

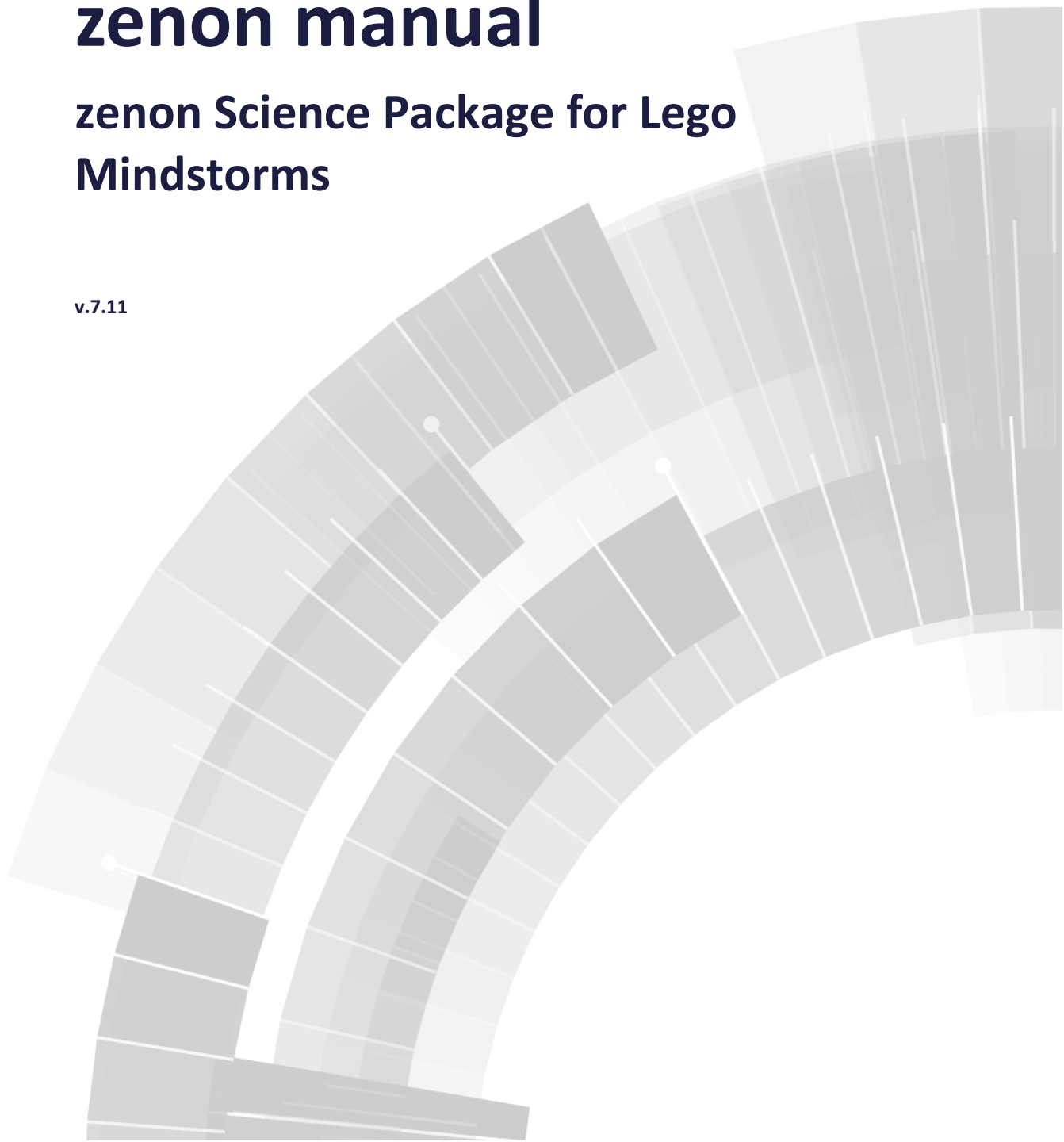


COPADATA
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zenon manual

zenon Science Package for Lego Mindstorms

v.7.11





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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

