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SP-013

Layer N Digital Pulse Smart Probe

omega.com   info@omega.com

Omega Engineering, Inc:

800 Connecticut Ave. Suite 5N01, Norwalk, CT 06854, USA
Toll-Free: 1-800-826-6342 (USA & Canada only)
Customer Service: 1-800-622-2378 (USA & Canada only)
Engineering Service: 1-800-872-9436 (USA & Canada only)

Tel: (203) 359-1660   Fax: (203) 359-7700
e-mail: info@omega.com

Omega Engineering, Limited:

1 Omega Drive, Northbank,
Irlam Manchester M44 5BD
United Kingdom

Omega Engineering, GmbH:

Daimlerstrasse 26 75392
Deckenpfronn Germany

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1 Notes, Warnings, and Cautions

If the equipment is used in a manner not specified in this manual, the protection by the equipment may be impaired.

Do not operate the equipment in flammable or explosive environments.

It is important to read and follow all precautions and instructions in this manual before operating or commissioning this device as it contains important information relating to safety and EMC. Failure to follow all the safety precautions may result in injury and/or damage to the equipment.

The following labels identify information that is especially important to note:

Note ☞ **Note:** Provides information that is important to successfully set up and use the SP-013.

Caution or Warning: Informs about the risk of electrical shock.

Caution, Warning, or Important: Informs of circumstances that can affect the functionality of the instrument and must refer to accompanying documents.

2 Introduction

The Layer N SP-013 Digital Interface Smart Probe provides an easy way to integrate digital pulse inputs into the Layer N Ecosystem. The SP-013 accepts digital pulse inputs through its M12 5-pin connector and Layer N Smart Interfaces through its M12 8-pin connector. The optional M12.8-T-SPLIT Sensor Splitter can be used to access the Discrete I/O pins on the M12 8-pin connector. The optional M12.5-S-M-FM and M12.8-S-M-FM mating connectors can be utilized to easily connect wire leads to the SP-013 or sensor splitter. The SP-013 may be configured to monitor the on/off state of the input signals, the pulse rate/ duty cycle of the primary input, or the pulse delay between the two signals. The pulse totalizing function supports both standard counting and up/down counting. A mixed-mode configuration option allows for the measurement of one digital pulse input and one process input which may be independently configured as a 0-24 mA, 0-1.0 V_{DC}, or 0-2.0 V_{DC} input.

The Layer N SP-013 features 2 configurable discrete I/O pins. These can be used for a myriad of applications including driving relays, physical alarms, or sensing dry contacts like door switches. The SP-013 can also be utilized as an edge controller, with autonomous independent decision-making capabilities to generate local alarms or provide control outputs based on sensor inputs.

Included with the SP-013

- SP-013 Unit
- Quick Start Guide

Additional Material Needed

- A Layer N Smart Interface
- A Windows 7, 8, 9, 10, or 11 OS PC or laptop with Omega's free SYNC configuration software
- A Layer N Cloud account or a qualifying Omega Enterprise Gateway license tier (Pro, Business, or Business Pro)
- A compatible Layer N Gateway

