Getting started with the P-NUCLEO-IOM01M1 full IO-Link master (PHY plus stack) evaluation board and development system

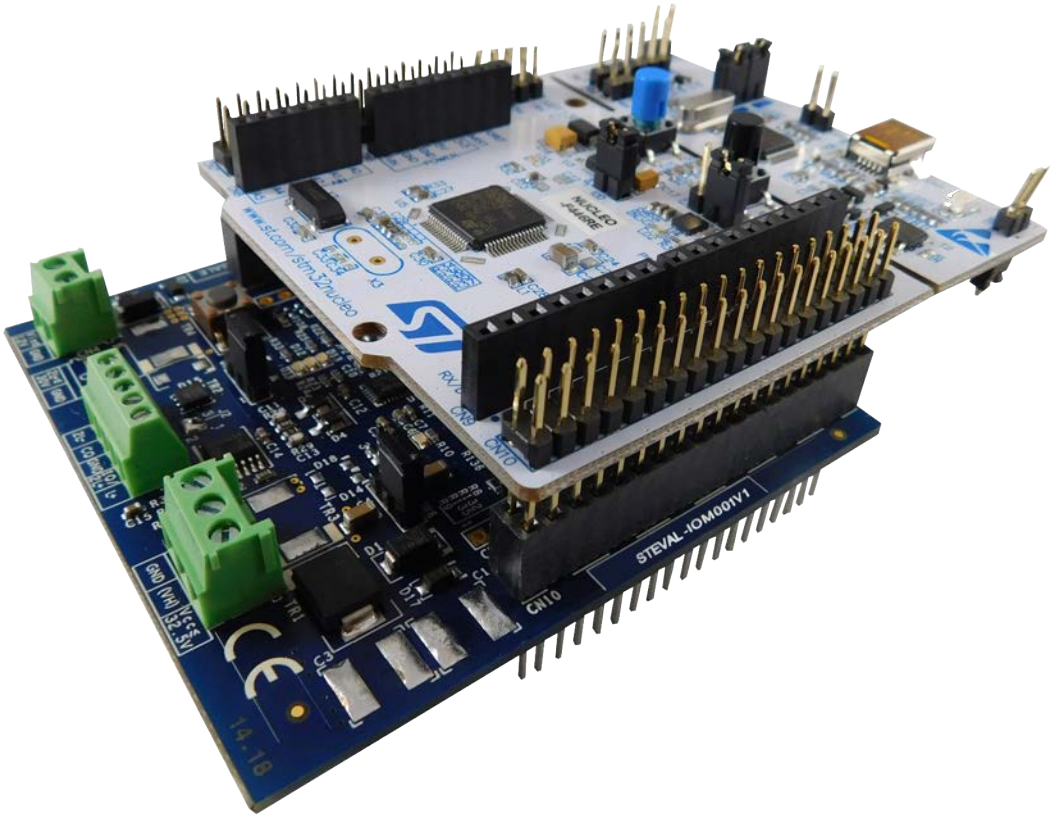
Introduction

The P-NUCLEO-IOM01M1 is an STM32 Nucleo pack composed of the STEVAL-IOM001V1 and the NUCLEO-F446RE boards. The STEVAL-IOM001V1 is a single IO-Link master PHY layer (L6360) while the NUCLEO- F446RE runs an IO-Link stack rev 1.1 (developed by and property of TEConcept GmbH, license limited to 10k minutes, renewable without additional costs).

The STM32 Nucleo pack provides an affordable and easy-to-use solution for the evaluation of IO-Link applications, L6360 communication features and robustness, together with the STM32F446RET6 computation performance. The pack, hosting up to four STEVAL-IOM001V1 to build a quad port IO-Link master, can access the IO-Link physical layer and communicate with IO-Link Devices.

You can evaluate the tool via the dedicated GUI (IO-Link Control Tool©, property of TEConcept GmbH) or use it as an IO-Link master bridge accessible from the dedicated SPI interface: source code of demo project (Low-Level IO-Link Master Access Demo Application, developed by TEConcept GmbH) and API specification are available for free.

