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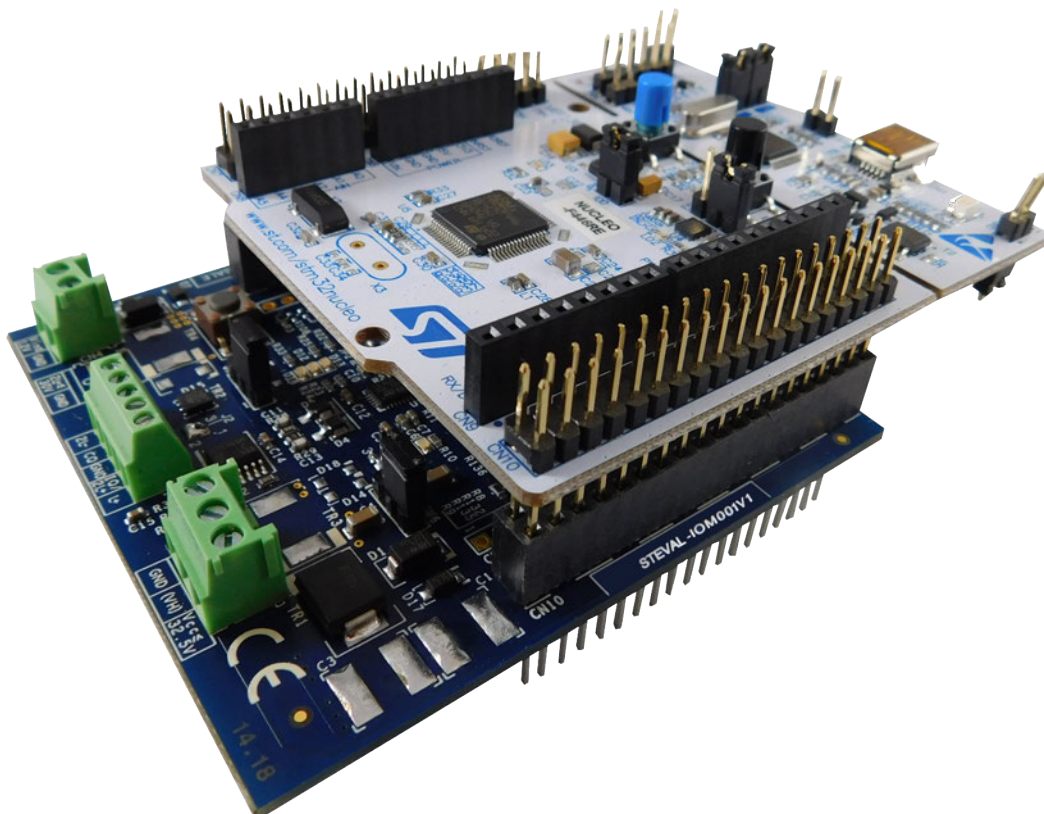
## Introduction

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 v.1.1 (developed by and property of TEConcept GmbH, license limited to 10k minutes, renewable without additional costs). IO-Link stack update is allowed exclusively by following the procedure described in Section 5 Firmware update. Any other erase/ overwrite of the pre-loaded stack makes impossible to restore it.

