# High Resolution Analog I/O Modules

Catalog Numbers 1756-IF8I, 1756-IF8IK, 1756-IRT8I, 1756-IRT8IK, 1756-OF8I,1756-OF8IK, 1756-IR12, 1756-IR12K, 1756-IT16, 1756-IT16K

Allen-Bradley
by ROCKWELL AUTOMATION

**User Manual**

Original Instructions

**Table 3 - Module Resolution in Various Configuration Selections**

| Module | Mode | Available Input/ Output Range(1) | Actual Input/Output Range Capability | Number of Bits Across the Theoretical Operating Range | Number of Bits Across the Actual Range Capability | Resolution (signal per count) |
|---|---|---|---|---|---|---|
| 1756-IF8I, 1756-IF8IK | Voltage | -10…10V<br>0…10V<br>0…5V | -10.5…10.5V<br>0…10.5V<br>0…5.25V | 24 bits | 23.75<br>22.75<br>21.75 | 1.49 µV/count |
| | Current | 0…20 mA<br>0…20 mA (sourcing) | 0…21 mA<br>0…21 mA (sourcing) | | 22.74 | 2.99 nA/count |
| 1756-IRT8I, 1756-IRT8IK<br>1756-IT16, 1756-IT16K | Thermocouple | -100…100 mV | -101…101 mV | 24 bits | 23.98 | 0.01 µV/count |
| 1756-IRT8I, 1756-IRT8IK<br>1756-IR12, 1756-IR12K | RTD | 1…500 Ω<br>2…1000 Ω<br>4…2000 Ω<br>8…4000 Ω | 0…510 Ω<br>0…1020 Ω<br>0…2040 Ω<br>0…4080 Ω | | 23.98 | 0.06 mΩ/count<br>0.12 mΩ/count<br>0.25 mΩ/count<br>0.50 mΩ/count |
| 1756-OF8I, 1756-OF8IK | Voltage | -10…10V<br>0…10V<br>0…5V | -10.5…10.5V<br>0…10.5V<br>0…5.25V | 16 bits | 16.00 | 0.32 mV/count<br>0.16 mV/count<br>0.08 mV/count |
| | Current | 0…20 mA | 0…21 mA | | 16.00 | 0.32 µA |

(1) These ranges represent the range choices available in the Logix Designer application.

**IMPORTANT** Because these modules must allow for possible calibration inaccuracies, resolution values represent the available Analog-to-Digital or Digital-to-Analog counts over the specified range.

Additionally, RPI and Notch Filter settings affect module resolution on the 1756-IF8I, 1756-IF8IK and 1756-IRT8I, 1756-IRT81K modules. For more information, see page 38 and page 55, respectively.

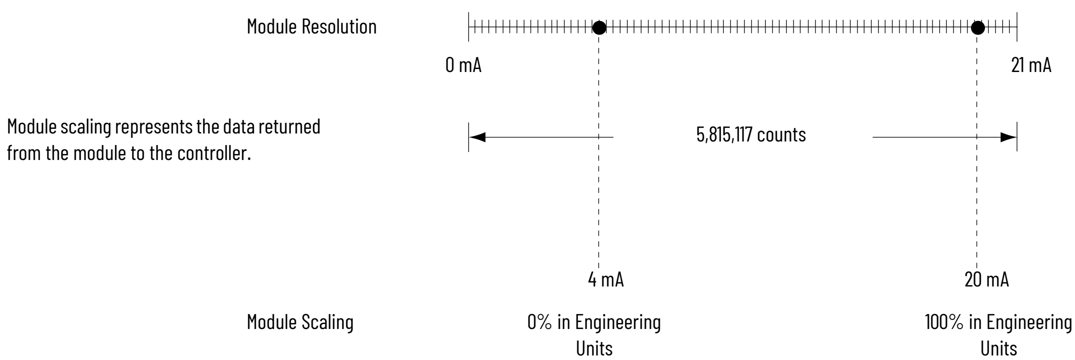
## Scaling

When scaling, you choose two points along the module's operating range and apply low and high values to those points.

