



www.rexcontrols.com/rex

Getting started with REX and Monarco HAT

User guide

REX Controls s.r.o.

Version 2.50.5

2017-09-06

Plzeň (Pilsen), Czech Republic

Contents

1	Introduction	3
1.1	Features of the REX Control System	3
1.2	Structure of the REX Control System	4
1.3	Programming in the REX Control System	4
1.4	Main components of the REX Control System	5
1.4.1	RexDraw – the development environment	5
1.4.2	RexHMI Designer – the user interface	5
1.4.3	RexComp – the compiler	5
1.4.4	RexCore – the runtime core	5
1.4.5	RexView – the diagnostic tool	5
2	Installation of the development tools	6
2.1	Windows 7/8/10	6
2.1.1	Installation procedure	6
2.1.2	Uninstall procedure	7
3	Installing the runtime modules of the REX Control System on Raspberry Pi	8
3.1	Installation of components on Raspberry Pi	8
3.2	Installed files and folders	9
3.3	Uninstall procedure	9
4	Configuration, compilation and execution	10
4.1	Creating a new project	10
4.2	Compiling and running a project	15
4.3	Adding a user interface (HMI)	21
4.4	Ready for interaction with the outer world	26
5	I/O configuration for the Monarco HAT	27
5.1	Physical connections	27
5.2	Adding inputs and outputs to the project	28
5.3	Working with I/O signals	28
5.3.1	Modifications in the project main file	28
5.3.2	Modifications in the task	30

5.4	Updating the HMI	32
5.5	Additional information	33
5.5.1	Detailed description of the driver	33
5.5.2	Examples	34
6	Summary	35
A	Graphical HMI with RexHMI Designer	36
A.1	Initializing the HMI design	36
A.2	Adding the first HMI components	38
A.3	Linking HMI components with the running algorithm	41
A.4	Adding more HMI components	45
A.5	Additional links to the running algorithm	46
A.6	The final steps	47
B	Licensing of the REX Control System	50
B.1	Obtaining a DEMO licence	50
B.2	Obtaining a permanent licence	52
B.2.1	Activation of the permanent licence	52
	Bibliography	56

Chapter 1

Introduction

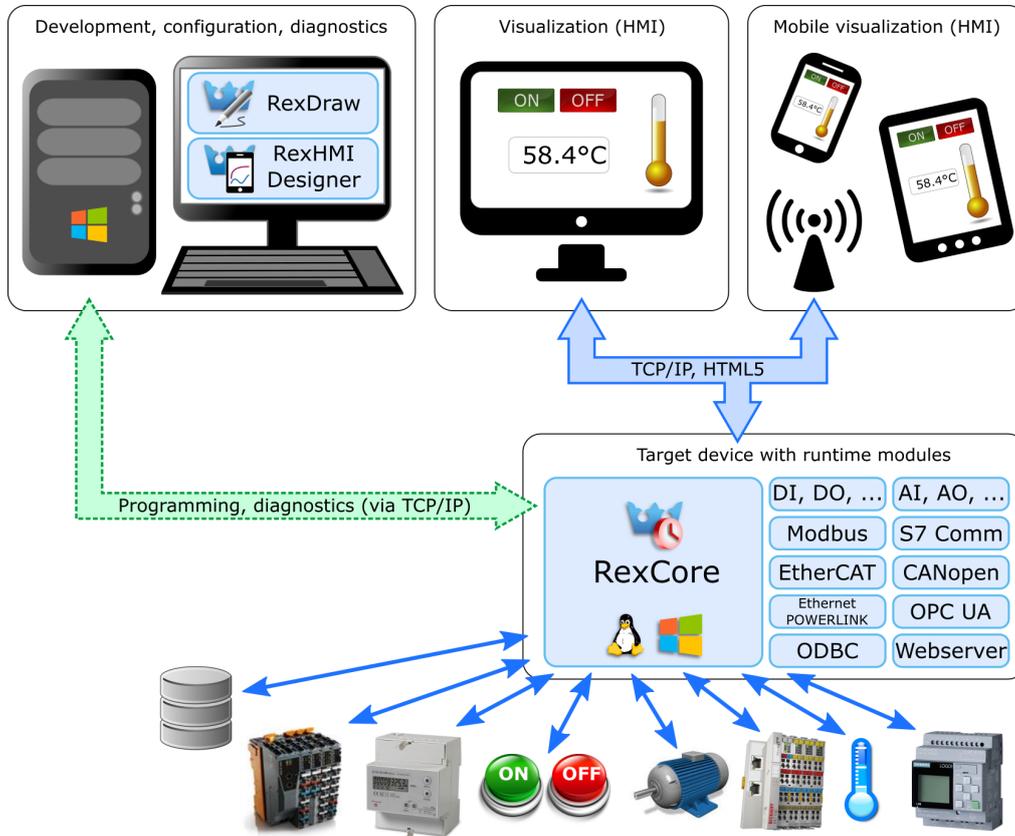
The REX Control System is a family of software products for automation projects. You can use it in all fields of automation, robotics, measurements and feedback control.

The runtime core of the REX Control System turns your Raspberry Pi into a programmable device which will run your algorithms.

1.1 Features of the REX Control System

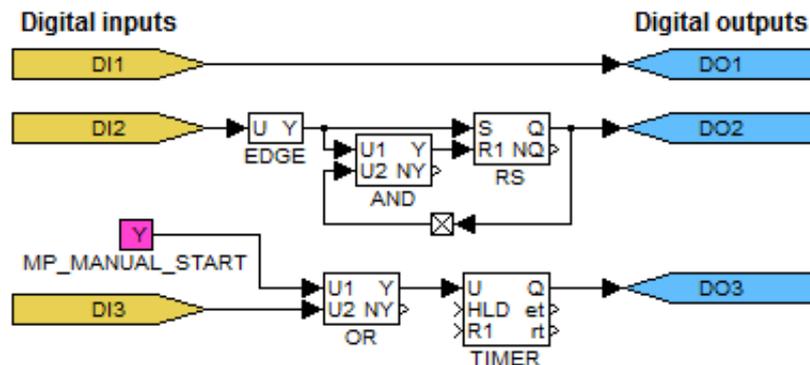
- Graphical programming without hand-coding
- Programming control units on a standard PC or laptop
- User interface for desktop, tablet and smartphone (HMI)
- Wide family of supported devices and input-output units (including Monarco HAT)
- Industry-proven control algorithms
- Easy integration into business IT infrastructure (ERP/BMS)
- REST API for seamless integration into Industry 4.0 and (I)IoT solutions

1.2 Structure of the REX Control System



1.3 Programming in the REX Control System

The REX Control System offers a graphical development environment for programming the algorithms. You can use standard desktop or laptop PC. You create the algorithms from the so-called function blocks. The library includes countless items (timers, comparators, filters, PID controllers and many more).



1.4 Main components of the REX Control System

1.4.1 RexDraw – the development environment

The RexDraw graphical environment is a developer's tool which runs on a standard PC with Windows. You create the algorithms using the function block library¹ of the REX Control System [1]. The library contains simple comparators and timers as well as advanced blocks for signal processing and feedback control (PID controllers etc.). You compile your project on your PC and run it on your Raspberry Pi.

Once running, you can watch your algorithm in real-time. Just select the signals and function blocks of your interest. You can also obtain detailed hierarchical information about the running algorithm and diagnose the runtime core and execution of your algorithm. You can connect via local network or over the Internet.

1.4.2 RexHMI Designer – the user interface

The RexHMI Designer is another developer's tool intended for designing graphical user interface (or HMI, Human Machine Interface, if you prefer) for your algorithms. The user interface is included in the project and it is copied to your Raspberry Pi along with the algorithm.

1.4.3 RexComp – the compiler

The RexComp compiler converts your algorithms into binary code of the REX Control System. The compiler is almost invisible for the user, it is invoked from the RexDraw development environment. The compiler detects and reports possible errors in your algorithms.

1.4.4 RexCore – the runtime core

The RexCore runtime core runs on the target device (Raspberry Pi). It handles timing and execution of your algorithms and provides various services. The individual tasks are prioritized and executed using preemptive multitasking.

RexCore further contains an integrated webserver providing user interface (HMI) and REST API.

1.4.5 RexView – the diagnostic tool

With RexView you can diagnose the runtime core and execution of your algorithm. It is an alternative standalone tool for commissioning and diagnostics of control algorithms. All the diagnostic functions are included in RexDraw, therefore RexView can be considered obsolete. You can connect via local network or over the Internet.

¹The IEC 61131-3 standard defines Function Block Diagram (FBD) as one of the PLC programming techniques.

Chapter 2

Installation of the development tools

This chapter describes the steps to install and uninstall the development tools of the REX Control System on Windows 7/8/10 operating systems.

2.1 Windows 7/8/10

The installation package of the REX Control System development tools contains the RexDraw and RexHMI Designer development environments, the RexComp compiler and the RexView diagnostic tool. It also includes the RexCore runtime module for developing and testing purposes.

The installation package can be downloaded from <https://www.rexcontrols.com/software-download>.

The installation process requires the administrator rights on your PC.

2.1.1 Installation procedure

1. Run the `REX-X.XX.XX.XXXX-PPP.exe` downloaded from <https://www.rexcontrols.com/software-download>.
2. Select the language and follow the installation wizard.
3. Select the target installation folder, the default is `C:\Program Files (x86)\REX Controls\REX X.XX.XX.XXXX`.
4. Afterwards you can select the components to install. The requirements are quite low (approx 400 MB disk space) therefore the `Full install` option is recommended.
5. The following steps are standard and do not require further explanation.

There is no need to restart the system after installation.

2.1.2 Uninstall procedure

The common procedure can be used to uninstall the REX Control System – go to *Control panel* and choose *Install/Uninstall programs*.

Chapter 3

Installing the runtime modules of the REX Control System on Raspberry Pi

It is necessary to have a correctly configured Internet connection on your Raspberry Pi running the so-called Raspbian distribution of GNU/Linux¹ prior to using this guide. Visit <http://www.raspberrypi.org> for more information.

3.1 Installation of components on Raspberry Pi

1. On your Raspberry Pi, install GIT
`sudo apt install git`
2. Go to your home directory
`cd`
3. Download the latest revision of installation scripts
`git clone https://github.com/rexcontrols/rex-install-rpi.git --branch v2.50`
4. Change the working directory
`cd rex-install-rpi`
5. Depending on your hardware, run **ONLY ONE** of the following installation scripts
 - For bare Raspberry Pi:
`sudo bash install-rex.sh`
 - For Raspberry Pi with the Monarco HAT:
`sudo bash install-rex-monarcohat.sh`
 - For Raspberry Pi with UniPi extension board:
`sudo bash install-rex-unipi.sh`

¹RexCore should also work on any other distribution based on Debian (e.g. Ubuntu).

- For Raspberry Pi with PiFace Digital extension board:
`sudo bash install-rex-pifacedigital.sh`

6. Perform reboot if you are asked for it and you are done.

Right after the installation the RexCore runtime module is started automatically in the background as a daemon and it is possible to establish connection between the host PC and the Raspberry Pi using the RexDraw program. RexCore also automatically runs upon system (re)start.

3.2 Installed files and folders

Please refer to the RexCore user guide [2] for detailed information about the files and folders of the REX Control System runtime modules.

3.3 Uninstall procedure

Use the `sudo apt-get remove rexcore` command to remove RexCore from the operating system.

Chapter 4

Configuration, compilation and execution

The process of creating a control algorithm will be demonstrated on a very simple example with four Boolean variables representing manual switches. In Chapter 5, two of them will be replaced by physical inputs of the Monarco HAT. A software timer will be used for measuring the time when the variables are true (i.e. the switches are in the ON position). A Boolean signal will indicate that the interval of predefined length has elapsed.

4.1 Creating a new project

The project configuration is created using the `RexDraw` program. Each project consists of at least two `.mdl` files. The first file is the main file of the project, which is used for configuration of tasks, drivers, priorities and timing. The other file(s) contain the individual control algorithms (tasks).

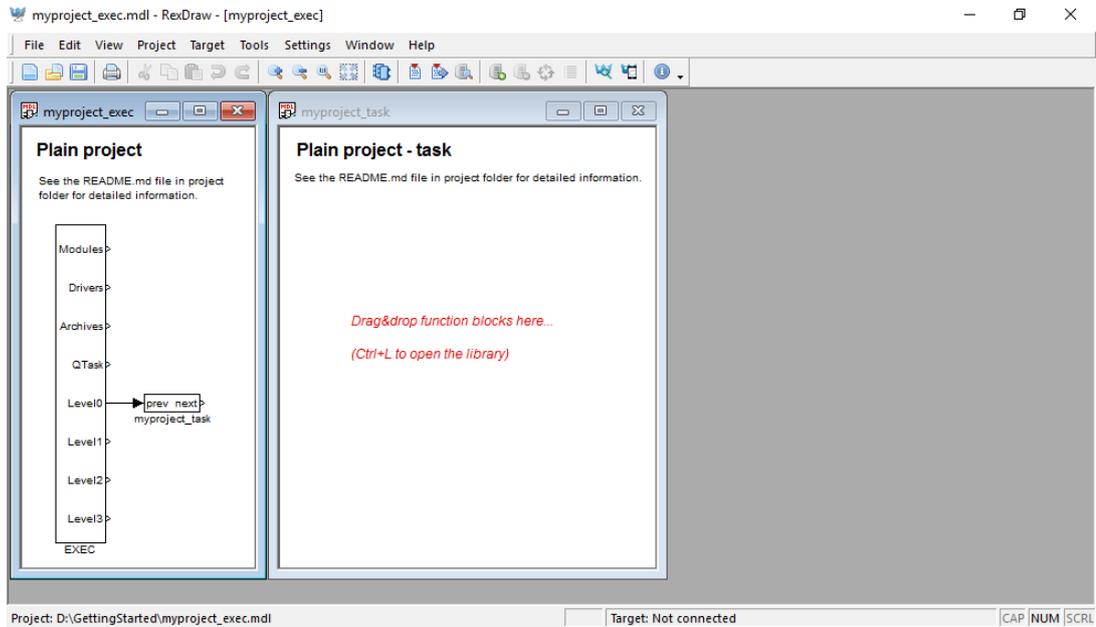
First we'll create the example 0101-01 from scratch¹.

Standard approach:

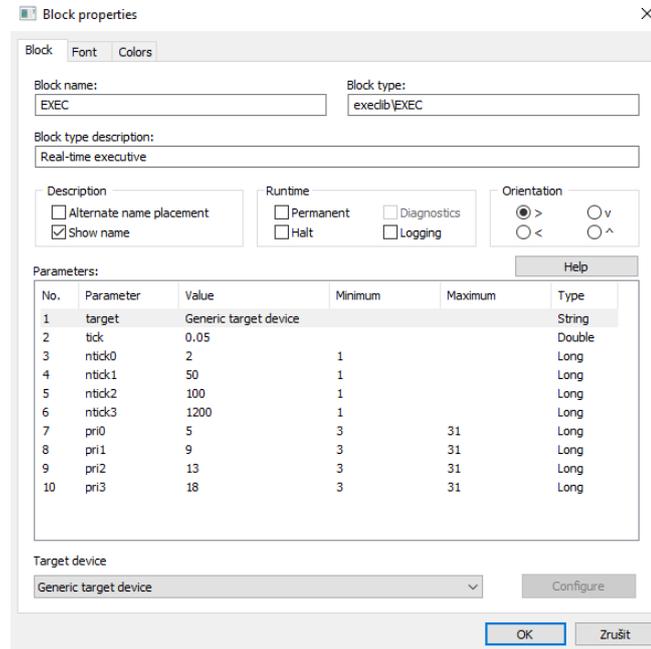
1. Run the `RexDraw` program. Start with a plain project and select a folder to save the project files in (e.g. `D:\GettingStarted`).
2. The folder will contain two important files:
 - `myproject_exec.mdl`
 - `myproject_task.mdl`
3. The `myproject_exec.mdl` is the project main file. It contains one `EXEC` block from the `EXEC` library. The other block is the `TASK` block from the same library

¹All examples which are part of the installation are marked by an ExampleID. The most up-to-date examples are available at <https://github.com/rexcontrols/REXexamples/archive/v2.50.zip>

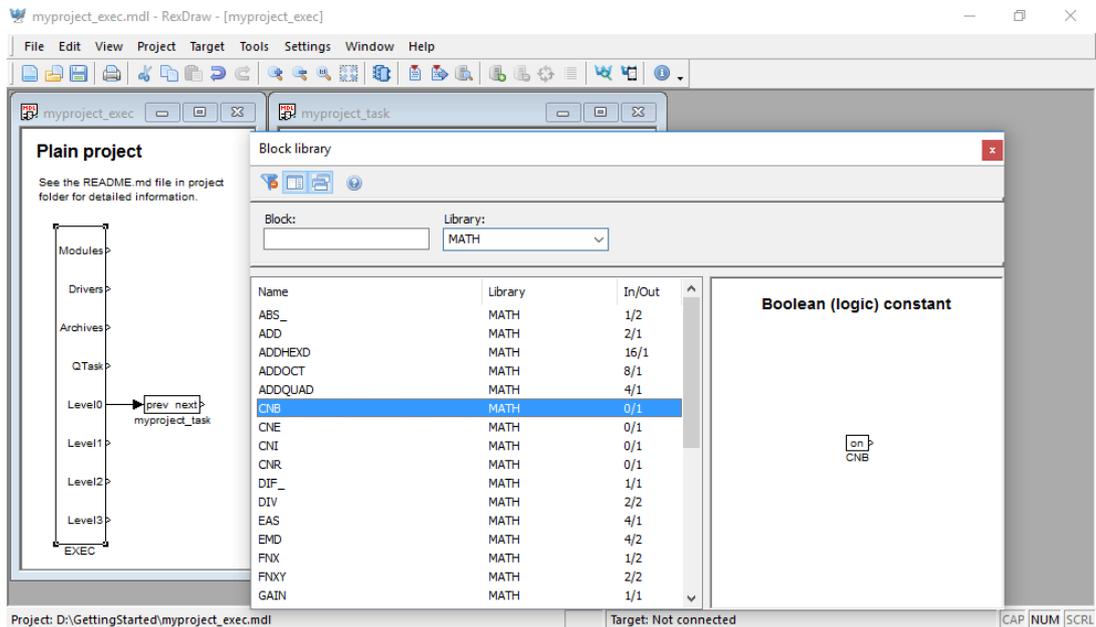
and it is renamed to `myproject_task` to reference the second file of the project (`myproject_task.mdl`), which will contain the algorithm (the so-called task).



