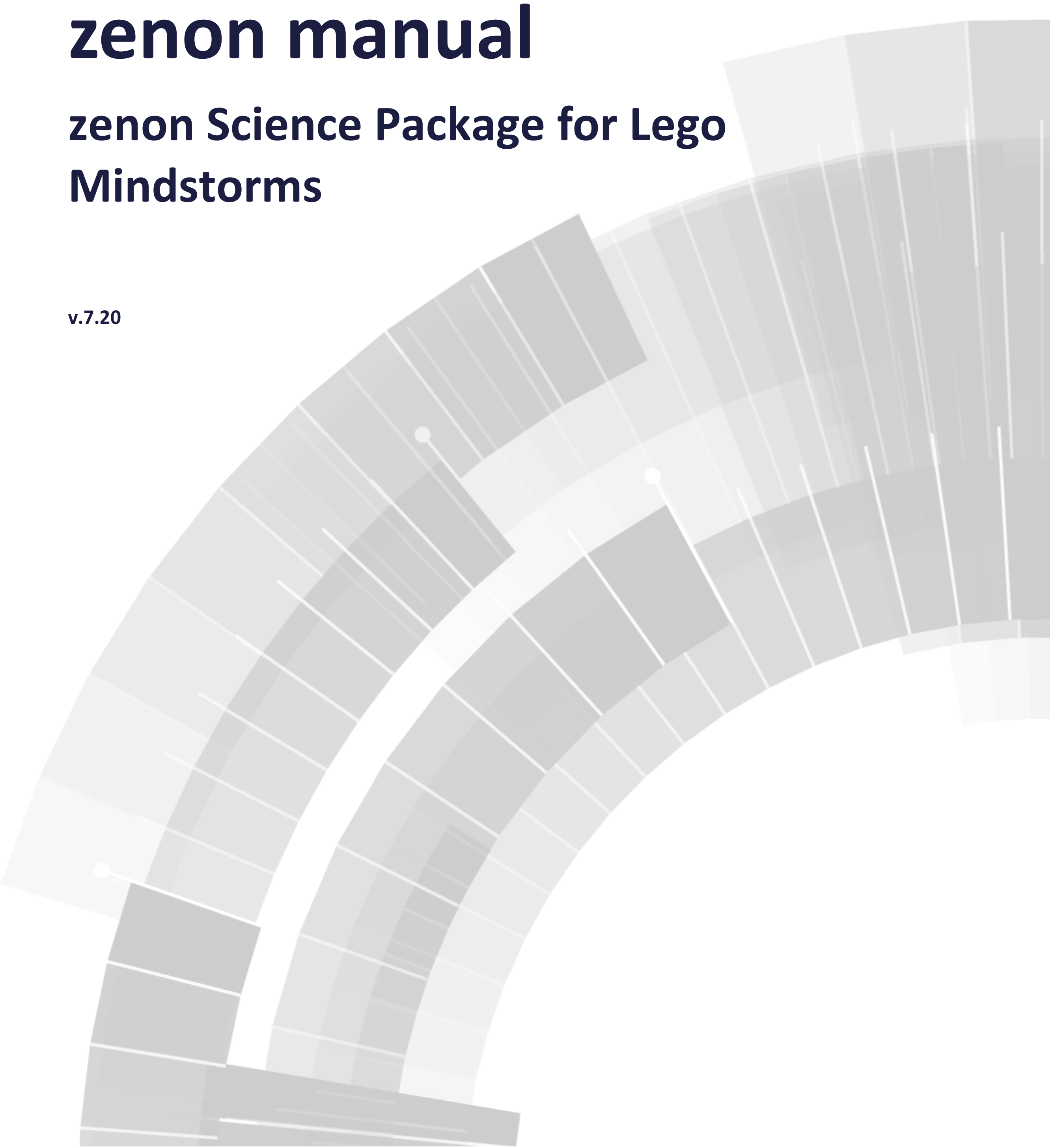
zenon manual

zenon Science Package for Lego Mindstorms

v.7.20



Contents

1. Welcome to COPA-DATA help

GENERAL HELP

If you cannot find any information you require in this help chapter or can think of anything that you would like added, please send an email to documentation@copadata.com (mailto:documentation@copadata.com).

PROJECT SUPPORT

You can receive support for any real project you may have from our Support Team, who you can contact via email at support@copadata.com (mailto:support@copadata.com).

LICENSES AND MODULES

If you find that you need other modules or licenses, our staff will be happy to help you. Email sales@copadata.com (mailto:sales@copadata.com).

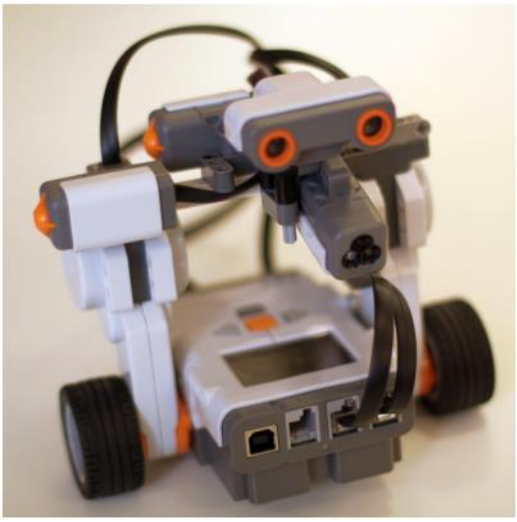
2. zenon Science Package for LEGO MINDSTORMS

The zenon Science Package for LEGO MINDSTORMS enables the programming of LEGO Mindstorms NXT and MINDSTORMS EV3 Brick. Programs are created in zenon Logic and executed on the LEGO Controller with straton. zenon Logic is the programming environment in accordance with IEC 61131-3 included in zenon.

License information

*The **`zenon Science Package for LEGO MINDSTORMS`** contains a limited license (for details, see the zenon Science Package license (on page 8) chapter). This is installed if you do not have a licensed zenon installation on the computer.*

This instruction takes you through the installation and programming for the automation of a LEGO Mindstorms NXT 2.0 or MINDSTORMS EV3 Brick with zenon. Only information with regard to the operation with zenon Logic/straton is contained in this documentation. Please find basic information on the programming and operation of LEGO MINDSTORMS objects in the LEGO documentation.



All necessary software is included on the installation medium for **`zenon Science Package for LEGO MINDSTORMS`**. This package does not contain any LEGO hardware, components or controls.

For the configuration of LEGO hardware with zenon use the following software:

- zenon: Software for monitoring and controlling which contains the integrated zenon Logic.
- zenon Logic Workbench: Programming environment for programs running on the embedded straton firmware.
- straton: Firmware for the LEGO Controller.

Please find all required applications and information on the installation media. These should already have been created in your zenon folder on the computer. The most important folders are:

- `FIRMWARE`**:** This folder contains the firmware you can load onto your LEGO MINDSTORMS Controller with the LEGO Firmware Loader.
- `USB_DRIVER`: This folder contains the INF file for the USB-to-serial driver.

Information

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3. zenon Science Package for Lego MINDSTORMS 2.0

The zenon Science Package for LEGO MINDSTORMS 2.0 enables the programming of LEGO Mindstorms NXT 2.0 objects. Programs are created in zenon Logic and executed on the LEGO Controller with straton. zenon Logic is the programming environment in accordance with IEC 61131-3 included in zenon.

3.1 Installation

For using the **`zenon Science Package for LEGO`** the following is required:

- zenon from version 7.00 SP0 on
- Firmware (on page 9) for the LEGO Controller

If you have already installed zenon 7.00 or higher on your computer you will also have a license for using the **`zenon Science Package for LEGO`**. If you haven't installed zenon yet install the zenon version from the installation medium (on page 7). This is a limited License (on page 8) for using LEGO MINDSTORMS 2.0.

3.1.1 Install zenon

In order to install zenonin the current version:

1. Connect the installation medium to the computer
2. If the installation does not start automatically, select **`start.exe`**
3. select zenon 7.20
4. follow the instructions of the installation wizard

Note: If you already have a zenon version from 7.00 on no installation is required.

zenon Science Package License

The **zenon Science Package for LEGO MINDSTORMS 2.0** is contained in the zenon standard license. If this version is installed on a system without zenon it will run with a zenon Science Package License. With this license it is also possible to create and edit zenon projects within the scope of the licensed modules.

This license contains:

- 128 variables
- Extended Trend Starter Edition
- Historian Starter Edition
- VBA
- zenon Logic Workbench
- straton firmware

Note: This license is executable for 90 minutes. The Editor must then be closed and re-started.

3.1.2 Demo projects

You can also get two demo projects in the COPA-DATA Forum (www.copadata.com/forums (http://www.copadata.com/forums)):

- MINDSTORMS_DEMO: Gives an overview over sensors and controller. Use this project to become familiar with LEGO MINDSTORMS 2.0 and its programming.
- LEGO_DEMO_SHOOTERBOT: A sample project for the **Shooterbot**. This can be adjusted to your needs.

Load the working area with both projects into zenon:

1. right-click on the current workspace
2. in the context menu working space select -> read backup...
3. Go to the working area backup on the installation medium (***.wsb**)
4. select the file and click on **OK**

To open projects:

1. in the working space go to node **zenon Logic (IEC 61131-3)**
2. select the node by left-clicking on it
3. select the project **mindstorms**
4. click on the symbol **open** in the toolbar or double-click on the project in order to open the project in the zenon Logic Workbench

3.1.3 Install firmware

In order to be able to use your LEGO MINDSTORMS 2.0 with zenon you have to load straton firmware on the Controller. This chapter will show you how to:

- load straton firmware on the Controller
- update already existing (on page 10) straton firmware or replace other already existing firmware
- create a USB connection (on page 11) with the Controller with the COPA-DATA USB driver
- establish a Bluetooth connection (on page 12) with the Controller

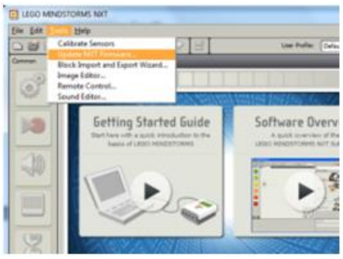
LOAD STRATON FIRMWARE ON THE CONTROLLER

In order to load straton firmware on the LEGO MINDSTORMS NXT 2.0 Controller the LEGO MINDSTORMS NXT 2.0 software is required, which was delivered with your LEGO MINDSTORMS NXT 2.0.

> ⚠ **Attention**
>
> *If on the Controller there already is a different firmware than the one delivered by LEGO please proceed as described in section* **`Dealing with already existing firmware`** *(on page 10).*

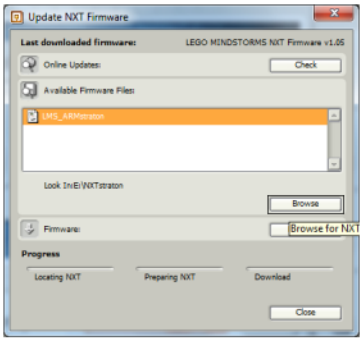
In order to load the firmware:

1. Start the LEGO MINDSTORMS NXT 2.0 software.
2. In menu Tools -> select Update NXT Firmware



3. Ensure that the correct format is used: **`*.rfw`**.
   If the file suffix is still **`*.bin`**, change this to **`*.rfw`**.
   In zenon 7.20, the file is called: **`STRATON_NXT_103_2011_08_10.rfw`**.
   You can find this on the installation medium in the path: `AdditionalSoftware\Science Package - Firmware\NXT2`.
4. Click on the **`Browse`** button.

5. Select the folder containing the firmware.



Update NXT Firmware

Last downloaded firmware: LEGO MINDSTORMS NXT Firmware v1.05

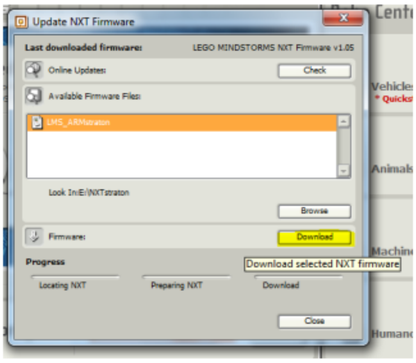
Available Firmware Files: LMS_ARMstraton

Look In:E:\NXTstraton

6. Start the NXT Controller.
   To do so, press the orange button.

7. Connect the Controller via USB with the computer.

8. Click on the button **`Download`** to load the firmware on the Controller.



Update NXT Firmware

Last downloaded firmware: LEGO MINDSTORMS NXT Firmware v1.05

Available Firmware Files: LMS_ARMstraton

Look In:E:\NXTstraton

9. Remove the USB cable.

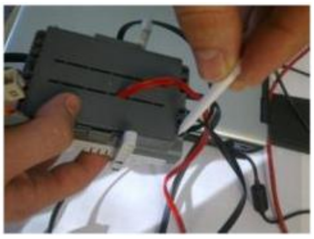
10. The Controller starts with the updated firmware

> **Information**
>
> *In order to update the loaded straton later on or replace it again with firmware by LEGO follow the instructions in section* ***`Dealing with already existing firmware`*** *(on page 10).*

3.1.4 Dealing with already existing firmware

If firmware not provided by LEGO is already present on the Controller this has to be set to the **`Firmware load mode`** in order to be able to install other firmware. This mode is also required if the straton firmware is supposed to be updated or LEGO firmware loaded again. In order to set the Controller to **Firmware load mode**:

1. Press for at least 5 seconds until you hear a quiet clicking noise
   - both the orange start button and
   - the Rest button on the back of the device.
     You can best reach the Rest button with a pointed object.

2. Switch on the NXT Controller by pressing the orange button.

3. The NXT Controller starts in the **Firmware load mode** . You can hear a regular sound.
4. Start the download of the desired firmware.
   To do so, a connection via USB (on page 11) or Bluetooth (on page 12) must be established. For the USB connection with zenon/straton the COPA-DATA driver is required.

> ⚠ **Attention**
>
> *The* ***Firmware load mode*** *can only be closed by downloading a firmware.*

USB connection without LEGO firmware

If the firmware applied is not provided by LEGO probably the corresponding driver must be installed. In this case the USB Controller is not recognized during the connection with the computer. To establish a USB connection:

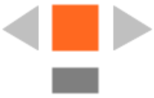
1. Open the System control -> System -> Device manager.
2. Double-click on **Unknown device**.
3. In the tab **Driver** click on **Update driver**.
4. The dialog for selecting the driver is opened.

5. Select `Search the computer for driver software`.
6. Select the folder containing the `Mindstorm_straton.inf` .
7. A warning regarding the driver manufacturer is displayed.
8. Select `Install driver nevertheless`.
9. The device can now communicate via USB.