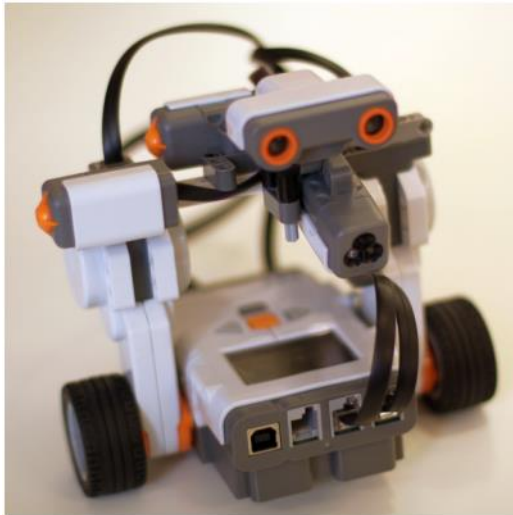
If you find that you need other modules or licenses, our staff will be happy to help you. Email sales@copadata.com (<mailto:sales@copadata.com>).

2. zenon Science Package for Lego MINDSTORMS 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 straton and executed on the LEGO Controller with straton. straton is the programming environment in accordance with IEC 61131-3 included in zenon.

This instruction takes you through the installation and programming for the automation of a LEGO Mindstorms NXT 2.0 object with zenon. Only information with regard to the operation with straton is

contained in this documentation. Please find basic information on the programming and operation of LEGO MINDSTORMS NXT 2.0 objects in the LEGO documentation.



License information

*If **zenon Science Package for LEGO MINDSTORMS 2.0** is used on a system which:*

- ▶ does not yet contain a zenon installation it will run with a limited zenon Science Package License (on page 9)
- ▶ already contains a zenon installation it will run with the already existing corresponding zenon license

All required software is contained on the installation medium "zenon Science Package for LEGO MINDSTORMS 2.0". 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 straton.
- ▶ straton 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 NXT 2.0 Controller with the LEGO Firmware Loader. You can find details in chapter Install firmware (on page 10).
- ▶ USB_DRIVER: This folder contains the INF file for the USB-to-serial driver.



Information

LEGO®, MINDSTORMS® and NXT are trademarks and products of the company LEGO.

3. Installation

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

- ▶ zenon from version 7.00 SP0 on
- ▶ Firmware (on page 10) 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 8). This is a limited License (on page 9) for using LEGO MINDSTORMS 2.0.

3.1 Install zenon

In order to install zenon in 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 7.11
4. follow the instructions of the installation wizard

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

3.1.1 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
- ▶ straton Workbench
- ▶ straton firmware

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

3.2 Demo projects

Two demo projects are included on the installation medium:

- ▶ **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.

If you have installed the Editor by means of the installation medium, the demo project is already located in the working area. If you are using an pre-existing zenon installation, you will find the demo projects on the installation medium in **Science Workspace**. Load the working area with both projects into zenon. To do this:

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 **straton** (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 straton Workbench

3.3 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 12) straton firmware or replace other already existing firmware
- ▶ create a USB connection (on page 13) with the Controller with the COPA-DATA USB driver
- ▶ establish a Bluetooth connection (on page 14) 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 12).*

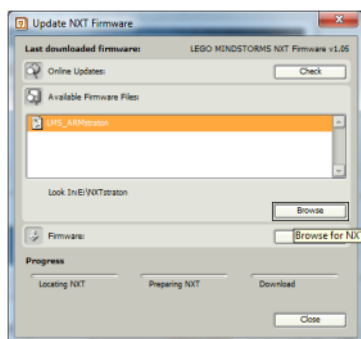
In order to load the firmware:

1. Start the LEGO MINDSTORMS NXT 2.0 software.

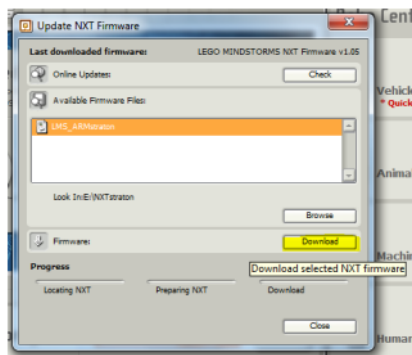
2. In menu *Tools* -> select *Update NXT Firmware*



3. Ensure that the correct format is used: *.**rfw**.
If the file still ends *.**bin** change it to *.**rfw**.
The file should be called **STRATON_NXT_100_2011_0414.rfw** or similar.
4. Click on the **Browse** button.
5. Select the folder containing the firmware.