For example, if you are using the 1756-IF8I module in Current mode, the module supports a 0…21 mA actual range capability. But your application uses a 4…20 mA transmitter. Scaling lets you configure the module to return data to the controller so that a low signal value of 4 mA returns a low engineering value of 0% and a high signal value of 20 mA returns a high engineering value of 100%.

The returned engineering unit's value is indicated in the *I.Ch[x].Data* tag as shown in Table 4.

**Figure 3 - Module Resolution Compared to Module Scaling**



## Error Calculated over Hardware Range

The calibration accuracy of a ControlLogix analog I/O module at 25 °C (77 **°F)** is calculated over the full hardware range of the module. It is not dependent on the application's use of the range. The error is the same if you are measuring it across a 10% or 100% portion of a given range.

However, a module's accuracy at 25 °C (77 **°F)** is dependent on the hardware range in which the module operates.

| **EXAMPLE** | When the 1756-IRT8I channel uses the Thermocouple (mV) input type, the input range is -100…100 mV, the module error is 0.2 mV when using 0.1% of range accuracy.<br>These error values are the same whether you use 10% or 100% of the chosen range. |
|---|---|

## RTD and Thermocouple Error Calculations

When you use a 1756-IRT8I, 1756-IRT8IK, 1756-IR12, 1756-IR12K, 1756-IT16, or 1756-IT16 K module in temperature mode, error calculations are achieved by a two-step process.

1. Calculate the error in ohms or volts.
2. Convert the ohm/volt error to temperature for the specific sensor and at the correct application temperature.

### RTD Error

RTD error on a 1756-IRT8I, 1756-IRT8IK, 1756-IR12, or 1756-IR12K module that is used with an RTD input is defined in ohms. The error is calculated across the entire input range selected, not the available range of a sensor used with the module. For example, if the 1…500 Ω input range is used, the module error is calculated across 510 Ω (actual range = 0…510 Ω).

The error in ohms translates to temperature, but that translation varies because the relationship is non-linear. The most effective way to check the module error is to calculate the error in ohms and use that value in a linearization table to check the temperature error.

If the module is calibrated at operating temperature and the operating temperature remains relatively stable, calibration accuracy is better than 0.05% of the full range. This 0.05% value is a worst case value. In other words, with the 1…500 Ω input range that is selected, the worst case module error is 0.255 Ω.

Finally, you must check an RTD linearization table to determine how the temperature error of 0.255 Ω translates.

For example, if the module has a 0.05% (or 0.255 Ω) error and is at a temperature of 0 °C (32 °F), the temperature error is ±0.65 °C (±1.17 °F) when the Platinum 385 sensor type is used. This same error at a temperature of 200 °C (392 °F) translates to a temperature error of ±0.69 °C (±1.26 °F).

# Temperature-sensing Analog Modules

| Module | Description |
|---|---|
| 1756-IRT8I, 1756-IRT8IK | The module has eight isolated channels. Each channel supports connection to the following input types:<br>• RTD, both 3-wire and 4-wire<br>• Thermocouple mV devices<br>The module provides 24-bit data resolution. Additional features are described in this chapter.<br>The 1756-IRT8IK catalog number has conformal coating. |
| 1756-IR12, 1756-IR12K | The module has 12 non-isolated channels. Each channel supports 3-wire RTD connections.<br>The module provides 24-bit data resolution. Additional features are described in this chapter.<br>The 1756-IR12K catalog number has conformal coating. |
| 1756-IT16, 1756-IT16K | The module has 16 non-isolated channels. Each channel supports connection to thermocouple mV devices.<br>The module provides 24-bit data resolution. Additional features are described in this chapter.<br>The 1756-IT16K catalog number has conformal coating. |

## Common Module Features

The modules have the following features:

| Feature | 1756-IRT8I, 1756-IRT8IK | 1756-IR12, 1756-IR12K | 1756-IT16, 1756-IT16K |
|---|---|---|---|
| Module Input Ranges | X | X | |
| Notch Filter | X | X | X |
| Underrange/Overrange Detection | X | X | X |
| Digital Filter | X | X | X |
| Process Alarms | X | | |
| Rate Alarm | X | | |
| Sensor Offset | X | X | X |
| 10 Ohm Copper Offset | X | X | |
| Wire Off Detection | X | X | X |
| Temperature Units | X | X | X |
| Sensor Types | X | X | X |
| 1756-IRT8I, 1756-IRT8IK Thermocouple Wire Length Compensation | X | | |
| Synchronized Sampling | X | | |
| Cold Junction Compensation | X | | X |

**IMPORTANT** Most of the features are software configurable. For more information on how to configure the module, see Chapter 6, Configure ControlLogix Analog I/O Modules on page 99.

