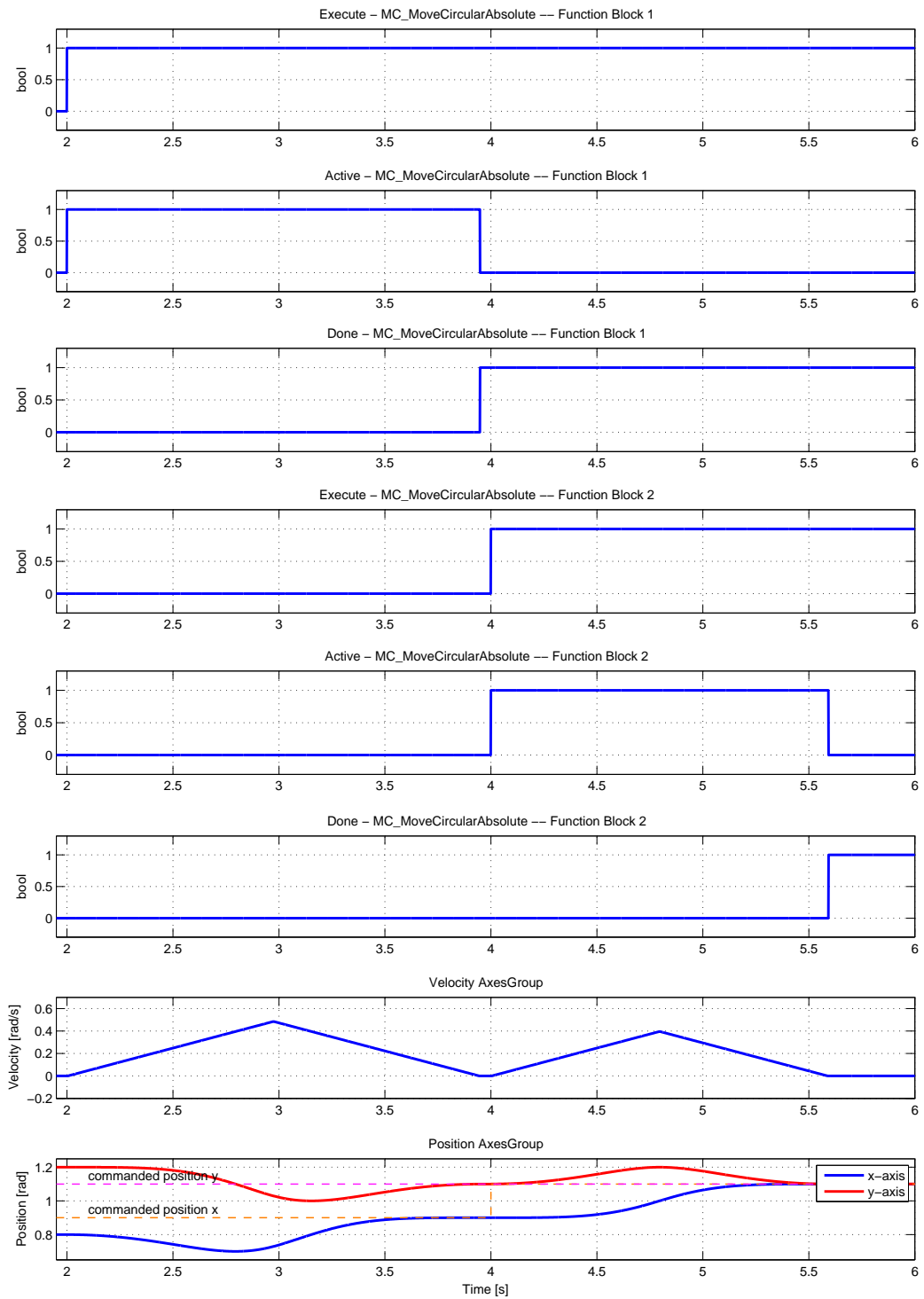
Outputs

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	Error code	error
i	REX general error	



MC_MoveCircularAbsolute - Example

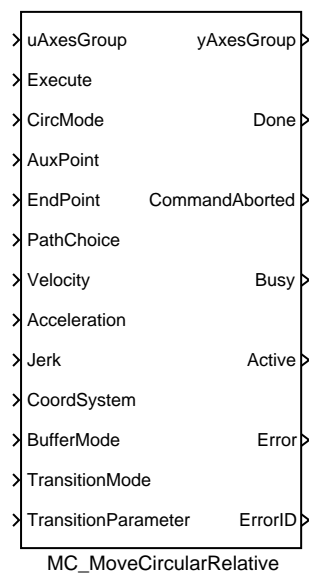




MC_MoveCircularRelative – Circular move to position (relative to execution point)

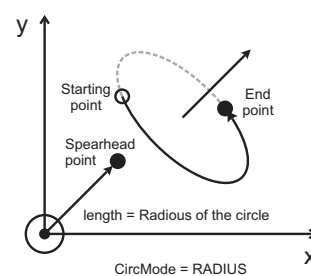
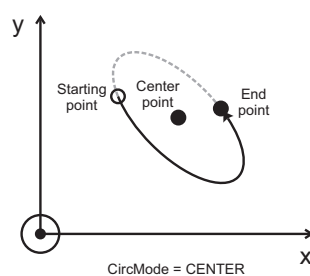
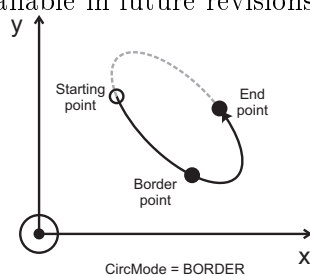
Block Symbol

Licence: [COORDINATED 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.



