Design Guide: TIDA-010263

IO-Link Device Implementation for Sensors and Actuator Reference Design

Description

This reference design gives an example implementation of an IO-Link device interface. The design includes the IO-Link device physical layer (PHY) including a low-dropout (LDO) as well as a low-power microcontroller. This combination supports IO-Link COM3 transfer rate and a cycle time of 400 µs. The MSPM0 microcontroller integrates an internal oscillator, so the MCU is able to run this application without the need of an external crystal, saving cost and space.

Resources

TIDA-010263	Design Folder
TIOX1X2XEVM	Tool Folder
LP-MSPM0L1306	Tool Folder

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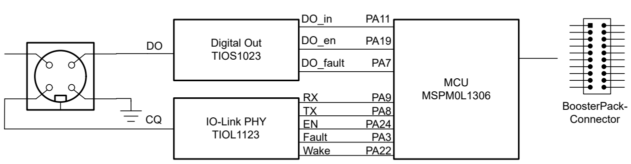
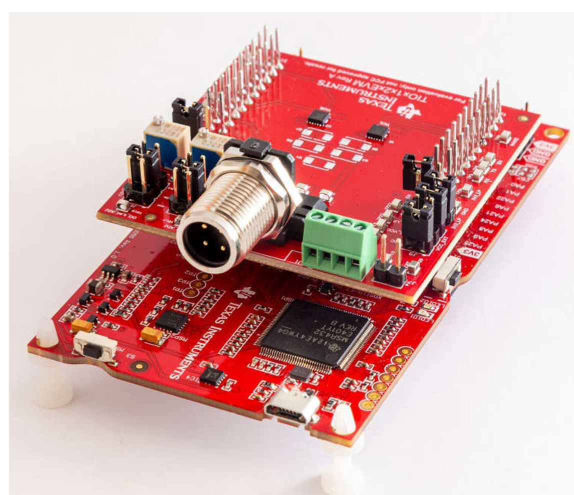
Features

- Crystal-less operation with internal 32-MHz oscillator, supporting COM3 and 400-µs cycle time
- Low-power Arm® Cortex® M0+ microcontroller, running IO-Link device stack developed by TEConcept
- Two-chip design with PHY internal 20-mA LDO
- Device transceiver with integrated EMC protection according to IEC 61000-4-2 (ESD), IEC 61000-4-4 (EFT), and IEC 61000-4-5 (Surge)
- Limited output driver rise time and fall time to minimize overshoots and EMI

Applications

- Condition monitoring sensor
- Flow transmitter
- Actuator
- Level transmitter
- Pressure transmitter
- Temperature transmitter
- Position sensor
- Proximity switch
- Access control
- Signage





1 System Description

This reference design gives an example implementation of the digital communication interface for sensors or actuators acting as an IO-Link device. The design includes the IO-Link device transceiver (PHY) as well as a microcontroller.

The TIOL112 IO-Link PHY includes a protection circuit according to IEC 61000-4-2 (ESD), IEC 61000-4-4 (EFT), and IEC 61000-4-5 (Surge) as well as a 20-mA LDO. This allows designers to build simple systems without the need for external protection devices or additional power supplies.

With a MSPM0L1306 microcontroller, it is possible to power the MCU directly from the LDO output of the PHY and have enough headroom left to also connect additional sensors or ADCs.

Besides the power connection between PHY and MCU, the PHY is also connected to an UART peripheral of the microcontroller. The software running on the MCU has to make sure to control the timing accordingly. The internal oscillator with an external timing resistor provides the needed precision to run in COM3 mode and meeting the requirements by the IO-Link standard. This helps to build small systems, because no external crystal is needed.

The overall combination of the TIOL112 EVM in the form of a BoosterPack™ Plug-in Module, together with an MSPM0L1306 LaunchPad™ Development Kit and the IO-Link stack from TEConcept gives an excellent evaluation platform, because all free interfaces are exposed on the BoosterPack™ Plug-in Module headers, allowing the addition of more sensors, ADCs, or other peripherals.

