L11 Smart Sensors for Your Architecture

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  - avoid a hazard
  - recognize the consequence
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- **BURN HAZARD** Labels may be located on or inside the drive to alert surfaces dangerous temperatures.
L11 Smart Sensors for Your Architecture

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Before you begin

IO-Link Overview

IO-Link is a worldwide standardized I/O technology for communications with sensors and actuators. It helps us solve the problem of clearing those final hurdles in the communication chain, allowing sensing devices to be connected on EtherNet/IP and therefore simplifying access to I/O data and configuration parameters. The standard interfaces that have been used on the sensor/actuator level up to now have not allowed the exchange of any data besides the actual process value. IO-Link makes transparent networking of all levels with one another - essential if we want to look at a machine as a whole - and optimizes the process and troubleshooting. The pillars of IO-Link are Simplified Installation, Simplified Integration, Consistent Engineering tools, Automated Parameter Settings and Advanced Diagnostics. A consistent communication concept right down to the lowest field level is key to using the features and technologies of state-of-the-art sensors and actuators, and making machines and systems more productive as a result. Being an integral part of the I/O module, the IO-Link master is installed in the control cabinet and can be configured through Studio 5000 Logix Designer. IO-Link is a point to point communication between sensor and IO-Link master (part of the I/O block). The IO-Link master is connected to the controller via EtherNet/IP. IO-Link is both forward and backward compatible with standard sensors – a standard sensor connected to an IO-Link master works the same as if connected to a discrete input terminal, while an IO-Link sensor connected to a standard input terminal will act as a standard, discrete, PNP sensor. Furthermore, IO-Link utilizes the same standard, unshielded cordsets and patchcords as used with standard discrete sensors.

Rockwell Automation is the only company with PLC, an IO-Link master, and IO-Link sensors. This enables the RA IO-Link solution to be differentiated, not just from traditional discrete and analog sensor connections, but even from competitive IO-Link solutions. RA Integrated Architecture technology enables “Premier Integration” of RA sensors via EtherNet/IP and IO-Link. As the company brings these solutions to market you will see additional technical collateral highlighting the capabilities and differentiation. In this lab we will focus on some of these main system features of the RA IO-Link solution further exhibited with RA IO-Link enabled devices.
About this Lab

For all the lab sections in this document we will walk through various aspects of “Premier integration” value-add features of particular types of Allen-Bradley IO-Link capable sensor(s) Portfolio and 1734-4IOL (in-cabinet) and the 1732E-8IOLM12R (on-machine) IO-Link masters with associated with the CAM Demo Case.

The purpose of these lab sections, supplemented by the PowerPoint presentation, is to introduce and demonstrate the key features and associated benefits of smart sensors from both an operator and configurators point-of-view. Furthermore, the intent is to showcase the added benefits in regards to “Premier integration” only available with IO-Link Allen-Bradley devices.

Note - This lab will take a total of 60 minutes!!!

Tools & Prerequisites

For this Hands-On lab, you will need the following hardware and software:

- IO-Link CAM – Component Sales Force Demo (Drawing No. 14P005A-01)

- PC Workstation with containing Studio5000, v20 or later, with the 1734-4IOL Master Add-On Profile (AOP) installed

- 1723E-8IOLM12R Master Add-On-Profile. The controller configuration files used in these lab sections are all pre-built and configured the same at every workstation

- Ethernet cable to connect from the PC to the 1734-AENTR EtherNet/IP port.
Sensors built into the demo case and connected to the 1734-4IOL Master:
- 45CRM-4LHT1-D4 – Slot 1, Ch0
- 42JT-D2LAT1-F4 – Slot1, Ch1
- 45LMS-D8LGC1-D4 – Slot1, Ch2
- 42EF-D2MPAK-F4 – Slot 1, Ch3
- 871TM – Slot 2, Ch0
- Generic Channels – Slot 2, Ch1 & Ch2
- 836P-D2NFG8D36PP-D4 – Slot 2, Ch3

Sensors that needs to be connected to the 1732E-8IOL-M12R Master:
- 871FM-MV7BA20-FD02X – Ch4
- 42EF-D2MPAK-F4 – Ch6

Note – These 2 sensors are not part of the CAM demo case. In the sections below, the lab walks through how to connect the sensors to the 8IO-Link Master.