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.



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 12).*

3.4 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 13) or Bluetooth (on page 14) 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.*

3.4.1 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.

3.5 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`.

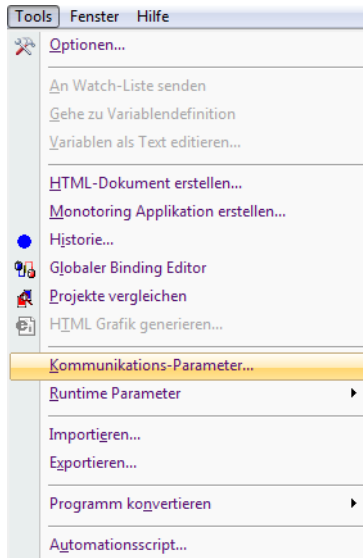
- d) The MINDSTORM Controller requires to enter a password for establishing the connection:
1234_ is suggested. Confirm the password by pressing the orange button.
 - e) The password defined in the MINDSTORMS 2.0 Controller must also be entered on the computer.
 - f) Click on **Next**.
10. The connection 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 straton 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.

4. Create a connection between straton and straton

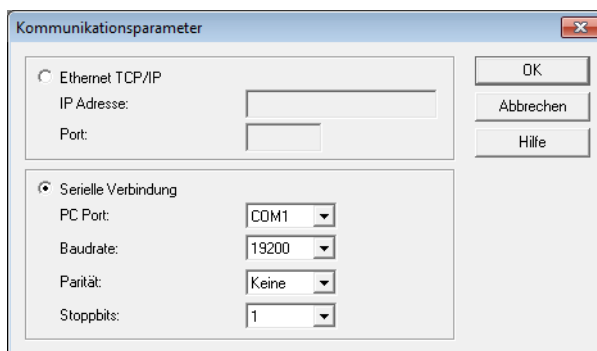
In order to create a connection between straton and straton:

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 straton project by first right-clicking on the node straton and then selecting in the project tree **straton Project new...**
2. Open the straton project by double-clicking in the Workbench.

3. In the straton Workbench click on *Tools* -> *communication parameter*.

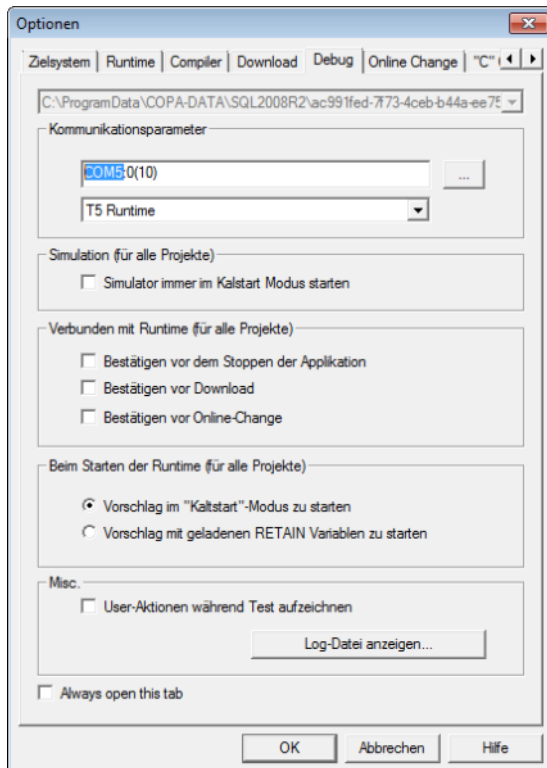


4. The dialog **Options** with the tab **Debug** is opened in order to configure the connection.
5. Click on the button ... in order to open the dialog for the settings of the serial communication.



- 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**.