4. The task is connected to the `Level0` output of the `EXEC` block and therefore its timing is defined by `tick` and `ntick0` parameters of the `EXEC` block.
5. The `EXEC` block (and any other block) can be configured by double-clicking on it. A block parameters and properties dialog appears. The parameters of all blocks of the REX Control System are described in the Help (press the F1 key) and in the Block reference manual [1].

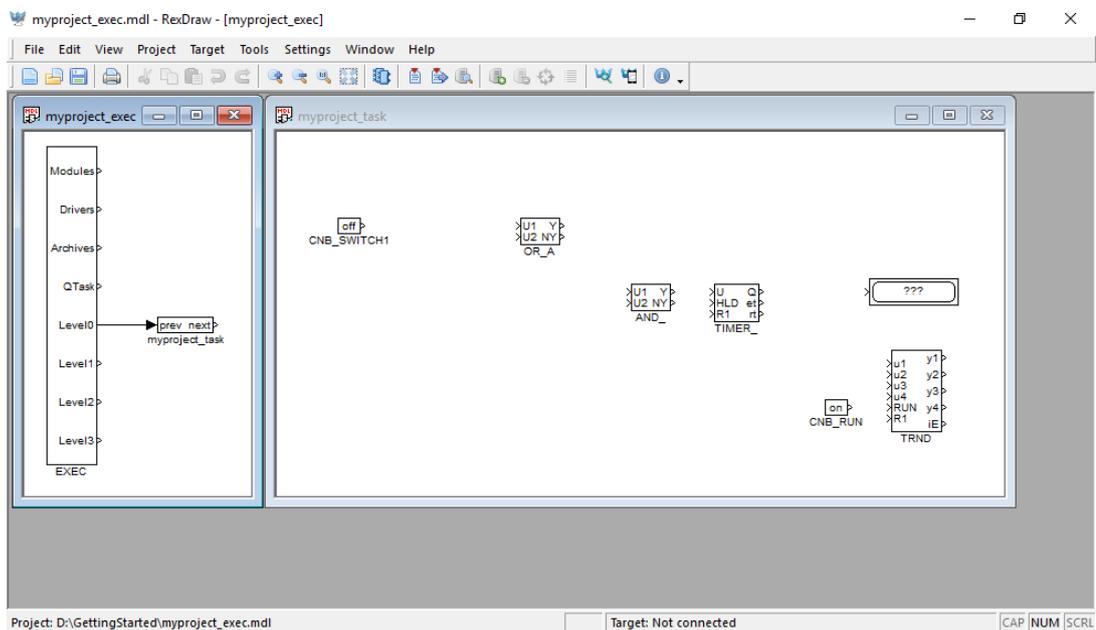


6. Note that `tick=0.05` and `ntick0=2`, therefore the task will run each 100 milliseconds ($0.05 \cdot 2 = 0.1s$). There is no need to change any parameter at the moment. Close the dialog.
7. You can delete all the descriptive texts in project files. These have no effect on the functionality and can be considered programmer's comments.
8. Open **Block Library**, choose *View/Block Library* in the menu or use the  icon from the toolbar.
9. The blocks are ordered in alphabetical order. Further the blocks are also organized in sublibraries and the location is always denoted as **sublibrary/block**, e.g. **LOGIC/AND** for the logical AND block in the LOGIC sublibrary.

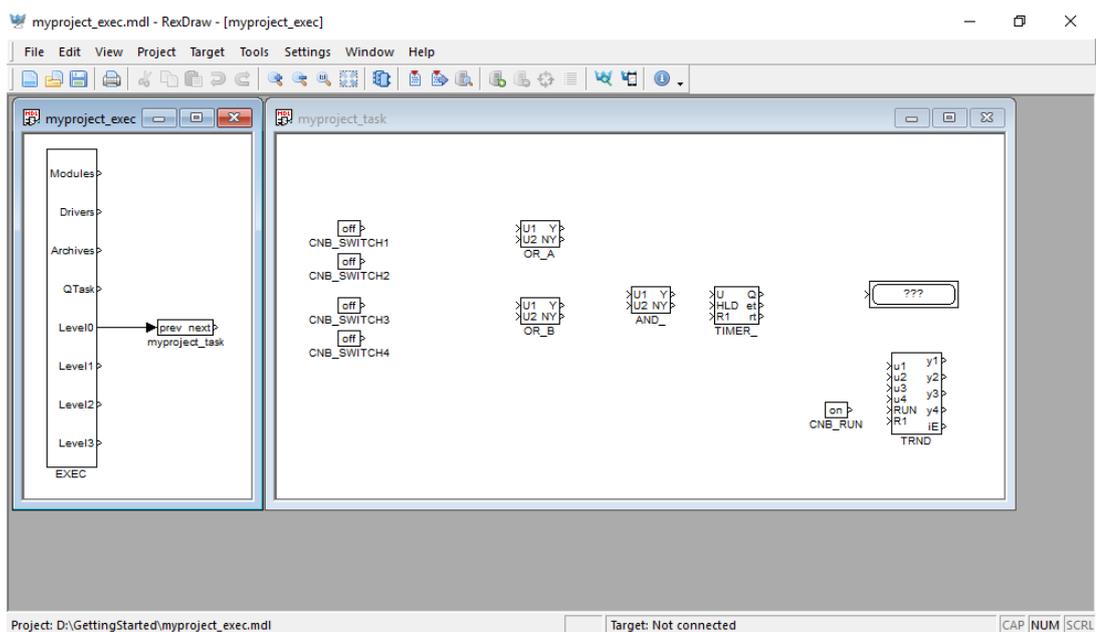


10. Locate the following function blocks in the Block Library and drag them to the task file:

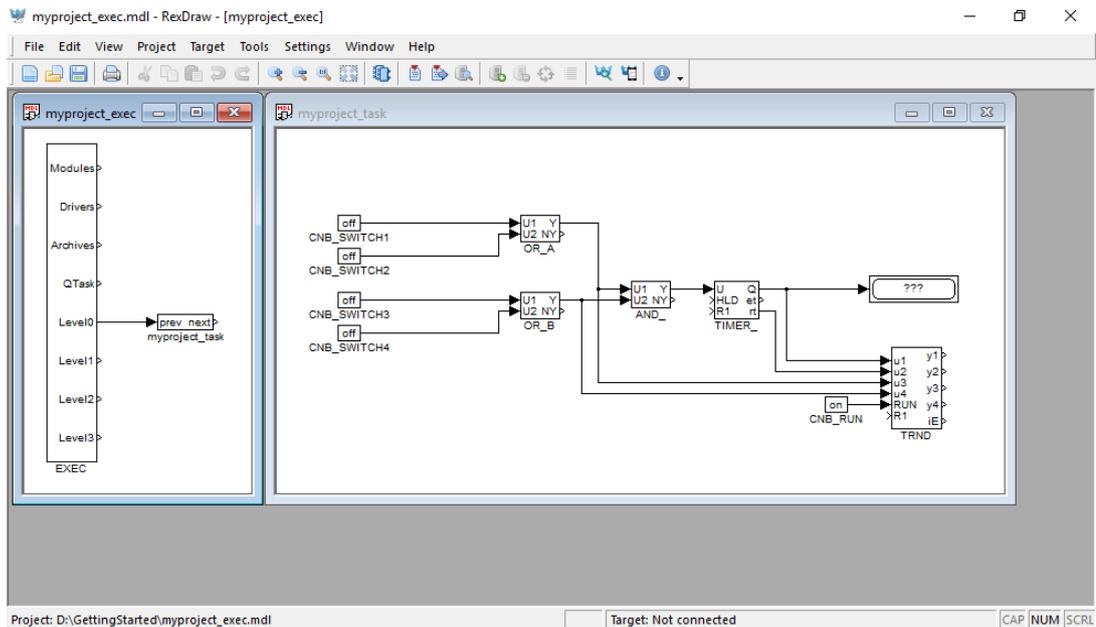
- MATH/CNB – constant of type Boolean. Once dropped, double-click its name and change it to CNB_SWITCH1. Double-click the block and set parameter YCN = off.
- LOGIC/OR_ – logical OR. Rename it to OR_A.
- LOGIC/AND_ – logical AND.
- LOGIC/TIMER_ – a timer block. Set parameter mode = 2: Delayed ON, pt = 5.0.
- INOUT/Display – a display to show values in real-time.
- ARC/TRND – real-time recording. Set parameters l = 2000, Title = My timer, leave the default values otherwise.
- MATH/CNB – constant of type Boolean, change name to CNB_RUN, set parameter YCN = on.



11. Duplicate the CNB_SWITCH1 block with right mouse button dragging. Or simply Copy&Paste the block.
12. Duplicate the block 2 more times.
13. Duplicate also the OR_A block. Rename the duplicate to OR_B.



- Connect the blocks as shown below. To connect the blocks, drag the output arrow of one block to the input arrow of the other block using the left mouse button. The connection will be established when the line goes bold and green. After releasing the mouse button you can recognize a successfully connected line by its style. A full line terminated by a full arrow at the input of the connected block indicates a valid connection. New branch of an existing line can be created by dragging an existing line with the right mouse button.

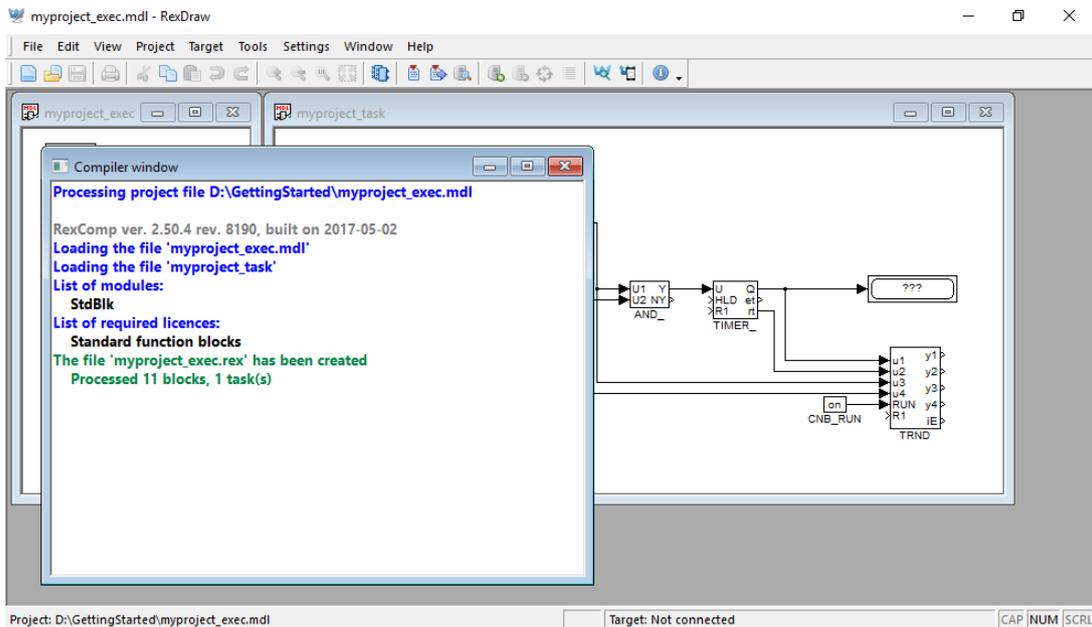


At this moment the executive configuration `myproject_exec.mdl` and the corresponding `myproject_task.mdl` file with the algorithm are ready. The algorithm will be evaluated in the direction of the arrows, starting from the source CNB blocks, passing through the OR_, AND_ and TIMER_ blocks and finishing at the Display and TRND blocks.

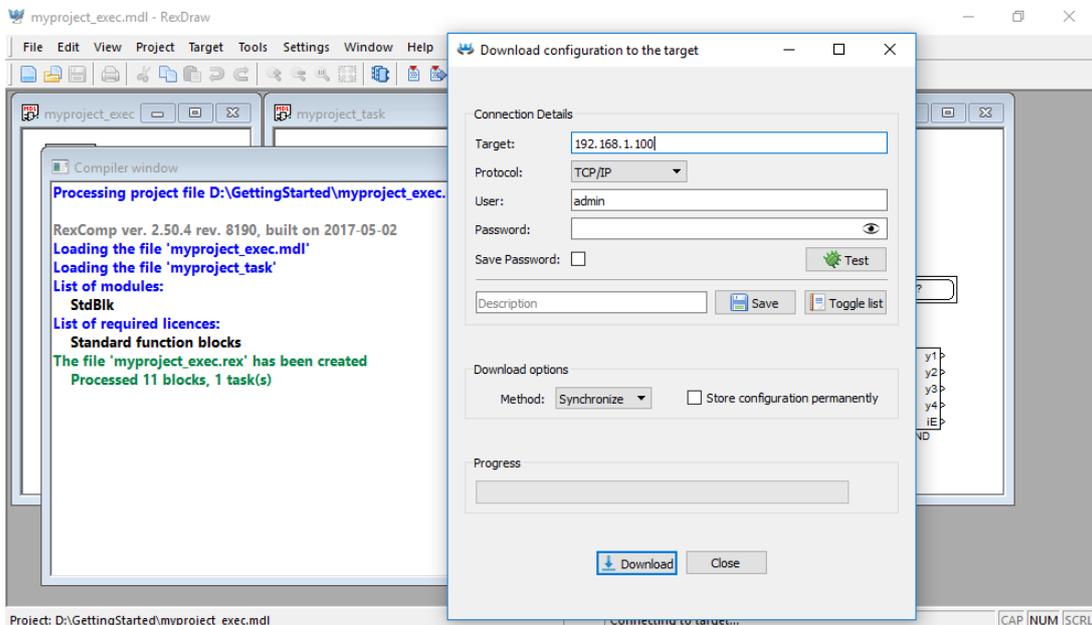
Congratulations, your first project is ready for compilation!

4.2 Compiling and running a project

The developed algorithm must be compiled to binary form prior to deploying. Pick *Project/Compile* from the menu or use the  icon from the toolbar. The compiler output is displayed in the **Compiler** window. If no error is found, the `myproject_exec.rex` file is created.



At this moment it is possible to deploy the control algorithm to the target platform. Use *Project/Compile and Download* in the menu or click the **Compile and Download** icon  for this purpose. A dialog for defining the target device appears upon successful compilation.