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**



**UM2421 - Rev 5 - October 2020**
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# 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**
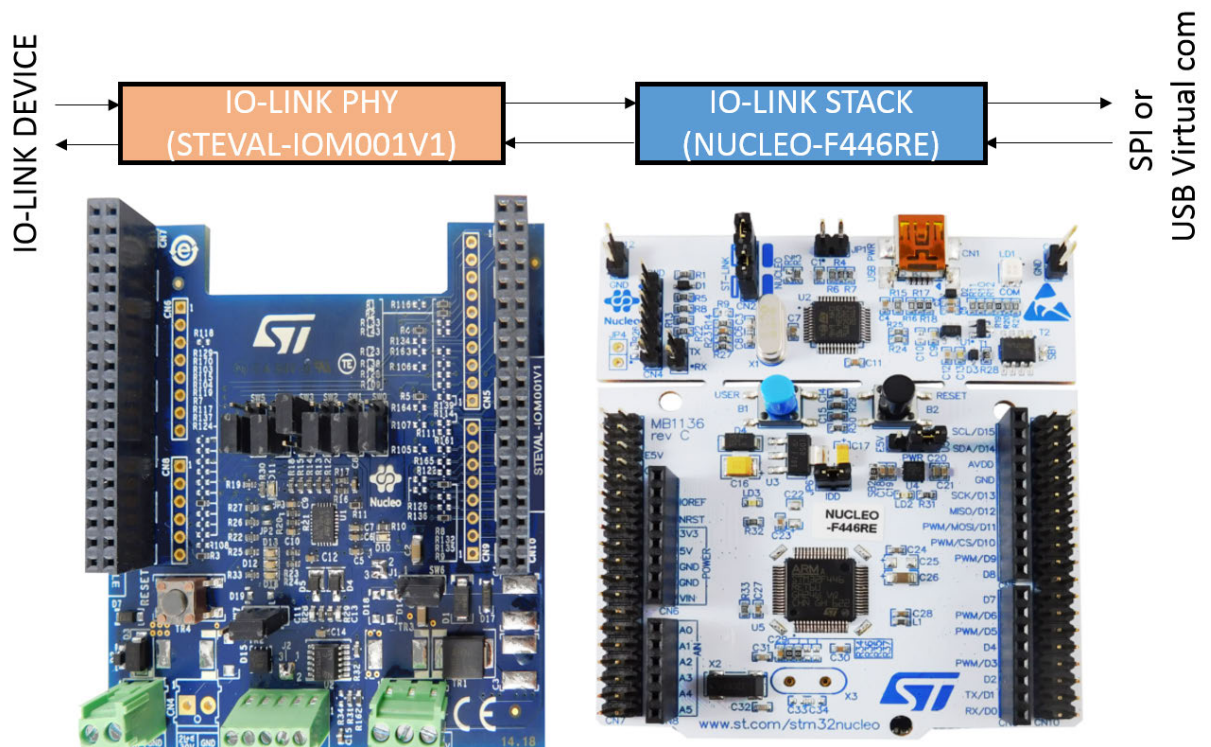
# 2 Getting started