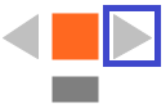
3.1.5 Establish a Bluetooth connection with the Controller

If the computer is provided with a Bluetooth port the connection with the Controller can also be established via Bluetooth. In order to configure Bluetooth for the connection between computer and Controller:

1. Switch on the LEGO Controller by pressing the orange button.



2. Press the orange button again.
3. Select `Settings` with the right gray arrow button.



4. Confirm selection by pressing the orange button.
5. Go to the menu for Bluetooth settings by using the gray buttons .
   a) Activate Bluetooth.
   b) Assign a Bluetooth name.
   c) Set the Bluetooth status to `visible`.
   d) Leave the Bluetooth menu by clicking on the dark gray button.
6. Change to menu `Connections`.
7. Select `Bluetooth` using the gray buttons.
8. Now the Controller can be found via Bluetooth.
9. Open the Bluetooth device manager on the computer.
   a) Select `Add device`.
   b) Windows will search for visible Bluetooth devices.

c) Select your MINDSTORMS NXT Controller from the list and click on **`Next`**.

d) The MINDSTORM Controller requires to enter a password for establishing the connection: **`1234_`** is suggested. Confirm the password by pressing the orange button.

e) The password defined in the MINDSTORMS 2.0 Controller must also be entered on the computer.

f) Click on **`Next`**.

10. The connection is being established and the drivers are being installed.
11. Double-click on the created Bluetooth device.
    The installed device and the assigned COM port are displayed. Connect the zenon Logic Workbench with this COM port or connect zenon with the **`stratonNG`** driver.In order to adjust the port:

    a) Click on properties.

    b) Click on the **`Advanced`** button.

    c) Change the port number according to your specifications.

3.2 Create a connection between zenon Logic and straton

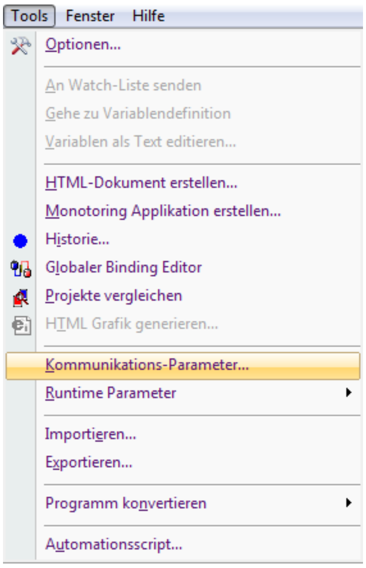
In order to create a connection between zenon Logic and straton:

1. Start zenon. The project MINDSTORMS is opened.
   If you would like to open a different project or working area open the working area for the project via the context menu for the working area.
   If you would like to create a new project:

   a) select the file -> Project new

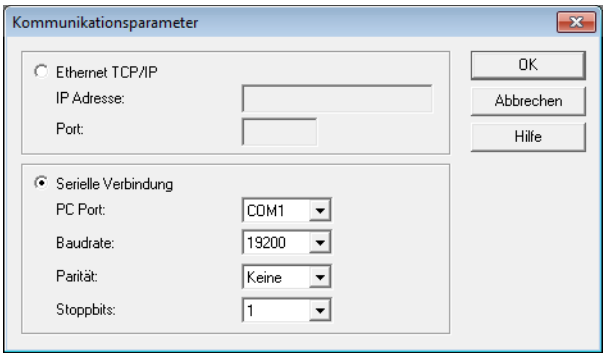
   b) create a new zenon Logic project by first right-clicking on the node zenon Logic and then selecting in the project tree **`zenon Logic Project new...`**
2. Open the zenon Logic project by double-clicking in the Workbench.

3. In the zenon Logic Workbench click on Tools -> communication parameter.



4. The dialog `Options` with the tab `Debug` is opened in order to configure the connection.

5. Click on the button `...` in order to open the dialog for the settings of the serial communication.



Kommunikationsparameter

○ Ethernet TCP/IP

IP Adresse:

Port:

● Serielle Verbindung

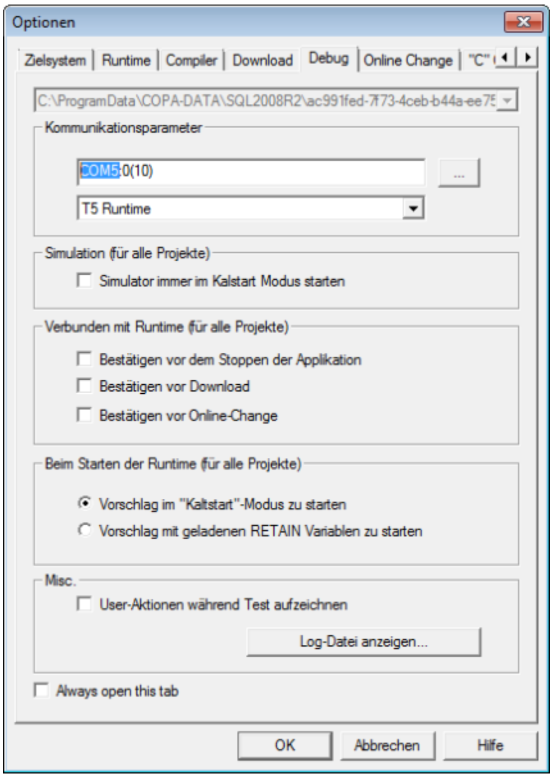
PC Port: COM1

Baudrate: 19200

Parität: Keine

Stoppbits: 1

6. Configure the serial setting corresponding to the settings for the LEGO Controller.
   Note: In this dialog only COM ports 1 to 4 can be selected. However, in the dialog **`Options`** tab **`Debug`** you can enter the COM port directly in to the field **`communication parameter`**.

   Optionen

   C:\ProgramData\COPA-DATA\SQL2008R2\ac991fed-7f73-4ceb-b44a-ee75

   Kommunikationsparameter

   COM5:0(10)

   T5 Runtime

   Simulation (für alle Projekte)

   □ Simulator immer im Kalstart Modus starten

   Verbunden mit Runtime (für alle Projekte)

   □ Bestätigen vor dem Stoppen der Applikation
   □ Bestätigen vor Download
   □ Bestätigen vor Online-Change

   Beim Starten der Runtime (für alle Projekte)

   ● Vorschlag im "Kaltstart"-Modus zu starten
   ○ Vorschlag mit geladenen RETAIN Variablen zu starten

   Misc.

   □ User-Aktionen während Test aufzeichnen

   □ Always open this tab

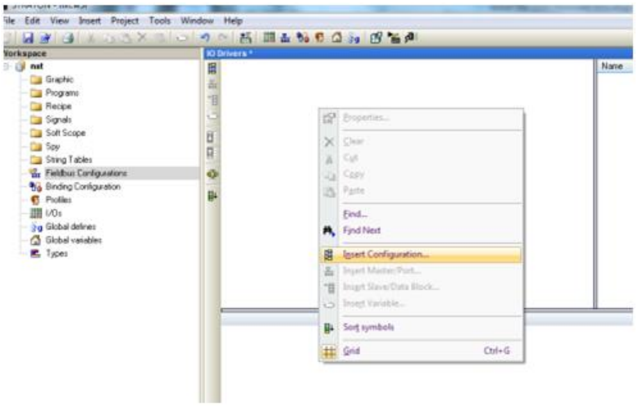
7. You will thus have configured the connection between zenon Logic and straton.

3.2.1 Add NXT driver in zenon Logic

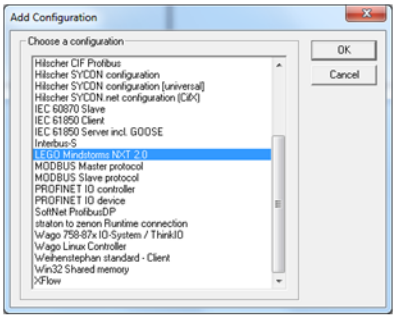
In order to add the NXT driver in zenon Logic:

1. In the project tree in the zenon Logic Workbench double-click on **`Fieldbus configuration`**.

2. In the window I/O driver click on the symbol or the command in the context menu for **`Add configuration`**.



3. The dialog for configuration is opened.



4. Select **`LEGO Mindstorms NXT 2.0`**.

5. There are three sections:

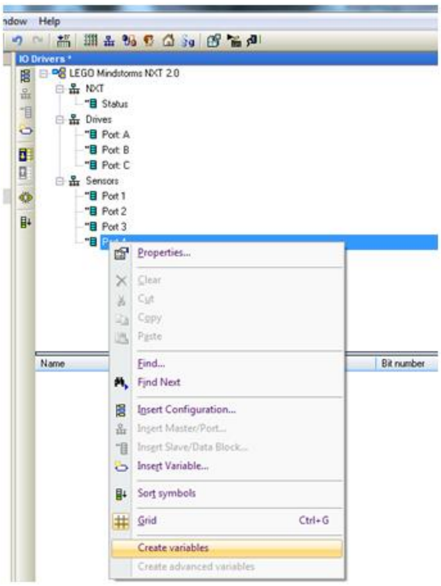
   - NXT (Status)
   - Drives
   - Sensors

   Clicking on the plus (+) before the section opens a subarea. For each of these sections predefined variables can easily be created.

CREATE VARIABLES

Create the required variables:

1. Right-click on the branch NXT, Drives or Sensors.



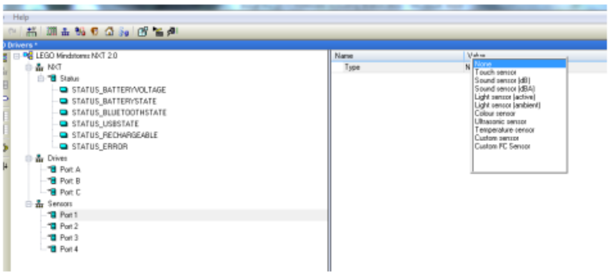
2. Select `Create variable` in the context menu.

DRIVES

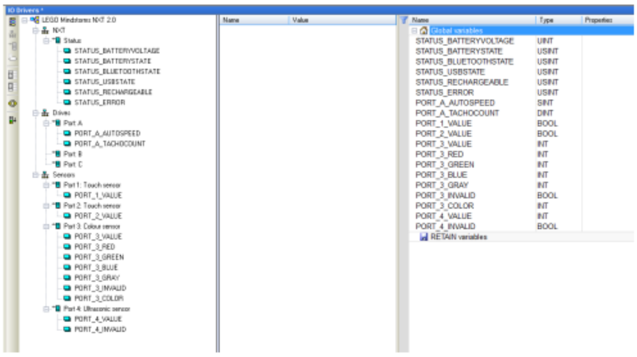
There are two versions: `easy` and `advanced`. As a start it is best to select `easy` and then `Create variable`. Please find more information on the use of Advanced Variables in section Use of complex variables (on page 39).

SENSORS

Before creating a variable in section `Sensors` a sensor type in field `Type` must be selected. To do so, double-click on the field `Value`.



CONFIGURATION EXAMPLE:



IO Drivers *

- LEGO Mindstorms NXT 2.0
  - NXT
    - Status
      - STATUS_BATTERYVOLTAGE
      - STATUS_BATTERYSTATE
      - STATUS_BLUETOOTHSTATE
      - STATUS_USBSTATE
      - STATUS_RECHARGEABLE
      - STATUS_ERROR
  - Drives
    - Port A
      - PORT_A_AUTOSPEED
      - PORT_A_TACHOCOUNT
    - Port B
    - Port C
  - Sensors
    - Port 1: Touch sensor
      - PORT_1_VALUE
    - Port 2: Touch sensor
      - PORT_2_VALUE
    - Port 3: Colour sensor
      - PORT_3_VALUE
      - PORT_3_RED
      - PORT_3_GREEN
      - PORT_3_BLUE
      - PORT_3_GRAY
      - PORT_3_INVALID
      - PORT_3_COLOR
    - Port 4: Ultrasonic sensor
      - PORT_4_VALUE
      - PORT_4_INVALID

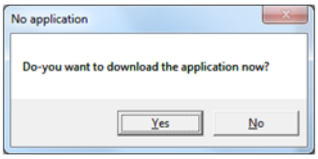
Name	Value

Name	Type	Properties
Global variables		
STATUS_BATTERYVOLTAGE	UINT	
STATUS_BATTERYSTATE	USINT	
STATUS_BLUETOOTHSTATE	USINT	
STATUS_USBSTATE	USINT	
STATUS_RECHARGEABLE	USINT	
STATUS_ERROR	USINT	
PORT_A_AUTOSPEED	SINT	
PORT_A_TACHOCOUNT	DINT	
PORT_1_VALUE	BOOL	
PORT_2_VALUE	BOOL	
PORT_3_VALUE	INT	
PORT_3_RED	INT	
PORT_3_GREEN	INT	
PORT_3_BLUE	INT	
PORT_3_GRAY	INT	
PORT_3_INVALID	BOOL	
PORT_3_COLOR	INT	
PORT_4_VALUE	INT	
PORT_4_INVALID	BOOL	
RETAIN variables		

3.2.2 Connect NXT Controller

In order to connect the NXT Controller:

1. On the Controller select **USB** as connection medium:
   a) Press the orange button.
   b) Use the gray buttons to go to the menu `Settings` and open it by pressing the orange button.
   c) Select `Connection`.
   d) Select **USB**.
   (If you would like to connect via Bluetooth select **Bluetooth**.)
2. Compile the zenon Logic project:
   a) Right-click on **mindstorms** in the project tree.
   b) Select **Compile project** in the context menu.
3. Go online:
   a) Select the entry **Online** in the zenon Logic menu **Project**.
   b) The request for download is opened:

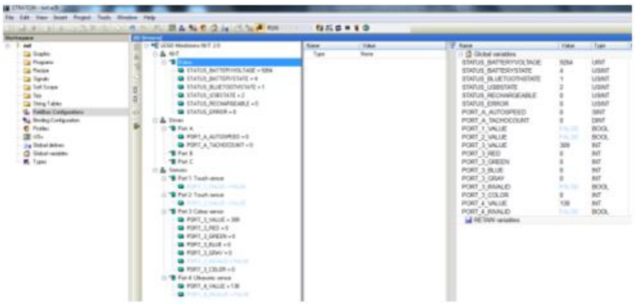


No application

Do-you want to download the application now?

   c) Click on **Yes**.

4. The project is online and you can watch how the sensors read values.



Name	Value	Type
Global variables		
STATUS_BATTERYVOLTAGE	[illegible]	UINT
STATUS_BATTERYSTATE	4	USINT
STATUS_BLUETOOTHSTATE	1	USINT
STATUS_USBSTATE	2	USINT
STATUS_RECHARGEABLE	0	USINT
STATUS_ERROR	0	USINT
PORT_A_AUTOSPEED	0	SINT
PORT_A_TACHOCOUNT	0	DINT
PORT_1_VALUE	FALSE	BOOL
PORT_2_VALUE	FALSE	BOOL
PORT_3_VALUE	309	INT
PORT_3_RED	0	INT
PORT_3_GREEN	0	INT
PORT_3_BLUE	0	INT
PORT_3_GRAY	0	INT
PORT_3_INVALID	FALSE	BOOL
PORT_3_COLOR	0	INT
PORT_4_VALUE	138	INT
PORT_4_INVALID	FALSE	BOOL
RETAIN variables		

3.2.3 Controller basic settings

BASIC CONFIGURATION

1. Configure the communication settings (details see following section: `Settings`).
2. Activate or deactivate Bluetooth (details see following section: `Connection`).
3. In case of active Bluetooth: Assign a unique name for the Bluetooth communication.