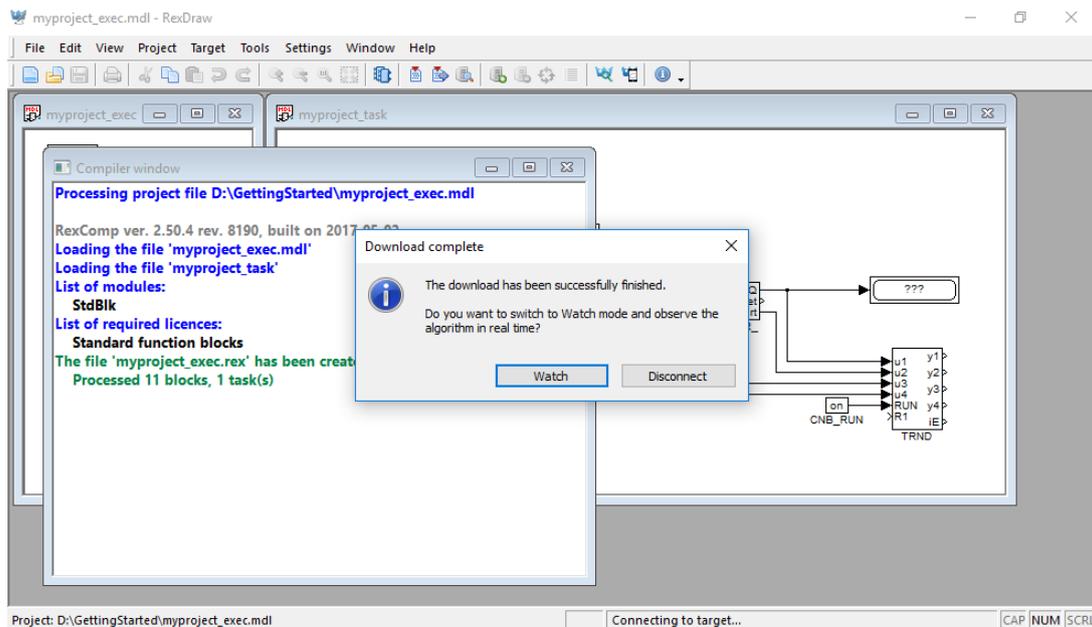


Enter the IP address of your Raspberry Pi in the **Target** field. **The default user is admin and there is no password by default.** Leave the other elements intact and

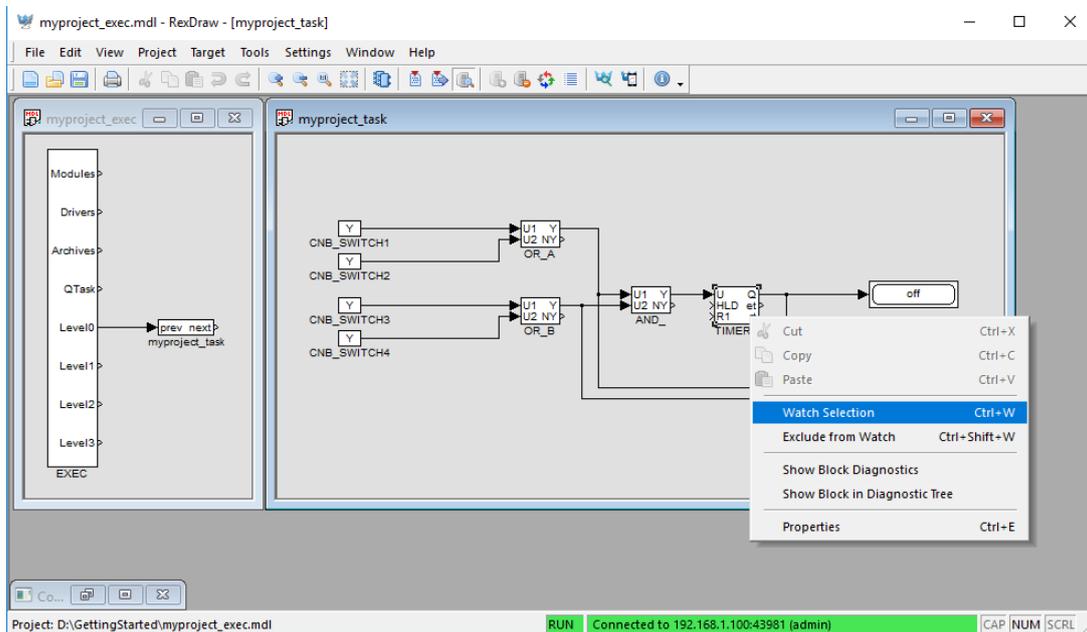
click Download.

If there is no licence on your Raspberry Pi, you need to get one first. You can get a DEMO licence for free. See Appendix B for details and come back afterwards.

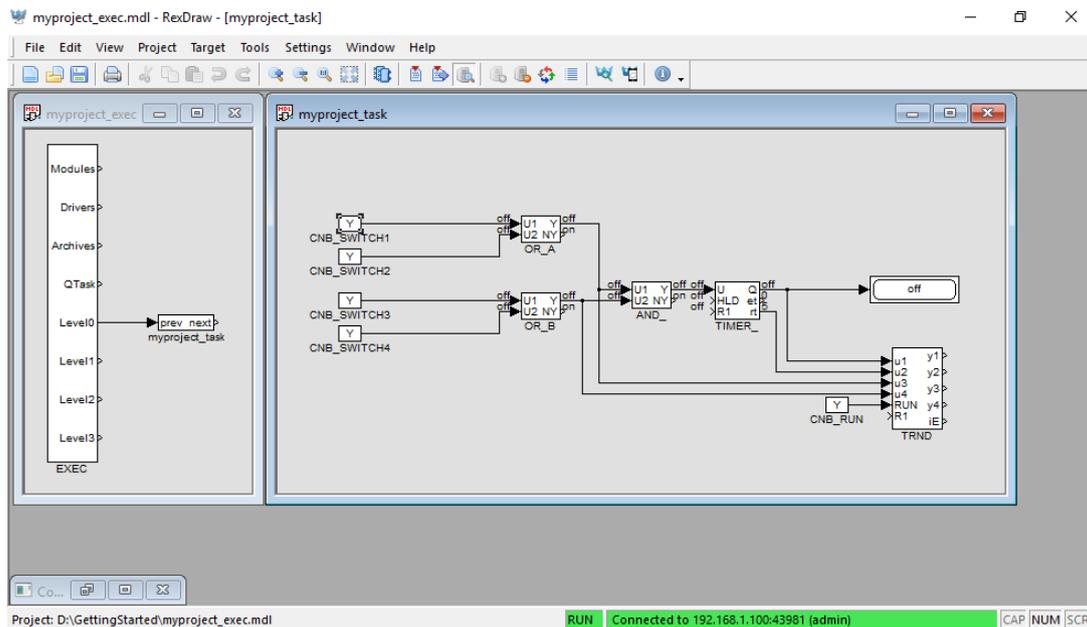
As soon as the download is complete it is possible to switch the RexDraw application to the so-called *Watch mode* and watch the control algorithm in real-time – click Watch.



In the *Watch mode*, the background of all files goes gray and you cannot move or delete any blocks or connections. Right-click the `TIMER_` block and select *Watch selection* in the menu to watch the inputs and outputs of the timer.



You can do the same with the OR_ and AND_ blocks (or any other selection).

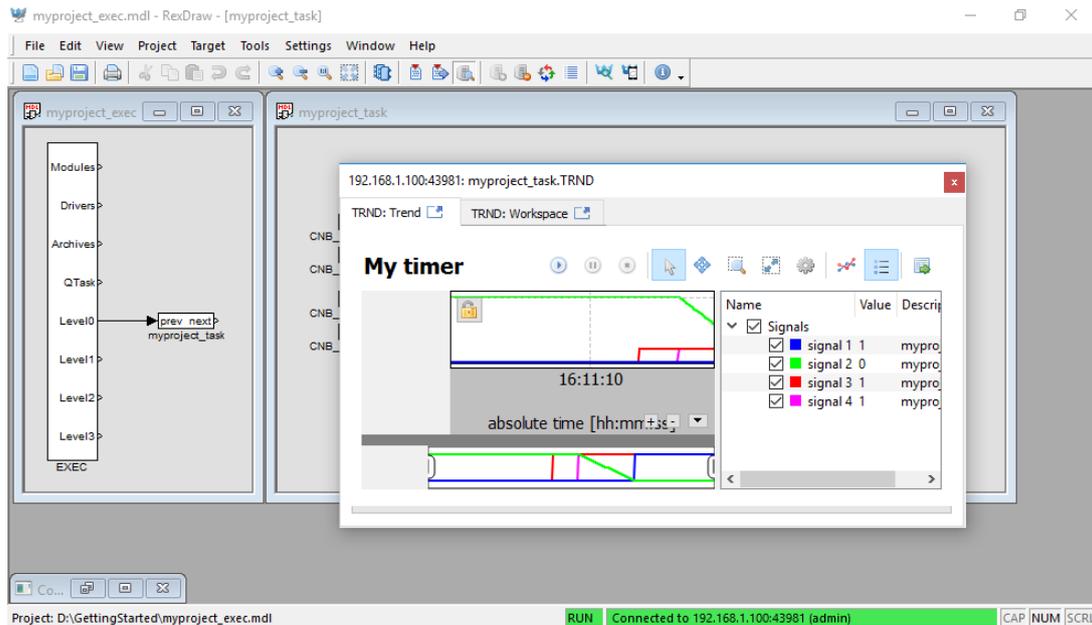


Now it is possible to double-click the CNB_SWITCH1 block and change the Boolean variable to YCN = on (tick the checkbox and click OK). Once you do the same with the CNB_SWITCH3 block, the outputs of both OR blocks are on and the Y output of the AND_ block goes on and the TIMER_ starts to count down. Observe the `rt` output.² Once the

²Do not get confused by the default 1 second refresh rate of the *Watch mode*. The algorithm on the target device runs each 100 milliseconds as mentioned earlier.

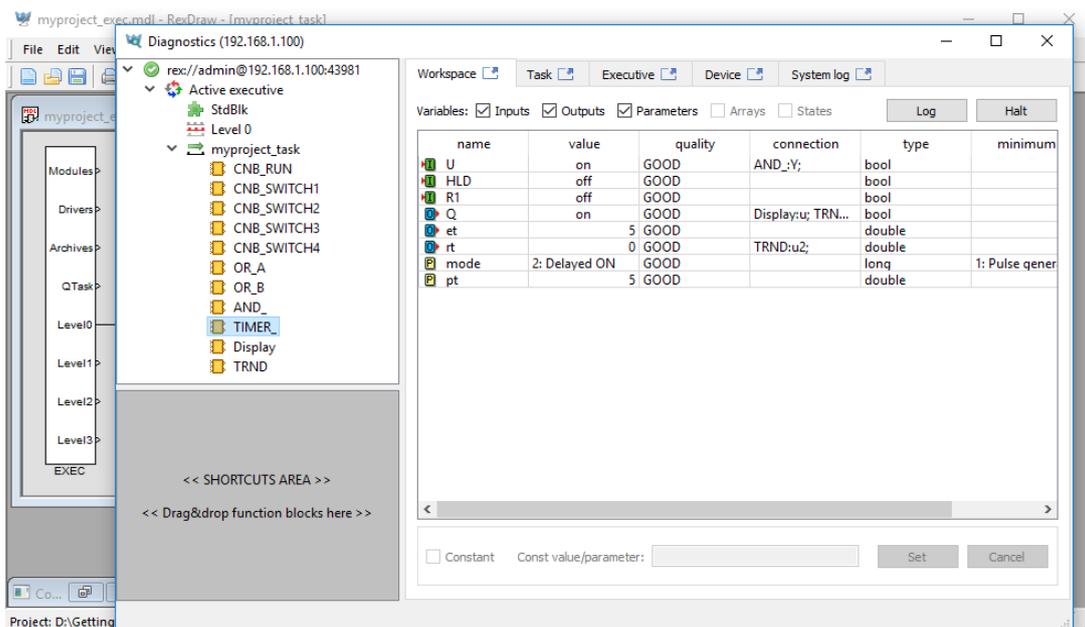
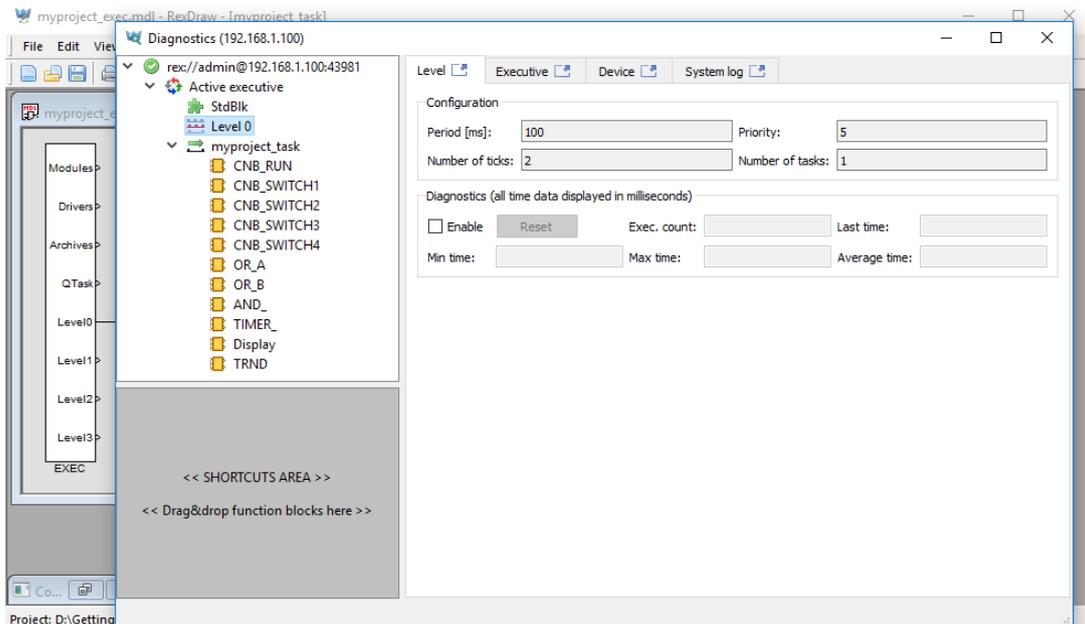
timer reaches zero, its output Q is set to on and it remains on as long as the U input is on.

You can double-click the TRND block to see the signals in a real-time graph. The red line is the output of the OR_A block, the magenta line is the output of the OR_B block, the green line is the remaining time of the timer and the blue line is the Boolean output of the timer.



Try turning the CNB blocks off and change the pt parameter of the $TIMER_$ block. Afterwards turn the CNB blocks on again and observe the signals in the TRND block again. As you can see, you can modify any parameter in real-time, which allows you to fine tune your algorithm.

It is also possible to open a **Diagnostics** view of the algorithm. Pick *Target/Diagnostics* from the menu or click the  icon and you will see the algorithm in a tree view which allows you to monitor the control algorithm in full detail. You can verify that the sampling rate of your algorithm is indeed 100 milliseconds. You can also adjust parameters of individual function blocks, which has the same effect as modifying them directly in the *Block properties* dialog.



Note: There is also a standalone diagnostics program called RexView. Click the RexView icon  and confirm the IP address of the target platform.

Now you can switch RexDraw back to the *Development mode*. You can do so by deactivating the *Watch mode* (use the  icon). You are offered synchronization of the changed parameters with the source files of the project, choose *No* at this moment.

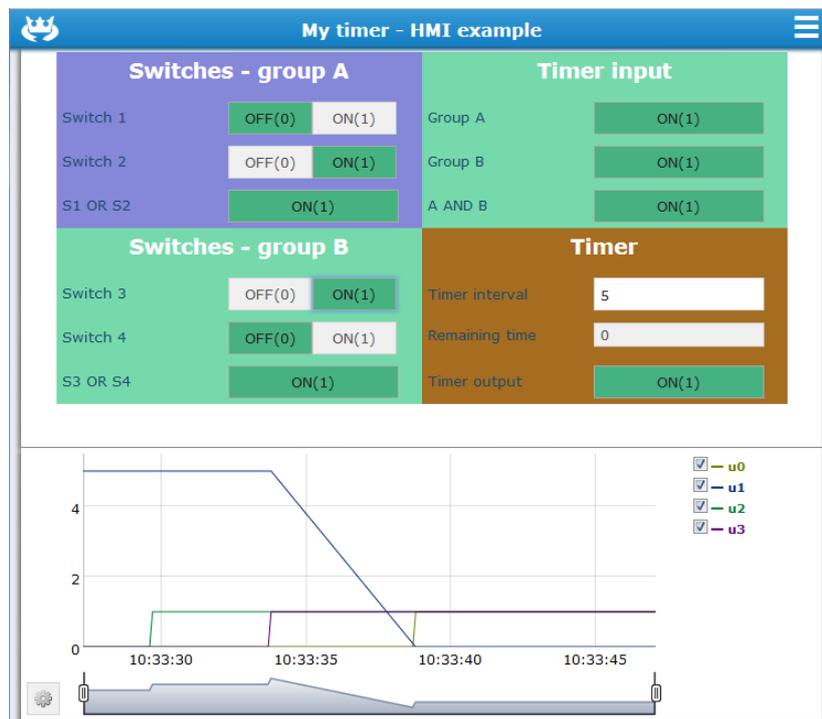
All changes made while in the *Watch mode* are not permanently stored in the target device (unless you decide so, see [3]). Upon restarting the *RexCore* runtime module the algorithm will start with the parameters defined in the project source files, which were valid when compiling and downloading the algorithm to the target device. To apply the changes permanently, you have to transfer the changes to the source files and *Compile and download* the project one more time which defines new startup values.