Inputs

uAxesGroup Axes group reference

reference

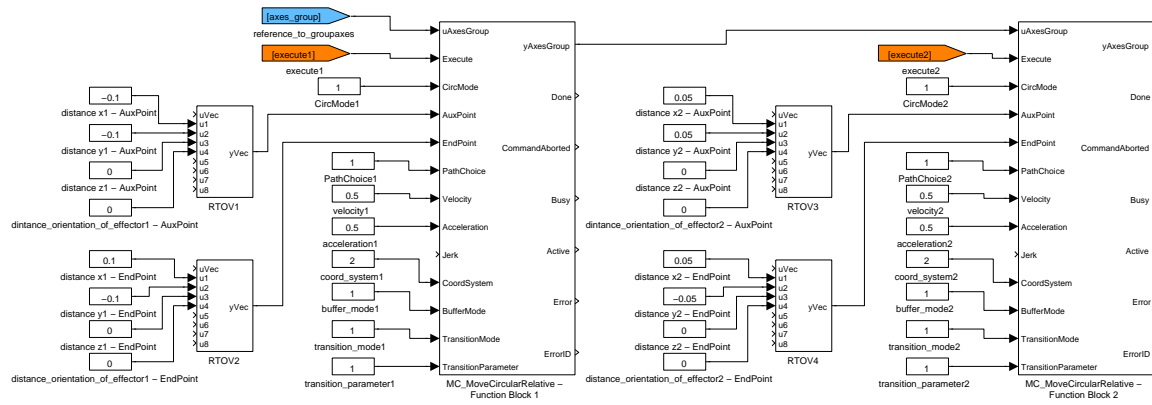
Execute The block is activated on rising edge

bool

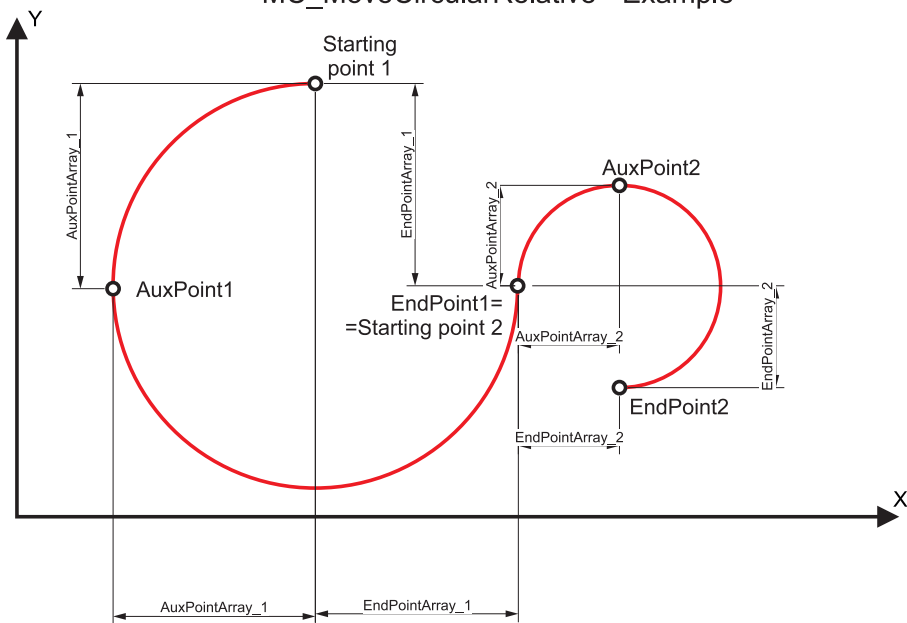
CircMode	Specifies the meaning of the input signals AuxPoint and CircDirection	long
1	BORDER	
2	CENTER	
3	RADIUS	
AuxPoint	Next coordinates to define circle (depend on CircMode)	reference
EndPoint	Target axes coordinates position	reference
PathChoice	Choice of path	long
1	Clockwise	
2	CounterClockwise	
Velocity	Maximal allowed velocity [unit/s]	double
Acceleration	Maximal allowed acceleration [unit/s ²]	double
Jerk	Maximal allowed jerk [unit/s ³]	double
CoordSystem	Reference to the coordinate system used	long
1	ACS	
2	MCS	
3	PCS	
BufferMode	Buffering mode	long
1	Aborting	
2	Buffered	
3	Blending low	
4	Blending high	
5	Blending previous	
6	Blending next	
TransitionMode	Transition mode in blending mode	long
1	TMNone	
2	TMStartVelocity	
3	TMConstantVelocity	
4	TMCornerDistance	
5	TMMaxCornerDeviation	
11	Smooth	
TransitionParameter	Parametr for transition (depends on transition mode)	double