OPERATION

SWITCH ON

In order to switch on the Controller press the orange button.

MENU NAVIGATION

- Open menu: Press the orange button.
- Close menu: Press the dark gray button.
- Navigate in the menu: Press the left or right gray arrow button. Select a menu entry with the orange button. In order to leave a submenu without saving press the dark gray button.

SWITCH OFF

1. Select **`Turn off`** in the main menu and press the orange button.
2. Select an option:

a) **Save:** Saves all settings on the flash memory and closes the Controller. The currently loaded straton application, retain data and the configuration (Connection, Volume) are saved on the flash memory.

b) **Don't save:** The application is saved without saving data or configuration on the flash memory.

c) **Cancel**: Saving is cancelled and the main menu opened.

During the next start the data saved last (straton application, retain data etc.) are loaded.

STRATON MENU

With the straton menu you can start or stop the loaded straton application. In order to open the menu select the entry **straton** in the main menu.

STATISTICS

Statistics displays information on the currently running application. In order to display the corresponding data select the entry Statistics in the main menu. The following is being displayed:

- the name of the loaded application
- code size in kB
- database size in kB
- the execution time of the straton cycle
- the cycle latency in microseconds

MENU SETTINGS

In this menu the following is configured and displayed:

- Versions: Information on the version used.
- **Bluetooth**: Bluetooth activation or deactivation. Name and contacts can be managed.
  - Name: Enter a name for the Bluetooth device. The name should be unique in the Bluetooth network.
  - On/Off: Activates/deactivates Bluetooth at the Controller.
  - Visibility: Determines if the device is visible for other Bluetooth devices.
  - Search: Starts search for Bluetooth devices. In order to add a device to the Bluetooth contacts select it from the list of devices found.
  - Contacts: Manage contacts. You can remove contacts (devices which may be connected) or establish connections (e.g. for pairing).

CONNECTION

Select the connection to be used by the straton communication server. Connection for the communication with the zenon Logic Workbench. The communication server also includes a MODBUS slave. The zenon driver for straton must also be connected with the communication server. Possible options are:

- **USB**
- **Bluetooth**: incoming Bluetooth connection
- **RS-485**: RS-485 port with the parameters 115200, E, 8, 1
  Attention: Using RS-485 deactivates the sensor port 4. Please also bear in mind that the straton communication server protocol can only be used point-to-point.
- None: The communication server is not used.

VOLUME

Defines the volume of the built-in speakers. Valid values are 0 to 4, with:

- 0: switched off
- 4: Maximum

3.3 Develop straton applications for NXT

The following restrictions apply for straton applications on LEGO MINDSTORMS 2.0:

STRATON RUNTIME:

- Maximum size of code: 26 kB
- Maximum size of straton database: 20 kB

Note: Size of code and database can be checked in the menu **Statistics**.

ZENON LOGIC WORKBENCH

- Only COM ports 1 - 9 can be used. If a USB device or a Bluetooth COM port was assigned a higher port number than 9 this has to be manually configured to a port number lower than 10.
- In the Workbench only ports COM1 – COM4 can be selected. However, port numbers can be entered directly into the parameter string, e.g. **COM9:19200,N,8,1**. (See also section Establish connection between zenon Logic and straton (on page 13).)
  Note: In case of a USB or Bluetooth connection it is sufficient to enter the port, e.g. **COM5**

Information

Please find general information on the programming of LEGO MINDSTORMS NXT 2.0 in the LEGO documentation.

3.3.1 Use NXT communication ports

NXT objects contain three communication ports which can be addressed by the straton application.

With the menu **Settings** (on page 19) one of these connections is selected for the communication server. This connection can subsequently not be used out of the straton application (e.g. by a MODBUS Master or a function block). However, if a MODBUS Slave configuration was added a MODBUS Slave can use the configured port.

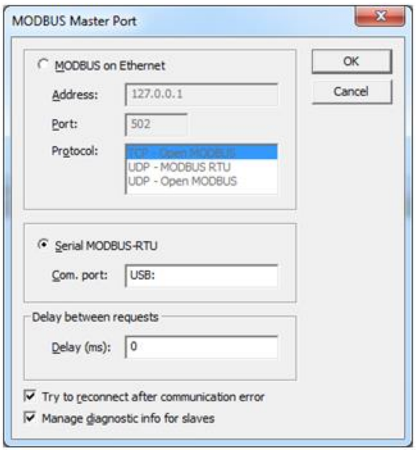
Please find further information on the use of the serial port in the straton program and on the MODBUS I/O driver in the zenon Logic documentation. To do so, in the Workbench press the key F1 or use the menu **Help**.

All ports which are not being used by the communication server can be used by the straton application and are addressed as follows:

USB

The NXT component can be connected with a computer via the USB port. NXT is recognized as serial connection by the computer.

The USB port can be addressed by the straton application by selecting USB as COM port.



○ MODBUS on Ethernet

Address: 127.0.0.1

Port: 502

Protocol: TCP - Open MODBUS | UDP - MODBUS RTU | UDP - Open MODBUS

● Serial MODBUS-RTU

Com. port: USB:

Delay between requests

Delay (ms): 0

☑ Try to reconnect after communication error

☑ Manage diagnostic info for slaves

Bluetooth

The Bluetooth port can be used in two different ways:

1. For incoming connections:
   in this case the connection is established from a remote device, e.g. a computer. In this case the string **BT** is sufficient in order to use the Bluetooth port.
2. For outgoing connections:
   NXT is configured in order to establish a connection with another Bluetooth device, for instance another NXT object. In this case use a string beginning with BT and ending with the name of the device, for instance: **BT:NXT**.
   Note: The device to be addressed must already be contained in the Bluetooth contacts. In order to manually add a device to the contacts start the Search (on page 19) and manually establish the connection once. For the first contact a pairing is probably required.

RS-485 Port (serial)

NXT objects also contain a serial RS-485 port. It is however shared with sensor 4. Thus only the port or the sensor can be used.

The RS-485 port is addressed via character string **HS**. With this the port is opened with the help of the following parameter per default:

- **Baud rate**: 115200 bit/s
- **Parity**: even
- **Data bits**: 8
- **Stop bit**: 1

ADAPT PARAMETER

If you want to adapt the communication parameters, add them after the colon separated by commas. The order:

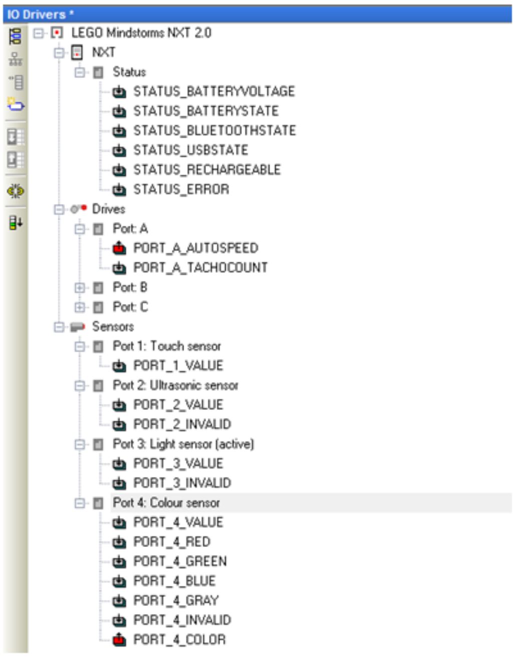
- **Baud rate** in bits/s
- **Parity**: N (none), E (even), O (odd), M (mark) and S (space)
- **Data bits**
- **Stop bit**

For example: **HS:19200,N,8,1**

Note: If you use the RS-485 port with MODBUS or the straton protocol, always set **Data bits** to 8.

Fieldbus

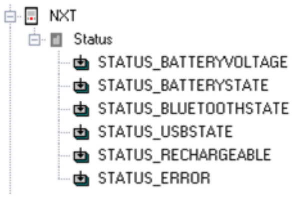
With straton NXT it is also possible to use the MODBUS Slave and MODBUS Master configuration. Please find information on MODBUS in the zenon Logic documentation. To do so, in the Workbench press the key `F1` or use the menu **`Help`**. The use of NXT sensor and motor ports are configured in the LEGO MINDSTORMS NXT 2.0 configuration.



```
IO Drivers *
LEGO Mindstorms NXT 2.0
  NXT
    Status
      STATUS_BATTERYVOLTAGE
      STATUS_BATTERYSTATE
      STATUS_BLUETOOTHSTATE
      STATUS_USBSTATE
      STATUS_RECHARGEABLE
      STATUS_ERROR
  Drives
    Port: A
      PORT_A_AUTOSPEED
      PORT_A_TACHOCOUNT
    Port: B
    Port: C
  Sensors
    Port 1: Touch sensor
      PORT_1_VALUE
    Port 2: Ultrasonic sensor
      PORT_2_VALUE
      PORT_2_INVALID
    Port 3: Light sensor (active)
      PORT_3_VALUE
      PORT_3_INVALID
    Port 4: Colour sensor
      PORT_4_VALUE
      PORT_4_RED
      PORT_4_GREEN
      PORT_4_BLUE
      PORT_4_GRAY
      PORT_4_INVALID
      PORT_4_COLOR
```

Status variables

The following status variables are available:



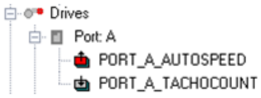
```
NXT
  Status
    STATUS_BATTERYVOLTAGE
    STATUS_BATTERYSTATE
    STATUS_BLUETOOTHSTATE
    STATUS_USBSTATE
    STATUS_RECHARGEABLE
    STATUS_ERROR
```

- STATUS_BATTERYVOLTAGE: current battery charge in millivolt.
- STATUS_BATTERYSTATE: Battery capacity.
  Value: `0` to `4` (as displayed on the NXT display)
- STATUS_BLUETOOTHSTATE: Bluetooth status
  Values:
  - `0`: on
  - `1`: visible

  - `2`: connected
  - `3`: connected and visible
  - `4`: off
- STATUS_USBSTATE: USB status
  Values:
  - `0`: disconnected
  - `1`: connected
  - `2`: operating
- STATUS_RECHARGEABLE: Status for rechargebale batteries
  Values:
  - `0`: No rechargeable batteries existing
  - `1`:   rechargeable batteries existing
- STATUS_ERROR: Error code

Drive Variables

The following variables are available for the drive:



Drives
Port: A
PORT_A_AUTOSPEED
PORT_A_TACHOCOUNT

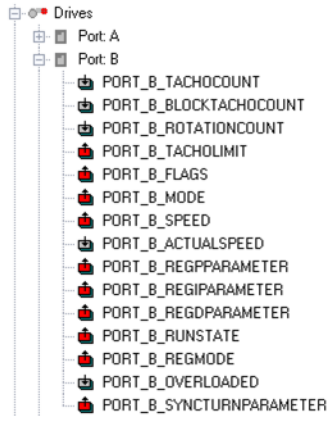
- PORT_x_AUTOSPEED (SINT, Output): Defines the motor speed.
  Values: from `-100` to `100`
  - `0`: Motor off
  - `-100`: Maximum speed backward
  - `100`: Maximum speed forward
- PORT_x_TACHOCOUNT (DINT, Input): Contains absolute number of motor revolutions in angular degrees. 360° are one complete revolution per second. Valid values: from `-2,147,483,648` to `2,147,483,647`.

COMPLEX VARIABLES

More complex drive operations are configured with more complex variables. Select them in the entry **`Create advanced variables`** in the context menu.

Attention

Do not use the AUTOSPEED variable and the Advanced Variables at the same time. Using them at the same time may result in an undefined behaviour of the drive.

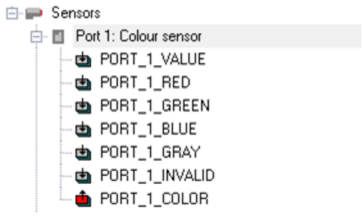


Drives
Port: A
Port: B
PORT_B_TACHOCOUNT
PORT_B_BLOCKTACHOCOUNT
PORT_B_ROTATIONCOUNT
PORT_B_TACHOLIMIT
PORT_B_FLAGS
PORT_B_MODE
PORT_B_SPEED
PORT_B_ACTUALSPEED
PORT_B_REGPPARAMETER
PORT_B_REGIPARAMETER
PORT_B_REGDPARAMETER
PORT_B_RUNSTATE
PORT_B_REGMODE
PORT_B_OVERLOADED
PORT_B_SYNCTURNPARAMETER

Please find a description on how to configure these variables in section Using complex variables (on page 39).

Color sensor variables

The following variables are available for the color recognition:



Sensors
Port 1: Colour sensor
PORT_1_VALUE
PORT_1_RED
PORT_1_GREEN
PORT_1_BLUE
PORT_1_GRAY
PORT_1_INVALID
PORT_1_COLOR

- PORT_x_COLOR (INT, Output): Defines the sensor mode.
  - 0: Passive mode (measure brightness)
  - 1: Red is being measured.
  - 2: Green is being measured.
  - 3: Blue is being measured.
  - 4: All colors are being measured
- PORT_x_VALUE (INT, Input)

  If the mode is passive, red, green or blue:

  - A value between 0 and 255 defines the color intensity.

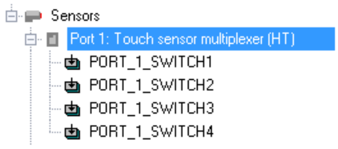
  If the mode is all colors:

- 1: black
- 2: blue
- 3: green
- 4: yellow
- 5: red
- 6: white

- PORT_x_RED: In the mode `all colors` the intensity of the color red is measured.
- PORT_x_GREEN: In the mode `all colors` the intensity of the color green is measured.
- PORT_x_BLUE: In the mode `all colors` the intensity of the color blue is measured.
- PORT_x_GRAY: Brightness is measured

Touch Sensor Multiplexer (HT)

The following variables are available for the touch sensors:



Sensors
Port 1: Touch sensor multiplexer (HT)
PORT_1_SWITCH1
PORT_1_SWITCH2
PORT_1_SWITCH3
PORT_1_SWITCH4

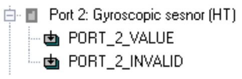
When using the HiTechnic Touch Sensor Multiplexer up to four sensors can be connected with a NXT port:

- PORT_x_SWITCH1: Status of sensor 1
- PORT_x_SWITCH2: Status of sensor 2
- PORT_x_SWITCH3: Status of sensor 3
- PORT_x_SWITCH4: Status of sensor 4

Gyroscopic sensor (HT)

The LEGO MINDSTORMS 2.0 NXT Gyro Sensor gives information on the number of motor revolutions and the direction of the revolutions. The revolutions are measured in angular degrees. 360° are one complete revolution per second.

After the start of the straton application the sensor is automatically calibrated during connection. To do so, the current zero value is calculated. This takes about 200 ms. During this period of time the sensor must not be moved.