Figure 1. P-NUCLEO-IOM01M1 evaluation pack



1 Architecture overview

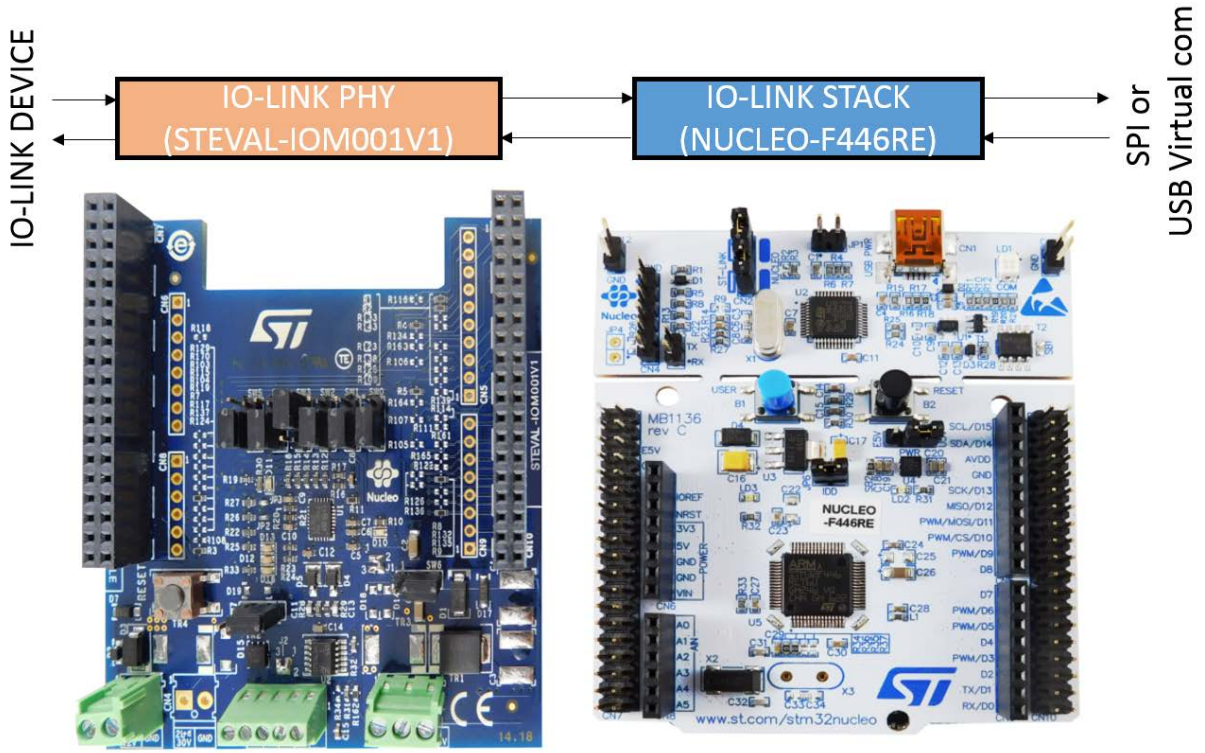
A generic IO-Link system is composed of an IO-Link master and an IO-Link device connected by an unshielded cable. Normally, the IO-Link master is the connection point between the IO-Link device and the automation system.

The IO-Link master is installed in the control cabinet or, as a remote I/O, directly in the field. It can have several IO-Link ports (channels): an IO-Link device can be connected to each port, hence, it is a point-to-point communication and not a fieldbus.

A single port master, as the P-NUCLEO-IOM01M1, can be schematized as the arrangement of two main blocks (see Figure 2. P-NUCLEO-IOM01M1 block details):

- **Control sub-system**: the NUCLEO-F446RE board runs the IO-Link stack and firmware accepting user commands, configuration parameters and controlling the remote IO-Link device. The NUCLEO-F446RE board provides all digital signals to perform the proper control for single and multi-port (up to 4) IO-Link master. You can evaluate the tool via the dedicated GUI (IO-Link Control Tool by TeConcept®) or use it as an IO-Link master bridge accessible from the dedicated SPI interface.
- **IO-Link physical**: the STEVAL-IOM001V1 mounts the ST transceiver L6360, which interfaces with the micro-controller by digital interfaces (I²C for status and configuration; UART for IO-Link data transfer) and the IO-Link device by the IO-Link interface (type A or type B as defined by the standard).

Figure 2. P-NUCLEO-IOM01M1 block details



2 Getting started

2.1 Hardware requirements

To evaluate the system, the hardware requirements are:

- a P-NUCLEO-IOM01M1 (STEVAL-IOM001V1 plus NUCLEO-F446RE)
- a power supply (18-32.5 V)
- a USB cable (type A to mini-B)
- an IO-Link (v1.1) device (e.g. P-NUCLEO-IOD01A1)
- connection cable/wires between IO-Link master and IO-Link device
- a Laptop/PC

The P-NUCLEO-IOM01M1 is a complete single port IO-Link master composed by two application boards (STEVAL-IOM001V1 and NUCLEO-F446RE) connected via the CN7 and CN10 ST morpho connectors.

A power supply (from 18 to 32.5 V) is necessary to supply the STEVAL-IOM001V1 via the CN1 connector, whereas the NUCLEO-F446RE can be supplied by connecting its mini-USB port to your PC/Laptop USB port through a USB type A to mini-B USB cable.

For a full evaluation of the system, an IO-Link device compatible with specification v1.1 (for example, P-NUCLEO-IOD01A1) is also necessary.

The IO-Link master can be controlled by the IO-Link Control Tool (through USB) of TEConcept, or by the SPI interface available on CN7: in this case, a SPI master (for example, another STM32 Nucleo board programmed with Low-Level IO-Link Master Access Demo Application) and the connection wires for SPI signals are necessary (see also Section 3.3 Development system setup).

2.2 Software requirements

To complete the system, you need a PC/laptop with:

- Windows®(version 7 or above)
- STSW-LINK009 driver installed

For system evaluation only:

- IO-Link Control Tool©(property of TEConcept GmbH)
- the IODD file of your IO-Link device

For application development:

- the SPI master control software (Low-Level IO-Link Master Access Demo Application)

2.2.1 Low-Level IO-Link Master Access Demo

The Low-Level IO-Link Master Access Demo application is an example of how to build host application for controlling the IO-Link. It provides low-level functions which make possible basic communication with IO-Link master (for example, to change the IO-Link port configuration, to read or write parameters, etc.).

The Low-Level IO-Link Master Access module has its own abstraction layers that run on different platforms (such as Windows, Linux, Cortex-M) and provides different peripherals for the connection with the IO-Link master (such as SPI, USB Virtual COM port, UART232, etc.).

For details on the control of the IO-Link master from your host application running on an embedded environment, refer to Figure 9. P-NUCLEO-IOM01M1 development system connections.