4.3 Adding a user interface (HMI)

The next step in developing a control algorithm is its user interface, or HMI, Human-Machine-Interface. It allows anyone (even those who are not familiar with the REX Control System) to interact with the algorithm. The HMI of the REX Control System relies on modern web-based technology and the HMI is therefore accessible via web browser on desktop PC, tablet or smartphone.

In this tutorial, a simple HMI will be created using the so-called WebBuDi technology. It provides very simple indicators and input elements to interact with the control algorithm via a web page (Web Buttons and Displays).

The steps to create the HMI are described below. This is how the HMI will look like in the end:



1. In the folder with the project files, create a `hmisrc` subfolder. Inside this folder, create a file named `index.hmi.js` and edit it with your favorite text editor. The content should be the following:

```

REX.HMI.init = function(){

//Indicators and virtual switches - group A
var switchesA = {
  column: 1,
  title: 'Switches - group A',
  rows: [
    {type: 'DW', alias: 'switch1', desc: 'Switch 1',
      cstring: 'myproject_task.CNB_SWITCH1:YCN'},
    {type: 'DW', alias: 'switch2', desc: 'Switch 2',
      cstring: 'myproject_task.CNB_SWITCH2:YCN'},
    {type: 'DR', alias: 'S1orS2', desc: 'S1 OR S2',
      cstring: 'myproject_task.OR_A:Y'},
  ]
};
REX.WebBuDi.addSection(switchesA);

//Indicators and virtual switches - group A
var switchesB = {
  column: 1,
  title: 'Switches - group B',
  rows: [
    {type: 'DW', alias: 'switch3', desc: 'Switch 3',
      cstring: 'myproject_task.CNB_SWITCH3:YCN'},
    {type: 'DW', alias: 'switch4', desc: 'Switch 4',
      cstring: 'myproject_task.CNB_SWITCH4:YCN'},
    {type: 'DR', alias: 'S3orS4', desc: 'S3 OR S4',
      cstring: 'myproject_task.OR_B:Y'},
  ]
};
REX.WebBuDi.addSection(switchesB);

//Timer input
var timerInput = {
  column: 2,
  title: 'Timer input',
  rows: [
    {type: 'DR', alias: 'inputA', desc: 'Group A',
      cstring: 'myproject_task.AND_:U1'},
    {type: 'DR', alias: 'inputB', desc: 'Group B',
      cstring: 'myproject_task.AND_:U2'},
    {type: 'DR', alias: 'AandB', desc: 'A AND B',
      cstring: 'myproject_task.AND_:Y'},
  ]
}

```

```

};
REX.WebBuDi.addSection(timerInput);

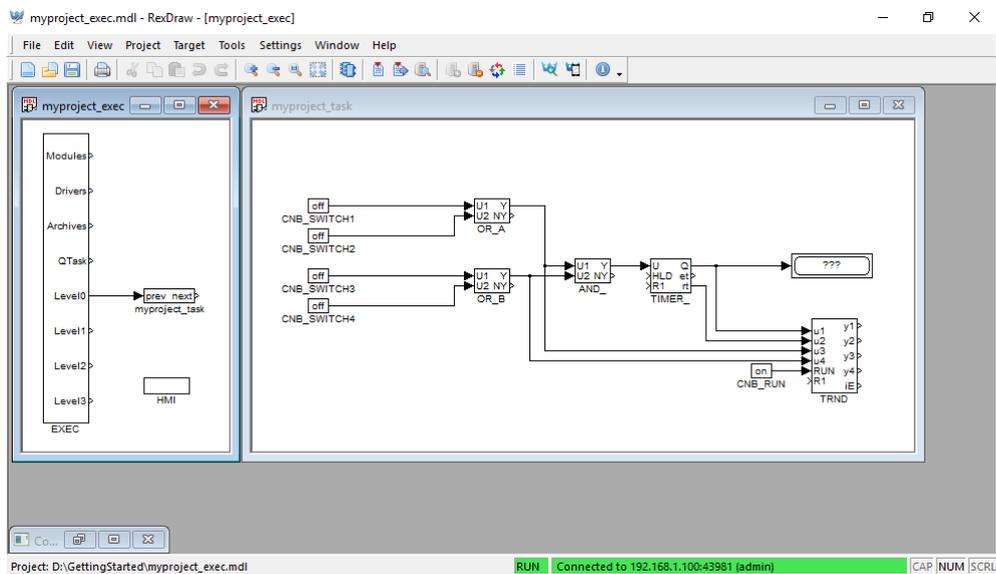
//Timer settings and status
var timer = {
  column: 2,
  title: 'Timer',
  rows: [
    {type: 'AW', alias: 'interval', desc: 'Timer interval',
      cstring: 'myproject_task.TIMER_pt'},
    {type: 'AR', alias: 'rt', desc: 'Remaining time',
      cstring: 'myproject_task.TIMER_rt'},
    {type: 'DR', alias: 'timerQ', desc: 'Timer output',
      cstring: 'myproject_task.TIMER_Q'},
  ]
};
REX.WebBuDi.addSection(timer);

//Add real-time trend
REX.HMI.Graph.addTrend({cstring: 'myproject_task.TRND'});
REX.HMI.Graph.setMaxBufferSize(200);

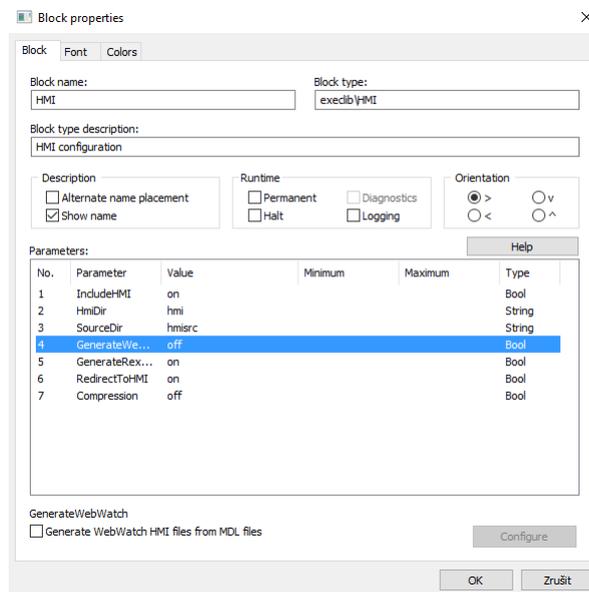
// Change title of the page
REX.HMI.setTitle('My timer - HMI example');
}

```

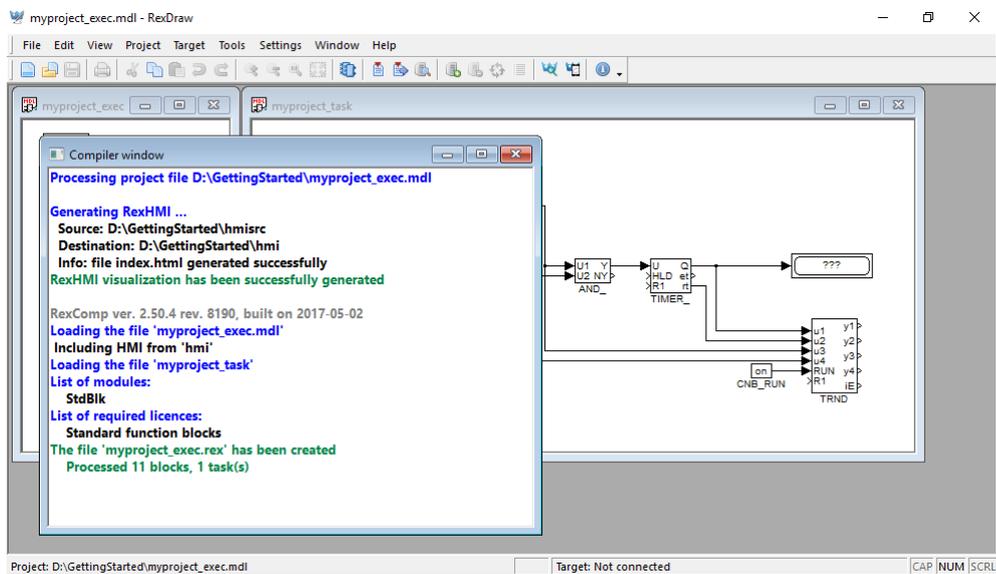
2. This file will be processed when compiling the project. However, it is necessary to add the EXEC/HMI block into the project main file first.



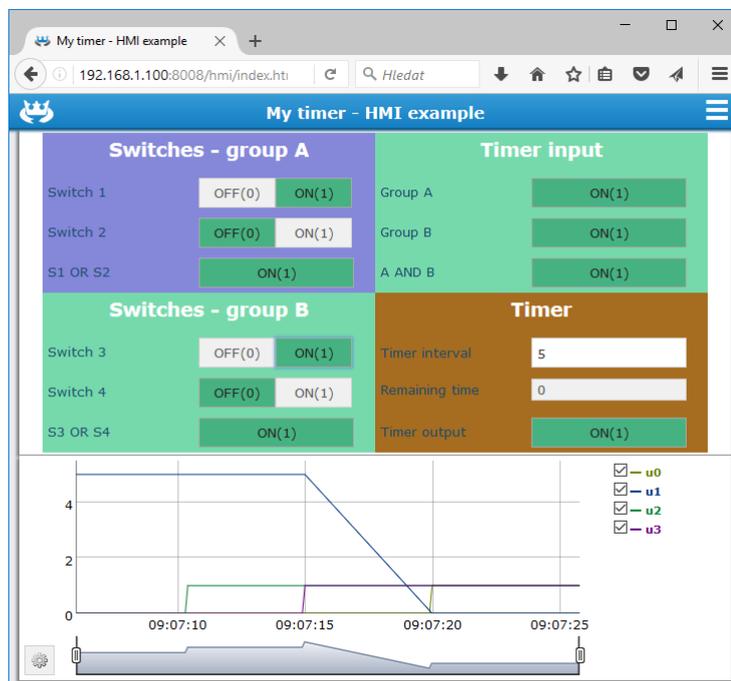
3. Double-click the HMI block to edit its parameters. Set **GenerateWebWatch** = **off** and confirm. WebWatch is another type of HMI, which you do not need at the moment. See [4] for details, it is a very interesting tool for developers and technicians.



4. The HMI is now an integral part of your project. Compile the project again and you will see that the compile log contains more information. The `index.html` file is generated from the source `index.hmi.js` file. All the HMI files are generated into the `hmi` subfolder (HTML, JS and CSS files) and included in the resulting binary `myproject_exec.rex` file.



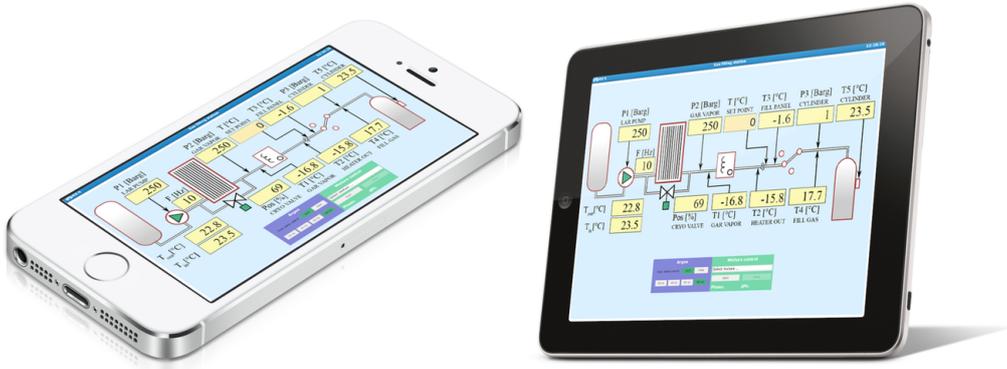
- After you download the project to the target device, you can access the HMI via web browser. Go to menu *Target/Web Interface* which will open the webpage. Remember the default login credentials: admin with no password.



- You can toggle the switches and observe the results. The virtual switches are linked to the individual CNB function blocks therefore the effect is the same as toggling the values directly in RexDraw.

7. You can also change the timer setting and shorten or lengthen the interval.
8. See [4] for detailed information about WebBuDi elements and possible customization (colors, backgrounds etc.).
9. The default URL address is <http://192.168.1.100:8008/hmi/index.html>.
10. The default port of the webserver (8008) can be changed in RexCore settings. See [2] for details.

Please note that there is also a program called RexHMI Designer, which allows you to create graphical user interfaces. Appendix A of this guide shows the steps to create a basic graphical interface. A more complex HMI is shown below solely for inspiration purposes.



4.4 Ready for interaction with the outer world

Well done! You have created the example 0101-01 from scratch³. You have learned the basic workflow for developing and running your algorithms using the REX Control System, which is the same for all platforms. Now it's time to add the so-called *input-output drivers* so that the algorithm can interact with sensors, actuators and external data.

³All examples which are part of the installation are marked by an ExampleID. The most up-to-date examples are available at <https://github.com/rexcontrols/REXexamples/archive/v2.50.zip>

Chapter 5

I/O configuration for the Monarco HAT

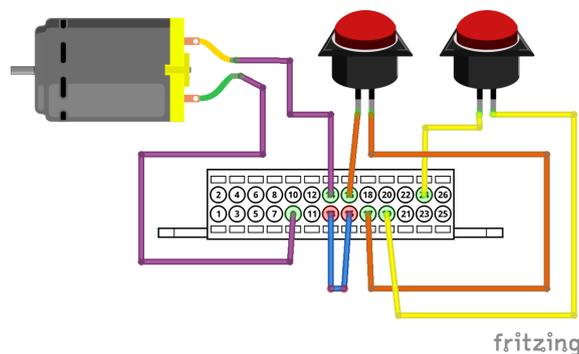
The previous chapter illustrated the process of creating a control algorithm in the REX Control System and deploying it to the target device. But so far, the algorithm does not interact with the outer world, it is not connected to any physical signal (or external data).

We will use the input and output signals of the Monarco HAT for interaction with the real world.

As mentioned in Chapter 4, two physical switches will be connected as inputs and a software timer will control one output signal. In other words, this chapter is devoted to advancing from the generic example 0101-01 to example 0121-01 for the Monarco HAT.

5.1 Physical connections

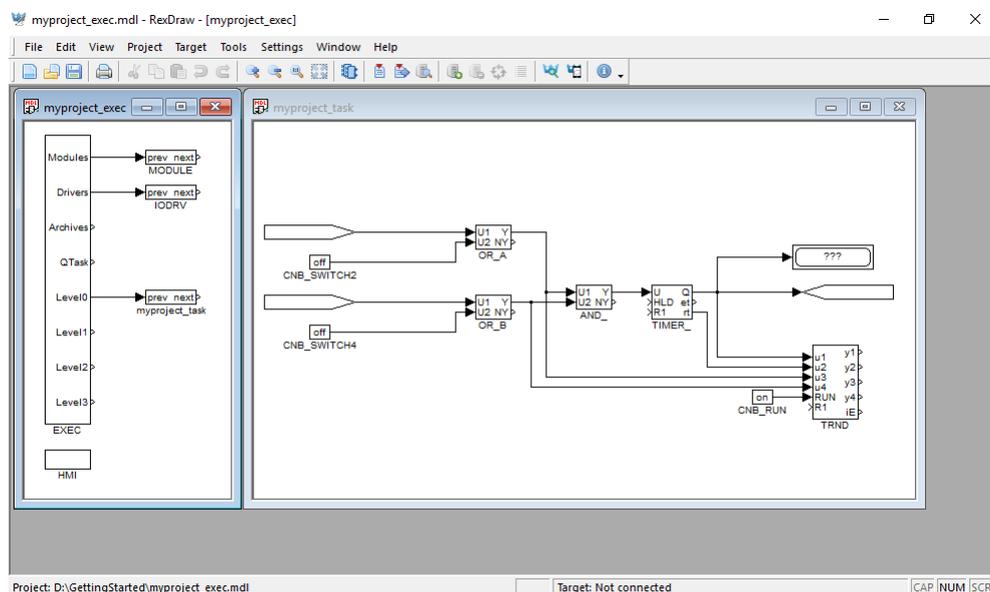
Connect the switches as shown below. The motor is optional, the onboard LED will indicate the status of the output.



5.2 Adding inputs and outputs to the project

Now when we have everything wired up, it's time to include the physical signals into the algorithm. You need to expand your project main file with 2 additional function blocks to access the inputs and outputs from the control algorithm in your project. Insert the **EXEC/MODULE** and **EXEC/IODRV** blocks from the *Block library* and attach them to the **EXEC** block as shown below.

In the task file, delete the **CNB_SWITCH1** and **CNB_SWITCH3** blocks and replace them with **INOUT/From** blocks. These will be the input signals. Also add one **INOUT/Goto** block, which will serve as an output and which will be controlled by the timer. You already know that a new branch of a line is created by right-button dragging, don't you?