1.1 Key System Specifications

COMMUNICATION INTERFACE	IO-Link 1.1.3
Transfer Rate	COM3 (230400 Baud)
Cycle Time	400 µs
Integrated EMC protection	• ±8 kV IEC 61000-4-2 ESD contact discharge • ±4 kV IEC 61000-4-4 electrical fast transient • ±1.2 kV, 500 Ω IEC 61000-4-5 surge

2 System Overview

2.1 Block Diagram

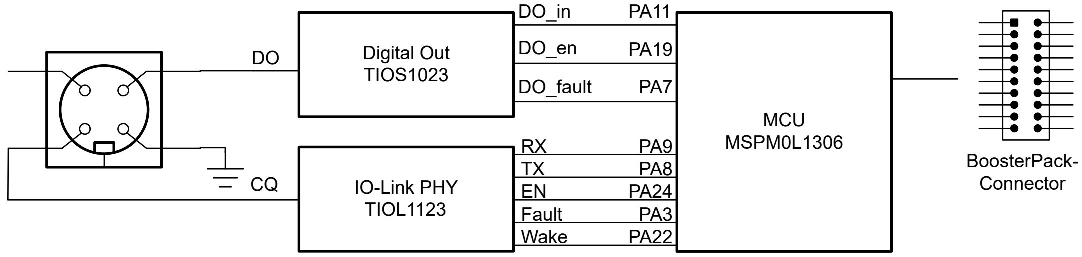


Figure 2-1. TIDA-010263 Block Diagram

2.2 Design Considerations

This design shows an implementation of the communication back end of a sensor or actuator. The implementation consists of TIOX1X2XEVM, which is the evaluation board of the TIOL112, combined with LP-MSPM0L1306, which is the evaluation board of the MSPM0L1306. Both boards can be stacked together and are ready for evaluation.

By default, the TIOX1X2XEVM comes populated with TIOL1123 and TIOS1023, which include a 3.3-V regulator. The default jumper settings of this board require the MSPM0 LaunchPad to be powered separately, to use the internal LDO of the TIOL devices, an additional jumper needs to be added on J9 to V_{CC}.

The current limit on the CQ line of the TIOL112 and TIOS102 can be adjusted by using an external resistor. The evaluation board provides a default resistor value of 25.5 kΩ, which equals a current of 200 mA. Optionally, a potentiometer is on the board to have an adjustable current limit.

In addition to the IO-Link transceiver, the clocking of the device is also an important aspect. The IO-Link standard requires the baud-rate tolerance to be better than 1%. The internal oscillator of the MSPM0 with an external reference resistor can operate much better than the required 1%. Together with a fractional divider for the UART baud-rate generation, it is possible to stay withing a tolerance of 1% with the resulting UART baud rate.

IO-Link also needs to have a way to store small amounts of configuration data. This can either be stored in the internal flash or in an external EEPROM. The internal flash has the benefit of already being available and does not require external components. However, the internal flash can be limited in size and requires a sector wide erase. During this erase cycle, the flash cannot be accessed and the time can be longer than the desired IO-Link cycle time. In some cases, the limited amount of erase cycles can also become a problem.

An external I2C EEPROM, FRAM, or flash can require more space and more components, but can solve other issues. Depending on the exact application, the one or the other design can be a good approach.

2.3 Highlighted Products

2.3.1 TIOL112

The TIOL112x family of transceivers implements the IO-Link interface for industrial bidirectional, point-to-point communication. When the device is connected to an IO-Link master through a three-wire interface, the master initiates communication and exchange data with the remote node while the TIOL112x acts as a complete physical layer for the communication.

These devices are capable of withstanding up to 1.2 kV (500 Ω) of IEC 61000-4-5 surge and feature integrated reverse polarity protection. A simple pin-programmable interface allows easy interfacing with the controller circuits. The output current limit can be configured using an external resistor. TIOL112x devices can be configured to generate wake-up pulse and be used in IO-link master applications. Fault reporting and internal protection functions are provided for undervoltage, overcurrent, and overtemperature conditions.