Setup
Lab 1: Designing your system (~20 minutes)

In order to use any smart sensor connected via IO-Link, we first need to add an IO-Link master to the system and configure it. In a Rockwell Automation system, this is done in following parts.

- Create a project with a compact or control logix controller. We are using a compact logix 1769-L36ERM controller and Studio V30 and add the IO-Link master (1732E-8IOLM12R) to the switch or any EtherNet port that is free on the system.
- Add and configure IO-Link capable devices by adding the IODD file (which contains the sensor specific information) to the channels 4(port 3) and 6 (port 4) of the IO-Link master.

In this section of the lab, we’ll experience the 871FM Metal Flat Pack Proximity smart sensor that is connected to Chanel 4 (Port 3) of 1732E-8IOLM12R IO-Link Master. We’ll download PLC program and experience the Add-On-Profile for the smart sensor.

Smart Sensor Add-On-Profile - Studio 5000

1. Open Studio 5000.

2. Under Open>Existing Project>Project File, Browse to Desktop Folder and Select “SmartSensing.ACD”. This lab is developed on 1769-L36ERM CompactLogix 5370 Controller.
3. **Click** on the WHO Active icon on the top of the window. **Expand** Workstation and then **Expand** AB_ETHIP-1, Ethernet and **Select** the 192.168.1.12 controller. **Click** on download.

![Image of a computer screen showing a software interface with a highlighted controller]

4. **Click** on Download again.

**Note** - If your Download button is not highlighted your controller may be in Run mode. Change to program mode or call your instructor.
5. **Click** Yes to change the controller to RUN mode. Once online (you can verify you are online when this is showing):

6. Now we will open the IO-Link Mater Add-On-Profile from the I/O Tree. **Double click** (or right click > Properties) on the last module “1732E-8IOLM12R/A My_8IOL” in the I/O Configuration tree.

7. Now on the “Module Properties: Local (1732E-8IOLM12R 1.001)” window, **Click** on the “IO-Link” tab.

   **Note:**
   - IO-Link Master IP address is 192.168.1.33
   - Module Definition for Connection is set to “Timestamp Data”
Note (Channel Modes) - There are 8 Channels (0 to 7) on the 1732E-8IOLM12R. Channels can be configured for ‘Disabled’ ‘Digital Output’ ‘Digital input’ and ‘IO-Link.’

For Your Information

The sensor can operate in two modes:

All Rockwell Smart Sensors can operate in Standard discrete mode or IO-Link Mode.

Standard IO (SIO) Mode: This mode is the sensor default operation mode. The sensor outputs and user interface behave as described in the installation instructions included with the product. This mode of operation is active when the sensor is connected to digital input devices such as a PLC inputs modules, distribution boxes, and input terminal connections.

When operating in SIO mode, the registration mark and background can only be taught using the rotary switch on the sensor.

IO-Link Mode: This mode is automatically activated when the sensor is connected to an IO-Link enabled master device. Upon entering this mode, the green LED on the sensor starts blinking at a rate of 1 Hz to indicate that IO-Link communication has been successfully established with the master. The sensor transmits more parameter and diagnostic information that can be accessed via the PLC process data. No user intervention is required to enable this functionality within the sensor.

When operating with IO-Link, other options become available, such as evaluation of the detected settings, display of measured values, and sensor diagnosis.
Note - Some changes can only be done in offline mode (i.e. Electronic Keying, Process Data Input, adding a new smart sensor to IO-Link Master etc.).

For Your Information:

**Electronic Keying Information:** Select **Exact Match** or **Disabled** from the pull-down menu. The **Exact Match** and **Disabled** keying options in this dialog correspond to the Compatible and No Check keying options in IO-Link terminology, respectively.