Figure 1: SP-013 unit

Optional Materials

- M12.8-T-SPLIT Sensor Splitter
- M12.8-S-M-FM Screw Terminal Accessory

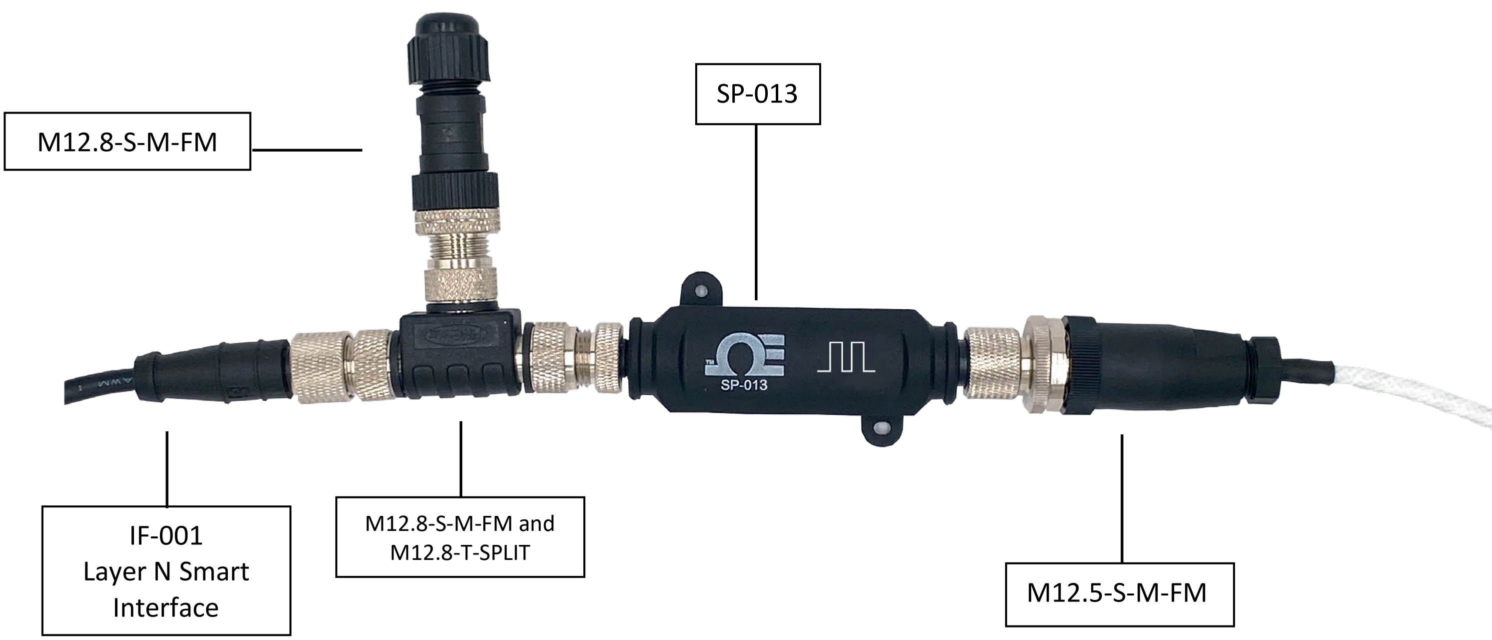


Figure 2: Example SP-013 integrated into a Layer N ecosystem

3 Specifications

INPUT POWER

Voltage: 2.8 V_{DC} - 3.3 V_{DC}

DIGITAL INPUT SIGNALS

ON: 1.0 V_{DC}
OFF: 0.7 V_{DC}
Internal Pull Up/Down: 1.5k to 3.0 V_{DC}
Comparator (PULSE) Input: 100 mV, 500 mV, 1.0 V_{DC}, 2.0 V_{DC}

Type	Range	Operating Conditions	Accuracy
Frequency (Rate)	0.01 Hz to 100 Hz	$T_{PW\ MIN}$ = 200 uS	± 0.5%
Frequency (Rate)	100 Hz to 1000 Hz	$T_{PW\ MIN}$ = 200 uS	± 1 Hz Averaged over 1s
Up Counter	0 to +8388608	1 kHz Max Rate	± 1 Count Max
Up/Down Counter	-8388608 to +8388608	1 kHz Max Rate	± 1 Count Max
Pulse Width (T_{PW})	200 uS min		± 50 uS ± 1%
Pulse Delay (T_{PP})	200 uS min		± 50 uS ± 1%
Duty Cycle	1% to 99%	0.01 Hz to 1000 Hz, $T_{PW\ MIN}$ = 200 uS	±1.5% Max

ANALOG (PROCESS) INPUT SIGNALS

Type	Range	Resolution	Min	Max	Accuracy	Input Impedance
Current Loop	0-20 mA	± 0.1 mA	0 mA	24 mA	± 0.2 mA	50 ohm
Voltage	0 – 1.0 V_{DC}	± 10 mV	0 V_{DC}	1.20 V_{DC}	± 10 mV	100k ohm
Voltage	0 – 2.0 V_{DC}	± 10 mV	0 V_{DC}	2.50 V_{DC}	± 20 mV	100k ohm

DIO DIGITAL INPUTS

$V_{inHighThreshold}$ = 2.2 V_{MAX}
$V_{inLowThreshold}$ = 0.3 V_{MIN}
V_{inMAX} = 30 V_{DC}