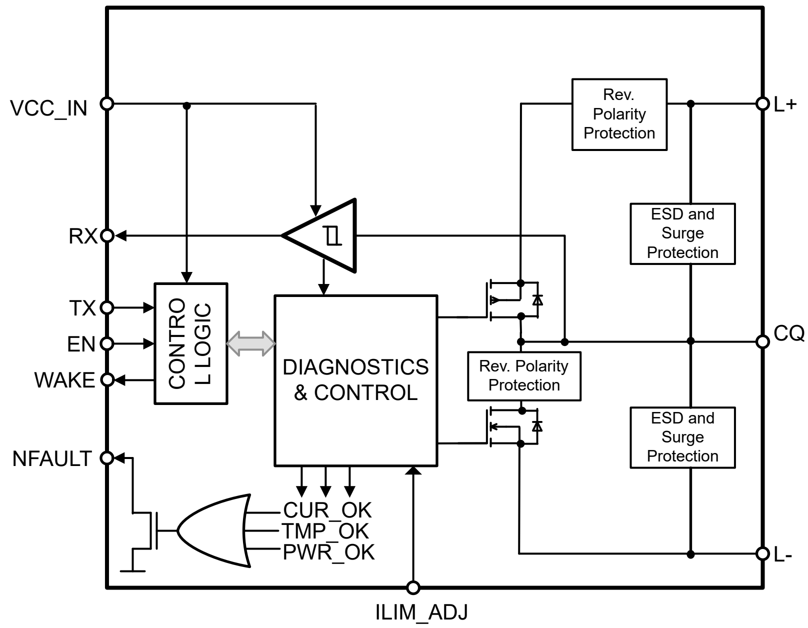


Figure 2-2. TIOL112 Block Diagram

TIOL112 or TIOL112x transceivers implement protection features for overcurrent, overvoltage, and overtemperature conditions. The devices also provide a current-limit setting of the driver output current using an external resistor.

The devices derive the low-voltage supply from the IO-Link L+ voltage (24-V nominal) via an internal linear regulator to provide power to the local controller and sensor circuitry.

2.3.2 MSPM0L1306

MSPM0L134x and MSPM0L130x microcontrollers (MCUs) are part of mixed-signal processors (MSPs) highly-integrated, ultra-low-power, 32-bit MSPM0 MCU family based on the enhanced Arm® Cortex®-M0+ core platform operating at up to 32-MHz frequency. These cost-optimized MCUs offer high-performance analog peripheral integration, support extended temperature ranges from –40°C to 125°C, and operate with supply voltages ranging from 1.62 V to 3.6 V.

The MSPM0L134x and MSPM0L130x devices provide up to 64KB embedded flash program memory with up to 4KB SRAM. These MCUs incorporate a high-speed on-chip oscillator with an accuracy up to ±1.2%, eliminating the need for an external crystal. Additional features include a 3-channel DMA, 16- and 32-bit CRC accelerator, and a variety of high-performance analog peripherals such as one 12-bit, 1.68-MSPS analog-to-digital converter (ADC) with configurable internal voltage reference, one high-speed comparator with built-in reference DAC, two zero-drift zero-crossover operational amplifiers with programmable gain, one general-purpose amplifier, and an on-chip temperature sensor. These devices also offer intelligent digital peripherals such as four 16-bit general purpose timers, one windowed watchdog timer, and a variety of communication peripherals including two UARTs, one serial-peripheral interface (SPI), and two I2Cs. These communication peripherals offer protocol support for LIN, IrDA, DALI, Manchester, Smart Card, SMBus, and PMBus.

The TI MSPM0 family of low-power MCUs consists of devices with varying degrees of analog and digital integration allowing for customers to find the MCU that meets the needs of their projects. The architecture combined with extensive low-power modes are optimized to achieve extended battery life in portable measurement applications.