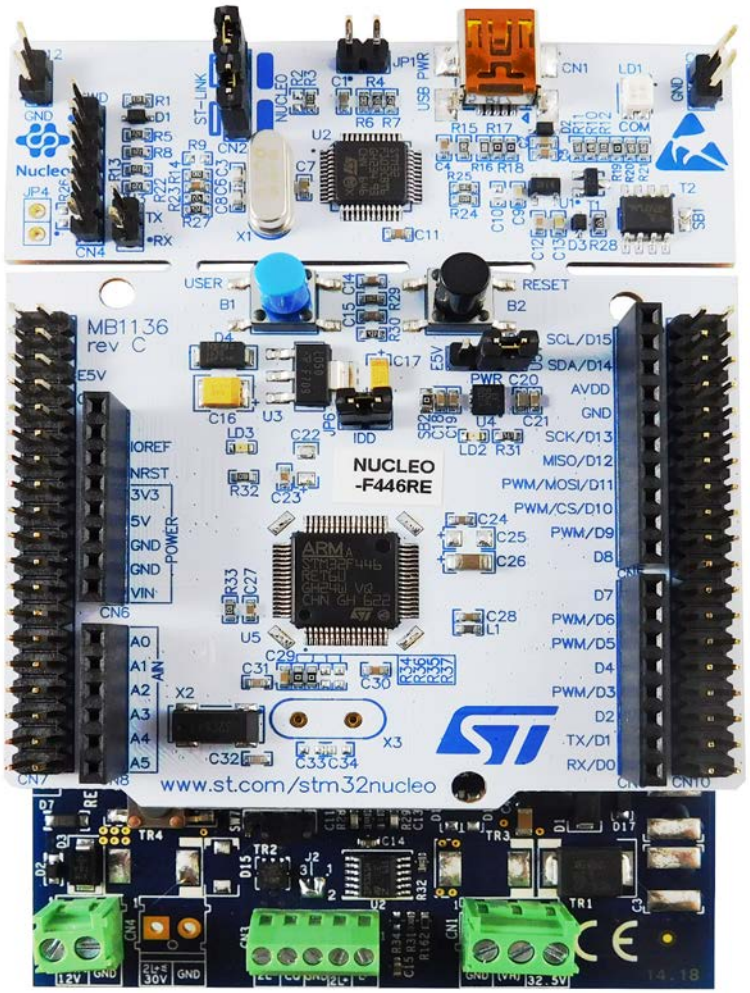
3 How to build and run the IO-Link master

3.1 Single port system evaluation setup

Step 1. Connect the STEVAL-IOM001V1 evaluation board to the NUCLEO-F446RE board through the ST morpho connectors.

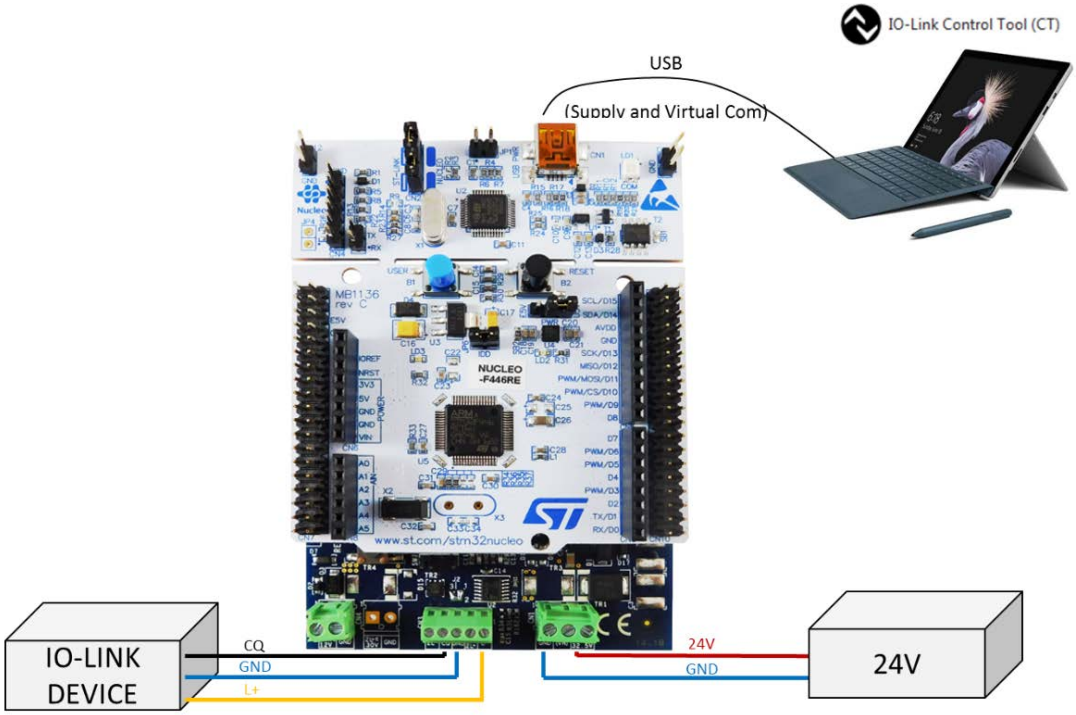
Important:
The STEVAL-IOM001V1 evaluation board must be on the opposite side with respect to the NUCLEO-F446RE board mini-USB connector, as shown in the figure below.