DIO DIGITAL OUTPUTS

2x Open Drain 100 mA max
V_{MAX} = 30 V_{DC}

ENVIRONMENTAL

Operating Temperature: -40 to 85°C (-40 to 185°F)
Rating: IP67 when mated

MECHANICAL

Dimensions: 22.1 mm W x 96.7 mm L (0.87" x 3.80") not including mounting tabs

GENERAL

Agency Approvals: CE, UKCA
Compatibility: Compatible with OEG, SYNC configuration software, Layer N Cloud, and Modbus Networks

4 Hardware Setup

4.1 Connecting to your Layer N Smart Interface

The SP-013 requires a Layer N Smart Interface to connect to a computer. Use the M12 8-Pin Connector diagram below to connect the SP-013 to a Layer N Smart Interface.

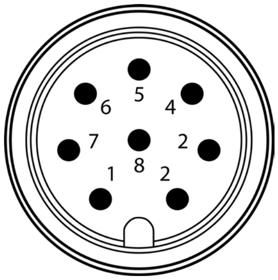


Figure 3: M12 8-Pin Male Connector Front View

Pin	Name	Function
Pin 1	DIO 0	Discrete I/O Signal 0
Pin 2	INTR	Interrupt Signal
Pin 3	SCL	I2C Clock Signal
Pin 4	SDA	I2C Data Signal
Pin 5	Shield	Shield Ground
Pin 6	DIO 1	Discrete I/O Signal 1
Pin 7	GND	Power Ground
Pin 8	3.3VDD	Power Supply

4.2 Digital Input Wiring Diagram

The Layer N SP-013 accepts digital pulse inputs through its M12 5-Pin connector and a single process input in the mixed input mode. Users connecting wires directly to the SP-013 may refer to the wiring diagram provided below:

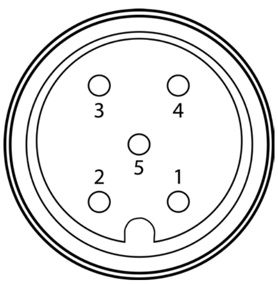


Figure 4: M12 5-Pin Female Connector Front View

Pin	Digital Mode	Mixed Mode
Pin 1	Excitation Power (3.3 V_{DC}, 100 mA)	Excitation Power (3.3 V_{DC}, 100 mA)
Pin 2	DIN 0 / Pulse A	DIN 0 / Pulse A
Pin 3	Ground Reference	Ground Reference
Pin 4	DIN 2 / Enable / Direction / Pulse B	Process 0
Pin 5	DIN 1 / Reset	DIN 1 / Reset

4.3 Discrete I/O

If the smart probe discrete I/O will be utilized, an M12.8-T-SPLIT and an M12.8-S-M-FM will need to be connected between the Smart Interface and Smart Probe. Refer to the previous pin diagram and the wiring diagram below to connect the accessories:

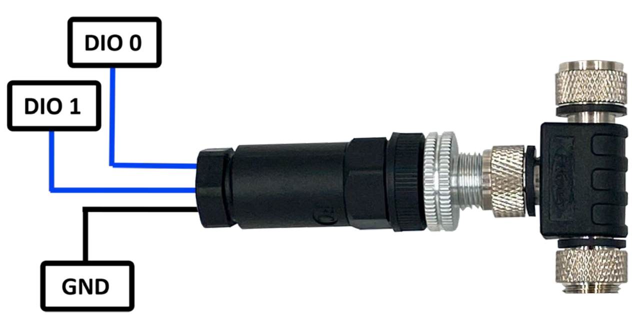


Figure 1: M12.8-T-SPLIT and M12.8-S-M-FM accessories for Discrete I/O access

5 SYNC Configuration

Layer N Smart Probe products are easily configured through Omega's free SYNC configuration software. Ensure SYNC is running on a Windows OS computer before continuing. Connect the SP-013 to the computer using your Layer N Smart Interface to begin.

Note: SYNC is available to download for free on the OMEGA website.

5.1 Connecting to SYNC - Automatic Detect

Once the SP-013 and Layer N Smart Interface are connected to the computer, SYNC will automatically detect the probe and begin displaying readings.