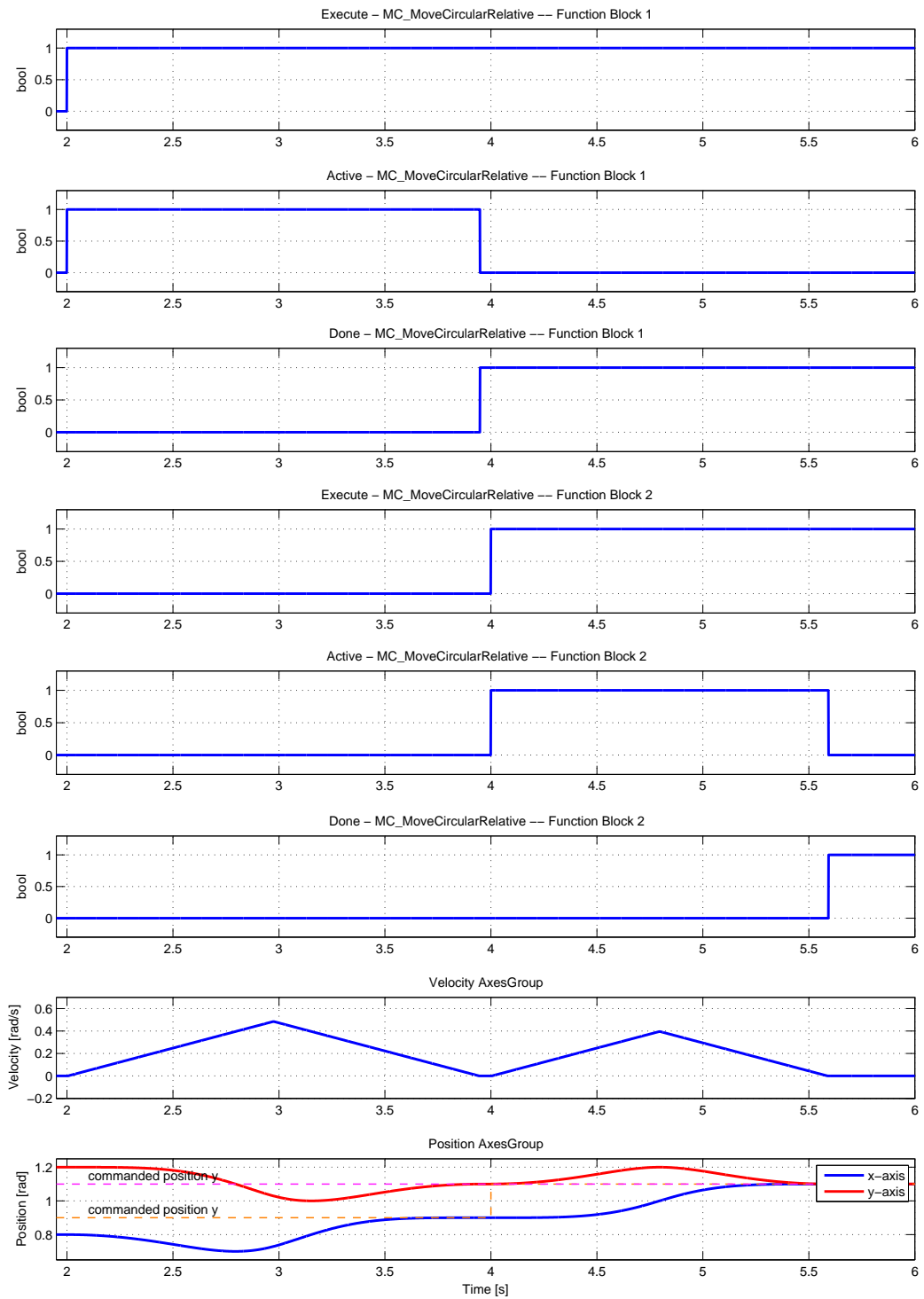
Outputs

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	Error code	error
i	REX general error	



MC_MoveCircularRelative - Example

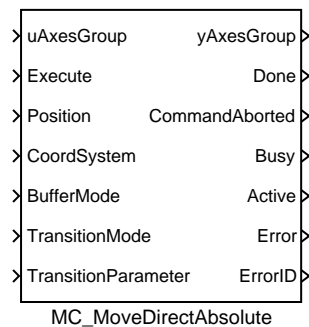




MC_MoveDirectAbsolute – Direct move to position (absolute coordinates)

Block Symbol

Licence: [COORDINATED 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.