## 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.*

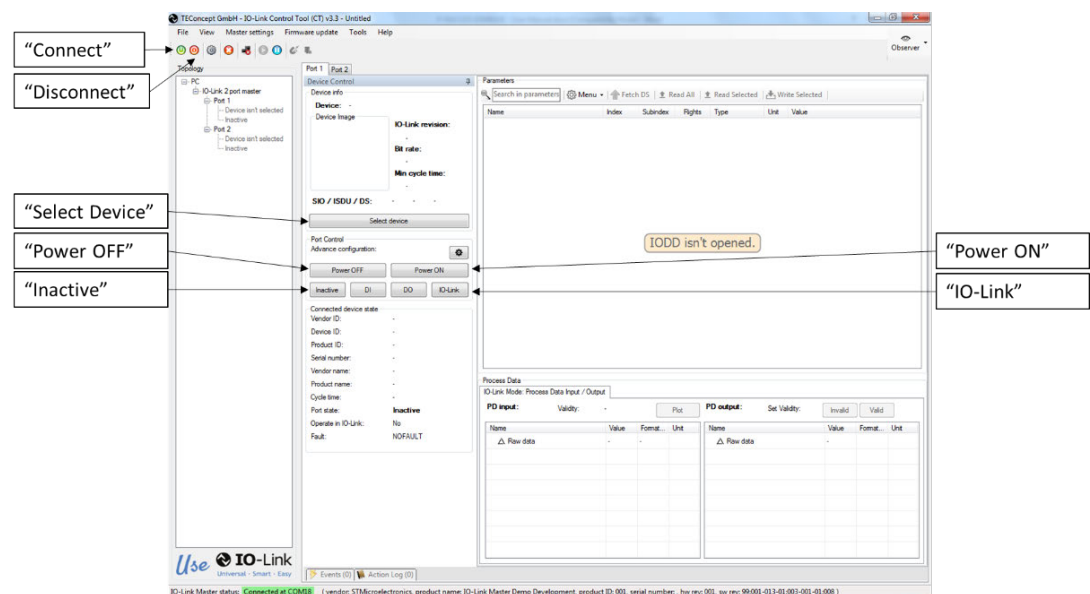**Figure 3. STEVAL-IOM001V1 connected to NUCLEO-F446RE (P-NUCLEO-IOM01M1 stack)**
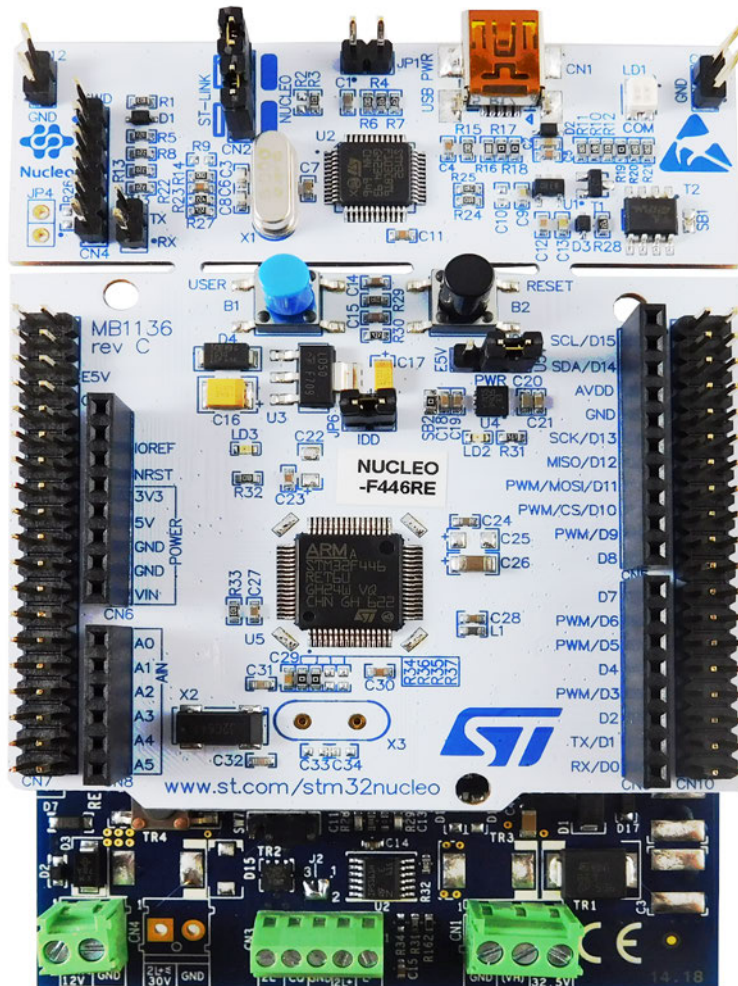
**Step 2.** Connect the STEVAL-IOM001V1 to the IO-Link device by screwing cables on CN3, taking care of the pin/signal correspondence.