Note: If living readings from the SP-013 are displayed on SYNC, skip ahead to section **5.3 Input Configuration.**

5.2 Connecting to SYNC – Manual

If SYNC does not automatically detect the device, follow these instructions to manually connect it.

Step 1: Click on the [+] icon located on the top left of the SYNC interface.

Step 2: Proceed through the **Add Device Wizard** and click **End Device / Probe**.

5.2.1 Communication Interface

Set the communication parameters for the Layer N Smart Interface that you are connecting to.

Note: The connection type and parameters must be accurate for a proper connection to be established. Failure to accurately setup communication parameters may result in communication errors.

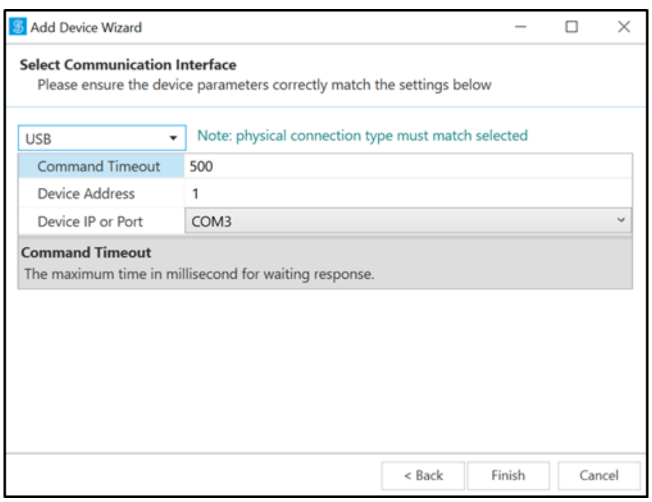


Figure 2: USB Communication Interface

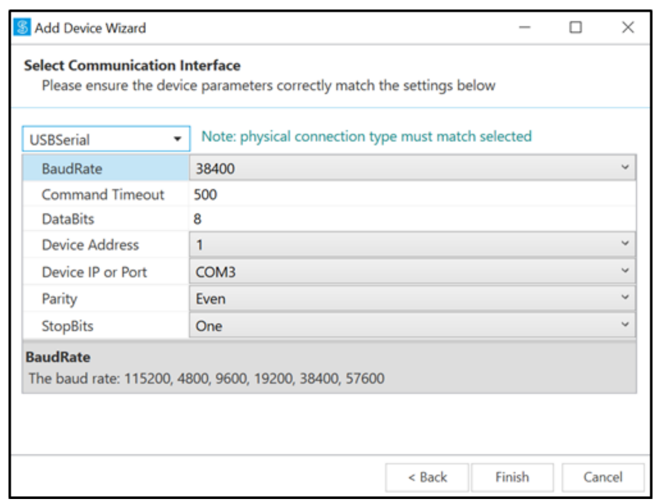


Figure 3: USB Serial Communication Interface

- **Connection Type:** Select the type of connection you have between your SP-013 and your computer.
- **Command Timeout:** The maximum time (in milliseconds) for a command to be completed before the command is aborted.

Note: The default command timeout is 500 milliseconds. It is recommended that this section be left alone to avoid communication errors.

- **Device Address:** If your Smart Interface is part of a network, enter the Network Address here. The default network address is 1 for most devices. Please refer to the manual of your Smart Interface for more information.

Note: The default Device Address is 1.

- **Device IP or Port:** The COM port number that your device is connected to on your computer.

Important: The following parameters should **NOT** be changed. These settings should **NOT** be changed unless the configuration has been done on the interface.

- **BaudRate:** Controls bits per second
- **DataBits:** The number of 'bits' in each character sent.
- **Parity:** A means of checking the correctness of character by adding an extra 'bit' to the character and setting the value based on all the other bits in the character.
- **StopBits:** The number of 'bits' used to indicate the end of the character.

Once you have completed setting the communication parameters for your device, click **Finish**.

5.3 Input Configuration

In Digital Inputs mode, the SP-013 accepts digital pulse inputs and may be configured to monitor the on/off state of the input signals, the pulse rate or pulse duty cycle of the primary input, the up/down count of the primary input, or the pulse delay between two signals. In Mixed Input mode, the SP-013 can accept one process input and one digital pulse input. In all modes, the general Discrete I/O may be configured. These modes are detailed in the sections below.