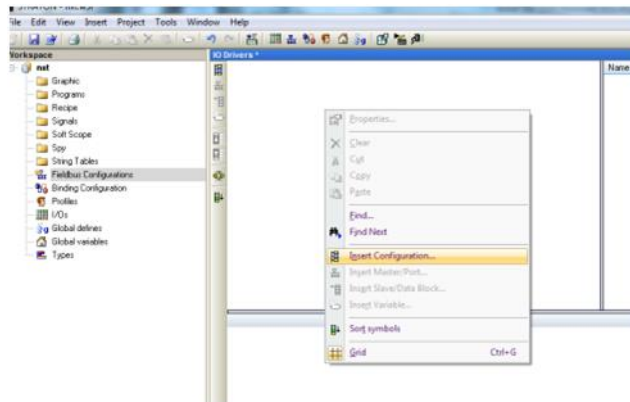
- You will thus have configured the connection between straton and straton.

4.1 Add NXT driver in straton

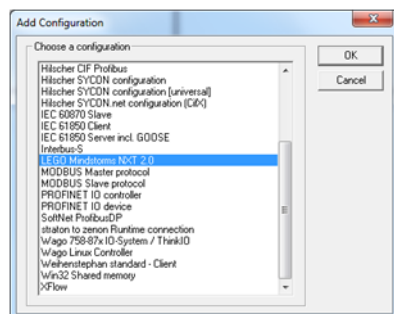
In order to add the NXT driver in straton:

- In the project tree in the straton 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.



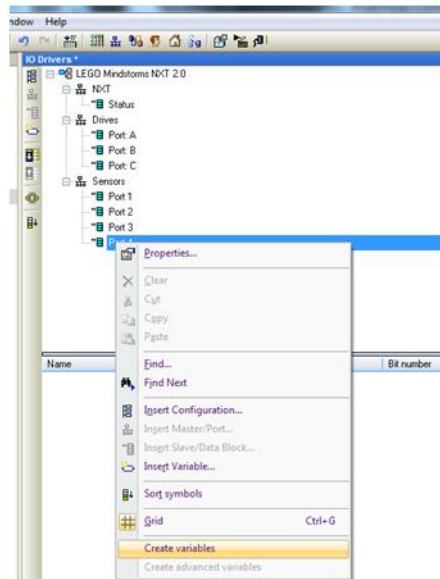
4. Select **LEGO Mindstorms NXT 2.0**.
5. There are three sections:
 - NXT (Status)
 - Drives
 - Sensors

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**.



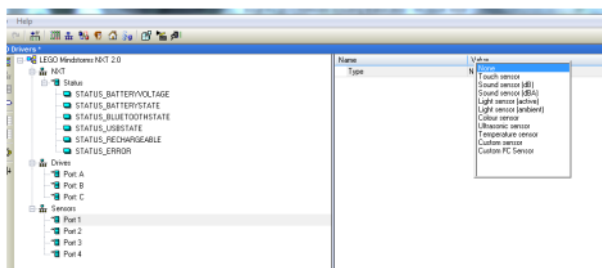
2. Select **Create variable** in the context menu.

DRIVES

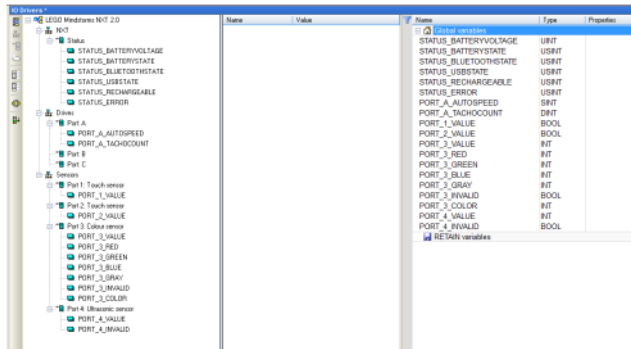
There are two versions: **easy** and **advanced**. As a start it is best to select **easy** and then **Create variable**. Please find more information on the use of Advanced Variables in section Use of complex variables (on page 45).