5.3 Working with I/O signals

5.3.1 Modifications in the project main file

Now we tell the compiler to use the Monarco HAT I/O driver. This is what needs to be done:

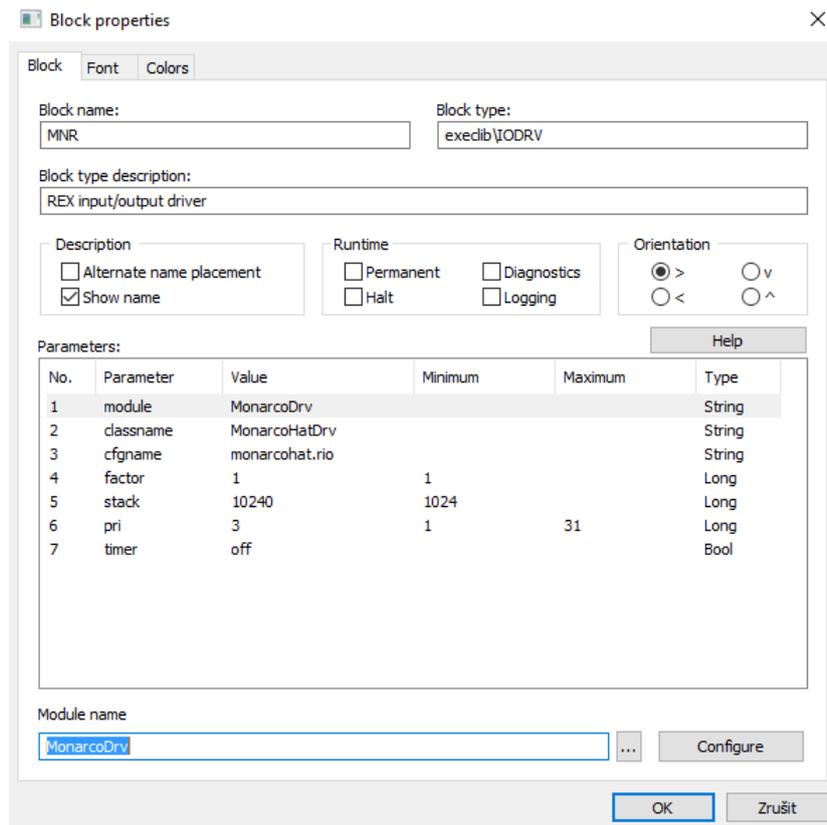
- Rename the **MODULE** block to **MonarcoDrv – CASE SENSITIVE!**

Next edit the **IODRV** block parameters. Link the **IODRV** block with the **MonarcoDrv** module by setting

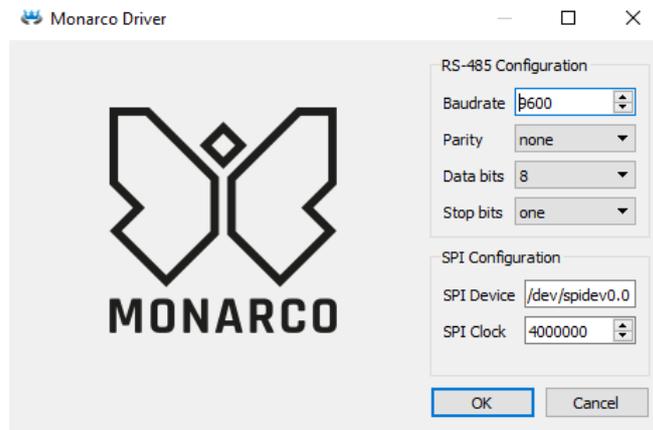
- `module = MonarcoDrv – CASE SENSITIVE!`

Continue editing the **IODRV** block parameters. For Monarco HAT set the following:

- `classname = MonarcoHatDrv` – CASE SENSITIVE!
- `cfgname = monarcohathat.rio`
- `factor = 1`
- Leave the other parameters intact.

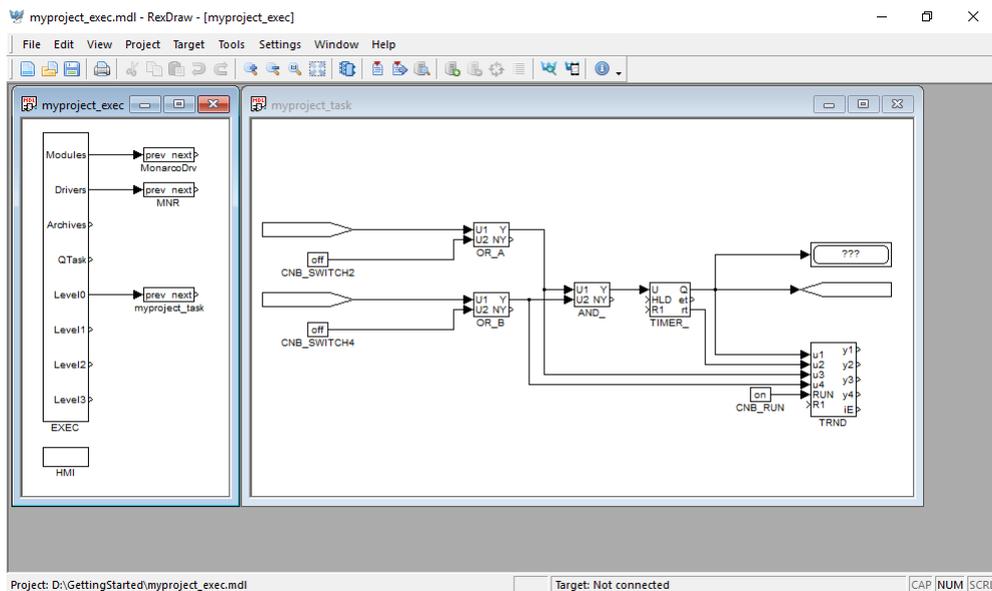


Remember to click the *Configure* button. This will create a default I/O driver configuration file (.rio). Keep the default values and close the dialog.



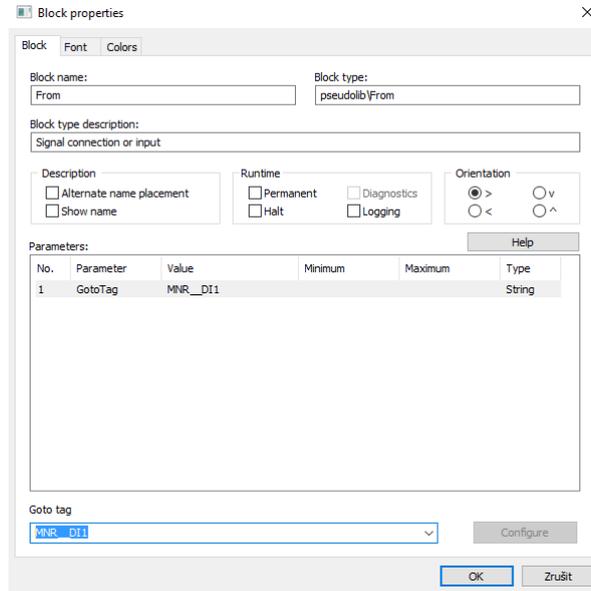
As the final step, rename the IODRV block to MNR, which will serve as a prefix for all I/O signals of this driver.

The executive of the REX Control System is configured, your project should look like this:



5.3.2 Modifications in the task

In the task double-click the input flag and set `GotoTag = MNR__DI1`. Note the MNR prefix and **two underscore characters**. The first physical switch will be connected to DI1.



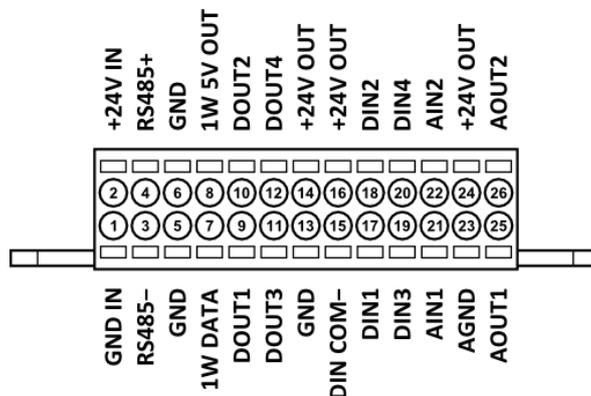
The second physical switch will be connected to DI2 (MNR_DI2).
 The timer output will be routed to DO1 which will serve as the output signal (MNR_DO1).

Similarly for other inputs and outputs we could use the following flags:

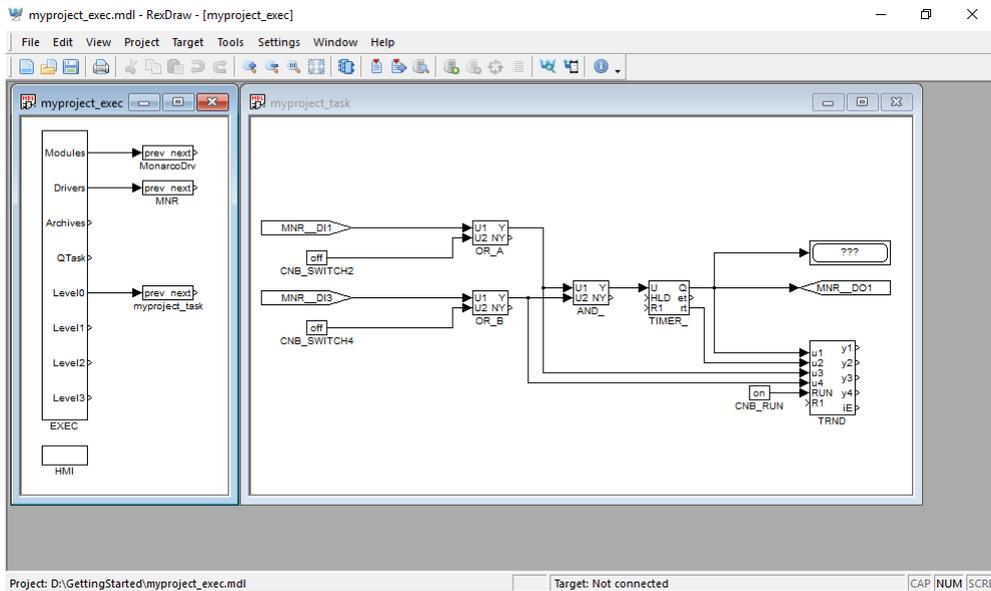
- Goto, MNR_DO4 – digital output 4
- From, MNR_DI3 – digital input 3
- From, MNR_AI1 – analog input 1

A detailed description of the I/O driver for Monarco HAT is available in a separate manual [5].

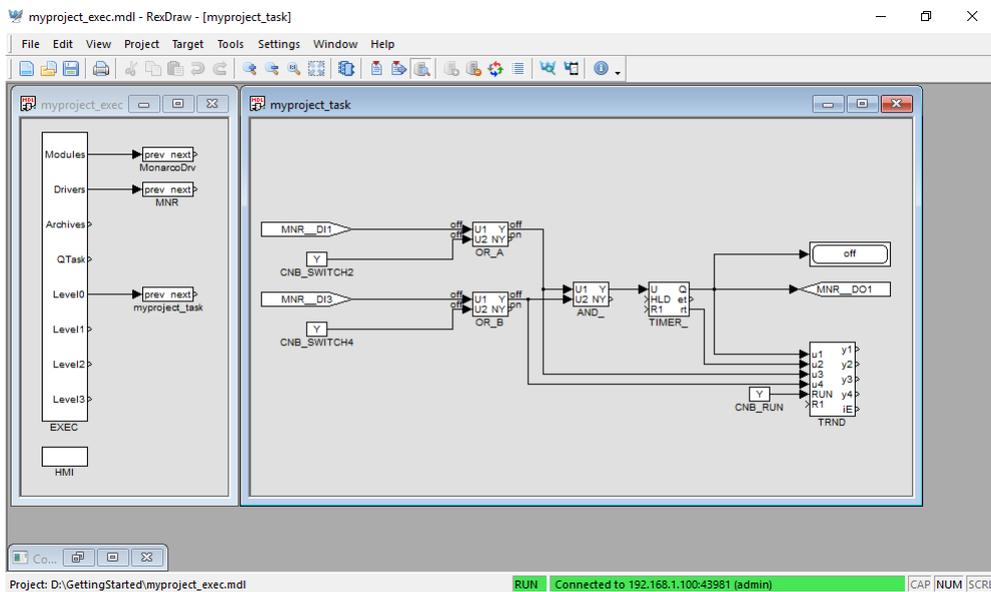
The pinout of the Monarco HAT is shown in the following picture:



Your project should now look like this:



After compiling the project and downloading it to the Raspberry Pi the control algorithm interacts with the physical world. Again it is possible to switch to Watch mode and observe the signals in real-time or analyze the trends of signals. Flip the physical switches and watch the signals.



5.4 Updating the HMI

It is also necessary to update the HMI. The CNB_SWITCH1 and CNB_SWITCH3 blocks are no longer present in the algorithm. Moreover, we need to replace virtual input elements (DW) with indicators (DR). Therefore open the `index.hmi.js` file and replace

```
{type: 'DW', alias: 'switch1', desc: 'Switch 1',
  cstring: 'myproject_task.CNB_SWITCH1:YCN'},
```

with

```
{type: 'DR', alias: 'switch1', desc: 'Switch 1',
  cstring: 'myproject_task.OR_A:U1'},
```

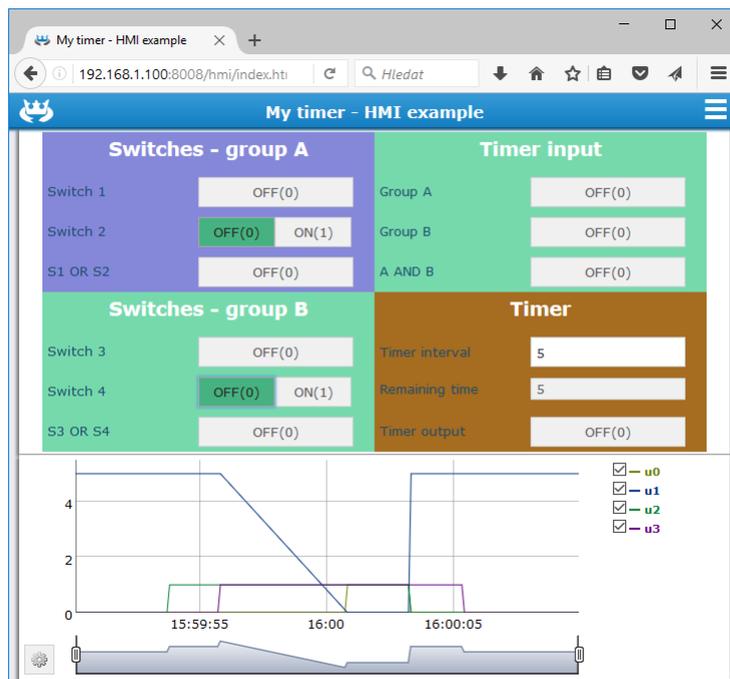
Similarly for switch no. 3, replace

```
{type: 'DW', alias: 'switch3', desc: 'Switch 3',
  cstring: 'myproject_task.CNB_SWITCH3:YCN'},
```

with

```
{type: 'DR', alias: 'switch3', desc: 'Switch 3',
  cstring: 'myproject_task.OR_B:U1'},
```

Save the file, compile and download the project again and open the web interface. Push the two physical switches and wait until the timer triggers the output. Alternatively, you can still use the virtual switches. This demonstrates that you can combine physical and virtual input elements.



5.5 Additional information

5.5.1 Detailed description of the driver

A detailed description of the IO driver for Monaco HAT is available in a separate manual [5].

5.5.2 Examples

Example projects and a set of all supported I/O flags are included in the installation package of the REX Control System development tools. In **RexDraw**, go to menu **File** → **Start from an Example Project** and select one of the Monarco HAT examples. As mentioned earlier, the most up-to-date examples are available at <https://github.com/rexcontrols/REXexamples/archive/v2.50.zip>

Chapter 6

Summary

Congratulations, you have created the example 0121-01 from scratch! You have learned how to develop, compile and run your algorithms on the Raspberry Pi. The interaction with sensors and actuators is provided via input-output driver of the REX Control System, which you have learned to configure and use.

You have achieved quite a lot in a relatively short time, haven't you? The purpose of this guide was to quickly show you the basic steps and tools for developing a project.

Now it's time to focus on your own project and keep learning on the go. There are function blocks which are much more powerful than the ones mentioned in this guide, there are many inspiring example projects, there are additional I/O drivers which you can use to expand the scope of your project, there are many ways to exchange data with external systems and devices, etc.

Remember that whenever you have some achievement to share, we will be happy to hear from you. And whenever you encounter any difficulties, we will be happy to help. You can reach us at support@rexcontrols.com.