Figure 3. STEVAL-IOM001V1 connected to NUCLEO-F446RE (P-NUCLEO-IOM01M1 stack)



Step 2. Connect the STEVAL-IOM001V1 to the IO-Link device by screwing cables on CN3, taking care of the pin/signal correspondence.

Figure 4. P-NUCLEO-IOM01M1 evaluation system connections

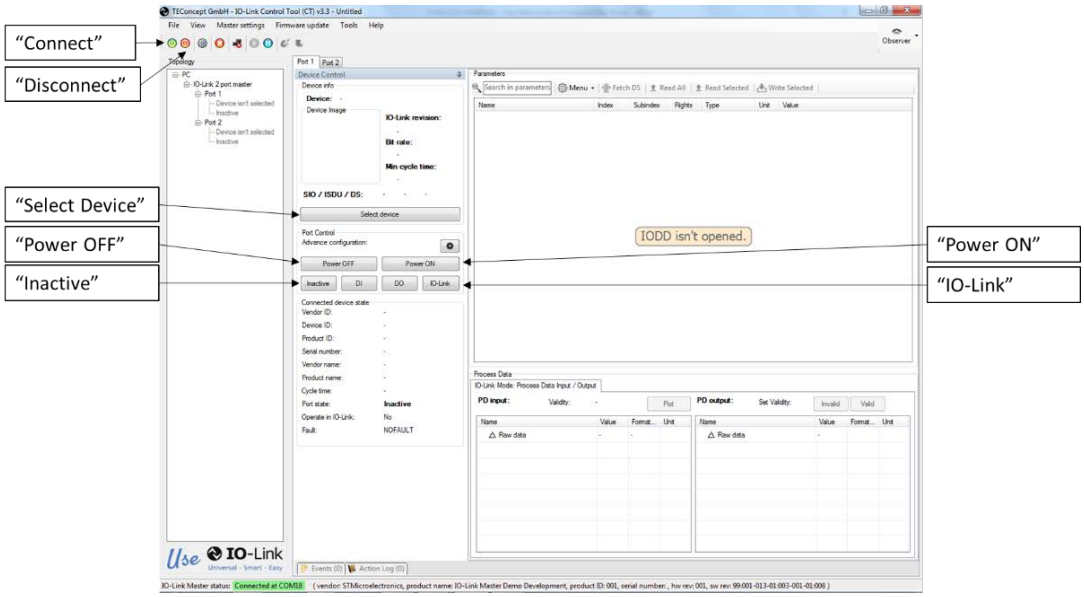


Step 3. Launch the IO-Link Control Tool (CT) on your laptop/PC.

Step 4. Connect the USB cable between the laptop/PC USB port and the P-NUCLEO-IOM01M1 mini-USB port.

Step 5. Click on the Control Tool [**Connect**] button (green icon).

Figure 5. IO-Link Control Tool interface



Step 6. Connect the power supply to the STEVAL-IOM001V1 CN1 connector, taking care of the polarity (refer to Figure 4. P-NUCLEO-IOM01M1 evaluation system connections).

Step 7. Activate the power supply connected to the STEVAL-IOM001V1.

Step 8. Reset the STEVAL-IOM001V1 by clicking the [**reset**] button.

Step 9. Reset the NUCLEO-F446RE by clicking the [**black**] button.

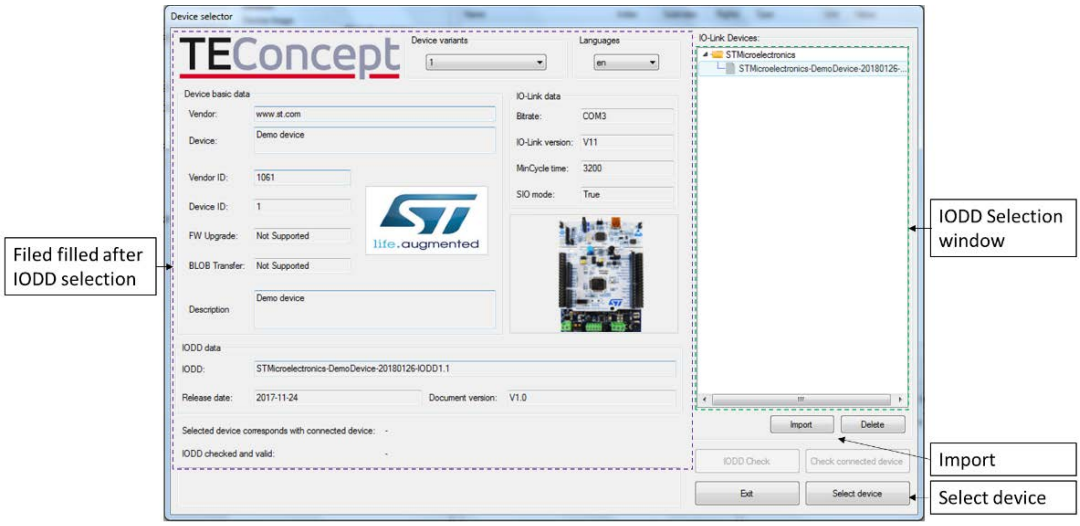
The system is now ready to operate and can be controlled by the IO-Link Control Tool.

Step 10. Click on [**Inactive**] to stop previous data exchange (refer to Figure 5. IO-Link Control Tool interface).

Step 11. Select [**Port 1**] tab and click on [**Power OFF**]: this action drives low the ENL+ signal and L+ line. CN3 does not supply the IO-Link device anymore (refer to Figure 5. IO-Link Control Tool interface).