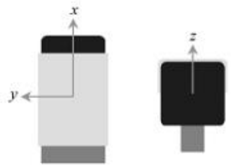


Port 2: Gyroscopic sesnor (HT)
- PORT_2_VALUE
- PORT_2_INVALID

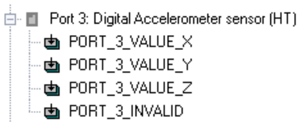
- PORT_x_VALUE: Number of angular grades per rotation second
- PORT_x_INVALID: Set to `TRUE` when:
  - the sensor is being calibrated
  - the value cannot be read

Digital Acceleration Sensor (HT)

The LEGO MINDSTORMS 2.0 NXT acceleration sensor includes a 3-axis accelerometer measuring acceleration in the three axes **`x`**, **`y`** and **`z`**. The acceleration is displayed within the scope of -2g to +2g with approximately 200 steps per g.



The acceleration sensor can also be used to measure the gradient in three axes. This is possible because gravitation is perceived as acceleration. If the sensor is motionless in the normal horizontal position the x-axis and y-axis, being horizontal, will be close to zero, while the z-axis' value will be close to 200, corresponding to 1g.   If the sensor is then inclined the other axes will also perceive gravity and the z-axis' value will decrease. Since gravity is divided among the three part vectors the gradient of the sensor can be determined.



Port 3: Digital Accelerometer sensor (HT)
- PORT_3_VALUE_X
- PORT_3_VALUE_Y
- PORT_3_VALUE_Z
- PORT_3_INVALID

- PORT_x_VALUE_X: Acceleration in direction of the x-axis
- PORT_x_VALUE_Y: Acceleration in direction of the y-axis
- PORT_x_VALUE_Z: Acceleration in direction of the z-axis
- PORT_x_INVALID: Set to `TRUE` if the data of the sensor cannot be read.

Digital Compass Sensor (HT)

The LEGO MINDSTORMS 2.0 NXT Compass Sensor contains a magnetic digital compass to measure the earth's magnetic field and calculate a heading angle. The Compass Sensor can be connected to a NXT port with a NXT standard cable and uses the digital I2C communication protocol. The current heading is calculated to the next integral angular degree.

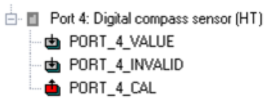
The HiTechnic Compass Sensor is influenced by local magnetic interferences, as is any other magnetic compass, too. Metal objects such as motors, batteries or cables may cause magnetic interferences. Local magnetic interferences may cause the compass to produce a heading deviating several degrees from the current magnetic heading. This effect is called compass deviation. In order to correct this deviation the HiTechnic Compass Sensor has a built-in calibration function correcting deviations and saving these values in the compass.

The calibration is optional and usually not required during normal operation. In order to minimize the need to calibrate install the compass in a distance of at least 10 to 15 cm (4 - 6 inches) to NXT and the NXT motors.

In order to calibrate the compass in the program:

- Select `calibration mode`.
- Program your NXT object so that it rotates within a very narrow circle.
- It must rotate between 1½ and 2 times (more than 360 degrees).
- It must complete a full turn in approximately 20 seconds.

The compass will maintain the calibration settings until another calibration is made, even though it is being unplugged.


Port 4: Digital compass sensor (HT)
PORT_4_VALUE
PORT_4_INVALID
PORT_4_CAL

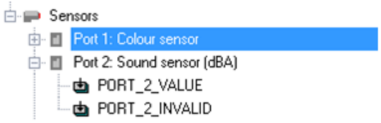
- PORT_x_VALUE: Current heading in degrees.

  0: North
- PORT_x_INVALID: Set to `TRUE` if the data of the sensor cannot be read.
- PORT_x_CAL: (Display) Controls the calibration mode.
  - `TRUE` change to calibration mode
  - `FALSE`: change to measuring mode.

  Note: In the calibration mode the sensor provides invalid data.

Other sensors

The following additional variables for sensors are available:

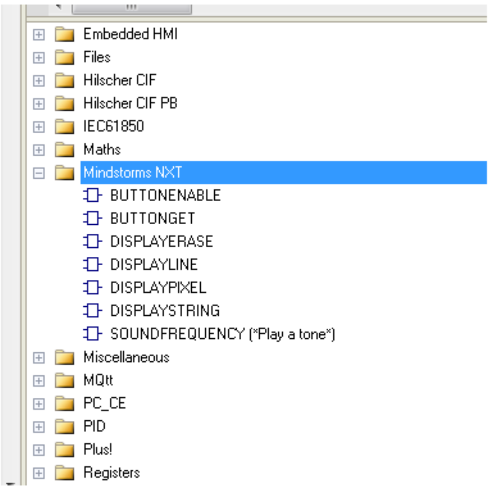


Sensors
Port 1: Colour sensor
Port 2: Sound sensor (dBA)
PORT_2_VALUE
PORT_2_INVALID

- PORT_x_VALUE: sensor value, depends on sensor
  - Sound dB
  - Sound dBA
  - Ultrasonic: distance in centimeters (cm)
  - Temperature: temperature in Celsius centigrade (°C/10)
- PORT_x_INVALID:
  - TRUE: sensor is in error status

3.3.2 Functions

In order to select functions these must be located in the corresponding folder. Copy the Mindstorms NXT folder from the HWDEF folder on the installation medium into the HWDEF folder of your straton installation.
For example:
%ProgramData%\COPA-DATA\zenon7.20711\straton\HWDEF\Mindstorms NXT



Embedded HMI
Files
Hilscher CIF
Hilscher CIF PB
IEC61850
Maths
Mindstorms NXT
BUTTONENABLE
BUTTONGET
DISPLAYERASE
DISPLAYLINE
DISPLAYPIXEL
DISPLAYSTRING
SOUNDFREQUENCY ("Play a tone")
Miscellaneous
MQtt
PC_CE
PID
Plus!
Registers

The following functions are available:

- BUTTONENABLE (on page 31): straton takes over control of NXT buttons.

- BUTTONGET (on page 31): Transmits information on which button was pressed.
- DISPLAYERASE (on page 32): Erases screen content.
- DISPLAYLINE (on page 32): Draws a line.
- DISPLAYPIXEL (on page 32): Draws a pixel.
- DISPLAYSTRING (on page 32): Writes a string.
- SOUNDFREQUENCY (on page 33): Sound output.

BUTTONENABLE

BOOL BUTTONENABLE (BOOL ENABLE)

During the activation with ENABLE and status `TRUE` the control is being passed on to straton using the buttons on the NXT object. The button status can be read with BUTTONGET (on page 31).

Note:

- The menu **`System`** on the NXT object is deactivated in this case.
- Activating this function is only possible if the menu on the NXT object is inactive.
- This status can be interrupted, for instance by a Bluetooth pairing dialog. In this case BUTTONGET (on page 31) returns the value `-1`.

Response value:

- `TRUE`: Activity successfully completed.

BUTTONGET

SINT BUTTONGET

Return values:

- `-1`: buttons cannot be read by straton. The menu **`System`** on the NXT object is activated.
- `0`: no button pressed.
- `1`: left button pressed.
- `2`: button `Entry` (orange button) pressed.
- `3`: right button pressed.
- `4`: button `Leave` (dark gray button) pressed.

DISPLAYERASE

BOOL DISPLAYERASE

Erases the screen contents.

Response value:

- `TRUE`: Activity successfully completed.

DISPLAYLINE

BOOL DISPLAYLINE (USINT X1,USINT Y1,USINT X2, USINT Y2, BOOL C)

Draws a line from point **`X1,Y1`** to point **`X2,Y2`**.

Values for C:

- `TRUE`: draws a line
- `FALSE`: erases the line

Response value:

- `TRUE`: Activity successfully completed.

DISPLAYPIXEL

BOOL DISPLAYPIXEL (USINT X, USINT Y, BOOL C)

Draws a point with the coordinates **`X,Y`**.

Values for C:

- `TRUE`: draws a point
- `FALSE`: erases the point

Response value:

- `TRUE`: Activity successfully completed.

DISPLAYSTRING

BOOL DISPLAYSTRING(USINT X, USINT Y, STRING TEXT)

Writes a string beginning with the indicated XY position.

Response value:

- TRUE: Activity successfully completed.

SOUNDFREQUENCY

BOOL SOUNDFREQUENCY(UDINT FREQ, UDINT DUR, USINT VOL)

Plays a tone with the indicated frequency in Hz during the defined length in milliseconds. The volume (VOL) is indicated in a range of 1 to 4. It is limited by the configured maximum volume (on page 19) in the menu **Volume**.

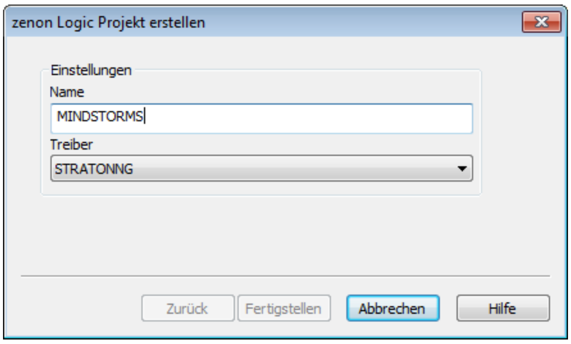
Response value:

- TRUE: Activity successfully completed.

3.4 Connect MINDSTORMS 2.0 Runtime with zenon

For creating a new zenon Logic project in zenon it is recommended to use the **stratonNG** driver. This supports serial communication.

When creating a new zenon Logic project in the dialog define the name of the project and the driver used.


zenon Logic Projekt erstellen

Einstellungen

Name: MINDSTORMS

Treiber: STRATONNG

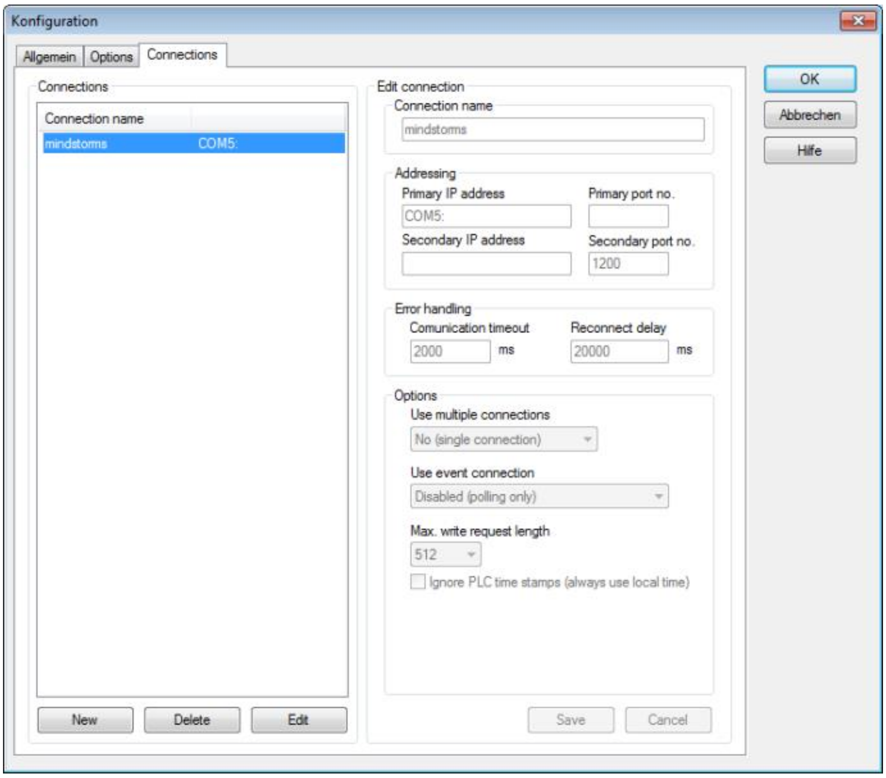
Select STRATONNG from the drop-down menu.

Note: The selection of the driver cannot subsequently be changed again.

CONFIGURATION OF STRATONNG DRIVER

To configure the driver:

1. in the zenon project tree select the node **`Variables -> Driver`**
2. highlight the stratonNG driver
   Note: this is displayed with the name defined for the project, e.g. **`straton: mindstorms`**
3. select **`Driver configuration`** in the context menu
4. the dialog for the driver configuration is opened
5. open the tab Connections



Connection name	
mindstorms	COM5:

Connection name: mindstorms

Primary IP address: COM5:

Primary port no.:

Secondary IP address:

Secondary port no.: 1200

Comunication timeout: 2000 ms

Reconnect delay: 20000 ms

Use multiple connections: No (single connection)

Use event connection: Disabled (polling only)

Max. write request length: 512

□ Ignore PLC time stamps (always use local time)

To edit the driver:

1. highlight the connection name
2. Click on **`Edit`**.
3. configure the link
4. click on **`Save`** and then **`OK`**

Configuration of the driver for the connection within the scope of LEGO MINDSTORMS 2.0:

Option	Description
Connection name	Must correspond to the project name. If the name is different from that of the project this will result in errors during the connection with the Controller.
Addressing	In the communication with straton NXT via USB or Bluetooth it is sufficient to set the port without further settings, e.g. **COM5:**
Primary IP address	Entering COM port. Entries beginning with COM and ending with a colon are interpreted as COM ports. Attention: The colon (**:**) must be present at the end of the port definition. Otherwise it is not possible to establish a connection. If no further parameters are indicated the standard configuration of the COM port is used: **Baud rate**: 115200 bit/s **Parity**: even **Data bits**: 8 **Stop bit**: 1 If you want to adapt the communication parameters, add them after the colon separated by commas. The order: **Baud rate** in bits/s **Parity**: N (none), E (even), O (odd), M (mark) and S (space) **Data bits** **Stop bit** For example: **COM5:19200,N,8,1** Limitations: If a COM port is indicated it is not possible to use: Event connection Multiple connections (more than one connection with a driver)

The documentation of these settings refers to the communication in the scope of LEGO MINDSTORMS 2.0. Please find details on the general configuration of the stratonNG driver in the online help (F1) in chapter stratonNG (stratonNG.chm::/27853.htm).

3.5 Questions and answers

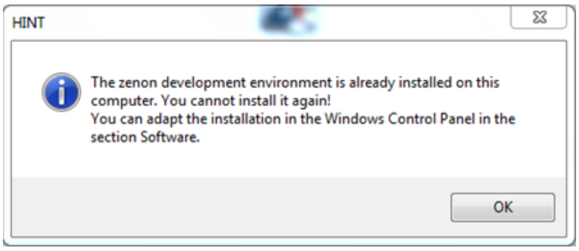
The most common questions regarding installation and operation of LEGO MINDSTORM with straton and the zenon Science Package.

Question	Answer
Why is an error message displayed during installation?	Probably there is already a zenon installation present in the system. Use the existing installation. Details: Error message during the installation of the zenon Science Package (on page 36).
How do I change back to the original LEGO firmware?	Changing back corresponds to the proceeding during the installation of the straton firmware if other firmware already exists. Details: Activate original LEGO firmware (on page 37).
How can I proceed if the LEGO Firmware Loader does not find the Controller?	Change the USB port or re-install its driver. Details: LEGO Firmware Loader does not find the Controller (on page 38).
How do I proceed if the zenon Logic Workbench driver does not communicate with my Controller?	This may have several causes. Check the settings and if all devices are online. Details: zenon Logic Workbench driver does not communicate with the Controller (on page 38)
How do I proceed if the stratonNG driver does not communicate with my Controller?	This may have several causes. Check the communication parameters, the Runtime and the project. Details: stratonNG driver does not communicate with the Controller (on page 39).