**Figure 4. P-NUCLEO-IOM01M1 evaluation system connections**
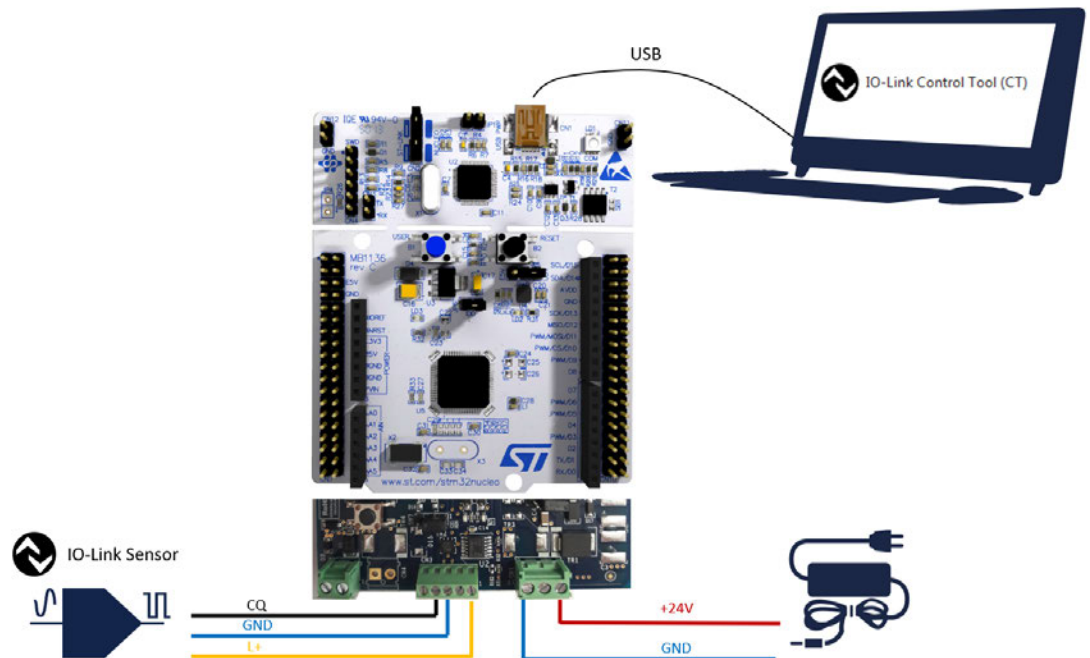


**Step 3.** Launch the IO-Link Control Tool (CT) on your laptop/PC.

**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**
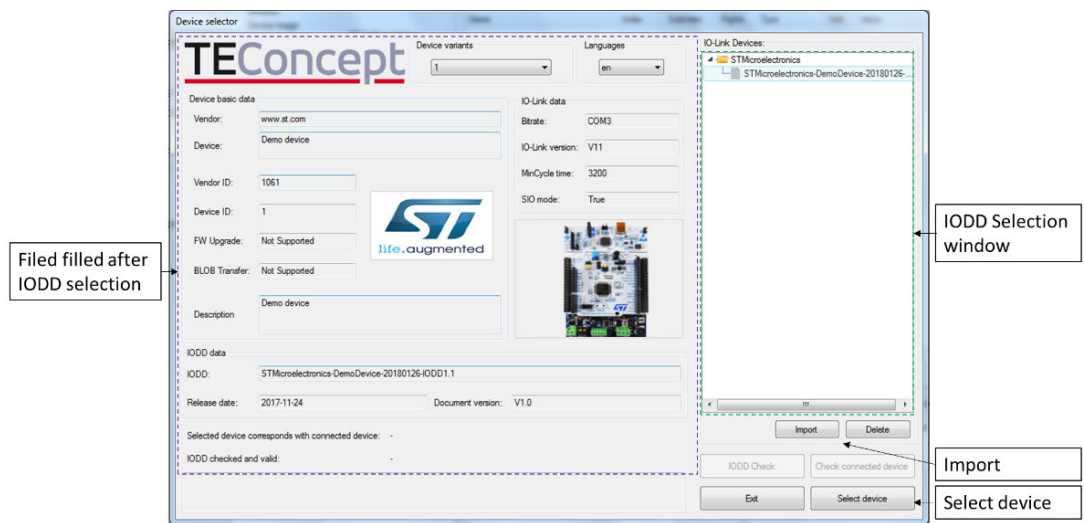


**Step 13.** Select the IODD XML file of your IO-Link device from the list and click [**Select Device**].
The Device selector is then closed.

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.