MSPM0L134x and MSPM0L130x MCUs are supported by an extensive hardware and software ecosystem with reference designs and code examples to get the design started quickly. Development kits include a LaunchPad available for purchase and design files for a Target-Socket Board. TI also provides a free MSP Software Development Kit (SDK), which is available as a component of Code Composer Studio™ IDE desktop and cloud version within the TI Resource Explorer. MSPM0 MCUs are also supported by extensive online collateral, training with MSP Academy, and online support through the TI E2E™ support forums.

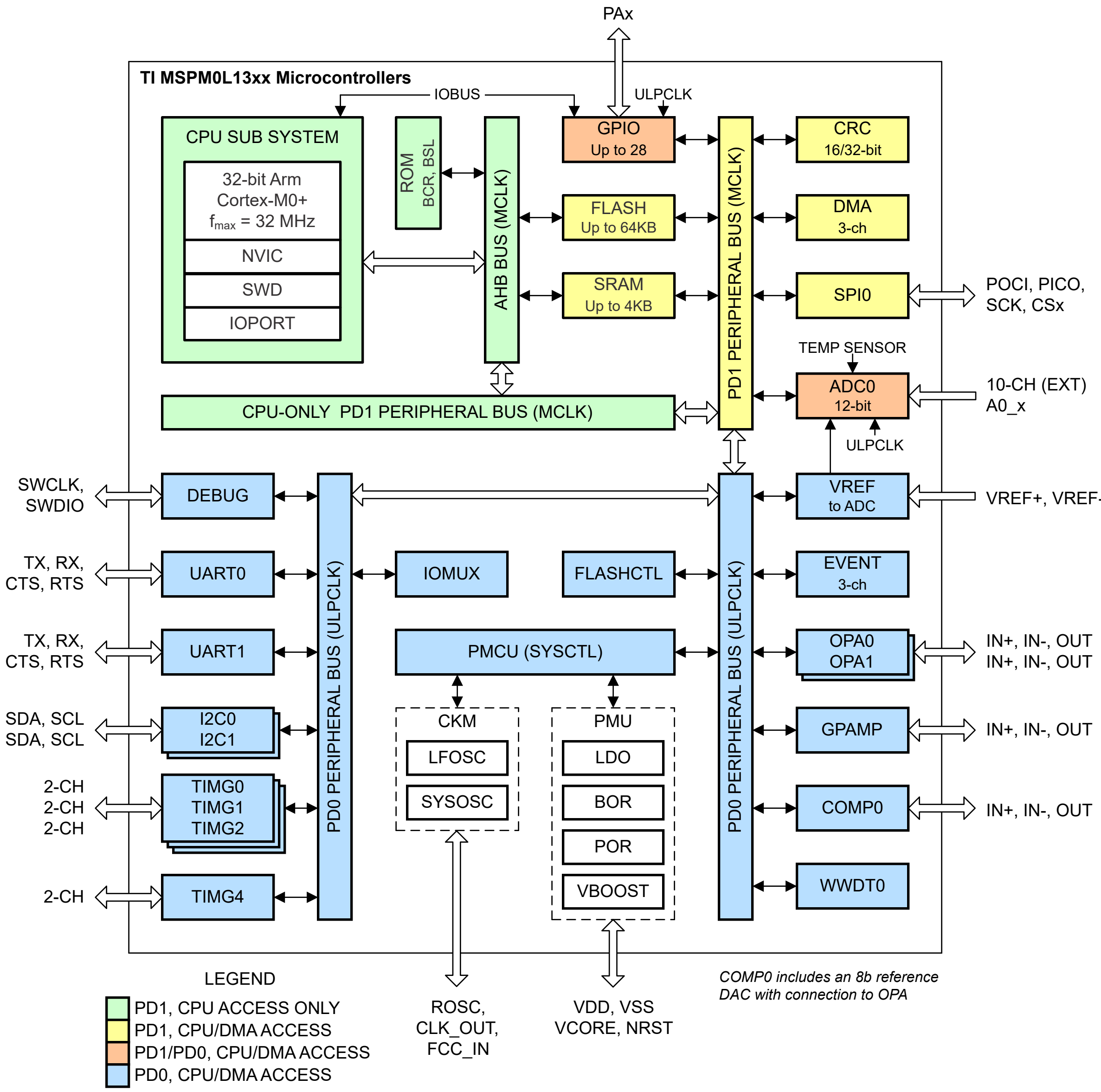


Figure 2-3. MSPM0L130x Functional Block Diagram

3 Hardware, Testing Requirements, and Test Results

3.1 Hardware Requirements

To get the TIOx1x2x EVM working for IO-Link on the MSPM0 LaunchPad Development Kit, make sure to set the jumpers correctly. Use Figure 3-1 as a guideline.

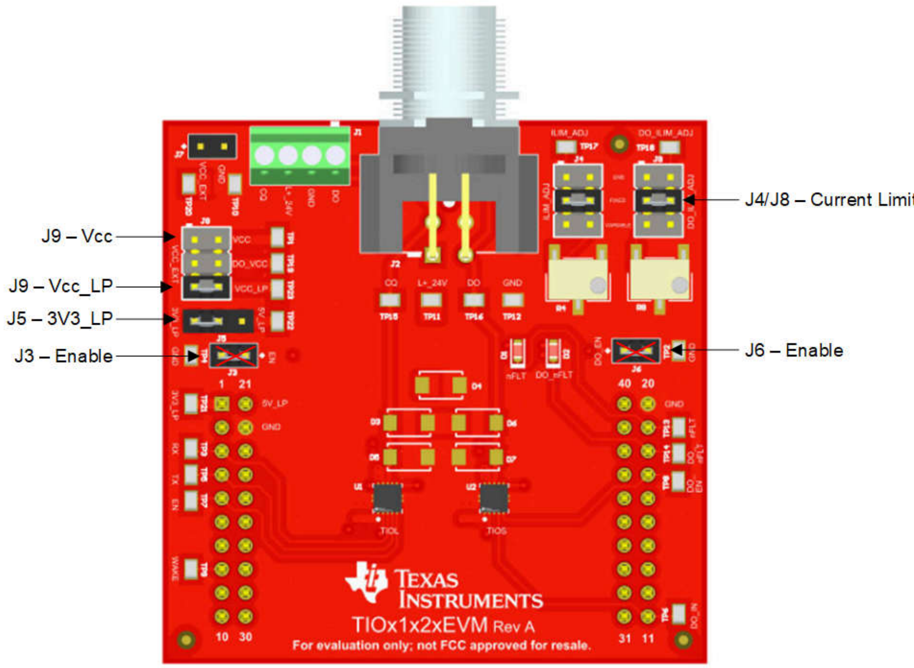


Figure 3-1. TIOx1x2xEVM Jumper Settings

To be able to control the TIOLs enable line, remove J3; otherwise, the IO-Link stack is not able to control the enable line and therefore the TIOL112 driver. The driver is not damaged, but causes a fault.

Also J6 must be removed, this is the enable line of the additional digital output device. The reason behind this change is not about enabling the device, but this line is shared with the SWDIO, so one of the debug lines. Pulling this line to GND with this jumper prevents debugging the microcontroller.

J9 and J5 control the power supply. As long as the TIOx1x2xEVM is not modified (and assembled with TIOL1123), always set J5 to 3V3_LP. J9 allows control of where the design is powered from. With a jumper on Vcc_LP, the LaunchPad Development Kit needs its own power supply. To power the LaunchPad from the L+ line and the linear regulator inside the TIOL1123, also set a jumper on V_{CC}.