## Module Input Ranges

The modules offer multiple input ranges. The input type and sensor type selections determine the available ranges.

The following table describes the modules' input ranges in relation to the sensor type. If a single range is listed in the Input Range column, the programming application automatically selects the range used with the previously listed sensor type.

**Table 10 - Module - Channel Input Ranges**

| Module | Input Type | Sensor Type | Input Range |
|---|---|---|---|
| 1756-IRT8I, 1756-IRT8IK, and 1756-IR12, 1756-IR12K | RTD | Ohm | One of the following:<br>• 0…500 Ω<br>• 0…1000 Ω<br>• 0…2000 Ω<br>• 0…4000 Ω |
| | | 100 Ω PT 385 | 0…500 Ω |
| | | 200 Ω PT 385 | 0…1000 Ω |
| | | 500 Ω PT 385 | 0…2000 Ω |
| | | 1000 Ω PT 385 | 0…4000 Ω |
| | | 100 Ω PT 3916 | 0…500 Ω |
| | | 200 Ω PT 3916 | 0…1000 Ω |
| | | 500 Ω PT 3916 | 0…2000 Ω |
| | | 1000 Ω PT 3916 | 0…4000 Ω |
| | | 10 Ω CU 427 | 0…500 Ω |
| | | 120 Ω NI 672 | 0…500 Ω |
| | | 100 Ω NI 618 | 0…500 Ω |
| | | 120 Ω NI 618 | 0…500 Ω |
| | | 200 Ω NI 618 | 0…1000 Ω |
| | | 500 Ω NI 618 | 0…2000 Ω |
| 1756-IRT8I, 1756-IRT8IK and 1756-IT16, 1756-IT16K | Thermocouple | mV | -100…100 mV |
| | | TC Type B | |
| | | TC Type C | |
| | | TC Type E | |
| | | TC Type J | |
| | | TC Type K | |
| | | TC Type N | |
| | | TC Type R | |
| | | TC Type S | |
| | | TC Type T | |
| | | TC Type TXK/XK(L) | |
| | | TC Type D | |

To see where to select the input range, see page 103.

## Notch Filter

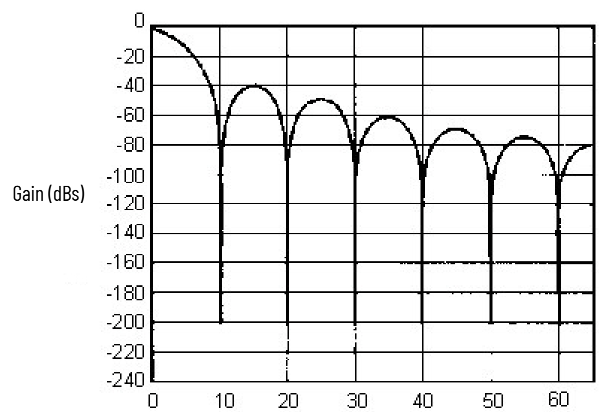
The Notch Filter is a built-in feature of the Analog-to-Digital convertor (ADC) that removes line noise in your application for **each channel**. The removal of line noise is also known as noise immunity.

The Notch Filter attenuates the input signal at the specified frequency. That is, the filter reduces the amplitude of the signal with minimal signal distortion.

Choose a Notch Filter based on what noise frequencies are present in the module's operating environment and any sampling requirements needed for control. The default Notch Filter setting is 60 Hz.

For example, a Notch Filter is typically set to 60 Hz to filter out 60 Hz AC line noise and its overtones. A 60 Hz Notch Filter setting attenuates frequencies of 60 Hz, 120 Hz, 180 Hz and so forth.