Step 12. Click on [**Select Device**]: the **Device selector** window appears.

Figure 6. IO-Link Control Tool - IODD selection



Step 13. Select the IODD XML file of your IO-Link device from the list and click [**Select Device**].

The Device selector is then closed.

If the IODD files does not appear in the list, click [**Import**], browse your folders and then click [**Open**] to add the XML file of your IO-Link Device to the list of the Device Selector window.

Step 14. Click on [**Power On**] (ENL+ is turned ON and the IO-Link device is supplied by L+ line).

Step 15. Click on [**IO-Link**] to activate the wake-up request and establish communication with the IO-Link device. The Device Status window shows the connection status (see Figure 7. IO-Link Control Tool - sensor and data format activators)

Step 16. In the **Parameter** tab, open the **Identification** menu and double click on the right side of the **Sensor Activator "var"**: a selection window opens to select the sensor to be activated.

If the P-NUCLEO-IOD01A1 is connected, select [**All sensors are enabled (30)**] and click anywhere outside the window.

Step 17. Click on the [**Sensor Activator**] row and then click on the [**Write Selected**] button to definitively activate the selection.

Step 18. In the **Parameter** tab, double click on the right side of the **Process Data Layout "var"**:

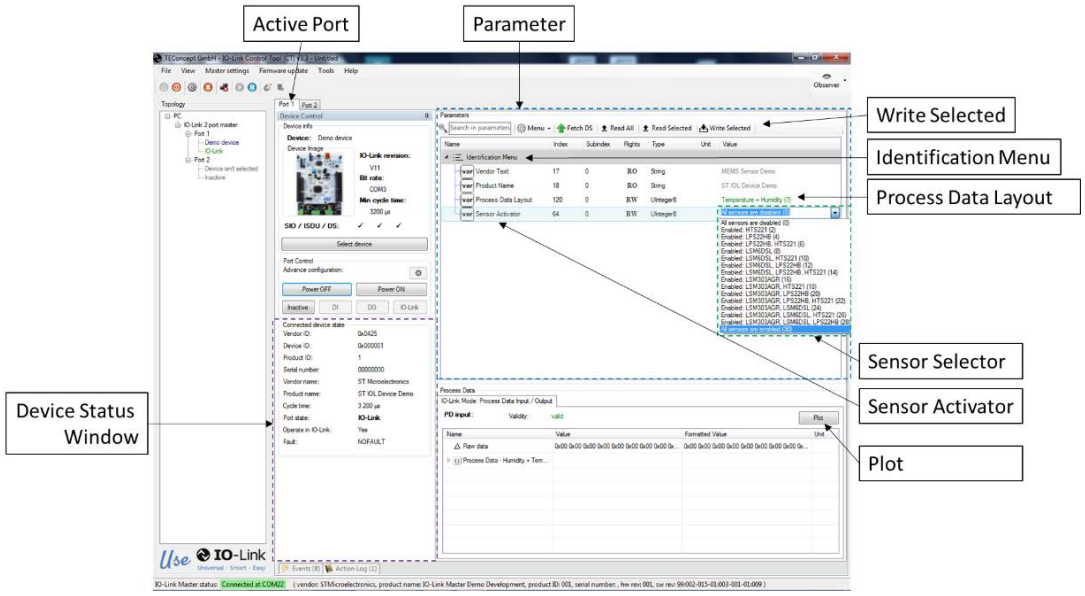
a selection window is open.

Step 19. Select the desired data to display (e.g. "Temperature + Humidity (7)", if P-NUCLEO-IOD01A1 is used) and then click anywhere outside the window.

Step 20. Click on the **Process Data Layout** row and then click on the [**Write Selected**] button to definitively activate the selection.

The selected data start to be transferred from IO-Link device to IO-Link master.

Figure 7. IO-Link Control Tool - sensor and data format activators

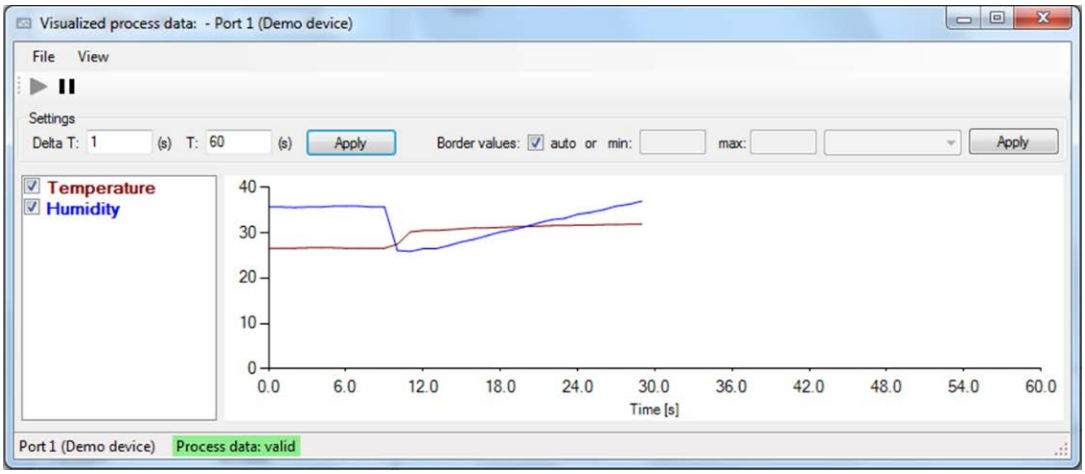


The data transferred from the IO-Link device to the master can be plot by the steps below (except if you are using P-NUCLEO-IOD01A1 and “raw data” were selected).