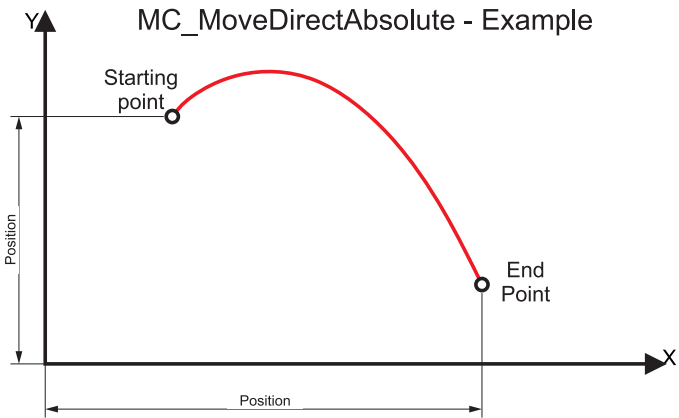
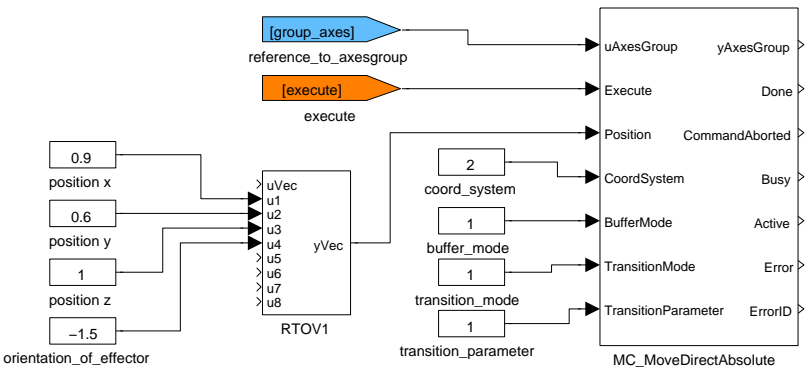
Inputs

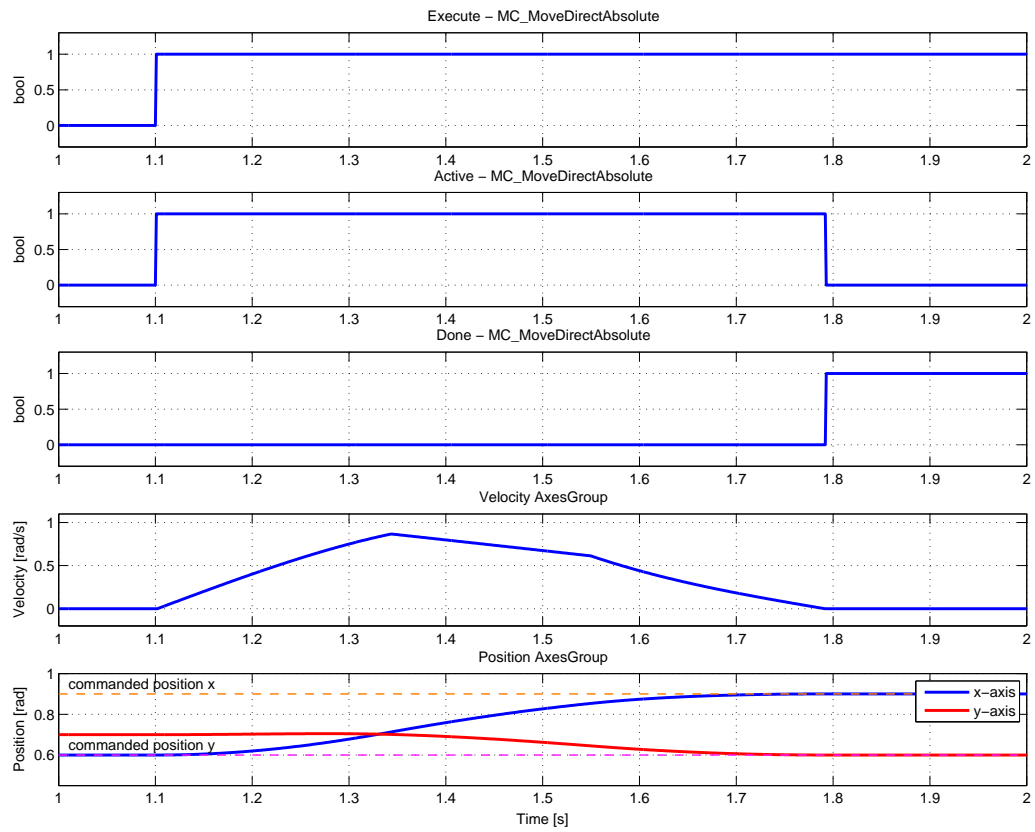
uAxesGroup	Axes group reference	reference
Execute	The block is activated on rising edge	bool
Position	Array of coordinates (positions and orientations)	reference
CoordSystem	Reference to the coordinate system used	long
	1 ACS	
	2 MCS	
	3 PCS	
BufferMode	Buffering mode	long
	1 Aborting	
	2 Buffered	
	3 Blending low	
	4 Blending high	
	5 Blending previous	
	6 Blending next	
TransitionMode	Transition mode in blending mode	long
	1 TMNone	
	2 TMStartVelocity	
	3 TMConstantVelocity	
	4 TMCornerDistance	
	5 TMMaxCornerDeviation	
	11 Smooth	

TransitionParameter Parametr for transition (depends on transition mode) double

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	Error code	error
	i REX general error	

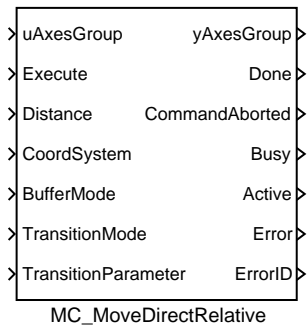




MC_MoveDirectRelative – Direct move to position (relative to execution point)

Block Symbol

Licence: [COORDINATED 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.