Further questions and answers can also be found in the COPA-DATA user forum: www.copadata.com/forums/ (http://www.copadata.com/forums/).

3.5.1 Error message during the installation of the zenon Science Package

An error message is displayed during the installation of the zenonScience Package which refers to an already existing installation.



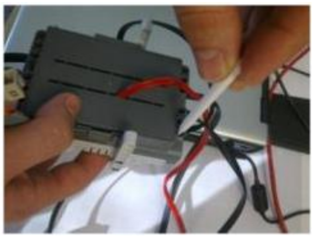
The zenon development environment is already installed on this computer. You cannot install it again!
You can adapt the installation in the Windows Control Panel in the section Software.

This zenon version has already been installed on your system. You don't have to install zenon and can use the existing version. Import the demo projects (on page 8) from the installation medium and continue with Install firmware (on page 9).

3.5.2 Activate original LEGO firmware

If firmware not provided by LEGO is already present on the Controller this has to be set to the **`Firmware load mode`** in order to be able to install other firmware. This mode is also required if the straton firmware is supposed to be updated or LEGO firmware loaded again. In order to set the Controller to **`Firmware load mode`**:

1. Press for at least 5 seconds until you hear a quiet clicking noise
   - both the orange start button and
   - the Rest button on the back of the device.
     You can best reach the Rest button with a pointed object.



2. Switch on the NXT Controller by pressing the orange button.

3. The NXT Controller starts in the **`Firmware load mode`** . You can hear a regular sound.
4. Start the download of the desired firmware.
   To do so, a connection via USB (on page 11) or Bluetooth (on page 12) must be established. For the USB connection with zenon/straton the COPA-DATA driver is required.

> ⚠ **Attention**
>
> *The **`Firmware load mode`** can only be closed by downloading a firmware.*

DOWNLOAD OF THE LEGO FIRMWARE:

1. Connect the Controller via USB with the computer.
2. Start the LEGO MINDSTORMS NXT 2.0 software.
3. In menu **`Tools`** select the entry **`Update NXT Firmware`**.
4. The original LEGO MINDSTOMS NXT firmware is preselected.
5. Click on the button **`Download`**.

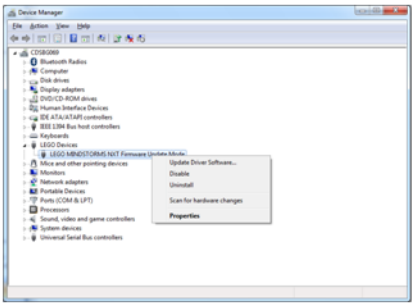
6. The Controller restarts with the original LEGO firmware.

3.5.3 LEGO Firmware Loader does not find the Controller

If the LEGO Firmware Loader does not find the Controller connect the USB cable with a different USB port By doing so the USB driver is installed for the Firmware Loader mode.

If this does not solve the problem deinstall the driver. To do this:

1. Open the device manager in the system control while the Controller is connected.
2. Select the **`LEGO MINDSTORMS NXT Firmware Update Mode`** driver.
3. Right-click on it.



4. Select **`Deinstall`** in the context menu.
5. Remove the USB cable from the LEGO MINDSTORMS 2.0 Controller and reconnect it.
6. The driver is automatically reinstalled.

3.5.4 zenon Logic Workbench driver does not communicate with the Controller

The communication with the Controller is a point-to-point communication via a virtual serial port. It is only possible to connect one application at a time.

If the communication fails there might be several reasons. The most frequent include:

1. The stratonNG driver and zenon are still online.
2. The COM port settings are incorrect. Select the correct COM port settings in the menu **`Communication parameters`** (on page 19).

3. The connection settings for the Controller are not set to the correct medium (USB or Bluetooth).
   Select the currently used connection.

3.5.5 stratonNG driver does not communicate with the Controller

The communication with the Controller is a point-to-point communication via a virtual serial port. It is only possible to connect one application at a time.

If the communication fails there might be several reasons. The most frequent include:

1. The zenon Logic Workbench is still online.
2. The COM port settings are incorrect.
3. The straton Runtime has not been started on the LEGO MINDSTORMS 2.0 Controller.
   In order to start the Runtime:
   a) Press the orange button.
   b) As soon as you see the entry straton press the orange button again.
   c) Select `Start` and press the orange button.

   You can tell that the Runtime is running when the square symbol next to the battery status is rotating.
4. The straton project was not downloaded to the Controller.
   If a project was downloaded please check if it is the correct project.
5. The symbol names of the variable have not been activated.
6. The connection name (on page 33) of the stratonNG driver is not identical with the name of the zenon Logic project.
7. The connection settings for the Controller are not set to the correct medium (USB or Bluetooth).
   Select the currently used connection.

3.6 Use of complex variables

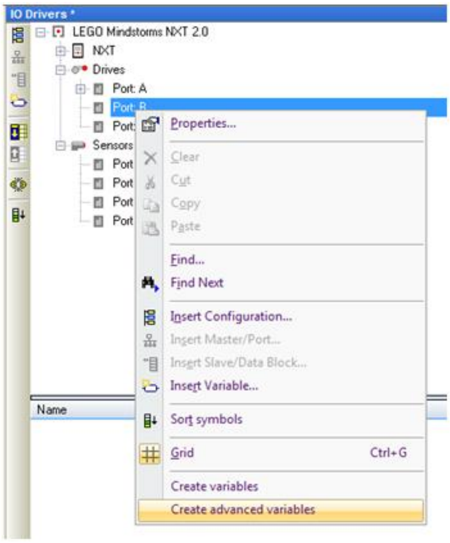
This section explains how to control a motor with complex variables.

Information

The use of complex variables is only recommended for experienced users!

With an additional programming you can make the NXT motors move by a predefined angle. This is required in order to engineer very precise movements. For engineering:

1. Create all variables by right-clicking on the port and selecting `Create advanced variables` in the context menu.



2. You receive 15 variables.

The variables relevant for you are:

- PORT_n_FLAGS
  - Bit mask from which variables should be written.
- PORT_n_TACHOLIMIT
  - The relative limit for the degrees with which the motor is supposed to rotate.
  - Attention: This value is always positive, even if the motor rotates backwards.
- PORT_n_MODE
  - Mode the motor is supposed to use.
  - Does not refer to forward or backward or increasing or decreasing speed, but to internal commands.
- PORT_n_SPEED
  - Motor speed.
  - Range: `-100` (backward) to `100` (forward)
- PORT_n_RUNSTATE

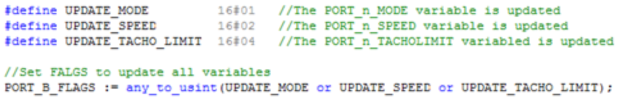
- How the motor is supposed to run.
- Physical properties (set speed instantly, Ramp UP or Ramp DOWN)

> **Attention**
>
> *All variables must be written in a cycle!*
>
> *That means: The variables cannot be forced from the zenon Logic Workbench.*

STRUCTURE

Internally, NXT uses a structure. Create all variables of this structure by right-clicking on the port and selecting **`Create advanced variables`** in the context menu. This structure is written in every cycle. However, since **PORT_n_FLAGS** is set by straton to 0 after each cycle nothing else will happen.

The variable **PORT_n_Flags** is a bit mask for those variables which are relevant in this cycle for the structure straton queries. In order to give a **`Move n degree`** command set the **PORT_n_FLAGS** variable to a bit mask [ST]:

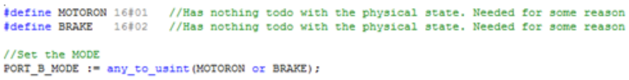


```
#define UPDATE_MODE         16#01   //The PORT_n_MODE variable is updated
#define UPDATE_SPEED        16#02   //The PORT_n_SPEED variable is updated
#define UPDATE_TACHO_LIMIT  16#04   //The PORT_n_TACHOLIMIT variabled is updated

//Set FALGS to update all variables
PORT_B_FLAGS := any_to_usint(UPDATE_MODE or UPDATE_SPEED or UPDATE_TACHO_LIMIT);
```

It is then defined that the data for **PORT_n_MODE, PORT_n_SPEED** and **PORT_n_TACHOLIMIT** are available. Which values must these variables have?

For **PORT_n_MODE** also a bit mask is required. In principle always both must be set if you would like to create a forward movement [ST]:

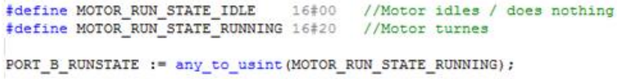


```
#define MOTORON 16#01   //Has nothing todo with the physical state. Needed for some reason
#define BRAKE   16#02   //Has nothing todo with the physical state. Needed for some reason

//Set the MODE
PORT_B_MODE := any_to_usint(MOTORON or BRAKE);
```

Now you have set the bit mask on which variables are supposed to be updated as well as some internal flag parameters.

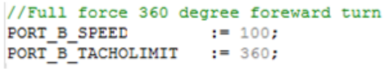
Now we can focus on the more interesting part: The rotation mode of the motor - **PORT_n_RUNSTATE**. No bit mask is available in this case. The values are exclusive.



```
#define MOTOR_RUN_STATE_IDLE    16#00   //Motor idles / does nothing
#define MOTOR_RUN_STATE_RUNNING 16#20   //Motor turnes

PORT_B_RUNSTATE := any_to_usint(MOTOR_RUN_STATE_RUNNING);
```

And finally: **PORT_n_SPEED** and **PORT_n_TACHOLIMIT**:



```
//Full force 360 degree foreward turn
PORT_B_SPEED        := 100;
PORT_B_TACHOLIMIT   := 360;
```

⚠ **Attention**

Make absolutely sure that these values are not written in every cycle. Otherwise the rotation command is executed in every cycle. However, you still have to write all variables in every cycle. Block the writing of these values.

4. zenon Science Package for LEGO MINDSTORMS EV3

The zenon Science Package for LEGO MINDSTORMS EV3 enables the programming of LEGO Mindstorms EV3 objects.

Preparation:

- zenon 7.20 already installed and installations medium available.
  If you have not installed zenon, you must install the zenon Science Package, version 7.20 or higher.

4.1 Requirements

Hardware:

- Netgear WNA1100 Wi-Fi Dongle
- LEGO MINDSTORMS EV3 with firmware version 1.03E or 1.03H or higher.

Software:

- zenon from version 7.20 on
- LEGO MINDSTORMS EV3 Runtime (available on the installation medium in the path `\AdditionalSoftware\Science Package - Firmware\EV3`)
- Bricx Command Center (available at http://bricxcc.sourceforge.net/ (http://bricxcc.sourceforge.net/))

FIRMWARE FOR LEGO MINDSTORMS EV3

The firmware on the LEGO MINDSTORMS EV3 must be at least version 1.03E or 1.03H or higher.

To check the version of the firmware, select **`Brick Info`** in the **`Settings`** tab of LEGO MINDSTORMS EV3. You can download the most recent firmware (*.bin file) from the LEGO website.

Use the LEGO software to update the firmware.

4.2 Installation

The installation comprises:

- zenon Science Package
- EV3 Setup
- zenon Logic Editor and Runtime

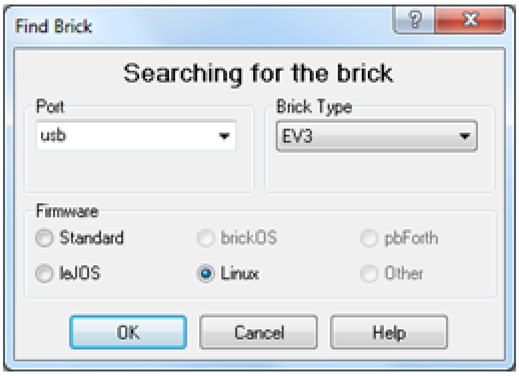
If you have already installed zenon 7.20 or higher, you can execute the EV3 setup immediately.

INSTALLATION OF THE ZENON SCIENCE PACKAGE

Start the installation from the zenon installation medium and follow the notes in the installation assistant. You can also download the zenon Science Package from the COPA-DATA home page. This installation already includes zenon Logic.

INSTALLATION OF STRATON RUNTIME ON LEGO EV3

1. Install the **Bricx Command Center**.
   You can find the program at http://bricxcc.sourceforge.net/test_releases (http://bricxcc.sourceforge.net/test_releases).
2. Download a current **test_release**.
   test_release2013007.zip is used in these instructions.
3. Connect the LEGO MINDSTORMS EV3 to the PC with a USB cable.
4. Open **Bricx CC**: **Tools -> Find Brick**
5. Configure the connection:


Find Brick

Searching for the brick

Port: usb

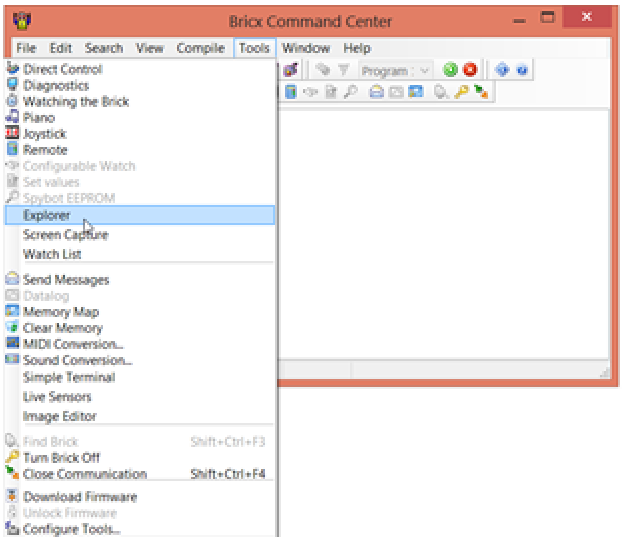
Brick Type: EV3

Firmware

○ Standard ○ brickOS ○ pbForth
○ leJOS ● Linux ○ Other

- **Port**: usb
- **Brick Type**: EV3
- **Firmware**: Linux

6. Open **`Bricx Explorer`**: **`Tools -> Explorer`**.



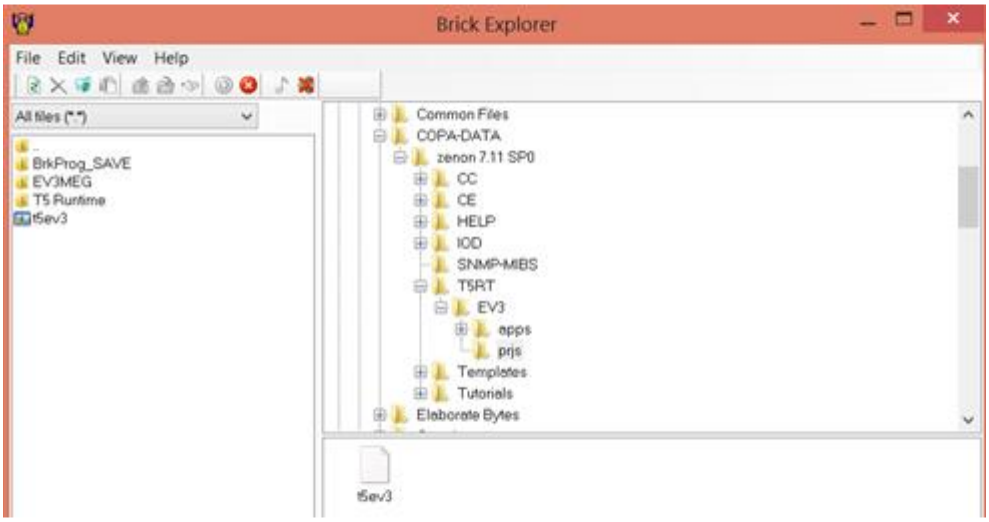
7. Create a new folder called **`T5 Runtime`**.