The following graphic shows 10 Hz Notch Filter selection and how the noise is dissipated over the entire spectrum but especially at the Notch Filter setting and its overtones.




*Relationship between Noise Rejection Level and RPI Setting*

The modules offer two levels of line noise rejection. Each level has a filter associated with it. The module automatically determines which filter is used based on the Notch Filter setting and RPI rate.

A trade-off exists between sampling speed and level of noise rejection:

- The faster the sampling speed, the less noise rejection. In this case, the 1756-IRT8I, 1756-IRT8IK module automatically uses a SINC^1 filter. The 1756-IR12, 1756-IR12K, 1756-IT16, and 1756-IT16K modules use a Sinc^5+Sinc^1 filter combination.

  This filtering option offers 34 dB noise rejection at the Notch Filter frequency and its overtones.
- At slower sampling rates (RPI > 3/Notch), the module has better noise rejection. In this case, the module automatically uses a SINC^3 filter.

  The SINC^3 filter offers 100 dB noise rejection at the Notch Filter frequency and its overtones.

### *1756-IRT8I, 1756-IRT8IK Notch Filter Settings*

The following tables lists the available Notch Filter settings.

**Table 11 - 1756-IRT8I, 1756-IRT8IK Notch Filter Settings**

| Notch Setting | 5 Hz | 10 Hz | 15 Hz | 20 Hz | 50 Hz | 60 Hz (Default) | 100 Hz | 500 Hz | 1000 Hz | 5000 Hz |
|---|---|---|---|---|---|---|---|---|---|---|
| Minimum Sample Time (RPI) - SINC^1 Filter(1) | 207.0 ms | 103.5 ms | 69.1 ms | 51.8 ms | 20.7 ms | 17.3 ms | 10.4 ms | 2.1 ms | 1.1 ms | 1.0 ms |
| Minimum Sample Time (RPI) - SINC^3 Filter(1) | 621.0 ms | 310.5 ms | 207.1 ms | 153.4 ms | 62.1 ms | 51.9 ms | 31.2 ms | 6.1 ms | 3.1 ms | 1.0 ms |
| 0…100% Step Response Time(2)(3) | 600 ms + 1RPI | 300 ms + 1RPI | 200 ms + 1RPI | 150 ms + 1RPI | 60 ms + 1RPI | 50 ms + 1RPI | 30 ms + 1RPI | 6 ms + 1 RPI | 3 ms + 1RPI | 1 ms + 1RPI |
| -3 dB Frequency(2) | 1.3 Hz | 2.7 Hz | 4.3 Hz | 5.1 Hz | 13 Hz | 15 Hz | 26 Hz | 128 Hz | 258 Hz | 1296 Hz |
| Typical Effective Resolution(2) (4) | 19 bits | 18 bits | 18 bits | 18 bits | 17 bits | 17 bits | 17 bits | 16 bits | 15 bits | 14 bits |

(1) The minimum RPI value for the module depends on the channel with the lowest Notch Filter setting. For example, if three of the channels on a module use a Notch Filter setting of 20 Hz and one channel uses a Notch Filter setting of 60 Hz, you cannot set the module RPI lower than 50.1 ms.
(2) Using the SINC^3 filter.
(3) Worst case settling time to 100% of step change includes 0…100% step response time plus one RPI sample time.z
(4) Measured in ±100 mV range.

If your application requires a Notch Filter setting of 50 Hz, the module’s minimum RPI rate is 20.7 ms. In this case, sampling speed is more important than noise rejection. The module automatically uses a SINC^1 filter.

If your application requires a Notch Filter setting of 50 Hz and the greater level of noise rejection provided by a SINC^3 filter, the minimum RPI rate is 62.1 ms. The module automatically uses a SINC^3 filter.

The RPI must be > 1/Notch Filter plus some small scan time for the ADC to sample properly. The SINC^3 filter takes three times as long and thus requires RPI > 3/Notch plus some small scan time. The module rejects combinations which violate that relationship.