Appendix A

Graphical HMI with RexHMI Designer

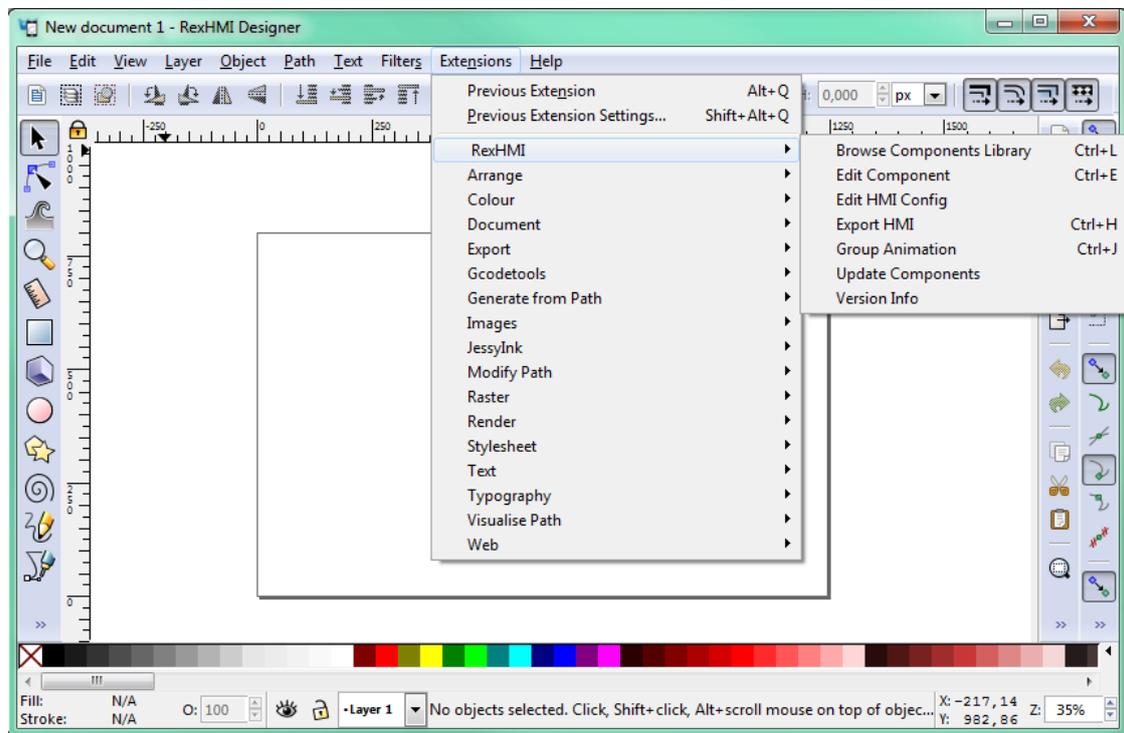
Chapter 4 describes the creation of a simple WebBuDi user interface. The REX development tools also contain the RexHMI Designer program which is a tool for designing custom graphical visualizations from predefined components¹. The RexHMI Designer is based on the well-known open-source vector editor InkscapeTM <https://inkscape.org/en/>.

In this chapter we'll develop an alternative HMI for the example 0101-01. Just like in the case of the WebBuDi user interface, the SVG file created with RexHMI Designer will serve as a source file which will become a part of your REX project. During compilation of the project the SVG file will be processed and converted to HTML, JS and CSS files.

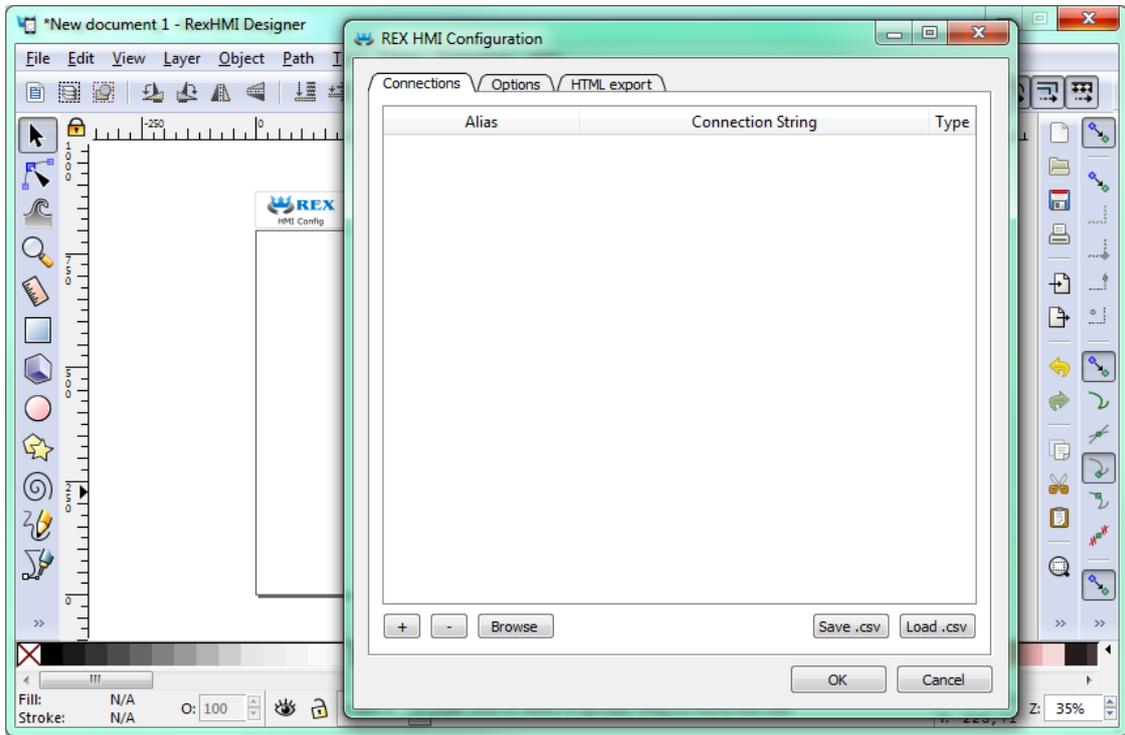
A.1 Initializing the HMI design

After launching the RexHMI Designer from *Start Menu* you will find a clean page. The first thing to do is to initialize the new visualization. The HMI is configured via the *RexHMI* extensions. Navigate to *Extensions* → *RexHMI* → *Edit HMI Config* in the menu.

¹Definition of custom components is also possible but it requires a bit of Javascript coding.



This extension adds a special component which contains general settings of the HMI. Close it with the OK button for now.

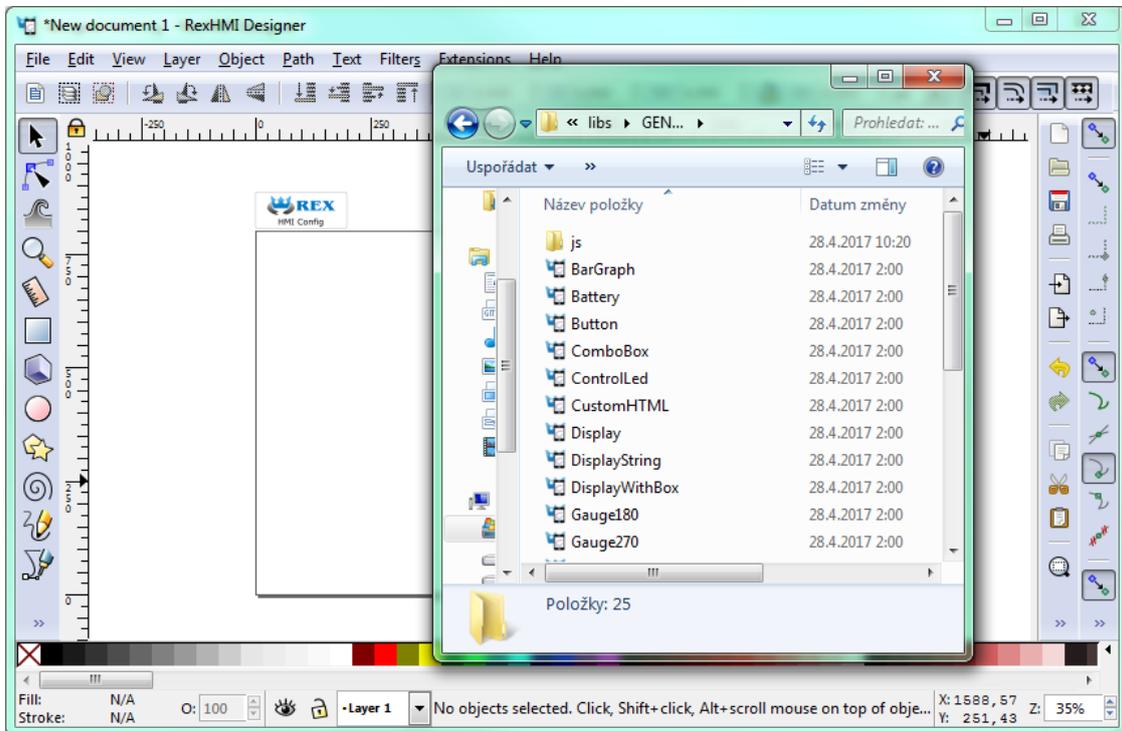


In order to include the HMI during the REX project compilation, the file name has to end with `.hmi.svg`. Save the file as e.g. `designer.hmi.svg` to the `hmisrc` subfolder of your project. Use the standard *File* → *Save as* menu.

Note: If you want to replace the WebBuDi interface with the RexHMI Designer interface just delete the `index.hmi.js` and save the HMI as `index.hmi.svg`.

A.2 Adding the first HMI components

Now we will add some displays and inputs. The RexHMI Designer contains a library of components which you can use to build your HMI. The library is available through *Browse Components Library* extensions. Navigate to *Extensions* → *RexHMI* → *Browse Components Library* (Ctrl+L). It will open the explorer window with several folders. Open the **GENERAL** folder and drag&drop the **Display** to the drawing. The display will be used as an indicator of the remaining time in the **TIMER** function block.



For configuration of the display settings select the display by mouse click on top of it and use the *Edit Component* extension from *Extensions* → *RexHMI* → *Edit Component* (Ctrl+E). When the configuration dialog is opened you can change the *Title* to *Display_remaining*. The Edit Component dialog has two tabs: *Data points* and *Options*.

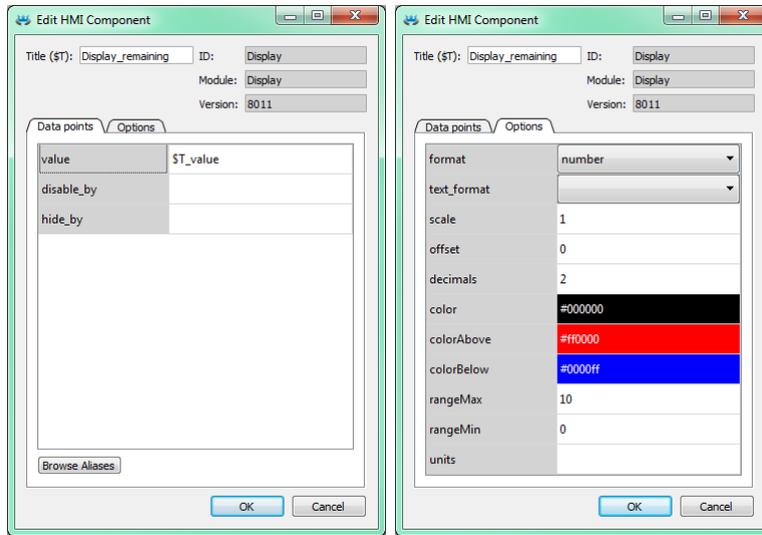
The *Data points* tab contains three items defining the behavior and animations of the component. Each data point contains an alias, which is in fact a connection to live data from the REX algorithm.

- *value* – The value to display.
- *disable_by* – If true the display is disabled and data are no longer updated.
- *hide_by* – If true the display is hidden.

The *value* property contains $\$T_value$. The $\$T$ will be later automatically substituted by the *Title* of the component, resulting in the *Display_remaining_value* alias. The *disable_by* and *hide_by* data points are optional. Leave them blank at the moment.

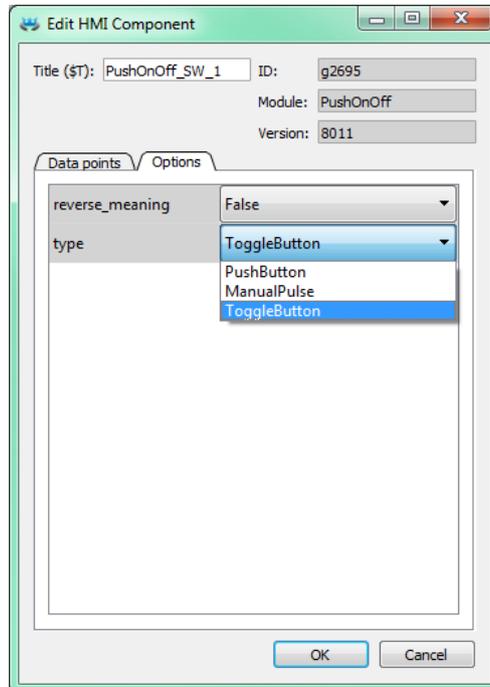
The *Options* tab contains several properties which are specific for the Display component. You can find the description of each component and property in [4]. Leave the default values for now and press OK.

Note: Each component is in fact one SVG group with unique content. You can copy the components all over the screen using copy (Ctrl+C) and paste (Ctrl+V) approach.



Now we will add controls for all the switches (CNB blocks). All of them will be controlled using the *PushOnOff* components. Add them from the library. Select the first *PushOnOff* and open the editor dialog *Extensions* → *RexHMI* → *Edit Component* (*Ctrl+E*). Change the title to *PushOnOff_SW_1* and select the *Options* tab. Select the *ToggleButton* item in the *type* property list. Close the *Edit Component* dialog using OK button. Copy-paste the button three times and remember to change the titles to *PushOnOff_SW_2*, *PushOnOff_SW_3*, *PushOnOff_SW_4*).

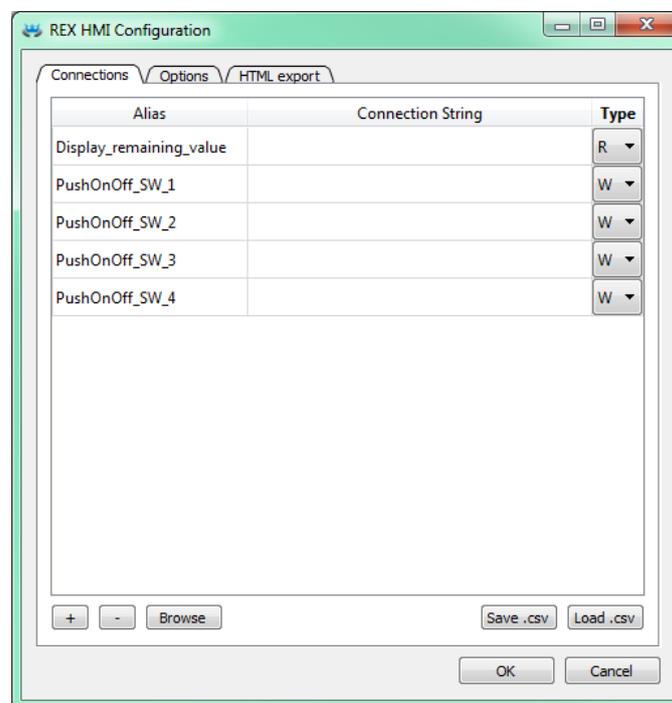
*Note: Throughout the RexHMI Designer you can use **double click** in Options tab to open the corresponding configuration dialog (color picker, number input, etc.).*



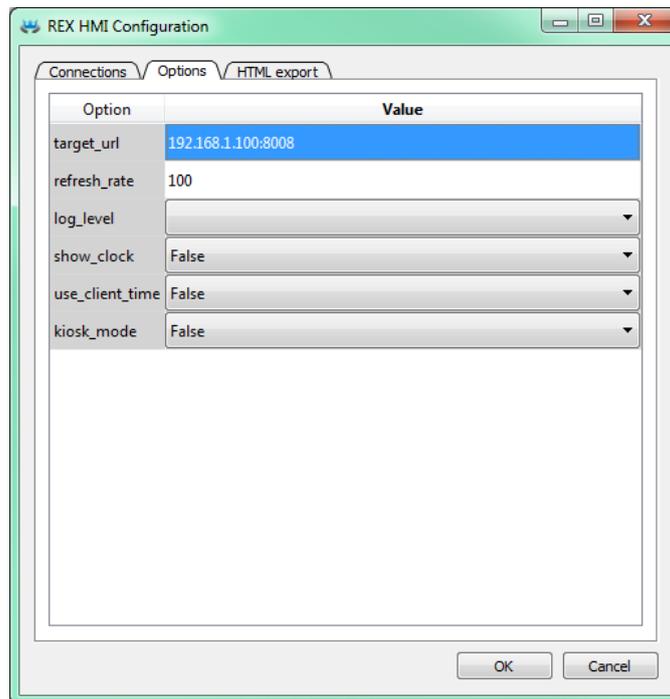
Now we have four *PushOnOff* buttons and one *Display* and we want to link all components with live data from the target device.