5.3.1 Digital Inputs Interface

To configure the Digital Inputs, follow the steps below:

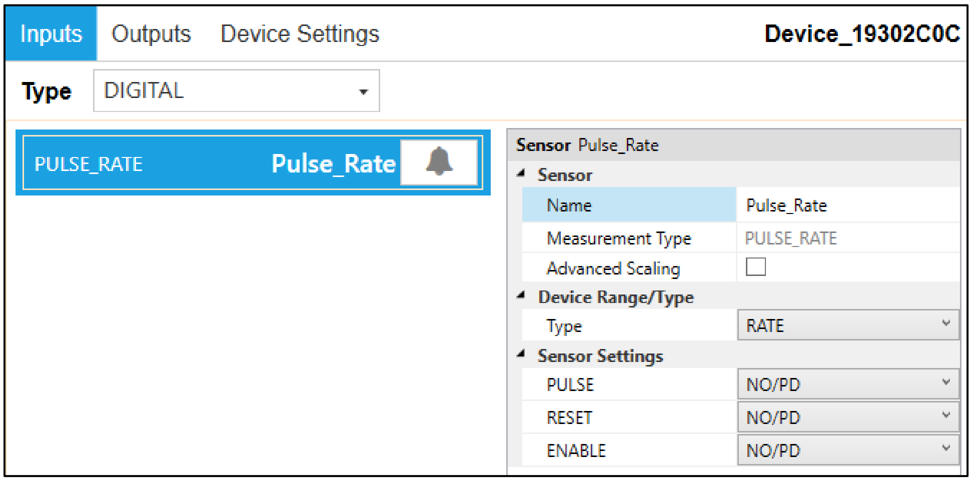


Figure 7: SYNC interface digital input without DIO configuration

Step 1: Click the **Inputs** configuration tab on SYNC and choose **Digital** or **Digital, DIO** from the **Type** dropdown.

Step 2: Select the type of digital input in the Device Range/Type dropdown in SYNC. The following types are available:

Selection	Measurement	Description
DIN	Digital Input	3-bit Binary Digital Input
RATE	Frequency	Measure the frequency of rising edges
WIDTH	Pulse Width	Measure the active time of a signal
DUTY	Duty Cycle	Measure the % of active time of a signal
DELAY	Phase Delay Timer	Measure the time between the rising edges of Pulse A and Pulse B
COUNT	Up Counter / Totalizer	Counter with Enable and Reset
UP/DOWN COUNT	Up/Down Counter/Totalizer	Counter with Direction and Reset

Digital Input Binary								
DIN_0	Inactive	Active	Inactive	Active	Inactive	Active	Inactive	Active
DIN_1	Inactive	Inactive	Active	Active	Inactive	Inactive	Active	Active
DIN_2	Inactive	Inactive	Inactive	Inactive	Active	Active	Active	Active
Digital_Input Display (Binary)	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0

5.3.1.1 *Pulse Measurements*

Pulse measurements include Digital Input (DIN), Frequency (RATE), Pulse Width (WIDTH), Duty Cycle (DUTY), Phase Delay Between Pulse Inputs (DELAY), Up Counter/Totalizer (COUNT), and Up/Down Counter/Totalizer (UP/DOWN COUNT). All measurements are derived from signal transitions and an internal 32.768 kHz time reference. The pulse input signal is read on the Pulse A input (pin 2) and the reset input signal is read on the Reset input (pin 5). The third input on pin 4 changes its functionality depending on the pulse measurement type and can be Enable, Direction, or Pulse. When the reset input is *activated* then the pulse input value is zeroed for all pulse measurement types. When the third input pin is configured as an enable input and is *deactivated* then the pulse input value is zeroed. Unless otherwise stated, the third input pin defaults to Enable functionality which must be set HIGH to allow measurement.

The **Digital Input (DIN)** mode reports the binary value on the DIN pulse input pins. Note the DIN inputs replace the functionality of the Pulse, Reset, and Enable inputs.