**Table 12 - 1756-IRT8I, 1756-IRT8IK Notch Filter Settings and the RPI Values**

| Notch Filter | Fastest Available RPI | Fastest RPI for a SINC^3 Filter |
|---|---|---|
| 5 Hz | 207.0 ms | 621.0 ms |
| 10 Hz | 103.5 ms | 310.5 ms |
| 15 Hz | 69.1 ms | 207.1 ms |
| 20 Hz | 51.8 ms | 153.4 ms |
| 50 Hz | 20.7 ms | 62.1 ms |
| 60 Hz (default) | 17.3 ms | 51.9 ms |
| 100 Hz | 10.4 ms | 31.2 ms |
| 500 Hz | 2.1 ms | 6.1 ms |
| 1000 Hz | 1.1 ms | 3.1 ms |
| 5000 Hz | 1.0 ms | 1.0 ms |

To see where to set the Notch Filter, see page 104.

### *1756-IR12, 1756-IR12K, 1756-IT16, and 1756-IT16K Notch Filter Settings*

The following tables lists the available Notch Filter settings.

**Table 13 - 1756-IR12, 1756-IR12K, 1756-IT16, and 1756-IT16K Notch Filter Settings**

| Notch Setting | 20 Hz | 50 Hz | 60 Hz (Default) | 100 Hz | 500 Hz | 1000 Hz | 5000 Hz |
|---|---|---|---|---|---|---|---|
| Minimum Sample Time (RPI) - SINC^1 Filter(1) | 200.4 ms | 80.4 ms | 67.1 ms | 50.0 ms | 50.0 ms | 50.0 ms | 50.0 ms |
| Minimum Sample Time (RPI) - SINC^3 Filter(1) | 600.4 ms | 240.4 ms | 200.4 ms | 120.4 ms | 50.0 ms | 50.0 ms | 50.0 ms |
| 0…100% Step Response Time(2)(3) | 600 ms + 1RPI | 240 ms + 1RPI | 200 ms + 1RPI | 120 ms + 1RPI | 6 ms + 1 RPI | 3 ms + 1RPI | 1 ms + 1RPI |
| -3 dB Frequency(2) | 5.1 Hz | 13 Hz | 15 Hz | 26 Hz | 128 Hz | 258 Hz | 1296 Hz |
| Typical Effective Resolution(2) (4) | 18 bits | 17 bits | 17 bits | 17 bits | 16 bits | 15 bits | 14 bits |

(1) The notch filter setting is set on a module basis.
(2) Using the SINC^3 filter.
(3) Worst case settling time to 100% of step change includes 0…100% step response time plus one RPI sample time.
(4) The 1756-IR12, 1756-IR12K setting is measured in 0…5000 Ω range. The 1756-IT16, 1756-IT16K setting is measured in ±100 mV range.

If your application requires a Notch Filter setting of 50 Hz, the module's minimum RPI rate is 80.4 ms. In this case, sampling speed is more important than noise rejection. The module automatically uses a SINC^1 filter.

If your application requires a Notch Filter setting of 50 Hz and the greater level of noise rejection provided by a SINC^3 filter, the minimum RPI rate is 240.4 ms. The module automatically uses a SINC^3 filter.

The RPI must be > 4/Notch Filter plus some small scan time for the ADC to sample properly. The SINC^3 filter takes three times as long and thus requires RPI > 12/Notch plus some small scan time. The module rejects combinations which violate that relationship.

| Notch Filter | Fastest Available RPI | Fastest RPI for a SINC^3 Filter |
|---|---|---|
| 20 Hz | 200.4 ms | 600.4 ms |
| 50 Hz | 80.4 ms | 240.4 ms |
| 60 Hz (default) | 67.1 ms | 200.4 ms |
| 100 Hz | 50.0 ms | 120.4 ms |
| 500 Hz | 50.0 ms | 50.0 ms |
| 1000 Hz | 50.0 ms | 50.0 ms |
| 5000 Hz | 50.0 ms | 50.0 ms |

To see where to set the Notch Filter, see page 104.