A.3 Linking HMI components with the running algorithm

Open the *HMI Configuration* dialog either using *Extensions* → *RexHMI* → *Edit HMI Config* or just unselect all components in the drawing (click outside any component) and press *Ctrl+E*. The configurator parses all components and creates a list of used *Aliases*. Each of them should be linked with one signal in the running algorithm. You can either fill in each connection string manually or you can use the *Browse* function.

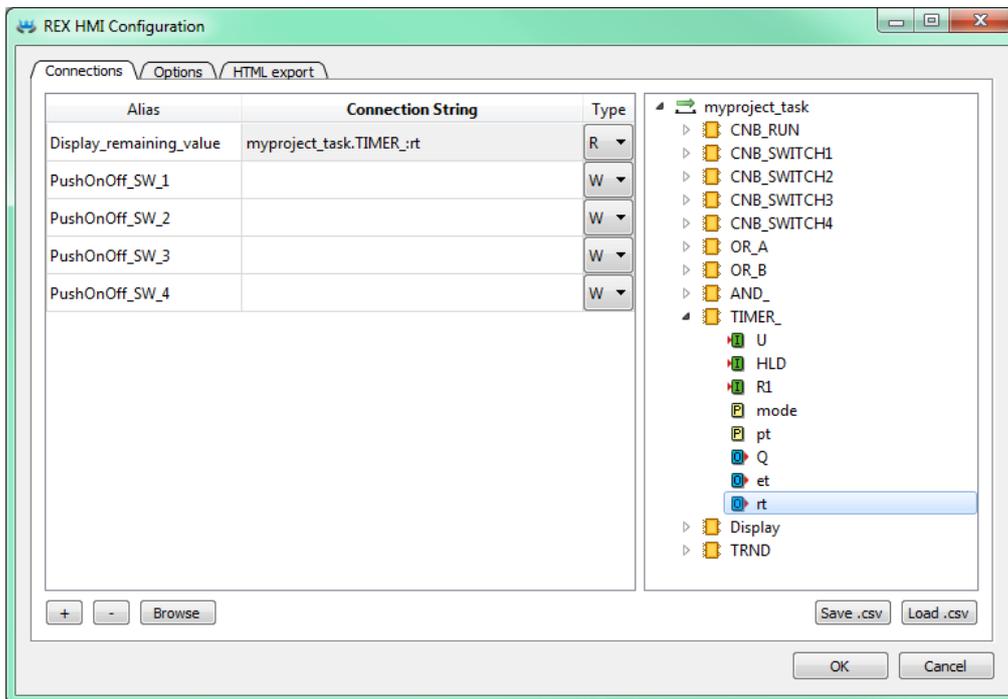


The *Browser* requires a target device with running algorithm. Make sure the algorithm is running, see Section 4.2. Also the target URL must be set. Switch to the *Options* tab and double click on the right side of the `target_url` property. Change it to `192.168.1.100:8008`. Then set the `refresh_rate` property to 100 (default is 500 ms) for more frequent display updates.

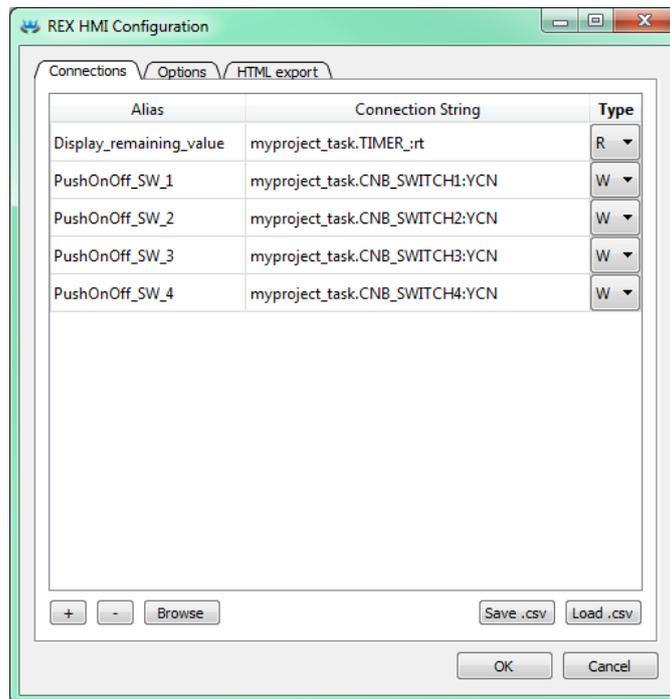


Return back to *Connections* tab and press *Browse* button. The login dialog will be opened. Unless you changed the login credentials, use the default username **admin** with an empty password. After a successful login the connection tab is expanded with a tree-view of the running algorithm (you have already seen this tree-view in algorithm diagnostics).

Select *Connection String* field of the *Display_remaining_value* item and afterwards browse the tree to the *TIMER_* block and **double-click** the *rt* parameter. The connection string of the parameter is copied to the *Display_remaining_value* alias, which is shown in the next figure.

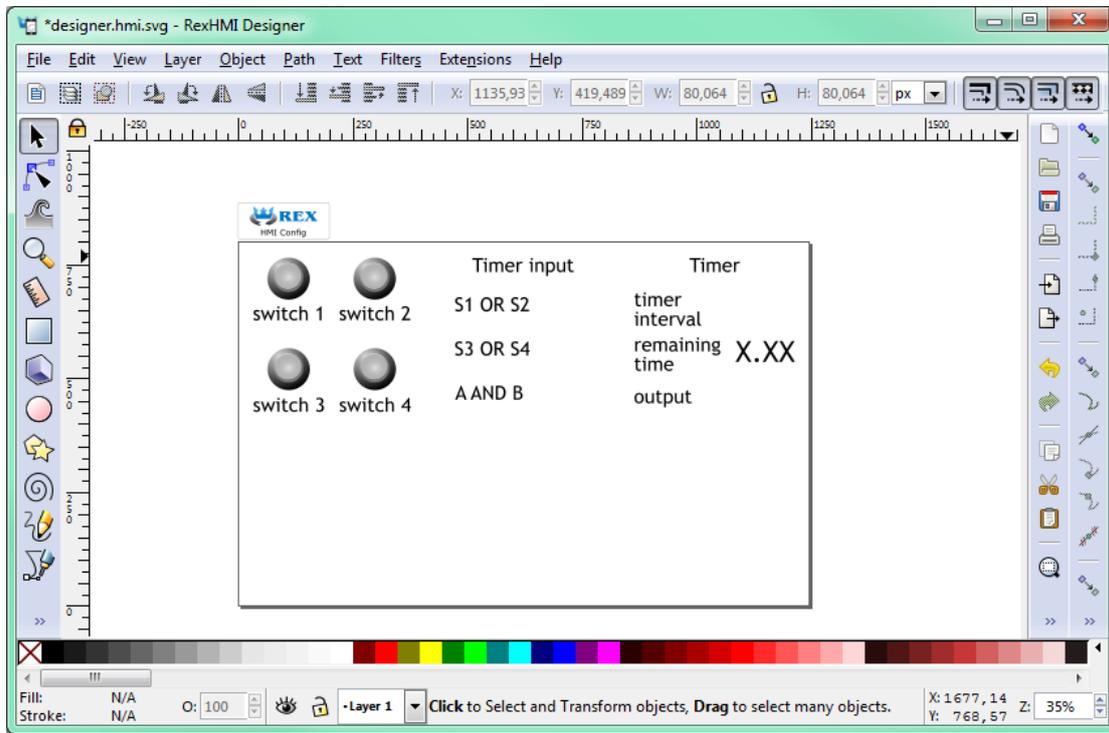


Once the display is linked we will also link the switches. Just browse the tree to CNB_SWITCH1, select the *Connection String* field of the *PushOnOff_SW_1* alias and double-click the YCN parameter. Repeat this for the remaining connection strings. Afterwards press OK to save the settings and close the dialog.



The interactive components in RexHMI Designer are just parts of the drawing. The user can position the components arbitrarily and add as many decorative static components to as needed. We will add some text descriptions to distinguish individual buttons. Use the *Text tool* (F8), click anywhere in an empty space and start typing. Pick the *Select and Transform tool* (F1) afterwards and move the texts and buttons.

Note: More information about custom drawing can be found in Inkscape tutorials (See the Help → Tutorials → Inkscape: Basic)

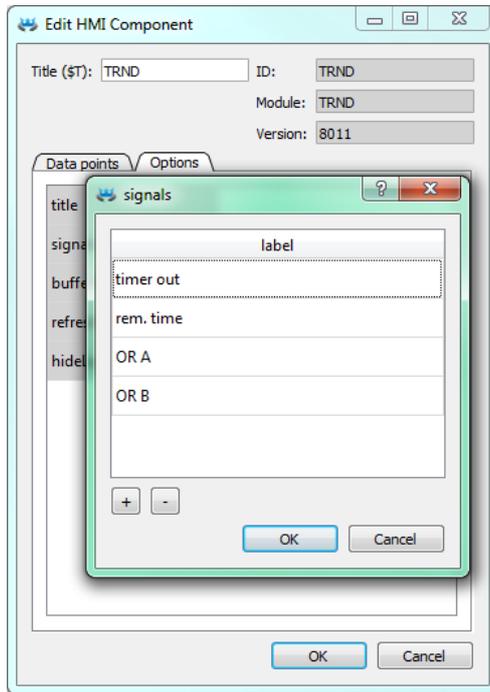


A.4 Adding more HMI components

Next we will add more components to control the timer and show the status of the OR and AND blocks. Open the Elements library (Ctrl+L) and add one *Input* and four *Led* components. The LEDs will show the status of Boolean values and the *Input* will be used for changing the default timer interval value.

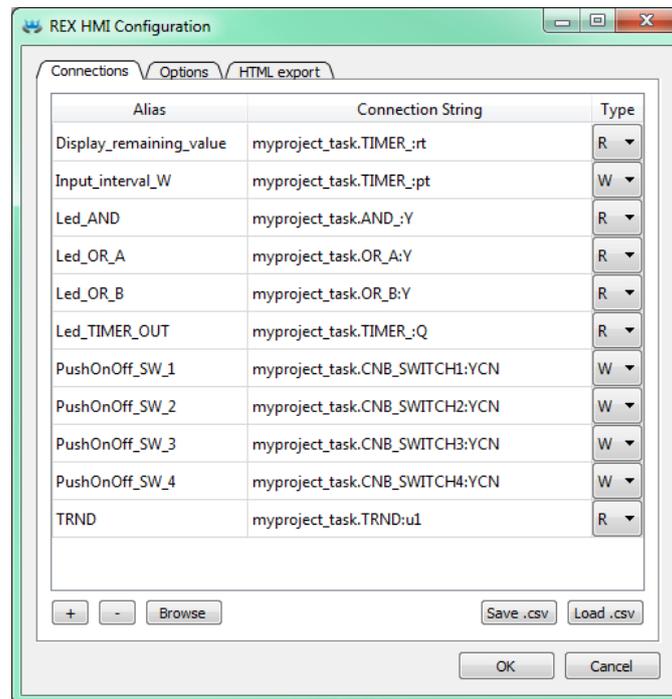
In the *Led* components just edit the *Title* via the *Edit Component* extension (select the component by single click and press Ctrl+E). The titles should be *Led_OR_A*, *Led_OR_B*, *Led_AND*, and *Led_TIMER_OUT* respectively. Finally edit the *Input* component by changing the *Title* to *Input_interval*.

The last component we need is a graph showing the time-plot of data from the TRND block. Use the components library (Ctrl+L) and add a *TRND* component. You can adjust its size to fit the desired position. Edit the component (Ctrl+E) and change the *Title* to *TRND* and switch to the *Options* tab. Double-click the *signals* property. Add the following labels using the plus (+) button: *timer out*, *rem. time*, *OR A*, *OR B*. These labels will be shown in the legend of the graph.



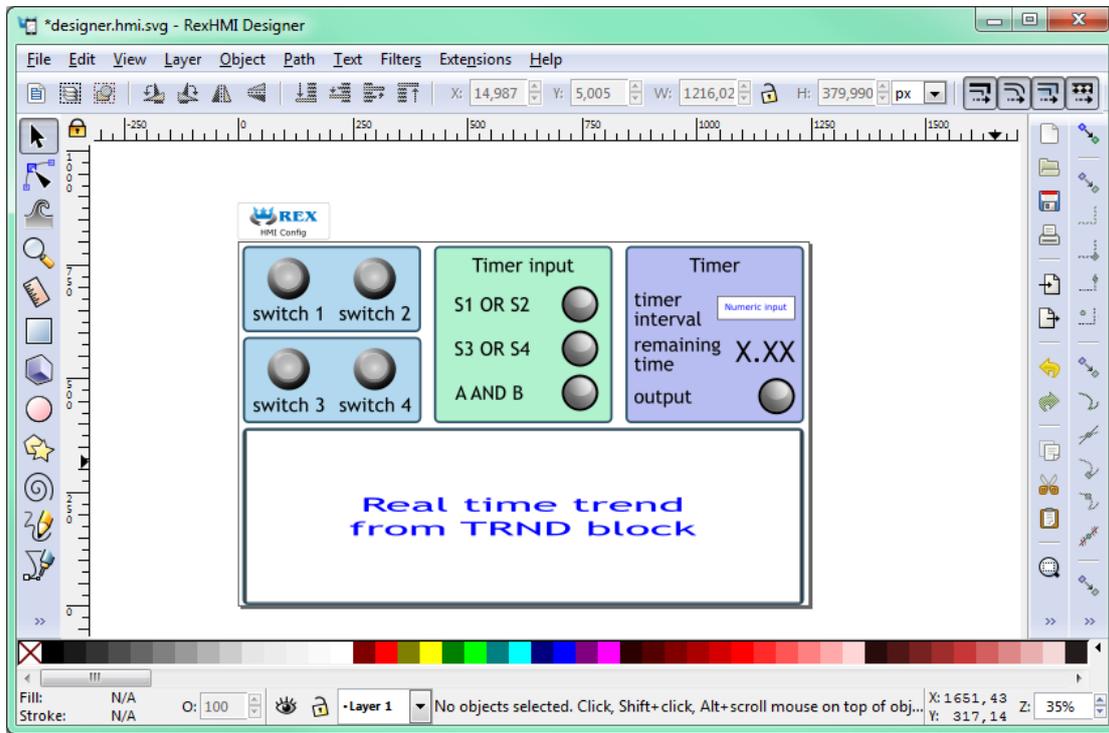
A.5 Additional links to the running algorithm

When all the components are in place we link them to the running algorithm again. Just repeat the procedure described in Section A.3, open the HMI Configuration dialog (*Extensions* → *RexHMI* → *Edit HMI Config*) and browse the running algorithm to pair the remaining aliases with corresponding connection strings. The list is shown in the following image.



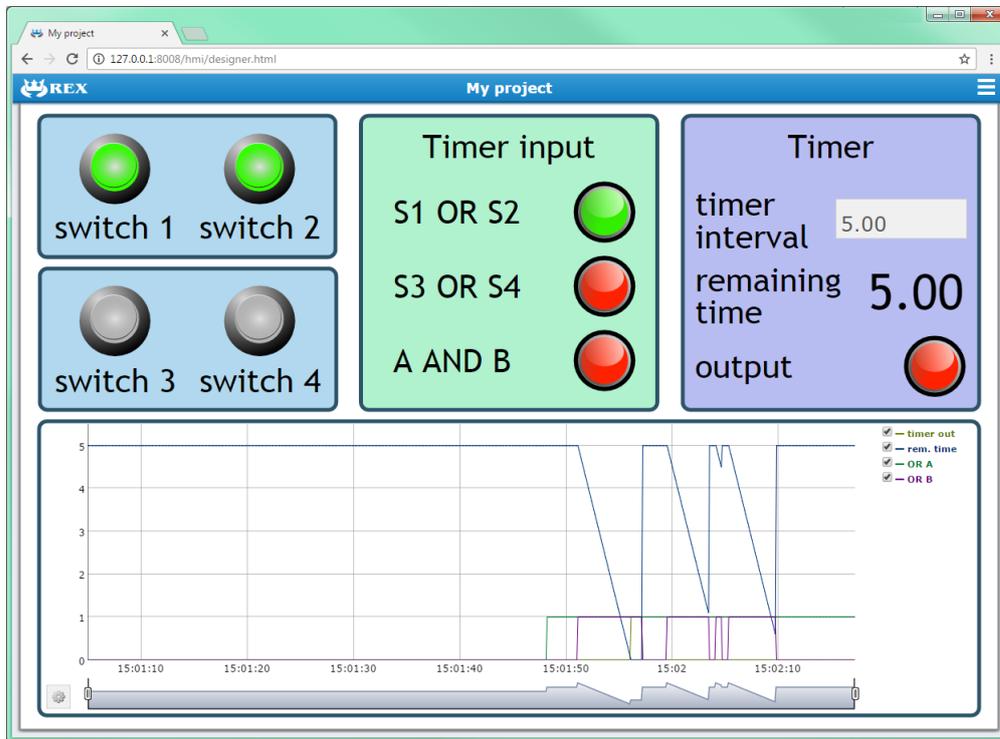
A.6 The final steps

Congratulations, your first graphical HMI is almost ready! Add a few rectangles which will visually divide the HMI into individual sections. Use the *Squares and rectangles tool* (F4), draw the rectangle, pick a color from the palette and send the rectangle to the background using the End key. Do not forget to save the drawing.