When **Exact Match** is selected, the connected IO-Link device must have the same Vendor ID, Device ID, and Revision information that has been configured for that channel. If they do not match, IO-Link communications are not established and a Keying Fault status bit is set. When **Disabled** is selected, key check is not performed.

**Process Data Input:** Select the input data from the pull-down menu (for devices that support multiple layouts of input data).

There are four options to select for the process data. This selection will affect the IO-Link parameters and controller tags, which are available in IO-Link mode and online with the controller.

- Triggered, Margin, Proximity, Gain, Signal (Default setting that is used in the lab)
- Triggered, Margin, Proximity, Gain, Contrast Temp
- Triggered, Margin, Proximity, Gain, Count
- Triggered, Margin, Proximity, Duration
8. Now we’ll go through 871FM in the Add-on-Profile. It’s already been configured for this lab. In the navigation pane, under Ch4 – IO-Link: Click on the 871FM-MV7BA20-FD02X.

Note - It will load 871FM information on the right side.

For Your Information
There are five different tabs to describe the sensor functionality and operation.

- **Common Tab**: Provides general product information about the sensor specifications and IO-link IOOD information.
- **Identification Tab**: Provides the sensor catalog number, series letter, general product description including the current product firmware, and hardware revisions.
- **Observation Tab**: Provides the sensors setting for viewing.
- **Parameter Tab**: Offers the different teach functions available in the 871FM.
- **Diagnosis Tab**: Provides the ability to test the basic features of the sensor, locate the sensor on the machine, lock/unlock the local sensor settings, and restore the sensor to its original factory settings.

Note - MinCycleTime is the time the combination device-master needs to update the value the sensor is measuring. As previously mentioned, using the classical connection method, the RA sensor reacts in 1ms, while using IO-Link it takes 2ms. Although this is a downside, for most applications, the advantages of IO-Link (you’ll see these later) will outweigh this disadvantage. Worth to note in this case is that remote IO (such as the Point-IO adapter) also has a configurable update rate. For the most common applications, this is normally set to 20ms (well above the update rate of the sensor).
9. With IO-Link, you can now easily change the sensor to polarity to make it function as in Light Operate (LO) /Dark Operate (DO) mode. By default, the sensor is programmed for LO. **Click** on the “Parameter” tab and **Select** “Inverted” from the drop-down box beside Polarity to change sensor operation to DO mode.

![IO-Link Configuration](image)

You have to **Apply** these change to get in effect. By inverting the polarity, now sensor starts to behave in the Dark Operate Mode (DO) and the Orange LED remains ON when there is no object present.

**Note** - This feature allows the customer to save downtime by easily configuring the sensor functionality.

10. Next we will explore the Diagnosis Tab. **Click** on the Diagnosis tab on the top. Your screen should look like this:

![Diagnosis Tab](image)

Notice in the Diagnosis tab there are some fields that are r/w – indicating read / write. We will change some of these settings and observe the changes on our sensor.
11. In particular, the Locator Indicator parameter activates the location indication sensor functionality. When enabled, the sensor LED start flashing synchronously until the operator disables this function. **Click** the dropdown box adjacent to the Locator Indicator and **Select** Enabled and **Click** Apply and **Click** YES.

![Locator Indicator Parameter](image)

You will notice that the sensor user interface (green and orange LEDs) start flashing synchronously until the operator disables this function. When finished, **Select** Disabled and **Click** Apply and **Click** YES. This will stop the location indicator.

**Note** - This parameter is ideal for applications where the operator needs to locate a sensor in the application where there may be multiple sensors in close proximity.

12. Now we’ll explore the controller tags. **Double click** the Controller Tags in the Controller Organizer.

![Controller Organizer](image)
13. In the Controller Tags window, expand the tree structure for the tag My_8IOL: I. to view all the Descriptive Tags that are available under the IO-Link master.

**Note** - You will notice that there are a number of tags that are named Timestamp. This is the timestamp data that gets populated when there is an event or any change of state. The Timestamp data map can be switched off by while selecting the master and choosing only a data input.