Step 21. Click on [**Plot**].

A pop-up window appears

Figure 8. IO-Link Control Tool - data plot



Step 22. Edit the time scale according to your preference (e.g. from 600s to 60s).

The plot starts to be filled (sample rate = 1s) with the data sensed by the receiver and received by the master through IO-Link connection. Click on the [**pause**] icon to stop plotting.

Step 23. When the system evaluation is completed, click on [**Inactive**] to stop the data flow.

Step 24. Click on the Control Tool [**Power OFF**] button to stop supplying the IO-Link device.

Step 25. Disconnect the P-NUCLEO-IOM01M1 by clicking on the Control Tool [**Disconnect**] icon, removing the power supply and unplugging the mini-USB cable.

3.2 Multi-port evaluation system setup

By default, the STEVAL-IOM001V1 switches and solder bridges are configured to work as an IO-Link single port.

You can stack up to four STEVAL-IOM001V1 evaluation boards below the same NUCLEO-F446RE to create a quad-port IO-Link master.

To configure the additional ports (from 2 to 4), you have to modify the STEVAL-IOM001V1 configuration according to the instructions reported in Table 1. IO-Link port configuration and Table 2. I²C address setting. After having configured the evaluation board, follow the procedure described in Section 3.1 Single port system evaluation setup for each port (a tab is associated to each IO-Link port).

Table 1. IO-Link port configuration

SIGNAL	SOLDER BRIDGE TO UNMOUNT	IO-Link PORT-2 (I2C address: see Table 4)		IO-Link PORT-3 (I2C address: see Table 4)		IO-Link PORT-4 (I2C address: see Table 4)	
		SOLDER BRIDGE TO MOUNT	CN[pin]	SOLDER BRIDGE TO MOUNT	CN[pin]	SOLDER BRIDGE TO MOUNT	CN[pin]
ENCQ	R3	R143	CN5[6]	R123	CN10[12]	R133	CN10[2]
INCQ	R5	R115	CN8[1]	R105	CN9[7]	R134	CN10[4]
OUTCQ	R9	R119	CN8[2]	R139	CN10[6]	R109	CN5[2]
ENL+	R4	R114	CN9[8]	R124	CN7[35]	R135	CN10[34]
RST	R8	R108	CN8[5]	R128	CN10[16]	R138	CN10[14]
OUTIQ	R106 (1)	R116 (1)	CN10[1]	R126 (1)	CN10[30]	R136 (1)	CN10[28]
IRQ	R7	R117	CN8[4]	R107	CN10[24]	R137	CN7[37]
L+ON	R162	R163	CN5[4]	R164	CN10[22]	R165	CN10[26]

1. *Modification is only required if OUTIQ is used.*

Table 2. I²C address setting

SW2	SW1	SW0	Port address	Note
0	0	0	0x00 (default)	Available
0	0	1	0x01	Available
0	1	0	0x02	Available
0	1	1	0x03	Available
1	0	0	0x04	Reserved
1	0	1	0x05	Reserved
1	1	0	0x06	Reserved
1	1	1	0x07	Reserved

Table 3. Digital signal description

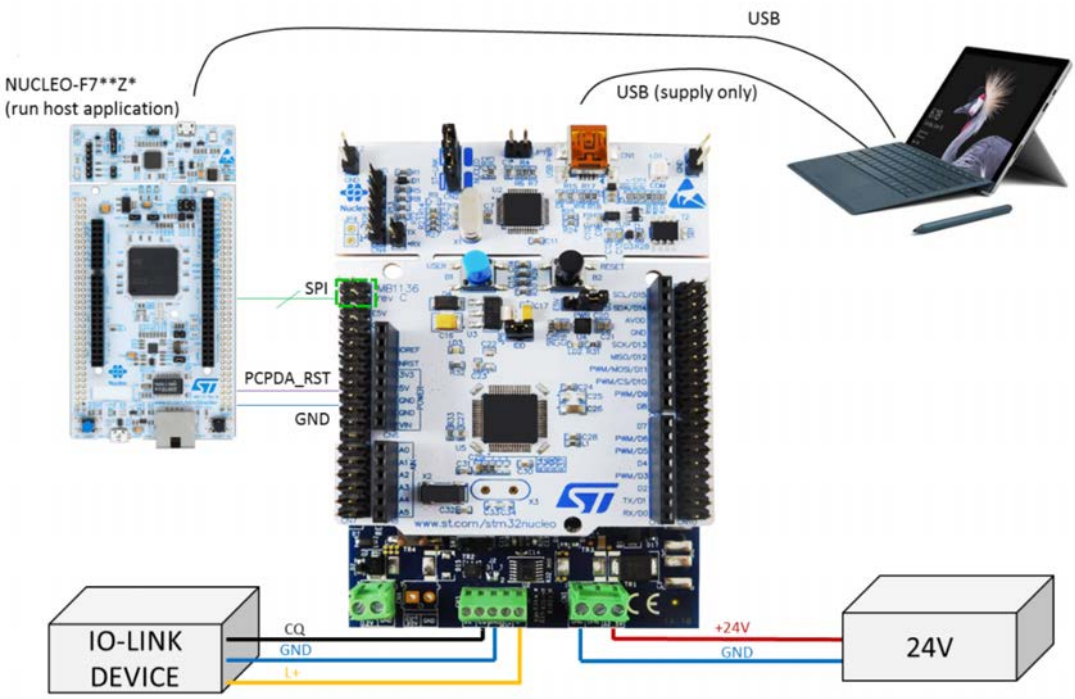
Signal	Functionality
ENL+	GPIO (out) controlling the ENL+ pin of L6360 (U1)
ENCQ	GPIO (out) controlling the ENCQ pin of L6360 (U1)
INCQ	UART (TX) controlling INCQ pin of L6360 (U1)
OUTCQ	UART (RX) controlling OUTCQ pin of L6360 (U1)
SCL	Serial clock line controlling I²C SCL pin of L6360 (U1)
SDA	Serial data line controlling I²C SDA pin of L6360 (U1)