Table 3-1. TIOx1x2xEVM Jumper Configuration

JUMPER	CONFIGURATION	COMMENT
J3	Remove	TIOL112 Enable line
J4	Set to fixed	TIOL112 Current limit
J5	Set to 3V3_LP	Power supply selection
J6	Remove	TIOS102 Enable line
J8	Don't care	TIOS102 Current limit
J9	Short Vcc_Lp and V_{CC}	Power supply selection

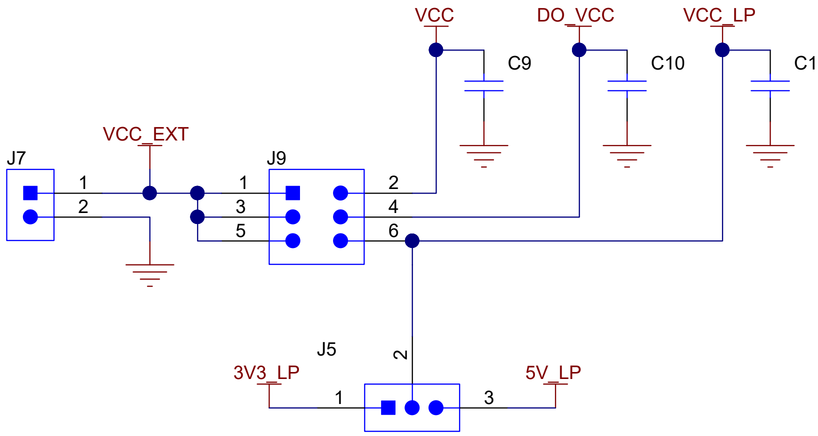


Figure 3-2. Jumper Settings V_{CC}

For further details refer to the *TIOx1x2x EVM User's Guide*.

Besides the previously-mentioned proper configuration, for proper communication, the MSPM0L1306 must be configured correctly. Figure 3-3 shows the MSPM0L1306 LaunchPad™ Development Kit jumper settings. The default configuration of J16 and J17 must be changed as shown.

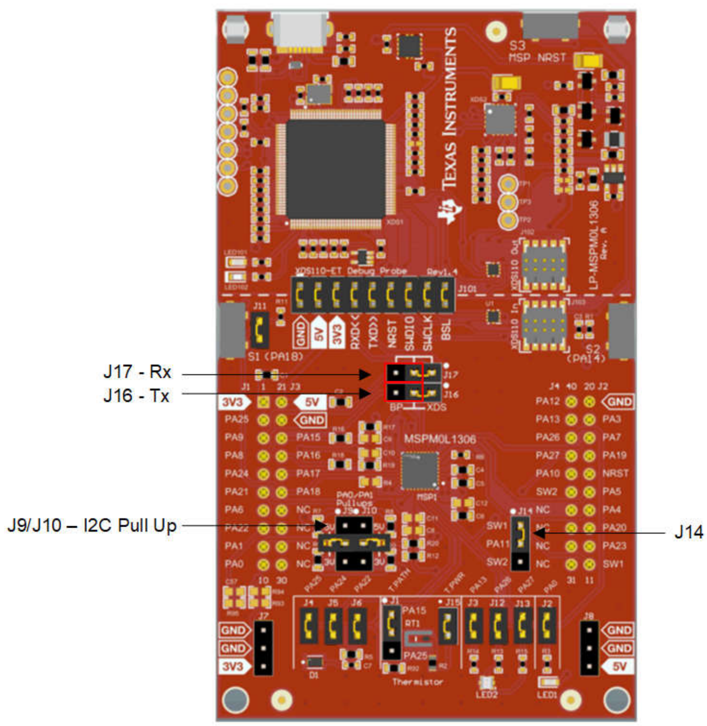


Figure 3-3. MSPM0L1306 LaunchPad™ Development Kit Jumper Settings

Table 3-2. MSPM0L1306 Jumper Configuration

JUMPER	CONFIGURATION	COMMENT
J9 and J10	Open or 2-3	Configures a pullup for I2C pins. If an external I2C EEPROM is used, set to 2-3.
J14	1-2	
J16 and J17	2-3	Configures the UART signals to the BoosterPack headers.