## Underrange/Overrange Detection

This feature detects when a temperature-measuring input module is operating beyond limits set by the input range. For example, if you are using the module in the 0…1000 Ω input range and the module resistance increases to 1050 Ω, the overrange detection detects this condition.

The table lists the input ranges of non-isolated input modules and the lowest/highest signal available in each range before the module detects an underrange/overrange condition.

**Table 14 - Low and High Signal Limits on Temperature-measuring Input Modules**

| Input Type | Available Range | Underrange Threshold | Overrange Threshold |
|---|---|---|---|
| RTD | 0…500 Ω | ≤ 0.00 Ω | 510.00 Ω |
| | 0…1000 Ω | ≤ 0.00 Ω | 1020.00 Ω |
| | 0…2000 Ω | ≤ 0.00 Ω | 2040.00 Ω |
| | 0…4000 Ω | ≤ 0.00 Ω | 4080.00 Ω |
| Thermocouple | -100…100 mV | - 101.00 mV | 101.00 mV |

**IMPORTANT** Be aware that the Disable All Alarms feature, does not disable the underrange/overrange detection feature. The Disable All Alarms feature disables all alarms on the module.

The underrange/overrange detection feature is not an alarm. It is an indicator that channel data has gone beyond the absolute maximum or minimum, respectively, for the channel's chosen range but does not trigger an alarm.

To disable the underrange/overrange detection feature, you must disable the channel.

To see where to set the Underrange/Overrange detection values, see page 109.

## Digital Filter

The digital filter smooths input data noise transients on each input channel. This value specifies the time constant for a digital first order lag filter on the input. It is specified in units of milliseconds. A value of 0 disables the filter.

The digital filter equation is a classic first order lag equation.

$$Y_n = Y_{n-1} + \frac{[\Delta t]}{\Delta t + TA} \; X_n - Y_{n-1}$$

$Y_n$ = Present output, filtered peak voltage (PV)

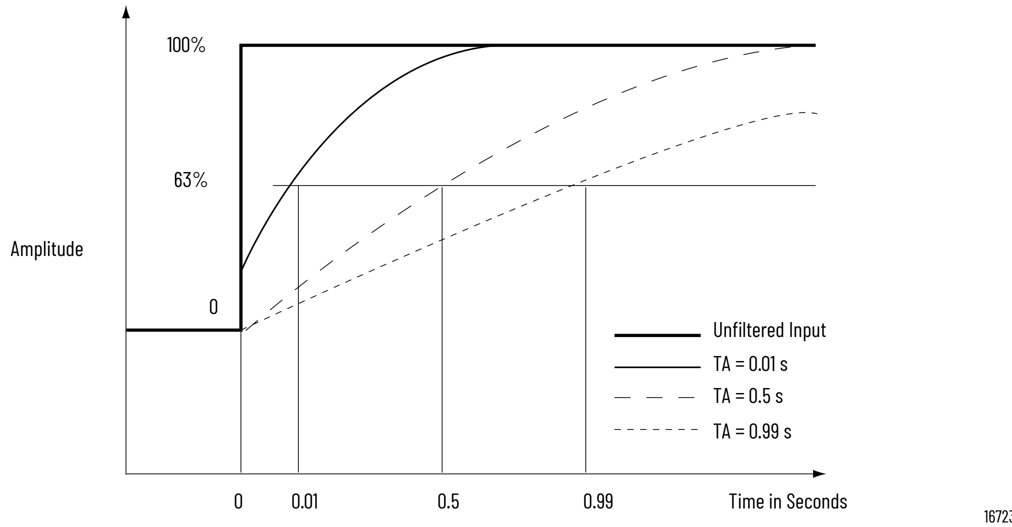
$Y_{n-1}$ = Previous output, filtered PV

$\Delta t$ = Module channel update time (seconds)

TA = Digital filter time constant (seconds)

$X_n$ = Present input, unfiltered PV

By using a step input change to illustrate the filter response, you can see that when the digital filter time constant elapses, 63.2% of the total response is reached. Each additional time constant achieves 63.2% of the remaining response.




To see where to set the Digital Filter, see page 103.