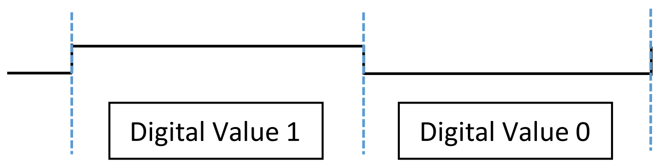


Figure 8: Digital Input example

Two measurement modes are used when measuring **Frequency (RATE)**. If the measured frequency is greater than 100 Hz the total number of pulses/second is used to determine the frequency. If the measured frequency is less than 100 Hz the time between rising edges is used to calculate the frequency.

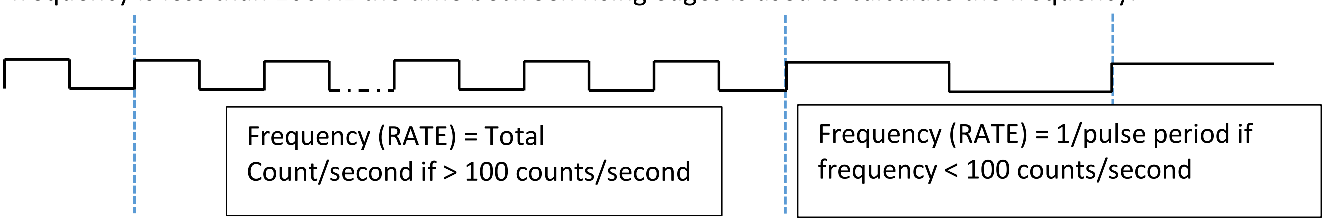


Figure 9: Frequency (rate) example

The **Pulse Width (WIDTH)** setting measures the active portion of a periodic signal in msec. The pulse input may be configured to be active high or active low to measure the positive or negative portion of the pulse width. See the Input Configuration Diagrams section for details.

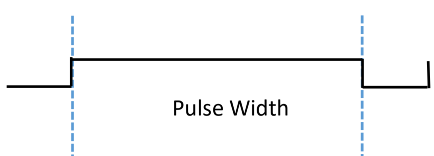


Figure 10: Positive pulse width example

The **Duty Cycle (DUTY)** setting measures the percentage of time a pulse is active (high) over the total period of the signal. The duty cycle measurement allows reading the input from PWM control signals.

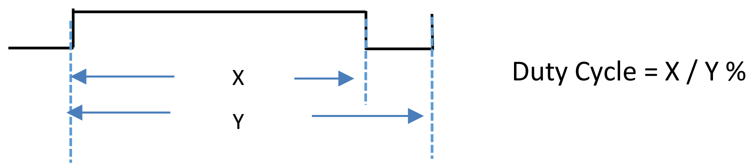


Figure 11: Duty cycle example

The **Phase Delay (DELAY)** mode measures the delay time in msec between the rising edges of Pulse A and Pulse B inputs. Note the Pulse B input replaces the functionality of the Enable input. This function is intended to be used on two input pulses operating at the same frequency but with different phase offsets.

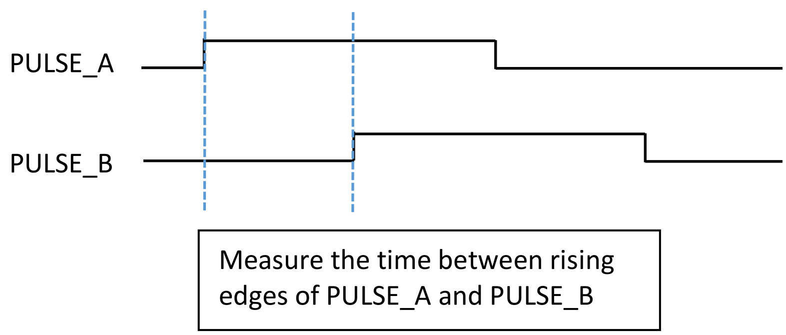


Figure 12: Phase Delay example

The **Up Counter/Totalizer (COUNT)** mode counts the number of rising edges while the Enable input is active until the Reset input is activated. The Enable Input (Pin 4) acts as a Stop/Start for the Up Counter when pulled up to 3.3 V. If the Enable Input is *Inactive*, it will pause/stop the up counter until it is re-enabled. If the Enable Input is *Active*, it will start the up-count. Activating the Reset input (Pin 5) will reset the counter back to 0. The Reset and Enable inputs can be configured to be active high or active low by configuring the Enable Input to Pull-Down (PD). See the ***Input Configuration Diagrams*** section for details.