Signal	Functionality
RST	GPIO (out) controlling the RST pin of L6360 (U1)
IRQ	GPIO (externa event) controlling the IRQ pin of L6360 (U1)
OUTIQ	Not used by default, it can be configured on a UART (RX) to control the OUTIQ pin of L6360 (U1)
L+_ON	GPIO (out) controlling the IN pin of IPS161H (U2)
OL-OFF	GPIO (input) controlling the DIAG pin of IPS161H (U2)

3.3 Development system setup

The P-NUCLEO-IOM01M1 provides an SPI interface allowing the user to develop his own application and to use the board as an IO-Link master node. The figure below shows this application architecture.

Figure 9. P-NUCLEO-IOM01M1 development system connections



To control the P-NUCLEO-IOM01M1 by the SPI interface, you need an SPI master peripheral, for example an STM32 NUCLEO-F746ZG running the Low-Level IO-Link Master Access Demo Application.

Both Low-Level IO-Link Master Access Demo Application and the API user guide of the SPI are available for free by contacting info@teconcept.de.

For wire connections, refer to the table below.

Table 4. NUCLEO-F446RE and NUCLEO-F746ZG - SPI and PCPA_RST signal-to-pin correspondence

Signal	NUCLEO-F446RE			NUCLEO-F746ZG			Functionality
	Connector	Pin	Port	Connector	Pin	Port	
SPI_CLK	CN7	1	PC10	CN12	11	PA5	SPI Clock signal
SPI_MISO		2	PC11	CN12	13	PA6	SPI MISO signal (P-NUCLEO-IOM01M1 implements SPI slave)
SPI_MOSI		3	PC12	CN12	15	PA7	SPI MOSI signal (P-NUCLEO-IOM01M1 implements SPI slave)
SPI_CS		4	PA15	CN11	32	PA4	SPI chip select pin
PCPDA_RST		17	PD2	Reserved for High-Level Master Access module			PCPDA reset signal, active only for High-Level Master Access module
GND		8, 19	-	CN12	9, 20	-	Ground

Note: The P-NUCLEO-IOM01M1 signal levels swing between 0 and 3.3 V (the same levels have to be respected by the SPI master interface).

4 Board status and LEDs

The STEVAL-IOM001V1 mounts different LEDs for the board status.

Table 5. STEVAL-IOM001V1 - LED functions

LED	Color	Function
D10	Green	Turns on when the voltage regulator integrated in the L6360 (VDD pin) is active
D11	Red	Turns on when the L6360 forces the IRQ pin low
D12	Yellow	See Table 7. P-NUCLEO-IOM01M1 - LED D12 functionality
D13	Yellow	See Table 6. P-NUCLEO-IOM01M1 - LED D13 functionality
D16	Red	Turns on when the DIAG pin of IPS161H is activated (open load or fault events)

Table 6. P-NUCLEO-IOM01M1 - LED D13 functionality

D13	Port status
OFF	L+ is not powered (→ IO-Link device is not supplied)
ON	L+ is powered (→ IO-Link device is supplied)

Table 7. P-NUCLEO-IOM01M1 - LED D12 functionality

D12	Port status
OFF	Port status is INACTIVE
ON	Port is running in one of the three operating modes: IO-Link, DI or DO
Blinking 2 Hz	Port is in START-UP or PRE-OPERATE state
Blinking 0.5 Hz	Port is in FAULT state

5 Firmware update

The P-NUCLEO-IOM01M1 evaluation pack is sold with the firmware already flashed, but it is anyway possible to update the firmware to its latest version using the IO-Link Control Tool.

Step 1. Download the updated firmware from TEConcept cloud (e-mail: info@teconcept.de to receive your user name and password to access the cloud).