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:

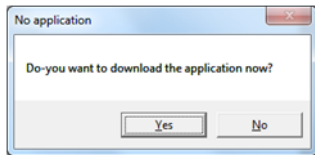


4.2 Connect NXT Controller

In order to connect the NXT Controller:

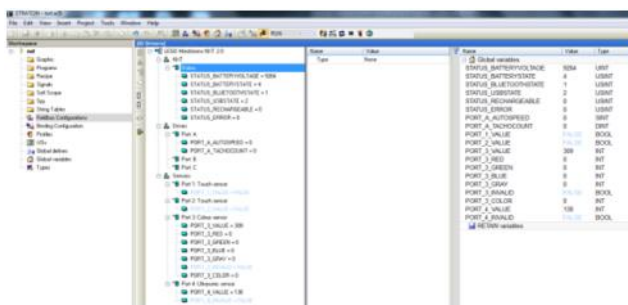
1. On the Controller select **usb** as connection medium:
 - a) Press the orange button.
 - b) Use the gray buttons to go to the menu **Settings** and open it by pressing the orange button.
 - c) Select **Connection**.
 - d) Select **usb**.
(If you would like to connect via Bluetooth select **Bluetooth**.)
2. Compile the straton 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 straton menu **Project**.

b) The request for download is opened:



c) Click on **yes**.

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



4.3 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 straton 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

5. 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**.

STRATON 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 straton and straton (on page 15).)

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.

5.1 Use NXT communication ports

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

With the menu **Settings** (on page 21) 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.

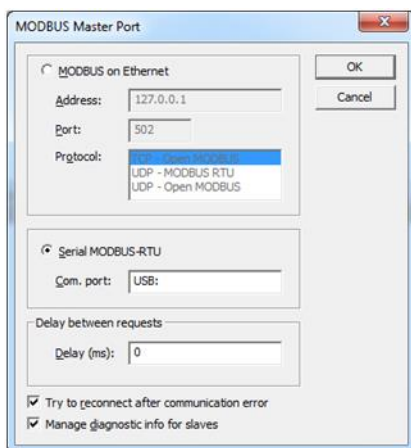
Please find further information on the use of the serial port in the straton program and on the MODBUS I/O driver in the straton documentation. To do so, in the Workbench press the key **F1** or use the menu **Help**.

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

5.1.1 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.



5.1.2 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 21) and manually establish the connection once. For the first contact a pairing is probably required.

5.1.3 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 `rs`. 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:

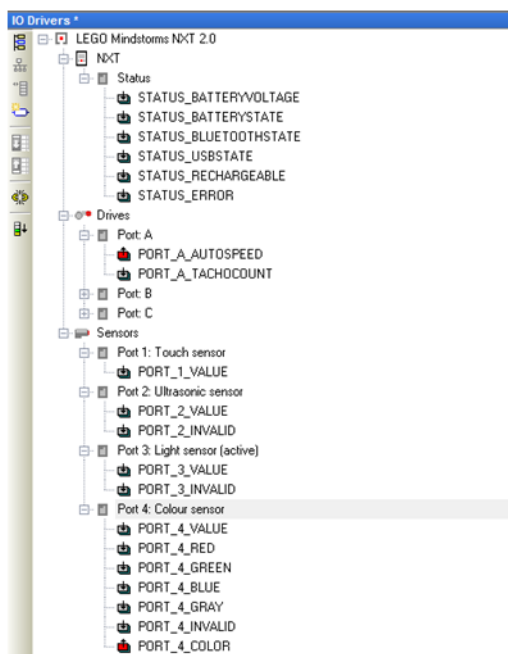
- ▶ Baud rate in bits/s
- ▶ Parity: N (none), E (even), O (odd), M (mark) and S (space)
- ▶ Data bits
- ▶ Stop bit

For example: `rs:19200,N,8,1`

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

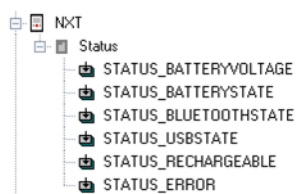
5.1.4 Fieldbus

With straton NXT it is also possible to use the MODBUS Slave and MODBUS Master configuration. Please find information on MODBUS in the straton 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.



Status variables

The following status variables are available:



- ▶ **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 rechargeable 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:



- 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.