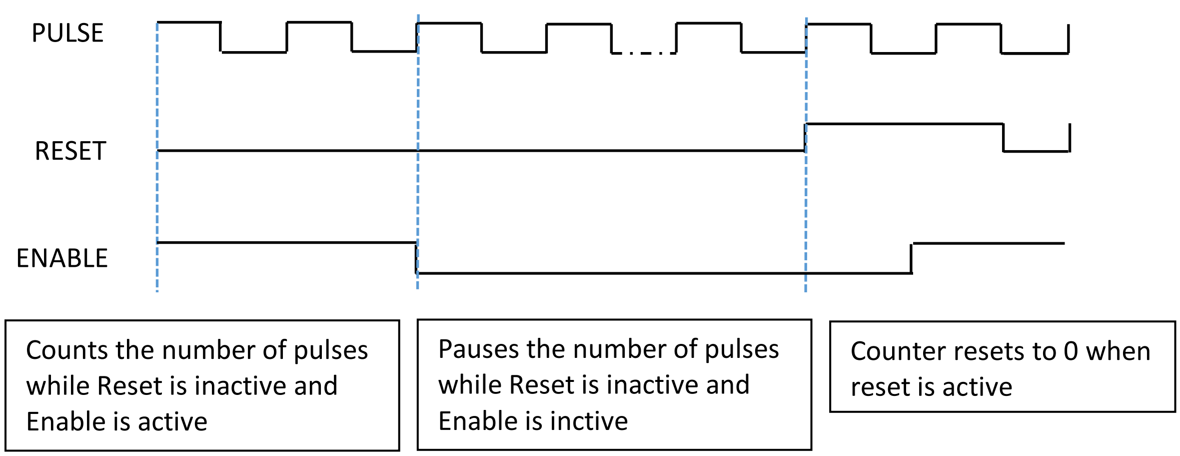


Figure 13: Up Counter/Totalizer example with Active High Reset and Enable

The **Up/Down Counter/Totalizer (UP/DOWN COUNT)** mode counts the number of rising edges until the Reset input is activated. Additionally, the direction of the counter may be controlled using the Direction input (Pin 4) so that it counts up when *Active* and down when *Inactive*. Note the Direction input replaces the functionality of the Enable input. The Reset and Direction input can be configured to be *active high* or *active low*. See the ***Input Configuration Diagrams*** section for details.

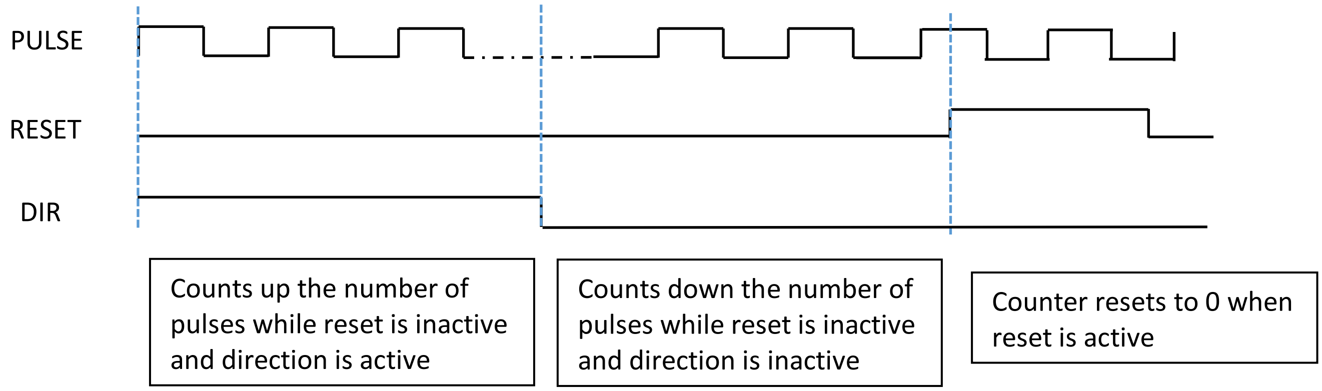


Figure 14: Up/Down Counter/Totalizer example with Active High Reset and Direction