As mentioned earlier, the **.hmi.svg* files in the `hmisrc` folder are automatically processed while the project is compiled in the RexDraw application. The project main file must contain the HMI block with `GenerateRexHMI` parameter enabled. This was already covered in Section 4.3 so you should have everything ready.

Once you compile the project again and download it to your Raspberry Pi, the HMI will be accessible via a web browser. Navigate to `http://192.168.1.100:8008/hmi/designer.html`. You will see your HMI with live data.



This tutorial covers only the very basic components. If you want to get more information about additional components, see [4].

Appendix B

Licensing of the REX Control System

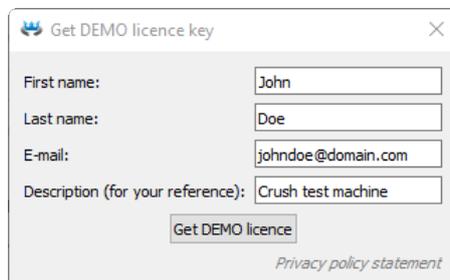
The licensing model of the REX Control System is quite simple:

- The development tools are free to use, you can install it on as many computers as you want.
- The RexCore runtime module always needs a licence to run on your Raspberry Pi. There are DEMO licences available at no cost and there are permanent licences which you can purchase. Each Raspberry Pi needs an individual licence.

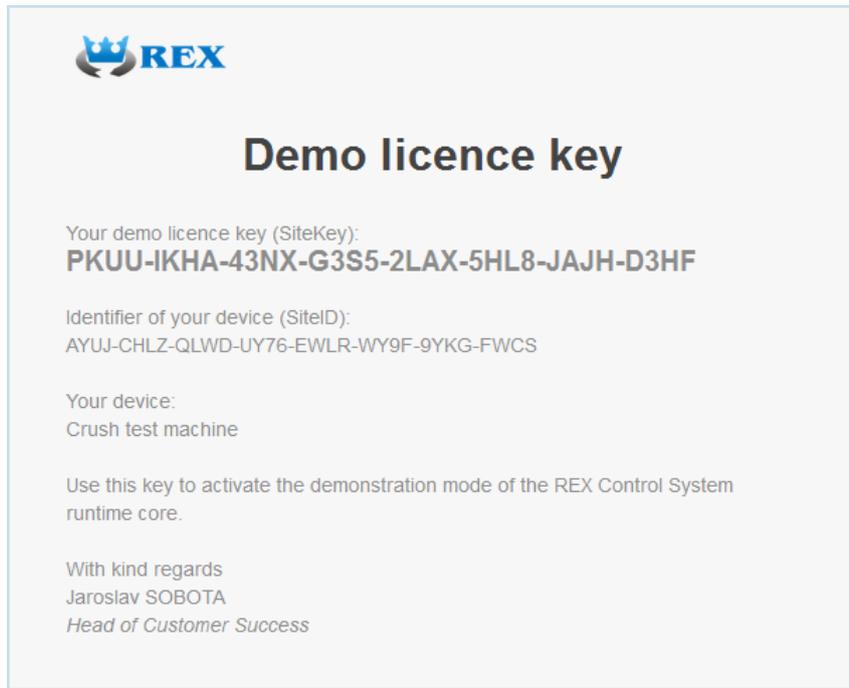
B.1 Obtaining a DEMO licence

The DEMO licence is intended for evaluating, testing and educational purposes. Feel free to experiment with the DEMO licence as long as you need. Commercial use of the DEMO licence is not allowed.

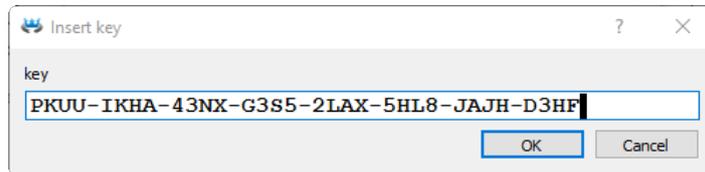
When you try to run your algorithm on a device which does not have a licence, you are offered a chance to get a DEMO licence. Identify yourself and you'll receive a DEMO licence via e-mail (the so-called **SiteKey**).



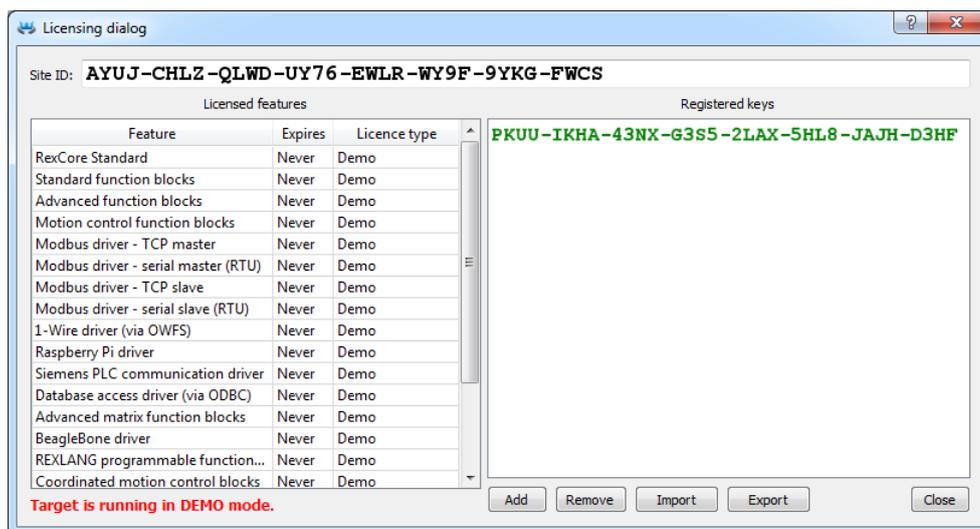
The image shows a web form titled "Get DEMO licence key" with a close button (X) in the top right corner. The form contains four input fields: "First name:" with the value "John", "Last name:" with the value "Doe", "E-mail:" with the value "johndoe@domain.com", and "Description (for your reference):" with the value "Crush test machine". Below the input fields is a button labeled "Get DEMO licence" and a link for "Privacy policy statement".



Try downloading your algorithm once again and apply the DEMO licence (SiteKey).



Once applied, you will see all the modules.



Now you can run your algorithms on your Monarco HAT.

Evaluation version of the RexCore runtime core is functional for 2 hours. It is possible to run your algorithm on the Monarco HAT but you cannot store it permanently. The algorithm resides only in the memory. You can use almost all function blocks, see [1]. The RexCore runtime core on the target device is terminated after 2 hours of operation in demo mode without any warning. After a restart, you have another 2 hours for your experiments.

B.2 Obtaining a permanent licence

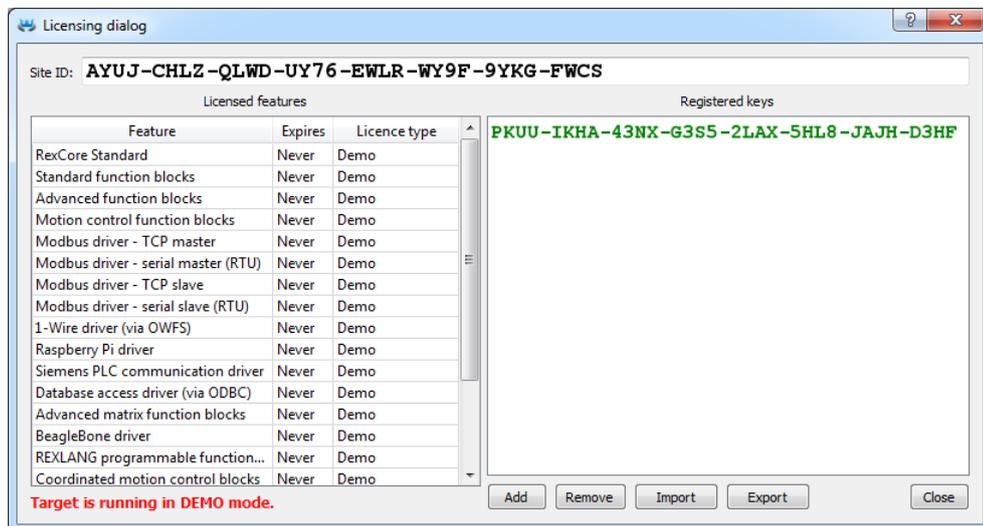
It is necessary to activate the RexCore runtime module and optional additional modules for permanent operation. This can be done using the licence, which you can obtain at

www.rexcontrols.com/e-shop

B.2.1 Activation of the permanent licence

Each device running the RexCore runtime module is identified by the so-called **SiteID** tag. The purchased licence must be associated with the hardware device, i.e. with the **SiteID** tag.

1. You can get the **SiteID** identifier in RexDraw. Connect to the device and go to menu *Target* → *Licensing...*. A dialog pops up and you can copy the **SiteID** identifier.



2. Afterwards, login to www.rexcontrols.com using your username and password and list the available licences which you possess.

REX CONTROLS

ABOUT PRODUCTS SERVICES VIRTUAL LABS REFERENCES CONTACT E-SHOP

RAPID DEVELOPMENT. EXCELLENT PERFORMANCE

REX Controls > Available licenses

REX User

Device and license management:

- [My devices](#)
- [Available licenses](#)

History of purchases:

- [My orders](#)

Available licenses

Title	Platform	Actions
REX Advanced Modbus pro Raspberry Pi (Raspberry Pi)	Raspberry Pi	show detail & associate with device

- Use the SiteID identifier to associate the licence with the hardware device.

Status Available
This license can be associated to device.
Association can be done in the form below.

[BACK](#)

Associate license

1. Select device → 2. Summary and confirmation → 3. Associate license to device

Select device to associate with this license:

Create new device

Title Solar Panels Monitoring
Title for your new device.

SiteCode 8ABH-F2C4-PAAA-BT42-6PAE-ZL2H-7ZNZ-WK7K
SiteCode identifier of your device.

Serial number
Serial number of your device (optional).

Central Heating Raspberry Pi

Greenhouse Control WinPAC

Associate selected device to license

- You are asked to confirm the association – this is the last and irreversible step.

Status	Available This license can be associated to device. Association can be done in the form below.
---------------	---

BACK

Associate license

1. Select device → 2. **Summary and confirmation** → 3. Associate license to device

License
REX Advanced Modbus for Raspberry Pi (Raspberry Pi)
+
Device
Solar Panels Monitoring 8ABH-F2C4-PAAA-BT42-6PAE-ZL2H-7ZNZ-WK7K

This is the final and irreversible step!

The license **REX Advanced Modbus for Raspberry Pi (Raspberry Pi)** will be associated with a new device **Solar Panels Monitoring (Raspberry Pi)** with SiteCode 8ABH-F2C4-PAAA-BT42-6PAE-ZL2H-7ZNZ-WK7K. The license is valid only for the given hardware configuration including storage media (hard drive, SD card etc.). However, you might be allowed to reuse the license in well justified cases.

Associate licence with the selected device (irreversible)

5. The so-called SiteKey activation key is generated upon associating the licence.

License was successfully associated to device!

Device "Solar Panels Monitoring (Raspberry Pi)"

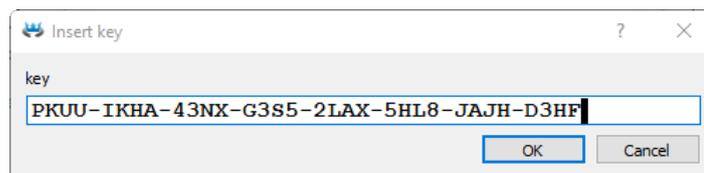
Title	Solar Panels Monitoring	Edit
Serial number		Edit
SiteCode	8ABH-F2C4-PAAA-BT42-6PAE-ZL2H-7ZNZ-WK7K	
Platform	Raspberry Pi	
Created	2014-04-09	
Text		Edit

[BACK](#)

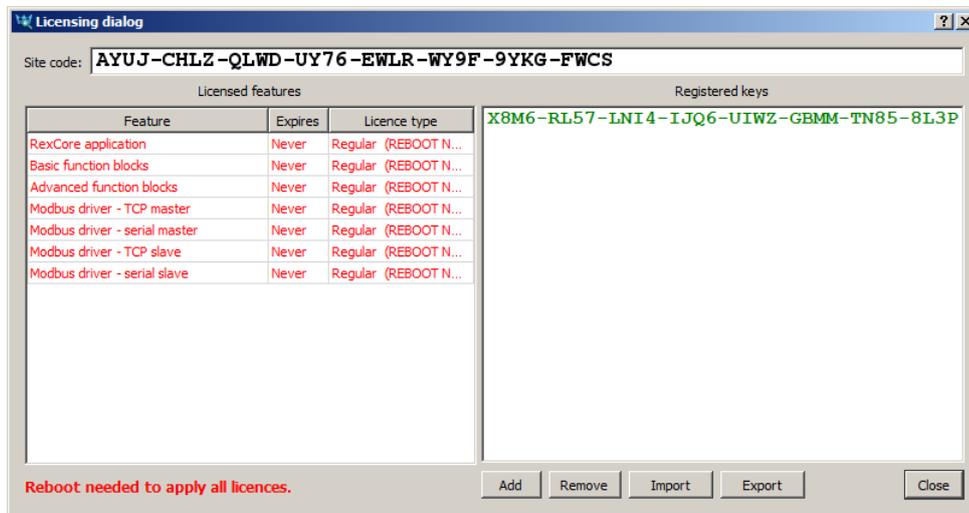
Associated licenses

Title	REX Advanced Modbus for Raspberry Pi	
SiteKey	X8M6-RL57-LNI4-IJQ6-UIWZ-GBMM-TN85-8L3P	
Platform	Raspberry Pi	
Created	2014-04-09	
Associated to device	2014-04-09 14:00:25	
Text	-	Edit
License	Product: REX Advanced Modbus for Raspberry Pi Platform: Raspberry Pi Modules: RexCore, Basic function blocks, Advanced blocks, Modbus TCP slave, Modbus TCP master, Modbus RTU master, Modbus RTU slave	
Product	Product in catalogue: REX Advanced Modbus for Raspberry Pi	
Order	-	
Status	Associated This license is associated to device.	

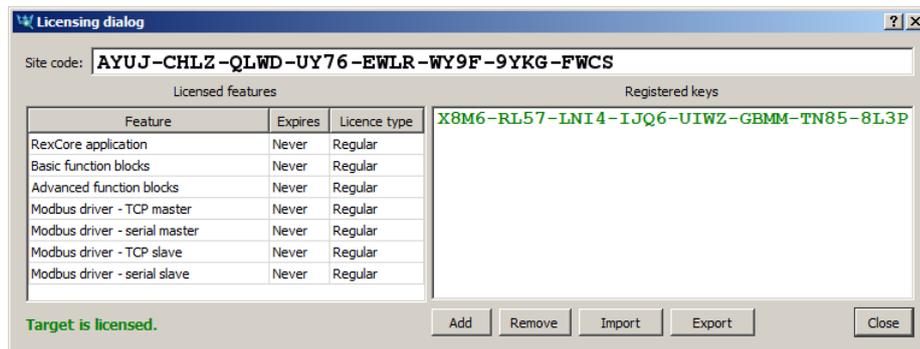
6. This key will allow permanent operation of the runtime core, but it must be applied to the target device. To do that, open the licensing dialog in RexDraw again.
7. **Delete any DEMO licence keys if present.**
8. Afterwards apply the SiteKey using the Add button.



9. If the key is valid, the activated modules appear. The Monarco HAT must be restarted afterwards.



- After reboot, check that the licence was applied correctly and that the RexCore runtime module no longer runs in demo mode.



Bibliography

- [1] REX Controls s.r.o.. *Function blocks of the REX Control System – reference manual*, 2017.
- [2] REX Controls s.r.o.. *RexCore – User manual*, 2017.
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