## Process Alarms

The 1756-IRT8I, 1756-IRT8IK supports process alarms. Process alarms alert you when the module has exceeded configured high or low limits for **each channel**. These are set at four, user-configurable, alarm trigger points:

- High high
- High
- Low
- Low low

You can enable or disable Process Alarms individually via the Output tags for each channel. When a module is added to your Logix Designer application project and tags are created, the Alarms are disabled by default.

Each individual Process Alarm enable tag, that is, *O.Ch[x].LLAlarmEn, O.Ch[x].LAlarmEn, O.Ch[x].HAlarmEn and O.Ch[x].HHAlarmEn*, is disabled when the module is created. You must enable the tags in the Output Data to allow the individual alarm to trigger.

If an enable bit of a Process Alarm is not set, the corresponding Input Process Alarm never triggers. To see where to set the Process Alarms, see page 109.

You can latch process alarms. The alarm remains on, even if the condition causing it to occur disappears, until the alarm is unlatched.

**IMPORTANT** You must manually unlatch the alarm. You can unlatch the alarm, by using one of the following methods:

- While the project is online, click the Alarm Configuration tab on the Module. Then click Unlatch to unlatch a specific alarm or Unlatch All to unlatch all alarms.
- Change the module output tag for the alarm that you want to unlatch. For example, the *Ch[x].LLAlarmUnlatch* tag to unlatch a Low Low Alarm.

For more information on module tags, see Appendix A, Analog I/O Module Tag Definitions on page 157.

- Use a CIP Generic message.

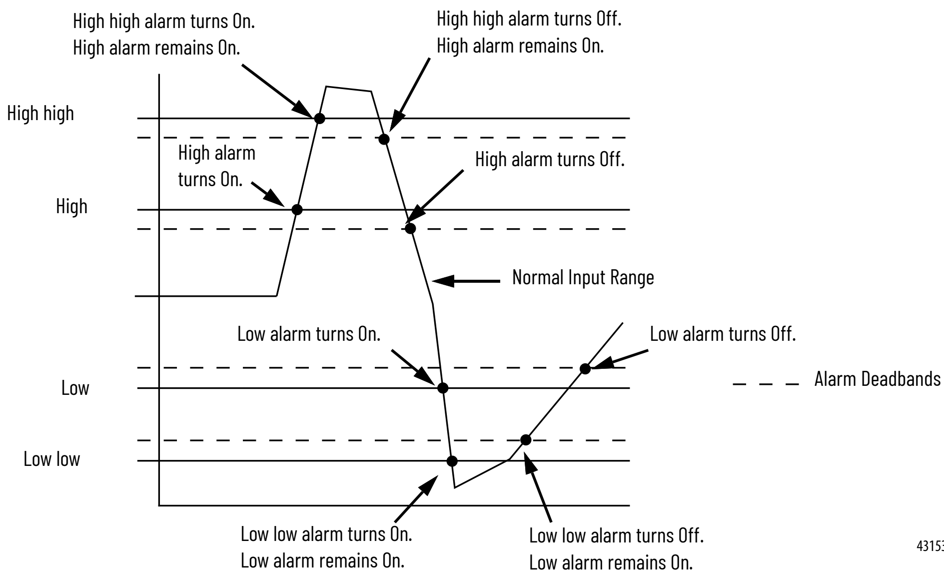
For more information how to use a CIP Generic message, see Rockwell Automation Knowledgebase article #63046, How to Reset Latched Status of an Analog Module. You can access the article at: https://rockwellautomation.custhelp.com/

*Alarm Deadband*

You can configure an alarm deadband to work with these alarms. The deadband lets the process alarm status bit remain set, despite the alarm condition disappearing, as long as the input data remains within the deadband of the process alarm. If the Alarm Deadband is mixed with Alarm Latching, an Unlatch command while the Alarm is within the Deadband causes the Alarm to be cleared.

Figure 12 shows input data that sets each of the four alarms at some point during module operation. In this example, latching is disabled; therefore, each alarm turns Off when the condition that caused it to set ceases to exist.

**Figure 12 - Alarm Deadband Alarm Settings**




To see where to set the Alarm Deadband, see page 109.