8. Open, on the installation medium, the folder **`T5 Runtime`** in the following path:`\AdditionalSoftware\Science Package - Firmware\EV3\apps`.

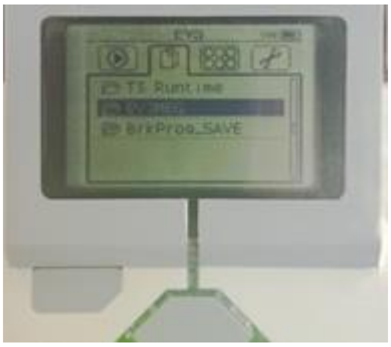
9. Copy the files contained therein and add these to your **`T5 Runtime`** folder in the **`Brick Explorer`**.

10. Open the `\AdditionalSoftware\Science Package - Firmware\EV3\prjs` folder on the installation medium.

11. Copy the file there called **`t5ev3`** to the folder in which the **`T5 Runtime`** folder is also located.



- On the LEGO EV3 Brick, the new entry **`T5 Runtime`** is now available.



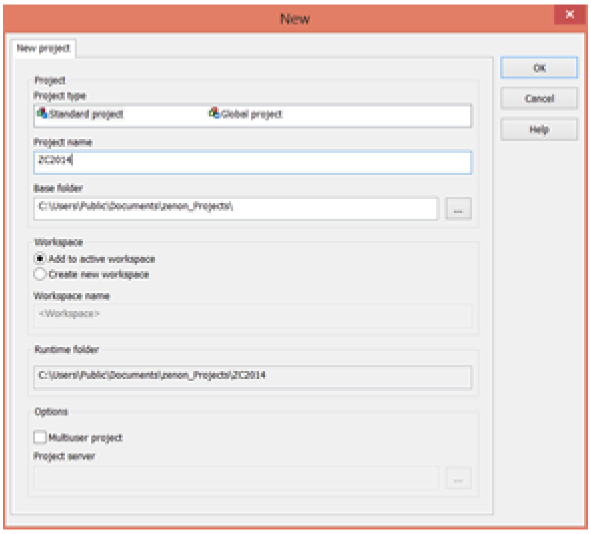
4.3 Create a zenon Logic project

zenon Logic contains a fully-integrated configuration tool for the LEGO MINDSTORMS EV3, as well as a library with Functions and Function Blocks.

The first stage is to create a zenon project and a zenon Logic project in this.

CREATE A ZENON PROJECT

1. Open the zenon Editor
2. Select File -> New project.
3. The dialog to create a project is opened.



Project

Project type: Standard project | Global project

Project name: ZC2014

Base folder: C:\Users\Public\Documents\zenon_Projects\

Workspace

● Add to active workspace

○ Create new workspace

Workspace name: <Workspace>

Runtime folder: C:\Users\Public\Documents\zenon_Projects\ZC2014

Options

□ Multiuser project

Project server:

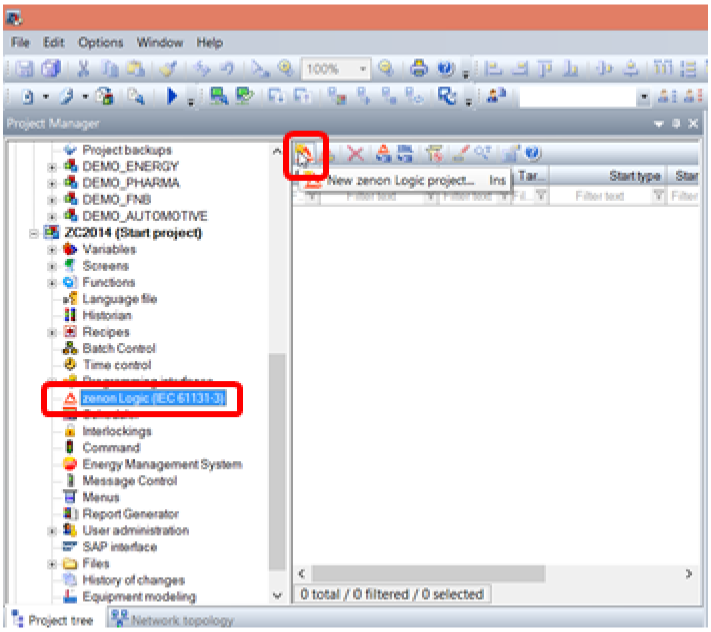
4. Enter a name for the project.
5. Click on **OK**.
   - The wizard to create the project is started.

- Close the wizard.

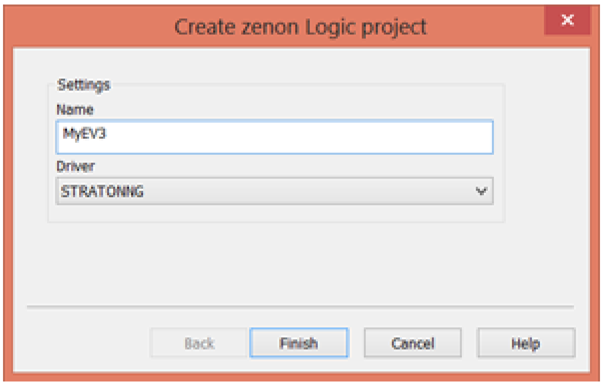
Alternatively, you can also open the supplied demo project.

CREATE A ZENON LOGIC PROJECT

1. In the zenon Editor, go to **`zenon Logic (IEC 61131-3)`**.
2. In the context menu or in the tool bar of the detail view, select **`zenon Logic New project`**.



3. The dialog to create a project is opened.
4. Enter a name for the project.
5. Click on **`Fertigstellen`**.


Create zenon Logic project

Settings

Name: MyEV3

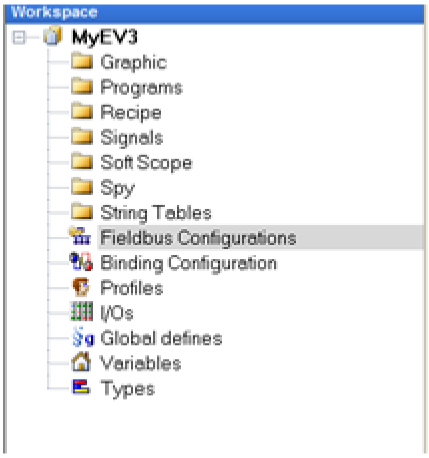
Driver: STRATONNG

4.4 EV3 configuration in zenon Logic

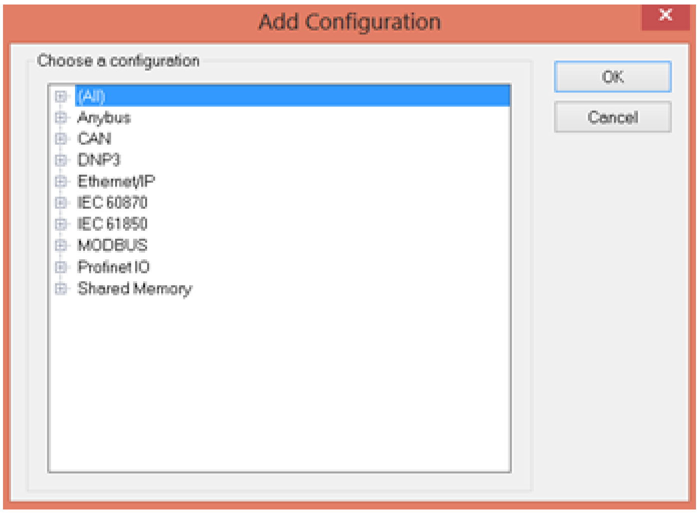
Runtime administers an allocation table, which contains the LEGO MINDSTORMS EV3 Inputs and Outputs. A tool for configuration is integrated into the zenon Logic Workbench.

To start the configuration:

1. In the zenon Logic Workbench, double click on **Field bus configuration**.

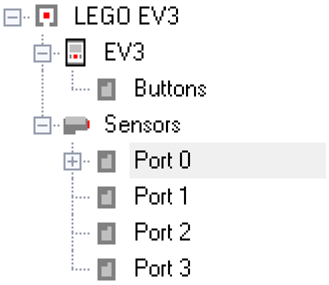


2. The **I/O driver** window is opened.
3. Right click on a free position in this window.
4. Select **Add configuration** in the context menu.
5. The **Add configuration** window is opened.



6. Select the **All** node.
7. Select **LEGO EV3**.
8. Click on **OK**.

The configuration is created in the tree view:



LEGO EV3
EV3
Buttons
Sensors
Port 0
Port 1
Port 2
Port 3

LEGO EV3 CONFIGURATION

- EV3
  - Buttons
- Sensors
  - Port 0
  - Port 1
  - Port 2
  - Port 3

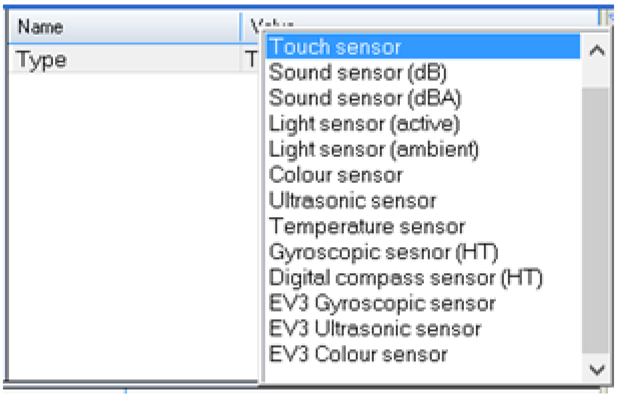
4.4.1 Define sensor type

You can define the type of sensor for each port in the Sensors group.

To do this:

1. Double-click on the port.
2. The configuration window will open
3. Double-click on **Type**.
4. The selection list is opened.

5. Select the desired `type`.



Name	Value
Type	T

Touch sensor
Sound sensor (dB)
Sound sensor (dBA)
Light sensor (active)
Light sensor (ambient)
Colour sensor
Ultrasonic sensor
Temperature sensor
Gyroscopic sesnor (HT)
Digital compass sensor (HT)
EV3 Gyroscopic sensor
EV3 Ultrasonic sensor
EV3 Colour sensor

6. Close the dialog by clicking on **OK**.

4.4.2 Create variables

You can create variables automatically or connect them manually.

CREATE VARIABLES AUTOMATICALLY

1. Right-click on the port.
2. Select **`Create variables`** in the context menu.
3. All required variables are created automatically.

Note: If the sensor type is set to `None`, no variables are created.

CONNECT VARIABLES MANUALLY

To connect variables manually:

1. Right-click on the port.
2. Select **`Add variables`** in the context menu
3. The dialog for configuration is opened.
4. Clicking on a value opens the selection list of the values that are possible for this type.

CONFIGURE VARIABLES

Parameter	Description
Symbol	Selection of a variable in accordance with IEC 61131-3 syntax.
Area	Range.
Format	Data type: - `32 bit float` - `Signed 16 bit integer` - `Signed 32 bit integer` - `Signed 8 bit integer` - `Single bit` - `Unsigned 16 bit integer` - `Unsigned 32 bit integer` - `Unsigned 8 bit integer`
Offset	Is not used.
Bit Number	Bit number.

DATATYPES

You can connect variables with any desired data type to the LEGO EV3 I/Os. Runtime automatically converts the values to the data type of the variable.

Note: STRING variables are not supported.

4.4.3 Blocks and Functions function

Some Function Blocks and Functions are provided in the library to control LEDs, sounds, LCD and motors of the LEGO EV3.

The following Function Blocks are described in more detail:

- **LED**
- **Sound**
- **Motor**

LED

Set LED pattern:

Parameter	Description
SetLed	Creates an LED pattern
[IN] LED	Index of the LED pattern to be applied: - 0: All LEDs off. - 1-9: Corresponding LED pattern.
[OUT] Q	Current LED pattern.

Sound

Set sound playback.

General:

Parameter	Description
PlaySnd	Play back sounds.
[IN] ENABLE	Switch on sound playback: - TRUE: Sounds are played back. To activate playback, the setting must have previously been FALSE. - FALSE: Sounds are not played back.
[IN] FREQ	Frequency of the sound.
[IN] DURATION	Duration of the signal.
[IN] VOLUME	Volume - Minimum: 0 - Maximum: 100
[OUT] PLAYING	TRUE, if sounds are played back.

System sounds:

Parameter	Description
PlaySysSnd	Play back system sound.
[IN] ENABLE	Switch on sound playback: - TRUE: Sounds are played back. To activate playback, the setting must have previously been FALSE. - FALSE: Sounds are not played back.
[IN] SND	Index of the system sound.
[IN] VOLUME	Volume. - Minimum: 0 - Maximum: 100
[OUT] PLAYING	TRUE, if a system sound is played back.
Symbol	Variable name in accordance with IEC 61131-3 syntax.
Area	- Data Exchange - Data Status.
Format	Data type: - 32 bit float - Signed 16 bit integer - Signed 32 bit integer - Signed 8 bit integer - Single bit - Unsigned 16 bit integer - Unsigned 32 bit integer - Unsigned 8 bit integer
Offset	Is not used.
Bit Number	Bit number.

Motor

Set motor.

MOTOR INFORMATION

Motor information:

Parameter	Description
`MotorInfos`	Call up motor information.
`[IN] MOTOR`	Index of the motor: `1` - `4`
`[OUT] SPEED`	Current speed.
`[OUT] TACHO`	Current number of revolutions to display the distance covered.

RUN MOTOR

Run a motor:

Parameter	Description
`Rotate`	Run a motor.
`[IN] MOTOR`	Index of the motor: `1` - `4`
`[IN] START`	Start motor: - `TRUE`: Motor is started. To start, the setting must have previously been set to `FALSE`. - `FALSE`: Motor is not started.
`[IN] POWER`	Force to be applied: - `−255` to `−1`: Backwards. - `0`: Stop. - `1` to `255`: Forward.
`[OUT] RUNNING`	`TRUE` if the motor is running.
`[OUT] SPEED`	Current speed.

Run several motors:

Parameter	Description
Rotate2	Run several motors.
[IN] MOTORS	Index of the motor numbers. - Motor 1: 1 - Motor 2: 2 - Motor 3: 4 - Motor 4: 8 Example: To address Motors 1 and 2, enter 3 (1 + 2).
[IN] START	Start motor: - TRUE: Motor is started. To start, the setting must have previously been set to FALSE. - FALSE: Motor is not started.
[IN] POWER	Force to be applied: -255 to -1: Backwards. 0: Stop. 1 to 255: Forward.
[OUT] RUNNING	TRUE if the motor is running.
[OUT] SPEED	Current speed.