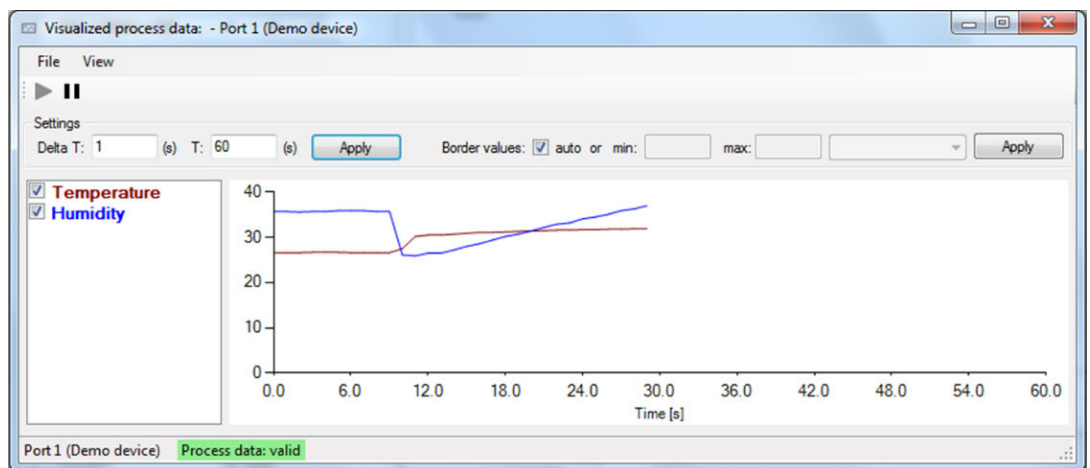**Figure 7. IO-Link Control Tool - sensor and data format activators**
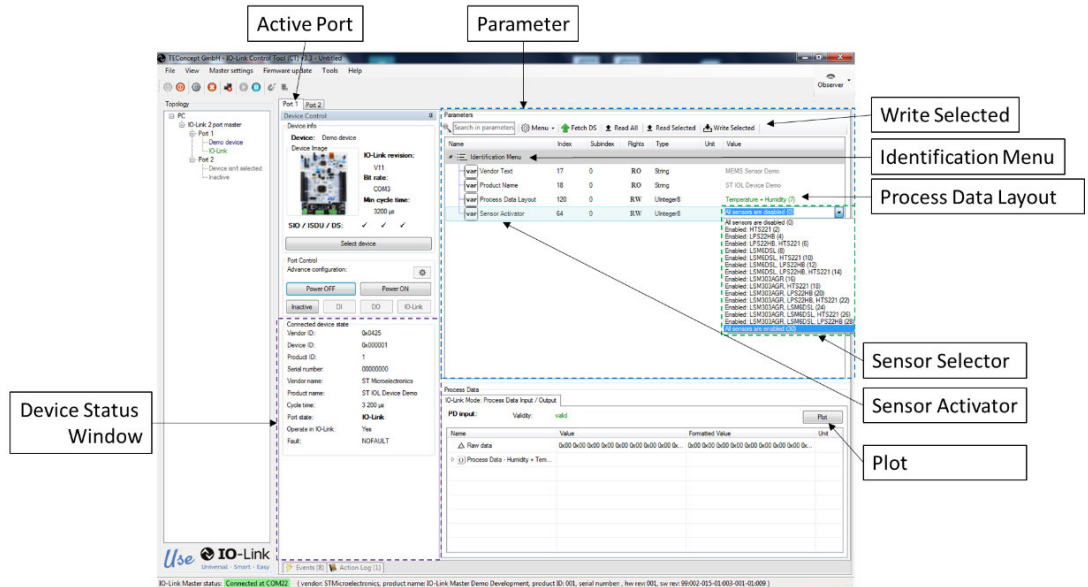


The data transferred from the IO-Link device to the master can be plot by the steps below (except if you are using P-NUCLEO-IOD01A1 and "raw data" were selected).