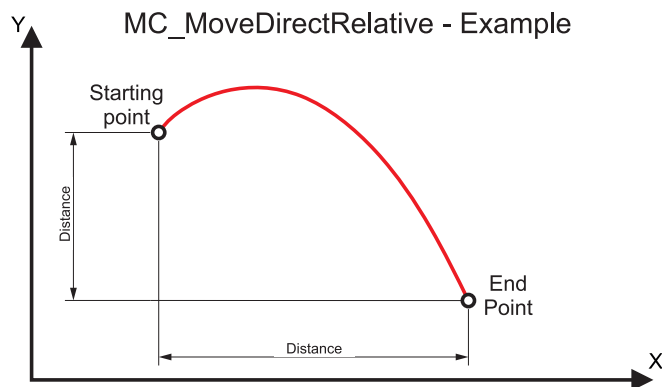
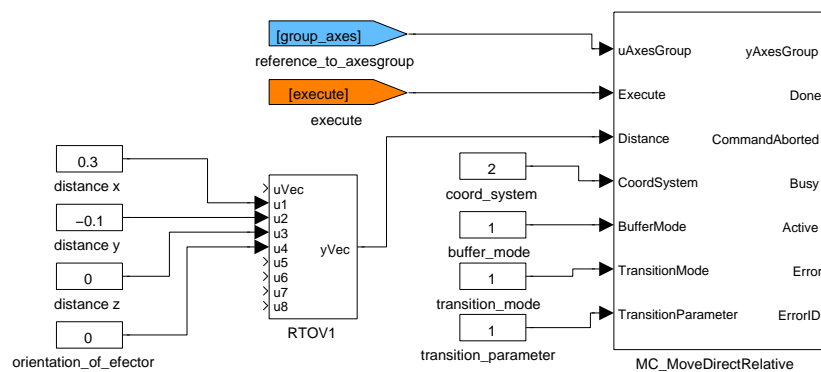
Inputs

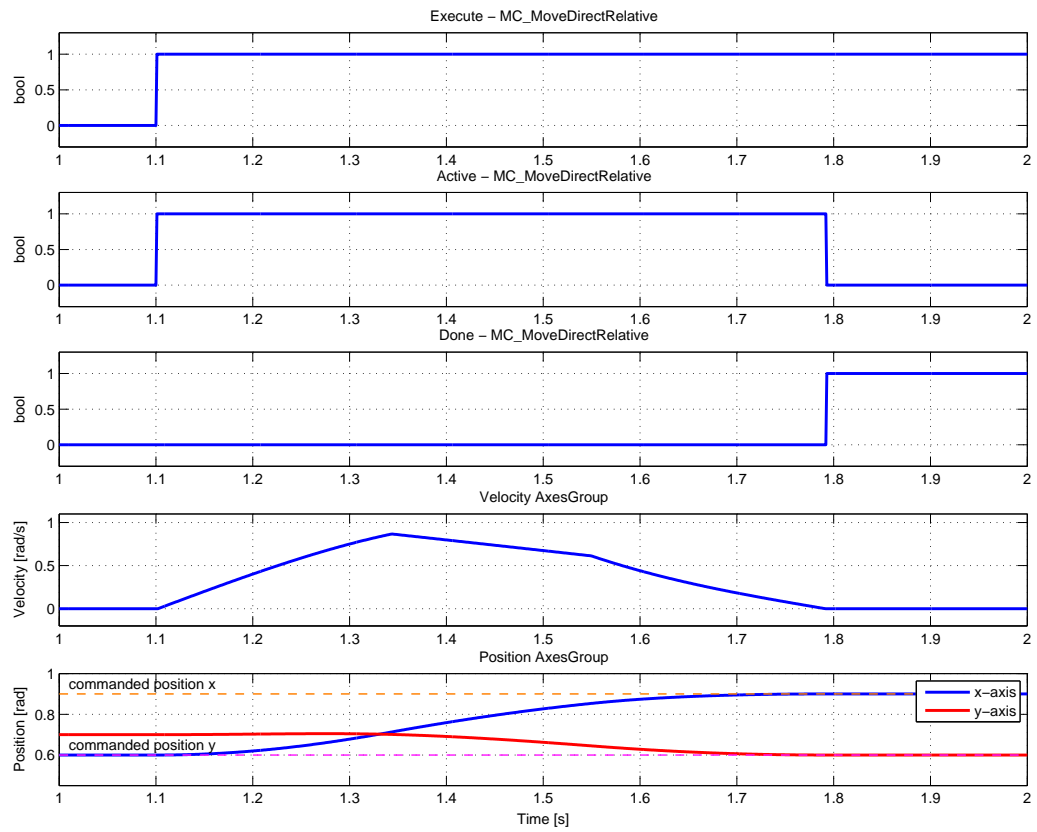
uAxesGroup	Axes group reference	reference
Execute	The block is activated on rising edge	bool
Distance	Array of coordinates (relative distances and orientations)	reference
CoordSystem	Reference to the coordinate system used	long
	1 ACS	
	2 MCS	
	3 PCS	
BufferMode	Buffering mode	long
	1 Aborting	
	2 Buffered	
	3 Blending low	
	4 Blending high	
	5 Blending previous	
	6 Blending next	
TransitionMode	Transition mode in blending mode	long
	1 TMNone	
	2 TMStartVelocity	
	3 TMConstantVelocity	
	4 TMCornerDistance	
	5 TMMaxCornerDeviation	
	11 Smooth	