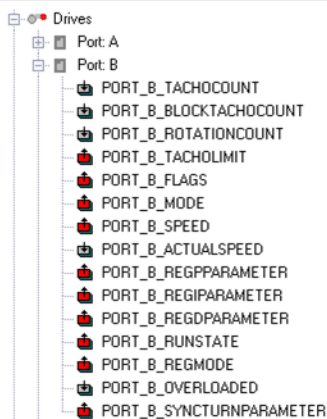
COMPLEX VARIABLES

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



Attention

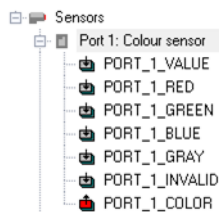
Do not use the AUTOSPEED variable and the Advanced Variables at the same time. Using them at the same time may result in an undefined behaviour of the drive.



Please find a description on how to configure these variables in section Using complex variables (on page 45).

Color sensor variables

The following variables are available for the color recognition:



- ▶ **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.

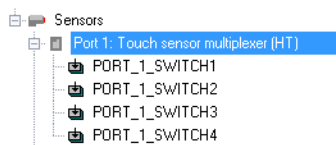
If the mode is `all colors`:

- 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:



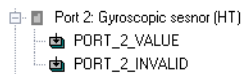
When using the HiTechnic Touch Sensor Multiplexer up to four sensors can be connected with a NXT port:

- 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.

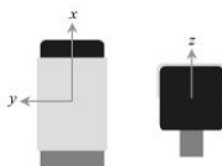
After the start of the straton application the sensor is automatically calibrated during connection. To do so, the current zero value is calculated. This takes about 200 ms. During this period of time the sensor must not be moved.



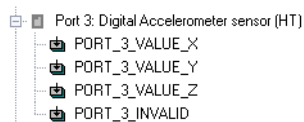
- ▶ PORT_x_VALUE: Number of angular grades per rotation second
- ▶ PORT_x_INVALID: Set to `TRUE` when:
 - the sensor is being calibrated
 - the value cannot be read

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_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.

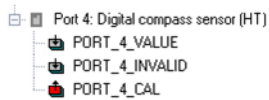
The calibration is optional and usually not required during normal operation. In order to minimize the need to calibrate install the compass in a distance of at least 10 to 15 cm (4 - 6 inches) to NXT and the NXT motors.

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.

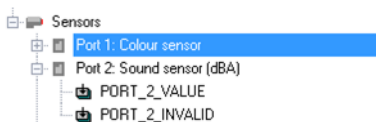


- ▶ PORT_x_VALUE: Current heading in degrees.
- 0: North
- ▶ PORT_x_INVALID: Set to `TRUE` if the data of the sensor cannot be read.
 - ▶ PORT_x_CAL: (Display) Controls the calibration mode.
 - `TRUE` change to calibration mode
 - `FALSE`: change to measuring mode.

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

Other sensors

The following additional variables for sensors are available:



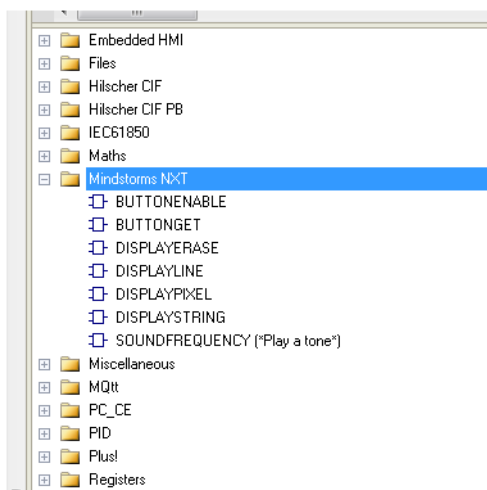
- ▶ PORT_x_VALUE: sensor value, depends on sensor
 - Sound dB
 - Sound dBA
 - Ultrasonic: distance in centimeters (cm)
 - Temperature: temperature in Celsius centigrade (°C/10)
- ▶ PORT_x_INVALID:
 - `TRUE`: sensor is in error status