**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) |
| RST | GPIO (out) controlling the RST pin of L6360 (U1) |
| IRQ | GPIO (external 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**
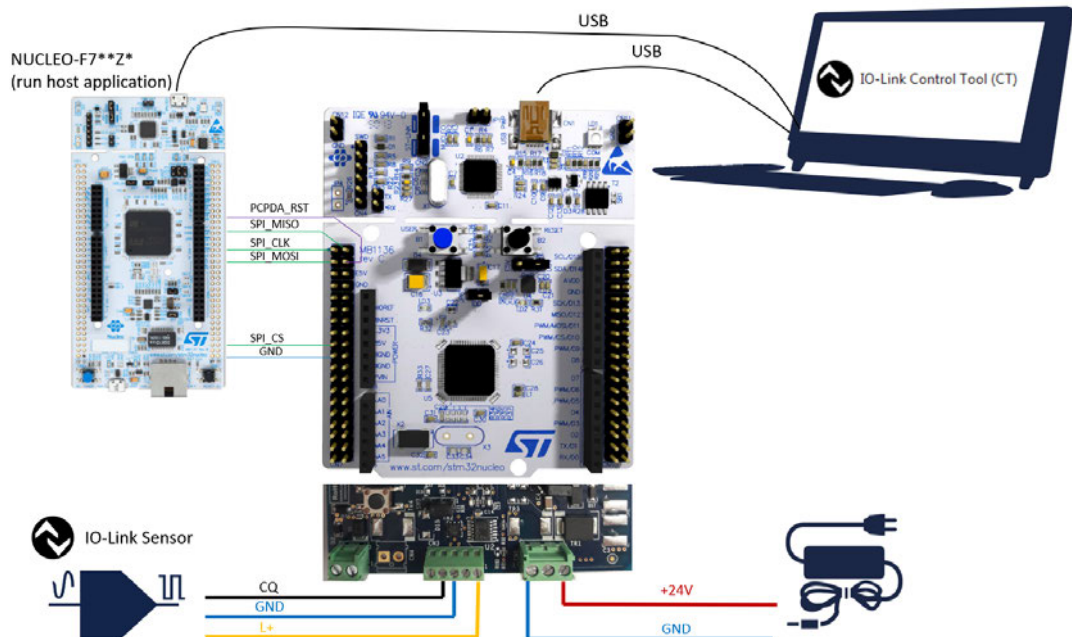


To control the P-NUCLEO-IOM01M1 by the SPI interface, you need an SPI master peripheral, for example an STM32 NUCLEO-F746ZG running the Low-Level IO-Link Master Access Demo Application.

Both Low-Level IO-Link Master Access Demo Application and the API user guide of the SPI are available for free by signing up to http://www.teconcept.de/en/CloudAccess/.

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 | | 17 | PA15 | CN11 | 32 | PA4 | SPI chip select pin |
| PCPDA_RST | | 4 | 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.

The procedure below is the only one allowed: any other erase/overwrite of the preloaded stack makes impossible to restore it.

**Step 1.** Download the updated firmware from TEConcept cloud (http://www.teconcept.de/en/CloudAccess/).

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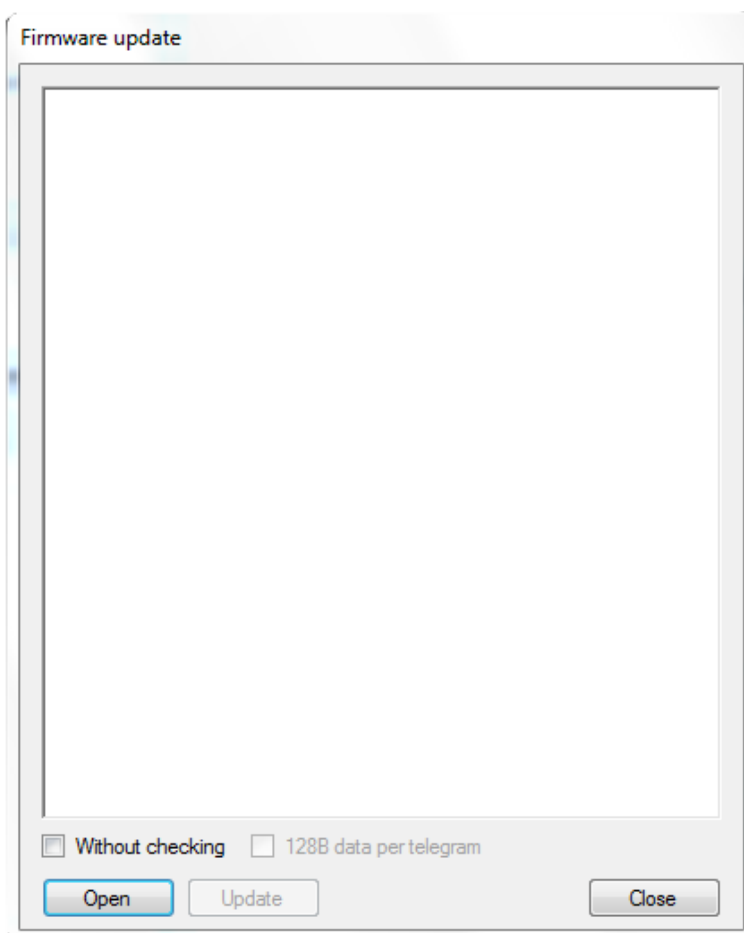
**Step 6.** Click [**Open**] and browse your folders to select the firmware to flash.
The Firmware update window is now ready to flash the new firmware.