ROTATION ANGLE

Rotation angle for a motor:

Parameter	Description
RotateAngel	Rotation angle for a motor.
[IN] MOTORS	Index of the motor: 1 - 4
[IN] START	Start motor: - TRUE: Motor is started. To start, the setting must have previously been set to FALSE. - FALSE: Motor is not started.
[IN] POWER	Force to be applied: - −255 to −1: Backwards. - 0: Stop. - 1 to 255: Forward.
[IN] ANGLE	Angle in degrees.
[IN] BRAKE	Brake. - TRUE: Motor is braked at the end. - FALSE: Motor is not braked.
[OUT] RUNNING	TRUE if the motor is running.
[OUT] SPEED	Current speed.

Angle of rotation for several motors:

Parameter	Description
RotateAngel2	Angle of rotation for several motors.
[IN] MOTORS	Index of the motor numbers. - Motor 1: 1 - Motor 2: 2 - Motor 3: 4 - Motor 4: 8 Example: To address Motors 1 and 2, enter 3 (1 + 2).
[IN] START	Start motor: - TRUE: Motor is started. To start, the setting must have previously been set to FALSE. - FALSE: Motor is not started.
[IN] POWER	Force to be applied: - -255 to -1: Backwards. - 0: Stop. - 1 to 255: Forward.
[IN] ANGLE	Angle in degrees.
[IN] BRAKE	Brake. - TRUE: Motor is braked at the end. - FALSE: Motor is not braked.
[OUT] RUNNING	TRUE if the motor is running.
[OUT] SPEED	Current speed.

SPEED

Speed for a motor:

Parameter	Description
RotateCount	Run a motor for a defined number of counter impulses.
[IN] MOTORS	Index of the motor: 1 - 4
[IN] START	Start motor: ▸ TRUE: Motor is started. To start, the setting must have previously been set to FALSE. ▸ FALSE: Motor is not started.
[IN] POWER	Force to be applied: ▸ −255 to −1: Backwards. ▸ 0: Stop. ▸ 1 to 255: Forward.
[IN] COUNT	Number of rotation impulses.
[IN] BRAKE	Brake. TRUE: Motor is braked at the end. FALSE: Motor is not braked.
[OUT] RUNNING	TRUE if the motor is running.
[OUT] SPEED	Current speed.

Speed for several motors:

Parameter	Description
RotateCount2	Run several motors for a defined number of counter impulses.
[IN] MOTORS	Index of the motor numbers. - Motor 1: 1 - Motor 2: 2 - Motor 3: 4 - Motor 4: 8 Example: To address Motors 1 and 2, enter 3 (1 + 2).
[IN] START	Start motor: - TRUE: Motor is started. To start, the setting must have previously been set to FALSE. - FALSE: Motor is not started.
[IN] POWER	Force to be applied: - -255 to -1: Backwards. - 0: Stop. - 1 to 255: Forward.
[IN] COUNT	Number of rotation impulses.
[IN] BRAKE	Brake. - TRUE: Motor is braked at the end. - FALSE: Motor is not braked.
[OUT] RUNNING	TRUE if the motor is running.
[OUT] SPEED	Current speed.

RUNNING TIME

Running time for a motor:

Parameter	Description
RotateTime	Run a motor for a defined time period.
[IN] MOTORS	Index of the motor: 1 - 4
[IN] START	Start motor: - TRUE: Motor is started. To start, the setting must have previously been set to FALSE. - FALSE: Motor is not started.
[IN] POWER	Force to be applied: - −255 to −1: Backwards. - 0: Stop. - 1 to 255: Forward.
[IN] SECONDS	Time that the motor runs, in seconds.
[IN] BRAKE	Brake. - TRUE: Motor is braked at the end. - FALSE: Motor is not braked.
[OUT] RUNNING	TRUE if the motor is running.
[OUT] SPEED	Current speed.

Speed for several motors:

Parameter	Description
RotateTime2	Run several motors for a defined time period.
[IN] MOTORS	Index of the motor numbers. - Motor 1: 1 - Motor 2: 2 - Motor 3: 4 - Motor 4: 8 Example: To address Motors 1 and 2, enter 3 (1 + 2).
[IN] START	Start motor: - TRUE: Motor is started. To start, the setting must have previously been set to FALSE. - FALSE: Motor is not started.
[IN] POWER	Force to be applied: - -255 to -1: Backwards. - 0: Stop. - 1 to 255: Forward.
[IN] SECONDS	Time that the motors run, in seconds.
[IN] BRAKE	Brake. - TRUE: Motor is braked at the end. - FALSE: Motor is not braked.
[OUT] RUNNING	TRUE if the motor is running.
[OUT] SPEED	Current speed.

MOTOR POWER OUTPUT

Define the power output for a motor:

Parameter	Description
SetPower	Define the power output for a motor whilst it is turning.
[IN] MOTORS	Index of the motor: 1 - 4
[IN] SET	Define power output: - TRUE: Power output is defined. To do this, the setting must have previously been set to FALSE. - FALSE: Power output is not changed.
[IN] POWER	Force to be applied: - −255 to −1: Backwards. - 0: Stop. - 1 to 255: Forward.

Define power output for several motors:

Parameter	Description
SetPower2	Run several motors for a defined time period.
[IN] MOTORS	Index of the motor numbers. - Motor 1: 1 - Motor 2: 2 - Motor 3: 4 - Motor 4: 8 Example: To address Motors 1 and 2, enter 3 (1 + 2).
[IN] SET	Define power output: - TRUE: Power output is defined. To do this, the setting must have previously been set to FALSE. - FALSE: Power output is not changed.
[IN] POWER	Force to be applied: - −255 to −1: Backwards. - 0: Stop. - 1 to 255: Forward.

STOP MOTOR

Stop a motor:

Parameter	Description
`StopMotor`	Stop a motor.
`[IN] MOTOR`	Index of the motor: 1 - 4
`[IN] STOP`	Motor is stopped.

Stop several motors:

Parameter	Description
`StopMotor2`	Stop several motors.
`[IN] MOTORS`	Index of the motor numbers. Motor 1: 1 Motor 2: 2 Motor 3: 4 Motor 4: 8 Example: To address Motors 1 and 2, enter 3 (1 + 2).
`[IN] STOP`	Motors are stopped.

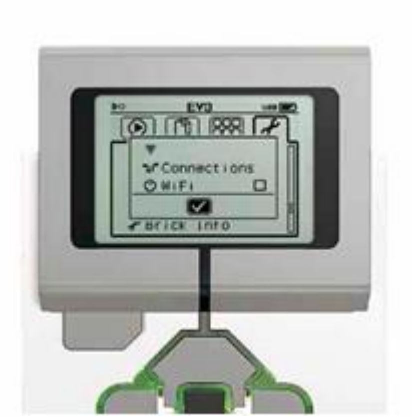
4.5 Connect EV3 to zenon Logic Editor

LEGO MINDSTORMS EV3 and zenon Logic communicate via Wi-Fi.

To establish communication:

1. Insert the **Netgear WNA1100 Wi-Fi Dongle** into the USB port of the Brick.
2. Switch on the Wi-Fi on the LEGO MINDSTORMS EV3.
   To do this:
   a) Open the **Settings** tab (tool symbol).
   b) Activate the **Wi-Fi**.

3. Connect to your network.



You can find further information about Wi-Fi in your LEGO MINDSTORMS EV3 instructions.

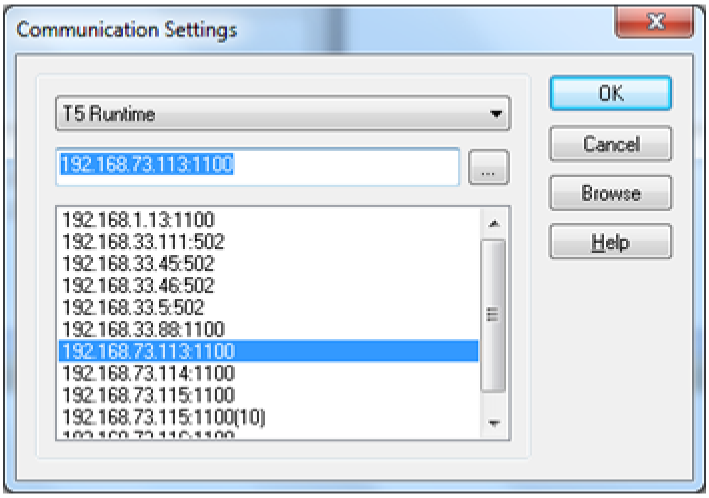
4. Define the IP address of the LEGO MINDSTORMS EV3 in zenon Logic Editor.
To do this:

a) Open the **Tools** menu.

b) Select the **Communication parameters** command.

c) The dialog to select the IP address is opened.

d) Select the IP address of the EV3. (See also the First steps in the demo project (on page 64) chapter.)



Communication Settings

T5 Runtime

192.168.73.113:1100

```
192.168.1.13:1100
192.168.33.111:502
192.168.33.45:502
192.168.33.46:502
192.168.33.5:502
192.168.33.88:1100
192.168.73.113:1100
192.168.73.114:1100
192.168.73.115:1100
192.168.73.115:1100(10)
```

Note:
- You can find the correct IP address in the Brick in the **Settings** tab (tool symbol) under **Brick Info**.
- Runtime uses port `1100`.

5. Start the T5 Runtime on the LEGO MINDSTORMS EV3.
To do this:

a) Select, in the **App** tab (arrow symbol) of the Brick, **T5 Runtime**.

b) Press the middle switch on the Brick.

c) Starts the Runtime.

You can now create a new program in the zenon Logic Workbench to control your LEGO MINDSTORMS EV3 with the help of the program.

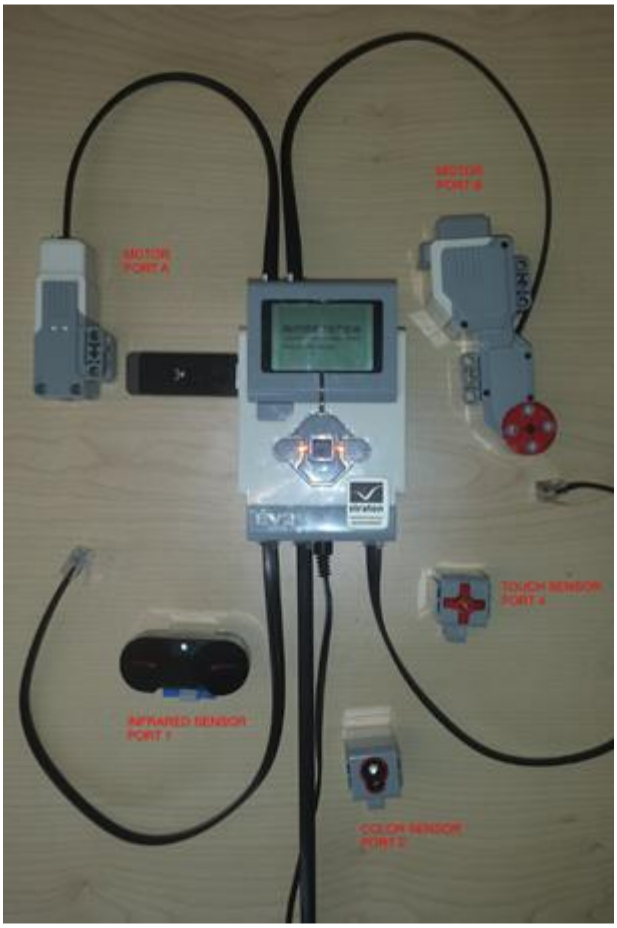
4.6 First steps in the demo project

You can try out the basic functions and configuration of LEGO MINDSTORMS EV3 with zenon and zenon Logic with the supplied demo project.

To do this:

1. Open the demo project called **`EV3_DEMO`** in zenon Editor.

2. Connect the sensors and motors to the corresponding ports.



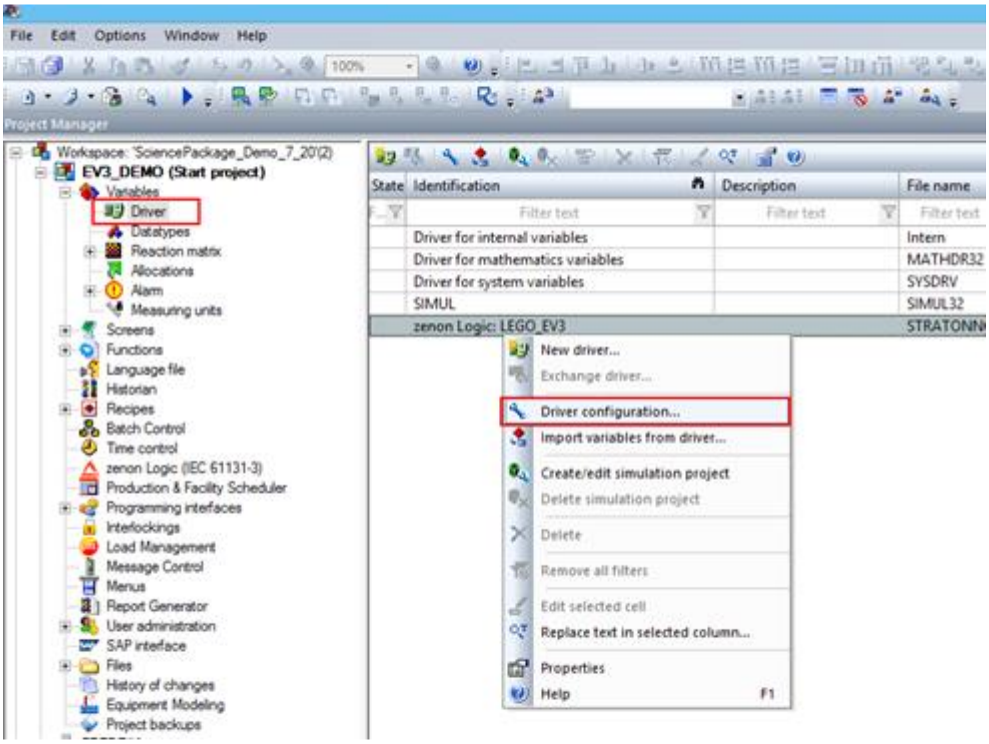
3. Configure the **`zenon Logic: LEGO_EV3`** driver.