14. **Sort** the tags in an alphabetical order. You can do this by **Clicking** the sorting button. Notice the Descriptive Tags for the 871FM on My_8IOL:I.Ch4**.

**Note** - Mark this step as we will be using these process data tags in the later section of the lab.

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<thead>
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<th>Scope</th>
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<th>All Tags</th>
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15. **Place** the sensor against different metal surfaces to see how these process data changes. Note the following on the input parameters:

- **Triggered**: Displays the status of the sensor output. This process data element is a bit that indicates when the target has been detected or not.
- **Margin**: Displays the status of the sensor margin low alarm. This process data element is a bit that indicates to the operator if the sensor signal is marginal or unstable.
- **Proximity**: Displays the status of the proximity alarm. This process data element is a bit that indicates if there is an object in close proximity to the threshold (below 1.0X) when the output is OFF.
- **Gain**: Displays the excess gain above the sensor threshold to ensure reliable detection of the target.
- **Signal Strength**: Provides the raw measurement value of the signal from the magnetic coil as reflected by the presence of the target.
Trending in Smart Sensing

Trending is a useful functionality part of the Studio5000 where it allows customers to trend certain points of data to understand and analyze how these data are changing. In this portion of the lab we will be trending the process data of the 871FM namely: Signal Strength, Proximity Alarm, Margin Low Alarm and Triggered.

Can you think of specific application where and how this might be useful to customers?

**Scenario** - An OEM who builds extrusion machines for aluminum plant is in need of a smart sensor. Since the application is in a very harsh environment, he has faced issues with sensors when the object comes too close to the face of the proximity sensor and damages it. He wants to be notified anytime if an object comes to close to sensor – so that he can adjust his machine and prevent damage of the sensor beforehand and thereby reduce downtime.

Also, he wants to be notified if the object drifts away from the sensor so that he can make necessary adjustments so that there is 100% object detection. Do you know how this can be solved?

Solution - Using the 871FM’s Signal Strength readings you can program the sensor through Studio5000 to trigger an alarm at various controlled ranges. Below are some of the steps to simulate this scenario.
16. Now we'll get interactive experience with smart sensor on the PanelView HMI. **Click** on the “871 FM Trending” button on HMI.

17. This opens up the Trending screen. Currently we are trending the Process Data Proximity Alarm, Triggered and Margin Low.
18. Slowly **Bring** the metal targets towards the metal face front of the sensor and observe how the trend chart is created.

**Note** – Use the metal plates in front of the CAM demo cases that have been provided for this lab.

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**Question** - How is this useful to the customer?

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**Answer** - To answer this we need to understand Proximity Alarm, Margin Low Alarm and Triggered. Refer previous section of the lab where each of these points are defined.

So for our customer - He can track a Proximity Alarm and know exactly at what point a target/object is approaching or in the vicinity of the sensor. Note at this point – the sensor is not triggered yet. When the object is at sensing range there will be a Triggered – so customer knows exactly when something was detected. When the object starts to drift away from the Sensing range a Margin Low Alarm is detected – so customer is alerted in time to adjust the system.

The second part of the problem is how can the customer now track if an object comes too close or hits the sensor face?

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**Answer** - Signal Strength is a useful feature that allows the user to detect and trend the behavior of the different object that is being detected by the 871FM.

Here we are using a simple comparison function to that detects every time the Signal Strength is above a certain threshold. For our lab we have set that limit to be 4,800 and using a counter that counts the number of such occurrence.

So if any object gets too close to the sensor – the Signal Strength will increase and when the Signal Strength crosses the defined threshold – an alarm is triggered. The counter allows you to count the number of times such an instance has occurred.

19. From the HMI, **Click** on Signal Strength to open the Signal Strength trend screen to open. It should look like the image below.
Note - The box in blue shows the actual signal strength in the process data.

20. Move the metal target back and forth to see the signal strength changing over time.

21. Now Move the large metal object closer to the surface of the sensor. This is to simulate that an object is hitting the sensor. You will notice a spike on the trend line.

22. You will get an alarm pop up saying CLOSE OBJECT ALARM.
Note - This will alert the user to perform corrective actions.