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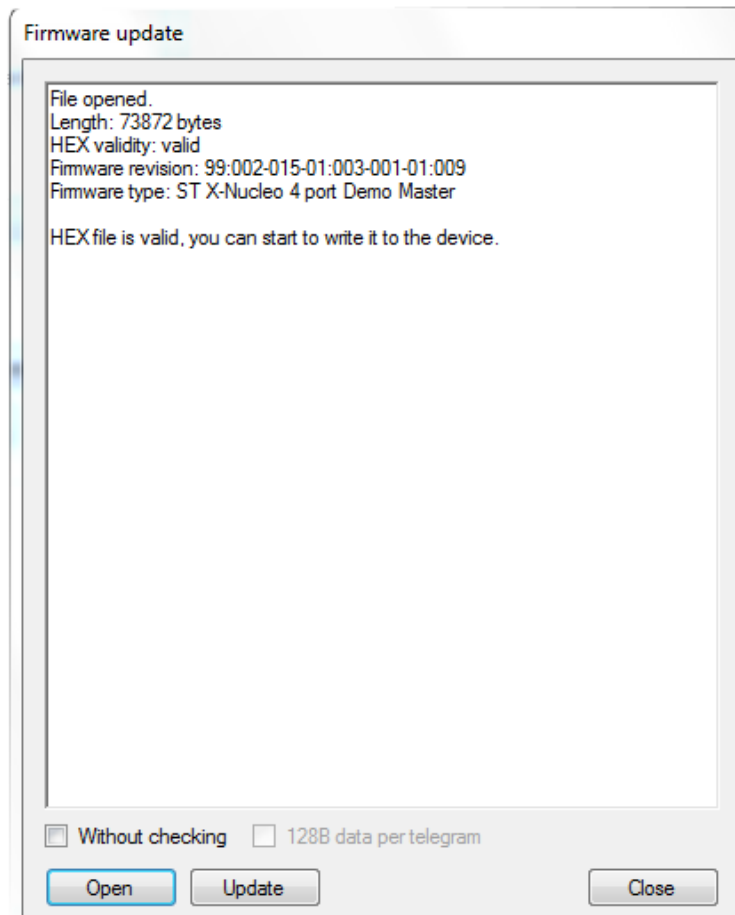


**Step 7.** Click on [**Update**] to start the flashing process.

*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.

# Appendix 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 cloud (http://www.teconcept.de/en/CloudAccess/):

1.  IO-Link Control Tool installation file
2.  IO-Link Master encrypted firmware
3.  IO-Link-Master-Access-Low-Level source code
4.  IO-Link-Master-Access-Low-Level user guide
5.  IO-Link-Master-Access-Low-Level SPI access description

# 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. |
| 30-Jul-2018 | 3 | Updated Section A References. Minot text edits. |
| 02-Mar-2020 | 4 | Updated introduction and Section 5 Firmware update. |
| 27-Oct-2020 | 5 | Updated Section 3.1 Single port system evaluation setup and Section 3.3 Development system setup. |

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