5.2 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\zenon7.11711\straton\HWDEF\Mindstorms NXT
```



The following functions are available:

- ▶ `BUTTONENABLE` (on page 35): straton takes over control of NXT buttons.
- ▶ `BUTTONGET` (on page 35): Transmits information on which button was pressed.
- ▶ `DISPLAYERASE` (on page 36): Erases screen content.
- ▶ `DISPLAYLINE` (on page 36): Draws a line.
- ▶ `DISPLAYPIXEL` (on page 36): Draws a pixel.
- ▶ `DISPLAYSTRING` (on page 37): Writes a string.
- ▶ `SOUNDFREQUENCY` (on page 37): Sound output.

5.2.1 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 35).

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 35) returns the value `-1`.

Return value:

- ▶ `TRUE`: Activity successfully completed.

5.2.2 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.

5.2.3 DISPLAYERASE

BOOL DISPLAYERASE

Erases the screen contents.

Return value:

- ▶ TRUE: Activity successfully completed.

5.2.4 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

Return value:

- ▶ TRUE: Activity successfully completed.

5.2.5 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

Return value:

- ▶ TRUE: Activity successfully completed.

5.2.6 DISPLAYSTRING

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

Writes a string beginning with the indicated XY position.

Return value:

- ▶ TRUE: Activity successfully completed.

5.2.7 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 21) in the menu **Volume**.

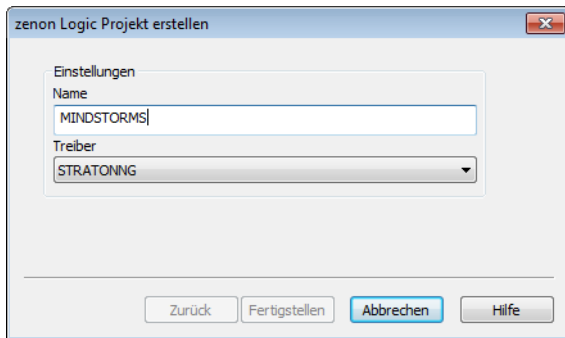
Return value:

- ▶ TRUE: Activity successfully completed.

6. Connect MINDSTORMS 2.0 Runtime with zenon

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

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



Select STRATONNG from the drop-down menu.

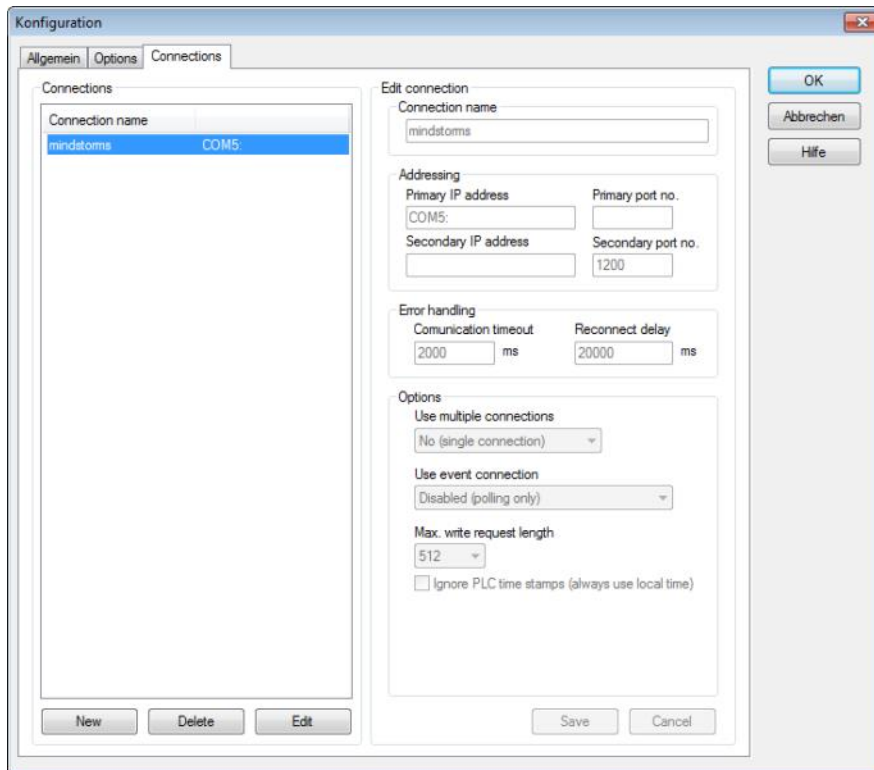
Note: The selection of the driver cannot subsequently be changed again.

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



To edit the driver:

1. highlight the connection name
2. Click on **Edit**.
3. configure the connection
4. click on **save** and then **ok**

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

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

7. Questions and answers

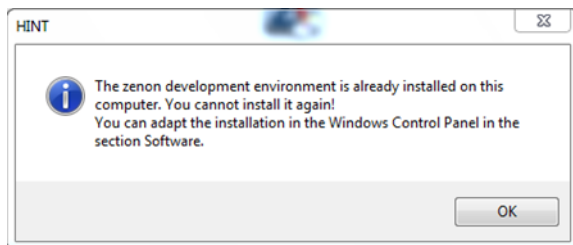
The most common questions regarding installation and operation of LEGO MINDSTORM with straton and the zenon Science Package.

Question	Answer
Why is an error message displayed during installation?	<p>Probably there is already a zenon installation present in the system.</p> <p>Use the existing installation.</p> <p>Details: Error message during the installation of the zenon Science Package (on page 42).</p>
How do I change back to the original LEGO firmware?	<p>Changing back corresponds to the proceeding during the installation of the straton firmware if other firmware already exists.</p> <p>Details: Activate original LEGO firmware (on page 42).</p>