23. **Press** the ALARM RESET button to clear out the alarm.

24. **Click** on X to close the Signal Strength Trending Window and **Click** on X again to close the main 871FM trending window.

**This concludes Lab 1**
Lab 2 Operation: Smart Pressure Sensors

836P Smart Pressure can also be added to IO-Link Master in similar fashion as the 871FM. Pressure sensor is connected to 1734-4IOL slot 2 Channel 3. The 836P pressure sensor portfolio has extensive range from -14.5 to 10,000 PSI.

About this lab

In this lab, we'll experience 836P pressure faceplates to view and change set points. Pressure sensor is connected to a rubber air bulb that would vary the pressure reading on the 836P pressure sensor. Pressure sensor has two Out1 and Out2 LEDs. This bladder (rubber air bulb) is used in this lab to simulate pressure.
836P Pressure Faceplate

1. **Click** on 836P Pressure Sensor which is connected to Channel 3 of 1734-4IOL IO-Link master.

This section of the lab is in free form. The objective of this lab is to experience the faceplates of smart pressure sensing for set point configuration and diagnostics.

Faceplate has 3 tabs: Home tab, Operation tab and Maintenance tab.

- **Home Tab**: Home tab has Triggered Set Points and other sensor settings such as Units (PSI, bar, Pa, etc.), mode, Lock/Unlock settings.
- **Operation Tab**: View Current Settings, operation information and set point configuration.
- **Maintenance Tab**: Sensor Catalog information, Application/Labe, and Locate Sensor function.
You can pump the rubber air bulb to observe the switch point trigger and release. This is a touch HMI, you can change/view the configuration by clicking on the buttons.

2. **Click** on Triggered Point 1 and in the Trigger Point 1 window > **Click** on Switch Point 1 value to change it to 4 PSI and Reset Point 1 to 10 PSI and **Change** Function from Hysteresis to Window. **Observe** Out1 is turned ON at the display head of 836P when the pressure is between 4 and 10 PSI. In a window mode, Out 1 LED is turned off when you are outside of 4 to 10 PSI window.

What is the difference between the 2 modes of function: HYSTERESIS and WINDOW?

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For Your Information

In the hysteresis mode, the sensor output will be triggered with set point reaches to set point threshold and releases when the process value falls below the release set point.

Note - In the window mode the process value is between set point and release point:

Hysteresis is limit test. When process variable hits the Setpoint and while it’s => Reset value.

Window mean while setpoint is within low and high setpoint.
3. **Click** Home button and then **Click** on Settings.

- **Change** the Units and Rotation.
- **Observe** changes on the display head of 836P Sensor. There are several Units selection.
- You can also change the update rate.
- Make sure to **Select** Write… to push the settings to the pressure sensor.
- Settings are done in 2 screens.
- On the second page (by **Clicking** Next), you can **Change** the Mode setting and **Observe** the display head.
- Again **Click** Write… to push the settings to the sensor.
4. **Click** on the Operation tab which is the middle wrench icon, it will display current settings.
5. **Click** on the Maintenance icon.
   - **Click** on Locate Sensor.
   - **Observe** the LEDs and the display are flashing.
   - Please **Click** on Locate Sensor again to turn-off the LED flashing.

![Screenshot of Locate Sensor interface]

**Note** - These faceplates are available at PCDC website.

**This concludes Lab 2**
Lab 3 Maintenance

About this lab

In this section of the lab we will use the 42EF RightSight sensor that is connected to Ch6 of the on-machine 1732E-8IOLM12R IO-Link master. Events with time stamping provide extra aid in troubleshooting and performing the maintenance.

1732E-8IOLM12R: Event Time Stamping:

1. **Click** on the 8IOLM12R IO-Link master module to reveal an HMI screen that focuses on the modules ability to microsecond time stamp events.

   - Rockwell Automation's CIP Sync Technology is built into the L36ERM Controller and the 8IOLM12R module.
   - All you need to do is to specify the Grand Master of time for the system and CIP Sync propagates 1588-PTP (Precision Time Packets) of data over Ethernet network to the designated devices.
   - It’s as easy as checking a box in the controller properties.