TransitionParameter Parametr for transition (depends on transition mode) **double**

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	Error code	error
	i REX general error	

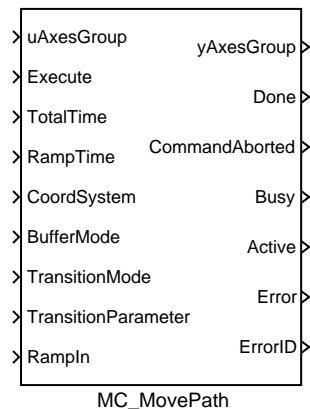




MC_MovePath – General spatial trajectory generation

Block Symbol

Licence: [COORDINATED 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.

Inputs

uAxesGroup	Axes group reference	reference
Execute	The block is activated on rising edge	bool
TotalTime	Time [s] for whole move	double
RampTime	Time [s] for acceleration/deceleration	double
CoordSystem	Reference to the coordinate system used	long
	1 ACS	
	2 MCS	
	3 PCS	
BufferMode	Buffering mode	long
	1 Aborting	
	2 Buffered	
	3 Blending low	
	4 Blending high	
	5 Blending previous	
	6 Blending next	

TransitionMode	Transition mode in blending mode	long
1 TMNone	
2 TMStartVelocity	
3 TMConstantVelocity	
4 TMCornerDistance	
5 TMMaxCornerDeviation	
11 Smooth	
TransitionParameter	Parametr for transition (depends on transition mode)	double
RampIn	RampIn factor (0 = RampIn mode not used)	double

Parameters

pc	Control-points matrix	double
	$\odot [0.0 \ 1.0 \ 2.0; \ 0.0 \ 1.0 \ 1.0; \ 0.0 \ 1.0 \ 0.0]$	
pk	Knot-points vector	double
	$\odot [0.0 \ 0.0 \ 0.0 \ 0.0 \ 0.5 \ 1.0 \ 1.0]$	
pw	Weighting vector	double
	$\odot [1.0 \ 1.0 \ 1.0]$	
pv	Polynoms for feedrate definition	double
	$\odot [0.0 \ 0.05 \ 0.95; \ 0.0 \ 0.1 \ 0.1; \ 0.0 \ 0.0 \ 0.0; \ 0.1 \ 0.0 \ -0.1; \ -0.05 \ 0.0 \ 0.05; \ 0.0 \ 0.0 \ 0.0]$	
pt	Knot-points (time [s]) for feedrate	double
	$\odot [0.0 \ 1.0 \ 10.0 \ 11.0]$	
user	Only for special edit	double
	$\odot [0.0 \ 1.0 \ 2.0 \ 3.0]$	

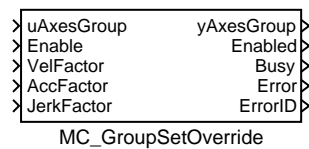
Outputs

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	Error code	error
	i REX general error	

MC_GroupSetOverride – Set group override factors

Block Symbol

Licence: [COORDINATED 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.

Inputs

uAxesGroup	Axes group reference	reference
Enable	Block function is enabled	bool
VelFactor	Velocity multiplication factor	double
AccFactor	Acceleration/deceleration multiplication factor	double
JerkFactor	Jerk multiplication factor	double

Parameter

diff	Deadband (difference for recalculation)	$\odot 0.05$	double
-------------	---	--------------	---------------

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	Error code	error
	i REX general error	

Appendix A

Licensing of individual function blocks

The function blocks of the REX Control System are divided into several licensing groups to provide maximum flexibility for individual projects.

The **STANDARD** function blocks are always available, the other groups require activation by a corresponding licence.