CONFIGURING THE DRIVER

To configure the driver:

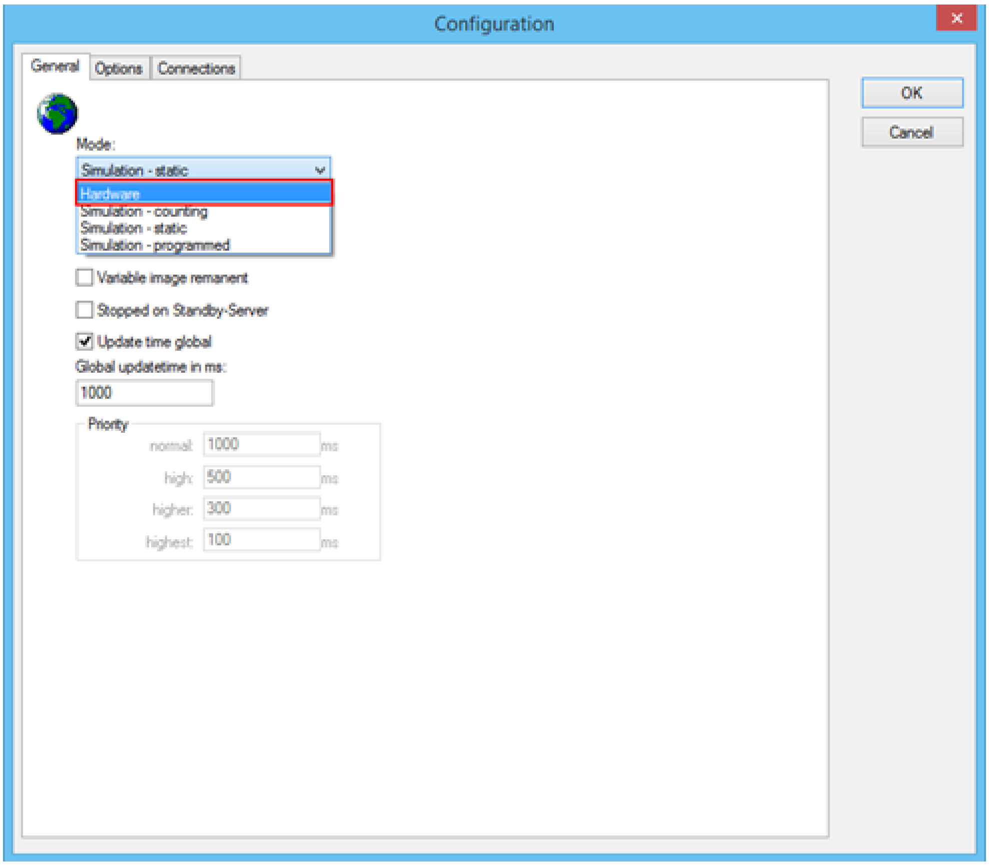
1. In the zenon project, go to the **`Driver`** node (below **`Variables`**).
2. Right-click on the driver **`zenon Logic: LEGO_EV3`**.

3. Select `Driver configuration` in the context menu



State	Identification	Description	File name
F...	Filter text	Filter text	Filter text
	Driver for internal variables		Intern
	Driver for mathematics variables		MATHDR32
	Driver for system variables		SYSDRV
	SIMUL		SIMUL32
	zenon Logic: LEGO_EV3		STRATONN

4. The configuration window will open



Mode:

Simulation - static

- Hardware
- Simulation - counting
- Simulation - static
- Simulation - programmed

☐ Variable image remanent

☐ Stopped on Standby-Server

☑ Update time global

Global updatetime in ms:

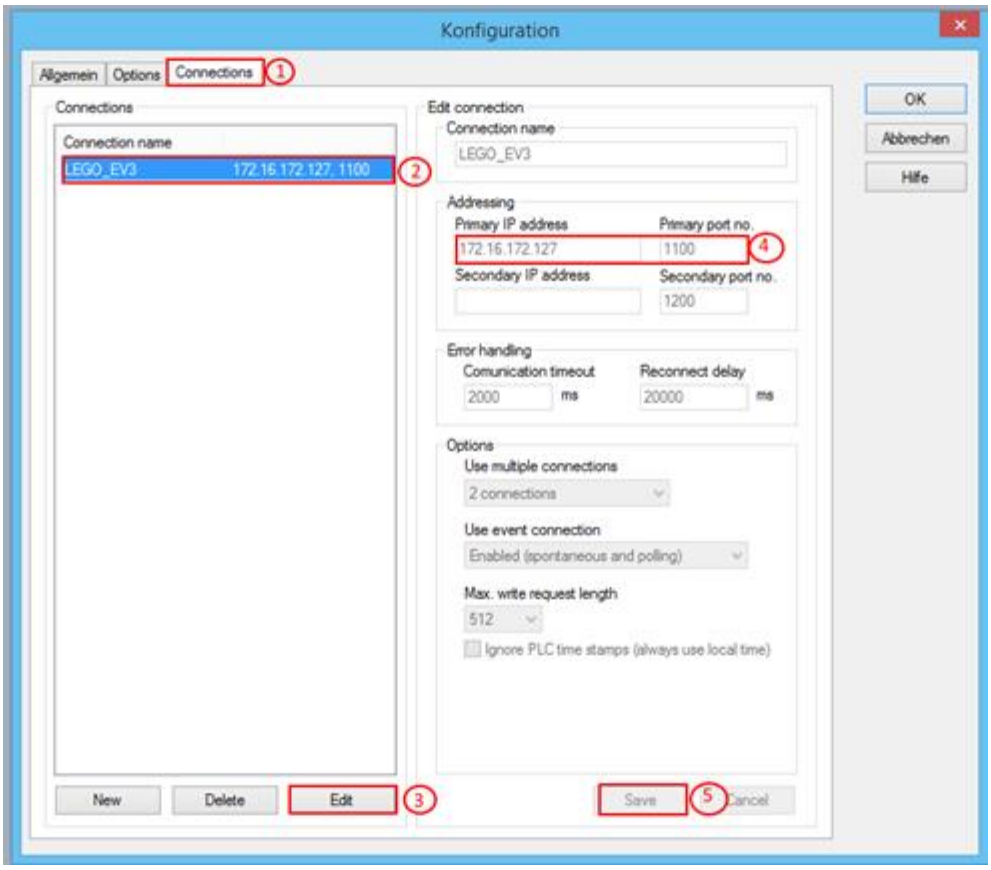
1000

Priority

normal:	1000	ms
high:	500	ms
higher:	300	ms
highest:	100	ms

5. In the `General tab`, select the `Hardware` entry for the **Mode** option.

6. Switch to tab `Connections` (1).



LEGO_EV3 172.16.172.127, 1100

Connection name: LEGO_EV3

Primary IP address: 172.16.172.127

Primary port no.: 1100

Secondary IP address:

Secondary port no.: 1200

Comunication timeout: 2000 ms

Reconnect delay: 20000 ms

Use multiple connections: 2 connections

Use event connection: Enabled (spontaneous and polling)

Max. write request length: 512

□ Ignore PLC time stamps (always use local time)

a) Highlight the `LEGO_EV3` connection (2).

b) Click on `Edit` (3).

c) For the **Primary IP address** option, enter the IP address of your Brick.
You can find the address in the Brick in the `Settings` tab (tool symbol) under `Brick Info`.

d) Change the **Primary port no** option (4) to `1100`.

e) Confirm the input by clicking `Save` (5).

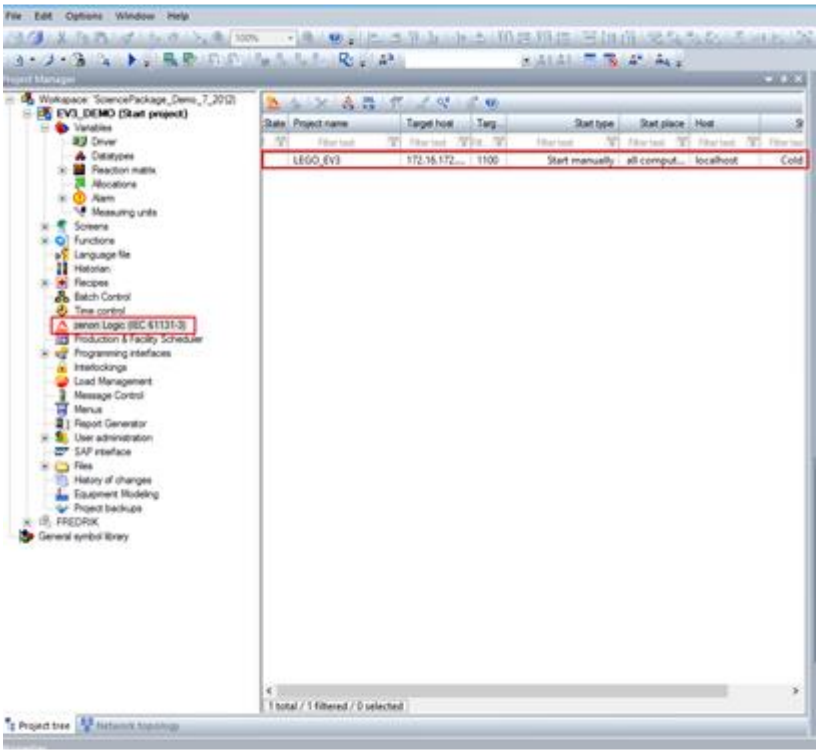
7. Close the window by clicking on `OK`.

CONFIGURE ZENON LOGIC PROJECT AND START RUNTIME

Once you have configured the driver, open the zenon Logic project.
To do this:

1. In the zenon Editor, go to `zenon Logic (IEC 61131-3)`.

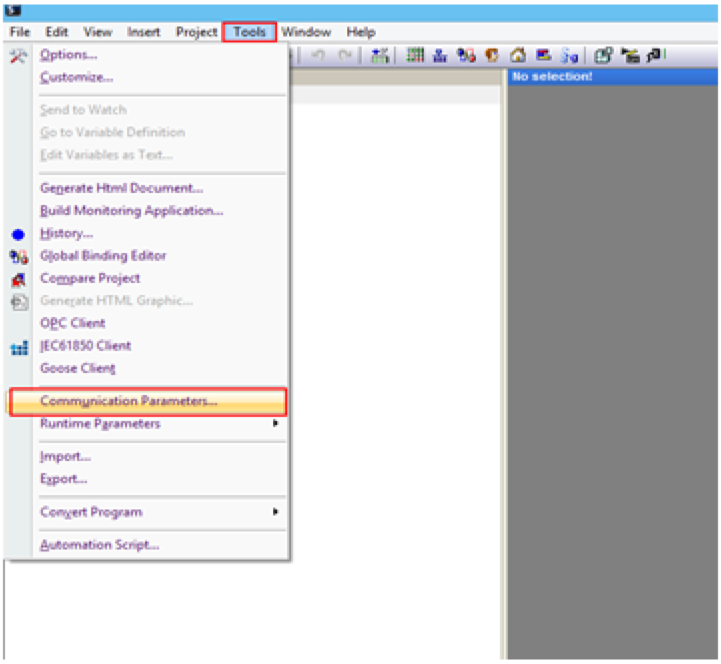
2. Double click on the project



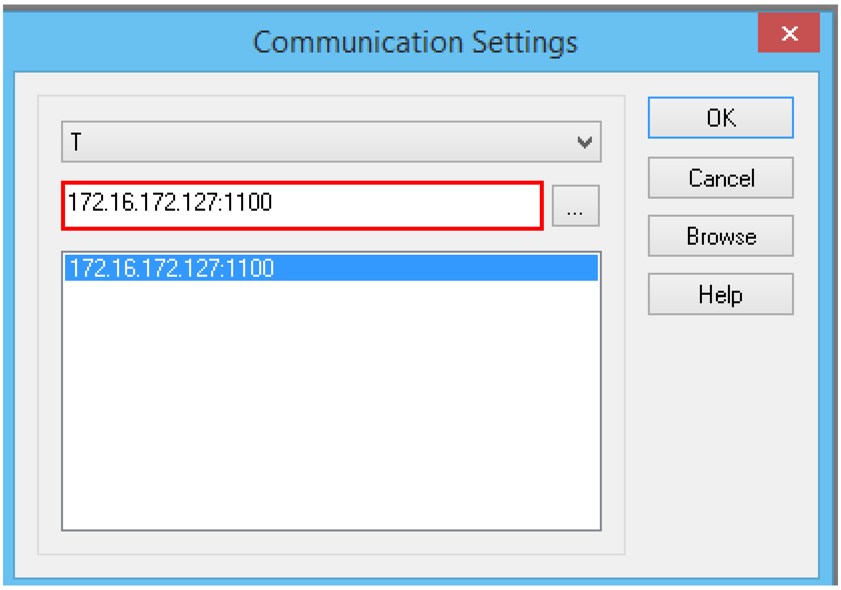
State	Project name	Target host	Targ.	Start type	Start place	Host	St
	LEGO_EV3	172.16.172....	1100	Start manually	all comput...	localhost	Cold

3. Open, in zenon Logic Workbench, the **`Tools`** menu.

4. Click on **`Communication parameters`**.



5. The dialog to configure communication parameters is opened.
   (See also Connect EV3 to zenon Logic Editor (on page 62) chapter.)



172.16.172.127:1100

172.16.172.127:1100

6. Enter the IP address of your LEGO MINDSTORMS EV3 Brick and its port number.
   Format: `IP address port number`.
   You can find the address in the Brick in the **Settings** tab (tool symbol) under **Brick Info**.
   Port number: `1100`.

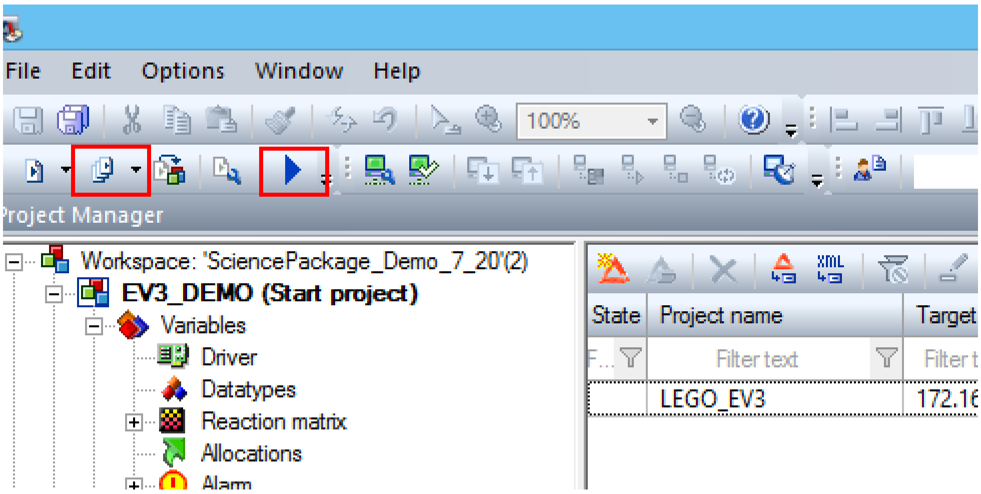
7. Use straton Runtime to connect to the EV3.
   to do this:

   - Open the menu **Project**
   - Select the **Online** entry.
   - Confirm the question after downloading the project with **OK**.
   - Load the project into the EV3.
     (Alternatively: Project -> Download application.)

8. Switch to the zenon Editor

9. In the **Runtime files** tool bar, click on **Create all Runtime files**.

10. Click on `Start Runtime`.



State	Project name	Target
F...	Filter text	Filter t
	LEGO_EV3	172.16

EV3 Runtime is started.

4.7 COPA-DATA Forum

For questions in relation to the zenon Science Package, you can also receive information and support in the Science Package Thread in the COPA-DATA Forum: www.copadata.com/forums (http://www.copadata.com/forums).