How can I proceed if the LEGO Firmware Loader does not find the Controller?	<p>Change the USB port or re-install its driver.</p> <p>Details: LEGO Firmware Loader does not find the Controller (on page 43).</p>
How do I proceed if the straton Workbench driver does not communicate with my Controller?	<p>This may have several causes. Check the settings and if all devices are online.</p> <p>Details: straton Workbench driver does not communicate with the Controller (on page 44)</p>
How do I proceed if the stratonNG driver does not communicate with my Controller?	<p>This may have several causes. Check the communication parameters, the Runtime and the project.</p> <p>Details: stratonNG driver does not communicate with the Controller (on page 45).</p>

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

7.1 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.



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 9) from the installation medium and continue with Install firmware (on page 10).

7.2 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 13) or Bluetooth (on page 14) 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:

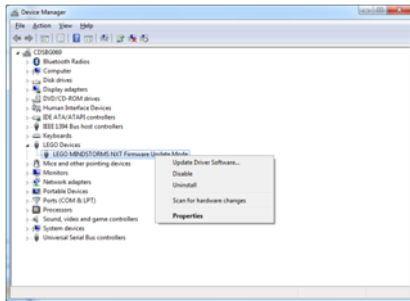
1. Connect the Controller via USB with the computer.
2. Start the LEGO MINDSTORMS NXT 2.0 software.
3. In menu **Tools** select the entry **Update NXT Firmware**.
4. The original LEGO MINDSTORMS NXT firmware is preselected.
5. Click on the button **Download**.
6. The Controller restarts with the original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

7.3 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, uninstall 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.

7.4 straton 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 21).
3. The connection settings for the Controller are not set to the correct medium (USB or Bluetooth). Select the currently used connection.

7.5 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 straton 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 37) of the stratonNG driver is not identical with the name of the straton project.
7. The connection settings for the Controller are not set to the correct medium (USB or Bluetooth).
Select the currently used connection.

8. Use of complex variables

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

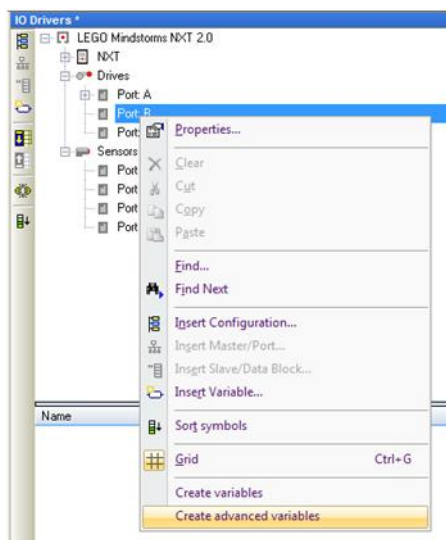


Information

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 straton 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 variable is updated

//Set FLAGS to update all variables
PORT_B_FLAGS := any_to_uint(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_uint(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 turns
PORT_B_RUNSTATE := any_to_usint(MOTOR_RUN_STATE_RUNNING);
```

And finally: PORT_n_SPEED and PORT_n_TACHOLIMIT:

```
//Full force 360 degree forward 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.