In this simple example, imagine we are tracking and time stamping parts going down a conveyor line as they pass by the photoelectric sensor. The sensor triggers the event and the 8IOLM12R master module records the event time stamps. The 8IOLM12R master module detects the On/OFF and OFF/ON Change of State (COS) of the photo eye trigger. This COS data, commonly known as Process Data, is only sent to the 8IOLM12R module upon a COS
transition to optimize/ reduce network traffic. We are only recording the ON/OFF COS Trigger below.

- **Curr. Controller (WCT):** This is the Current Controller (L36ERM) Wall Clock Time being read directly from the controller.

- **Set Controller (WCT):** This is how you can set the Controller (L36ERM) Wall Clock Time if you want to Time Stamp at your local time. **Push** the SET button after you enter your local time.

- **Parts Tracking:** These are the parts being tracked and time-stamped as they pass by the photo eye. **Push** the Reset Event Buffer button to clear the Events Log 1-5.

**Note** - The Ch6 Time Stamp data is displayed in pre-defined 8IOLM12R module controller tags.
2. **Push** the Reset Event Buffer button to reset the event buffer back to all zeros.

3. To demonstrate event time stamping, **Wave** your hand in a (left to right to left motion) in the path of the 42EF Photo Eye and watch the orange led turn (on/off) on top. This is how you can tell if it is being triggered properly. The faster you wave your hand in front of the sensor the tighter the event time stamps get.

**Note** - If you log more than 5 events the 6th event will roll over to the Event 1 buffer, so there is no need to reset the buffer unless you need to clear the entire buffer.

![Image of 1732E-8IOLM12R: Time Stamping using CIP Sync. Technology](image)

**Note**: The Ch6 Time Stamp data is displayed in pre-defined 8IOLM12R module controller tags.

**1732E-8IOLM12R: Diagnostic Capabilities:**

The 1732E-8IOLM12R master module has the diagnostic data is displayed in pre-defined module controller tags. We will concentrate on the Ch6. Diagnostics in this section.

4. **Click** on the button below.

5. The on-machine master module diagnostics are designed to help Operators and Maintenance people detect and troubleshoot device issues in a matter of minutes. The 42EF Photo Eye device diagnostics ranges from detecting if a device is properly connected and communicating to the 8IOLM12R master module to Under/ Over-Temperature situations. Let’s explore the CH6 Diagnostic Data for the 42EF Photo eye below.

6. **Click** the button to first clear all CH6 Diagnostic Event Data out of the buffer.
7. **Disconnect** the 42EF Photo Eye from the 8IOLM12R master module and watch the Current Event Status register. It will display a Channel Reset, then a Sensor Disconnected Code and Time Stamp. These Events are differentiated by the Code and Qualifier numbers below.

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<td>242</td>
<td>2017</td>
<td>03</td>
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<td>11</td>
<td>13</td>
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**Note** - This is the 4th Sequenced Event recorded.

8. **Reconnect** the 42EF Photo Eye to the 8IOLM12R Master module and watch the Current Event Status register. It will display a Sensor Reconnected Code and Time Stamp. The qualifier number has changed again.

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**Note** - The Sequence number has incremented to 6.

9. To reveal all the Event History, **Click** the button.

- As you can see, we have retrieved several CH6 Device Diagnostic Events with Time Stamps to track when the device lost communications with the 8IOLM12R Master and when it reconnected.
- This is very important when correlating other events that may have happened elsewhere in the machine control system.
- Each channel can store up to 40 Diagnostic Events.
As you can imagine, this helps reduce the amount of time it takes to troubleshoot an issue like this.

Note - In the future this 8IOLM12R Diagnostic Data will be added to a HMI Faceplate. There is no IO-Link Master Faceplate available for the 1732E-8IOLM12R Master module at this time. These Faceplates are being designed with a new modern look and feel. Release Date

10. Push the Main button to go back to the main screen.

This concludes Lab 3