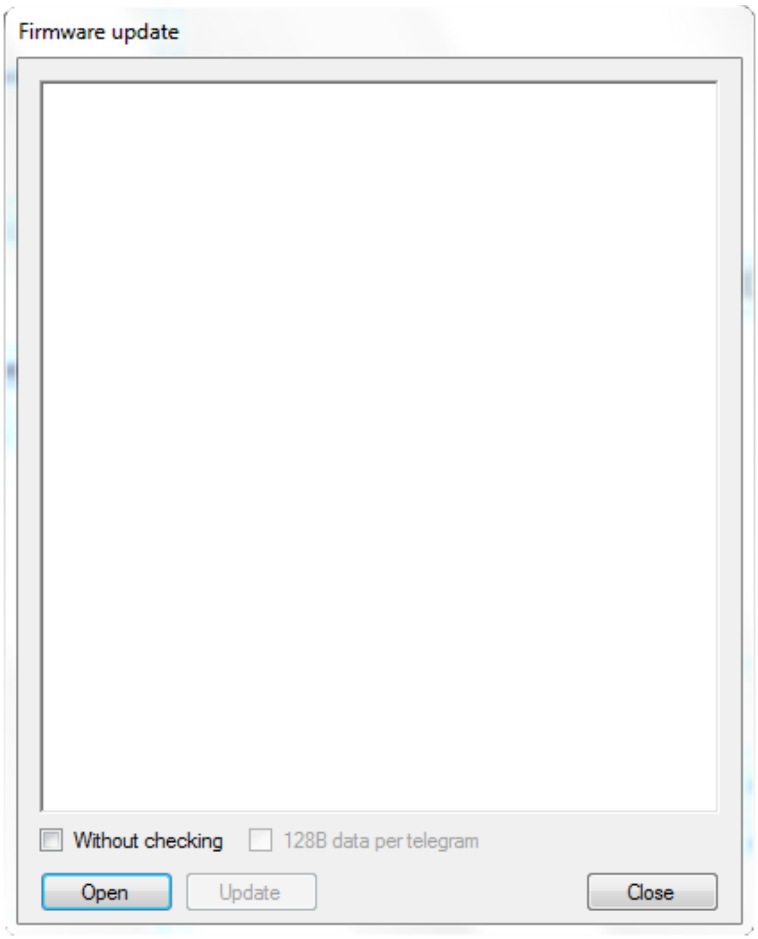
Step 2. Launch the IO-Link Control Tool on your laptop/PC.

Step 3. Connect the USB cable between laptop/PC and the P-NUCLEO-IOM01M1.

Step 4. Click on the [**Connect**] green icon of the CT (see Figure 5. IO-Link Control Tool interface).

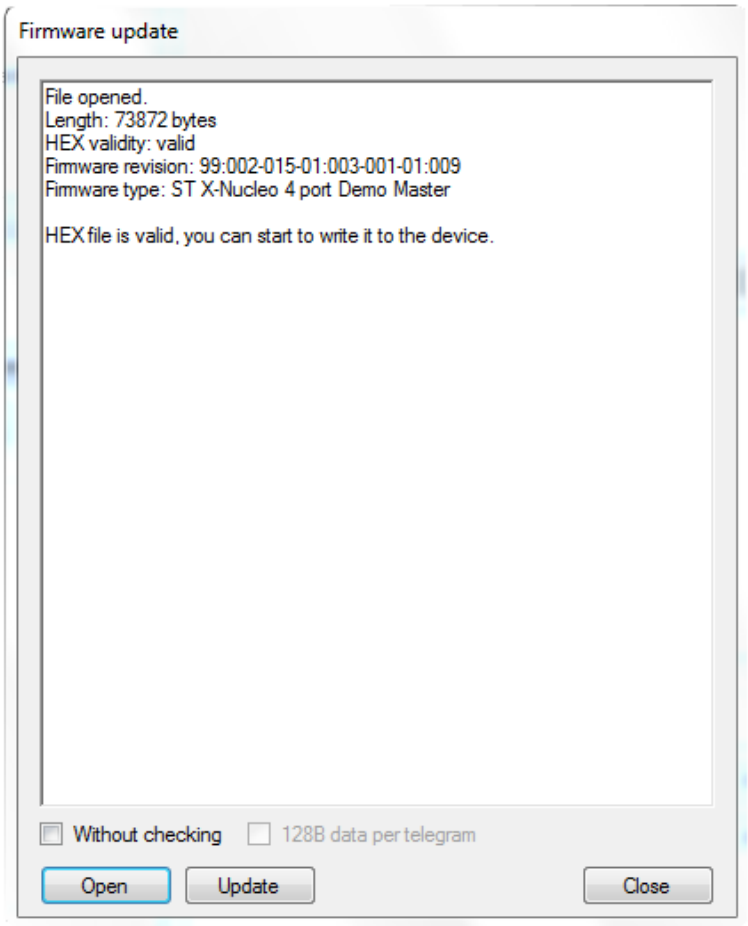
Step 5. Click on [**Firmware update**]>[**Master firmware update/change**].
The firmware update window appears.

Figure 10. Firmware update window - ready to load the firmware



Step 6. Click [**Open**] and browse your folders to select the firmware to flash.
The Firmware update window is now ready to flash the new firmware.

Figure 11. **Firmware update window - ready to flash the firmware**



Step 7. Click on [**Update**] to start the flashing process.

*Note: Do not tick the **Without checking** flag.*

When the flashing procedure finishes, the firmware is automatically reset and the P-NUCLEO-IOM01M1 is disconnected by the Control Tool.

Step 8. Click on the Control Tool green icon to connect again the P-NUCLEO-IOM01M1.

The system is now running the updated firmware and ready to work.

A References

The following resources are freely available on www.st.com.

1. L6360 datasheet
2. IPS161H datasheet
3. P-NUCLEO-IOM01M1 data brief
4. P-NUCLEO-IOM01M1 quick start guide
5. STEVAL-IOM001V1 data brief
6. STEVAL-IOM001V1 user manual
7. P-NUCLEO-IOD01A1 data brief
8. P-NUCLEO-IOD01A1 quick start guide
9. P-NUCLEO-IOD01A1 user manual

The following resources are all freely available on teconcept.de

1. IO-Link Control Tool quick start guide
2. IO-Link API user guide through SPI

Revision history

Table 8. **Document revision history**

Date	Revision	Changes
25-Jun-2018	1	Initial release.
04-Jul-2018	2	Removed schematic diagrams and bill of materials.

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