Function block name	Licensing group	
	STANDARD	Other
ABS_	•	
ABSROT		ADVANCED
ACD	•	
ADD	•	
ADDHEXD	•	
ADDOCT	•	
ADDQUAD	•	
AFLUSH	•	
ALB	•	
ALBI	•	
ALN	•	
ALNI	•	
AND_	•	
ANDHEXD	•	
ANDOCT	•	
ANDQUAD	•	
ANLS	•	
ARC	•	
ARLY	•	
ASW		ADVANCED

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
ATMT	•	
AVG	•	
AVS		ADVANCED
BDHEXD	•	
BDOCT	•	
BINS	•	
BIS	•	
BITOP	•	
BMHEXD	•	
BMOCT	•	
BPF	•	
CDELSSM		ADVANCED
CMP	•	
CNA	•	
CNB	•	
CNDR	•	
CNE	•	
CNI	•	
CNR	•	
CNS	•	
CONCAT	•	
COUNT	•	
CSSM		ADVANCED
DATE_	•	
DATETIME	•	
DDELSSM		ADVANCED
DEL	•	
DELM	•	
DER	•	
DIF_	•	
Display	•	
DIV	•	
DSSM		ADVANCED
EAS	•	
EATMT		ADVANCED
EDGE_	•	
EMD	•	
EPC		ADVANCED
EVAR	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
EXEC	•	
FIND	•	
FLCU		ADVANCED
FMUCS		ADVANCED
FMUINFO		ADVANCED
FNX	•	
FNXY	•	
FOPDT	•	
FRID		ADVANCED
From	•	
GAIN	•	
GETPA	•	
GETPB	•	
GETPI	•	
GETPR	•	
GETPS	•	
Goto	•	
GotoTagVisibility	•	
GRADS		ADVANCED
HMI	•	
HTTP		ADVANCED
I3PM		ADVANCED
IADD	•	
IDIV	•	
IMOD	•	
IMUL	•	
INFO	•	
INHEXD	•	
INOCT	•	
Inport	•	
INQUAD	•	
INSTD	•	
INTE	•	
INTSM	•	
IODRV	•	
IOTASK	•	
ISSW	•	
ISUB	•	
ITOI	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
KDER		ADVANCED
LC	•	
LEN	•	
LIN	•	
LLC	•	
LPBRK	•	
LPF	•	
MC_AccelerationProfile		MOTION CONTROL
MC_AddAxisToGroup		COORDINATED MOTION CONTROL
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 CONTROL
MC_GroupDisable		COORDINATED MOTION CONTROL
MC_GroupEnable		COORDINATED MOTION CONTROL
MC_GroupHalt		COORDINATED MOTION CONTROL
MC_GroupInterrupt		COORDINATED MOTION CONTROL
MC_GroupReadActualAcceleration		COORDINATED MOTION CONTROL
MC_GroupReadActualPosition		COORDINATED MOTION CONTROL
MC_GroupReadActualVelocity		COORDINATED MOTION CONTROL
MC_GroupReadError		COORDINATED MOTION CONTROL
MC_GroupReadStatus		COORDINATED MOTION CONTROL
MC_GroupReset		COORDINATED MOTION CONTROL
MC_GroupSetOverride		COORDINATED MOTION CONTROL
MC_GroupSetPosition		COORDINATED MOTION CONTROL
MC_GroupStop		COORDINATED MOTION CONTROL
MC_Halt		MOTION CONTROL
MC_HaltSuperimposed		MOTION CONTROL
MC_Home		MOTION CONTROL
MC_MoveAbsolute		MOTION CONTROL
MC_MoveAdditive		MOTION CONTROL
MC_MoveCircularAbsolute		COORDINATED MOTION CONTROL
MC_MoveCircularRelative		COORDINATED MOTION CONTROL
MC_MoveContinuousAbsolute		MOTION CONTROL
MC_MoveContinuousRelative		MOTION CONTROL
MC_MoveDirectAbsolute		COORDINATED MOTION CONTROL

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
MC_MoveDirectRelative		COORDINATED MOTION CONTROL
MC_MoveLinearAbsolute		COORDINATED MOTION CONTROL
MC_MoveLinearRelative		COORDINATED MOTION CONTROL
MC_MovePath		COORDINATED MOTION CONTROL
MC_MovePath_PH		COORDINATED MOTION CONTROL
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 CONTROL
MC_ReadParameter		MOTION CONTROL
MC_ReadStatus		MOTION CONTROL
MC_Reset		MOTION CONTROL
MC_SetCartesianTransform		COORDINATED MOTION CONTROL
MC_SetOverride		MOTION CONTROL
MC_Stop		MOTION CONTROL
MC_TorqueControl		MOTION CONTROL
MC_UngroupAllAxes		COORDINATED MOTION CONTROL
MC_VelocityProfile		MOTION CONTROL
MC_WriteBoolParameter		MOTION CONTROL
MC_WriteParameter		MOTION CONTROL
MCP_AccelerationProfile		MOTION CONTROL
MCP_CamIn		MOTION CONTROL
MCP_CamTableSelect		MOTION CONTROL
MCP_CombineAxes		MOTION CONTROL
MCP_GearIn		MOTION CONTROL
MCP_GearInPos		MOTION CONTROL
MCP_GroupHalt		COORDINATED MOTION CONTROL
MCP_GroupInterrupt		COORDINATED MOTION CONTROL
MCP_GroupSetOverride		COORDINATED MOTION CONTROL
MCP_GroupSetPosition		COORDINATED MOTION CONTROL
MCP_GroupStop		COORDINATED MOTION CONTROL
MCP_Halt		MOTION CONTROL