3.2 Test Setup

To test the reference design, connect TIDA-010234 as shown in Figure 3-4. An IO-Link communication with COM3 and 400 µs can be initiated and the timings can be measured.

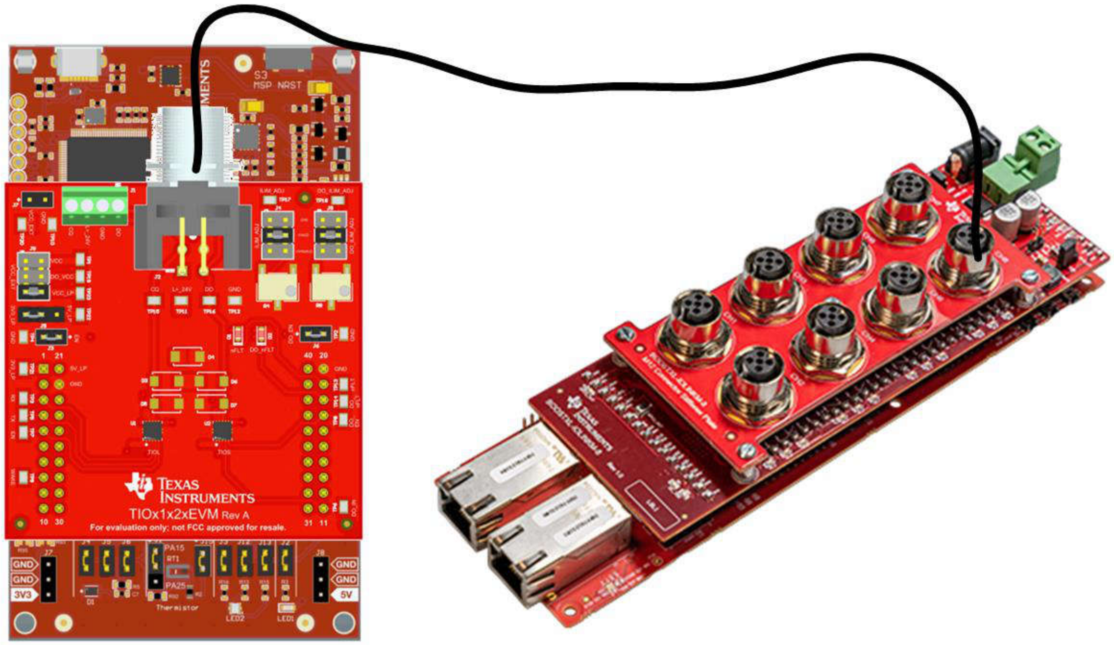


Figure 3-4. Test Setup

3.3 Test Results

The TIDA-010263 test results are dependent on the availability of the latest software release. At the time of this document publication, the needed software was incomplete. Find updated test results in the next version of this design guide.

4 Design and Documentation Support

4.1 Design Files

4.1.1 Schematics

To download the schematics, see the design files at TIDA-010263.

4.1.2 BOM

To download the bill of materials (BOM), see the design files at TIDA-010263.

4.2 Tools and Software

Tools

LP-MSPM0L1306	MSPM0L1306 LaunchPad™ development kit for 32-MHz Arm® Cortex®-M0+ MCU
TIOx1x2xEVM	TIOL112x and TIOS102x evaluation module for IO-Link
TIDA-010234	Eight-port IO-Link master reference design

4.3 Documentation Support

1. Texas Instruments, *TIOx1x2x Evaluation Module* user's guide
2. Texas Instruments, *MSPM0L1306 LaunchPad Development Kit (LP-MSPM0L1306)* user's guide

4.4 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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5 About the Author

STEFFEN GRAF is a systems engineer at Texas Instruments, where he is responsible for developing reference designs in the industrial segment. Steffen has an extensive experience in single-pair Ethernet, Power over Data Lines, as well as IO-Link. He earned his master of science degree in electrical engineering at the University of applied science in Darmstadt, Germany.

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