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
MCP_HaltSuperimposed		MOTION CONTROL
MCP_Home		MOTION CONTROL
MCP_MoveAbsolute		MOTION CONTROL
MCP_MoveAdditive		MOTION CONTROL
MCP_MoveCircularAbsolute		COORDINATED MOTION CONTROL
MCP_MoveCircularRelative		COORDINATED MOTION CONTROL
MCP_MoveContinuousAbsolute		MOTION CONTROL
MCP_MoveContinuousRelative		MOTION CONTROL
MCP_MoveDirectAbsolute		COORDINATED MOTION CONTROL
MCP_MoveDirectRelative		COORDINATED MOTION CONTROL
MCP_MoveLinearAbsolute		COORDINATED MOTION CONTROL
MCP_MoveLinearRelative		COORDINATED MOTION CONTROL
MCP_MovePath		COORDINATED MOTION CONTROL
MCP_MovePath_PH		COORDINATED MOTION CONTROL
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 CONTROL
MCP_SetKinTransform_Arm		COORDINATED MOTION CONTROL
MCP_SetOverride		MOTION CONTROL
MCP_Stop		MOTION CONTROL
MCP_TorqueControl		MOTION CONTROL
MCP_VelocityProfile		MOTION CONTROL
MCU	•	
MDL	•	
MDLI	•	
MID	•	
MINMAX	•	
MODULE	•	
MP	•	
MUL	•	
MVD	•	
NOT_	•	
NSCL	•	
OR_	•	
ORHDX	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
OROCT	•	
ORQUAD	•	
OSCALL	•	
OUTHEXD	•	
OUTOCT	•	
Outport	•	
OUTQUAD	•	
OUTRHEXD		ADVANCED
OUTROCT		ADVANCED
OUTRQUAD		ADVANCED
OUTRSTD		ADVANCED
OUTSTD	•	
PARA	•	
PARB	•	
PARI	•	
PARR	•	
PARS	•	
PIDAT		AUTOTUNING
PIDE		ADVANCED
PIDGS		ADVANCED
PIDMA		AUTOTUNING
PIDU	•	
PIDUI		ADVANCED
PJROCT	•	
PJSOCT	•	
POL	•	
POUT	•	
PRBS	•	
PRGM	•	
PROJECT	•	
PSMPC		ADVANCED
PWM	•	
QFC		ADVANCED
QFD		ADVANCED
QTASK	•	
RDC		ADVANCED
REC	•	
REGEXP		ADVANCED
REL	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
REPLACE	•	
REXLANG		REXLANG
RLIM	•	
RLY	•	
RM_AxesGroup		COORDINATED MOTION CONTROL
RM_Axis		MOTION CONTROL
RM_AxisOut		MOTION CONTROL
RM_AxisSpline		MOTION CONTROL
RM_Feed		COORDINATED MOTION CONTROL
RM_Gcode		COORDINATED MOTION CONTROL
RM_GroupTrack		COORDINATED MOTION CONTROL
RM_Track		MOTION CONTROL
RS	•	
RTOI	•	
RTOS	•	
RTOV	•	
S10F2		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	•	

The list continues on the next page...

Function block name	Licensing group	
	STANDARD	Other
SILOS	•	
SINT	•	
SLEEP	•	
SMHCC		ADVANCED
SMHCCA		AUTOTUNING
SMTF		ADVANCED
SOPDT	•	
SPIKE		ADVANCED
SQR	•	
SQRT_	•	
SR	•	
SRTF		ADVANCED
SSW	•	
STOR	•	
SUB	•	
SubSystem	•	
SWR	•	
SWU	•	
SWVMR	•	
TASK	•	
TIME	•	
TIMER_	•	
TIODRV	•	
TRND	•	
TRNDLF		ADVANCED
TRNDV	•	
TRNDVLF		ADVANCED
TSE	•	
VDEL	•	
VIN		ADVANCED
VOUT		ADVANCED
VTOR	•	
WSCH	•	
WWW	•	
ZV4IS		ADVANCED

Appendix B

Error codes of the REX Control 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 REX I/O driver warning
- 10 No more archive items
- 11 Object is array
- 12 Closed
- 13 End of file

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 REX Module error - some driver or block is not installed or licensed
- 109 REX 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 REX configuration is being changed
- 117 Invalid target device
- 118 Access denied by REX 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 REX 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

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 Communication closed unexpectedly
- 404 Unknown command
- 405 Unexpected command
- 406 Communication closed unexpectedly, probably 'Too many clients'
- 407 Communication timeout
- 408 Target device not found
- 409 Link failed
- 410 REX configuration has been changed
- 411 REX executive is being terminated
- 412 REX 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 block
- 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 sum 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 HALT input
- 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 - Not used
- 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 outputs
- 1122 ... FMU has too many parameters

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