5.3.1.1.1 Input Configuration Diagrams

The digital pulse input pins can be independently set to either have an internal 1.5k **Pull Up (PU)** or **Pull Down (PD)** and can be set to be either Active High or Active Low by selecting **Normally Open (NO)** or **Normally Closed (NC)** in the SYNC input configuration interface. Some typical circuits are shown below:

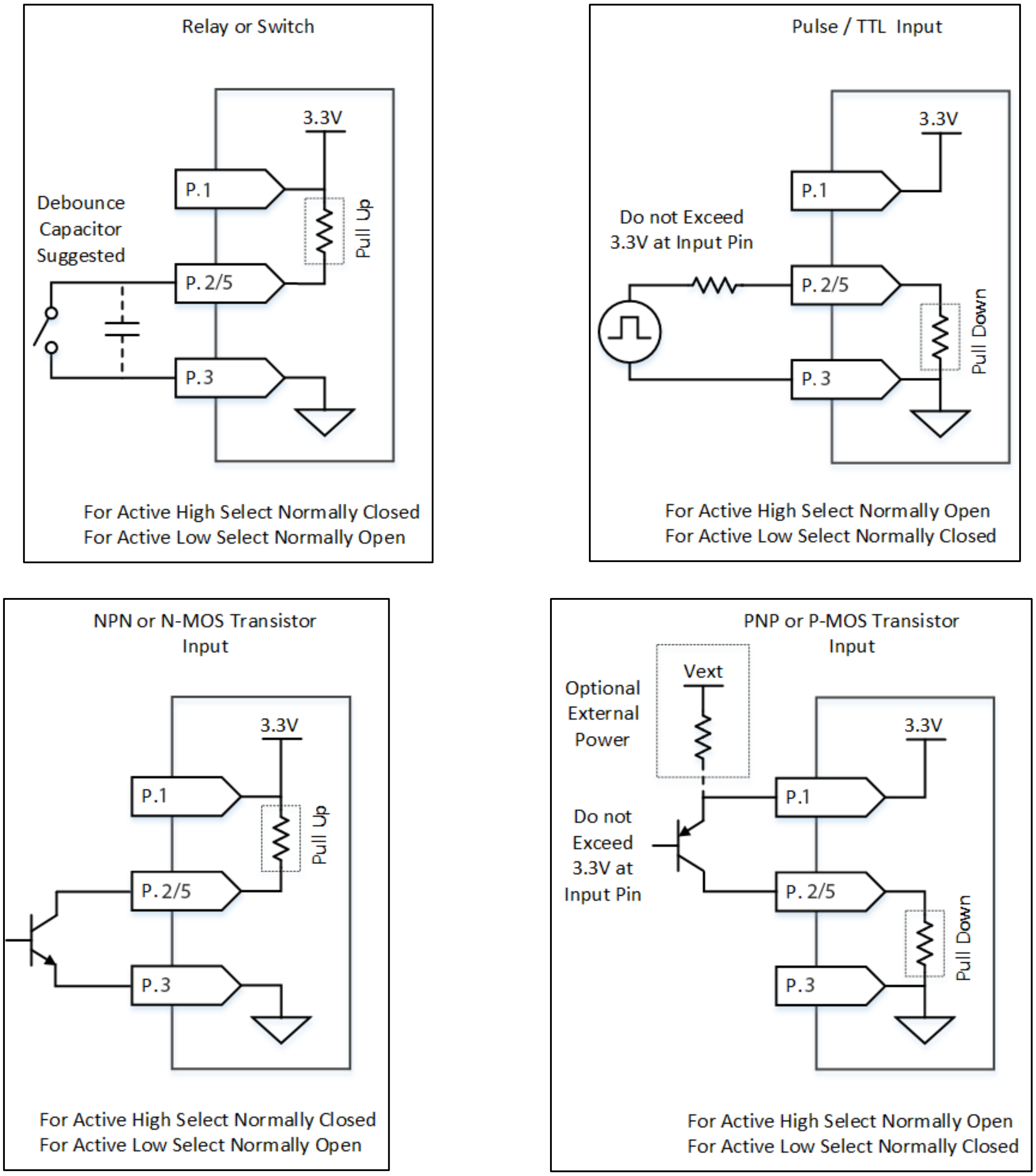


Figure 15: Active High/Low Circuit Examples

The DIN 0 / Pulse A input pin may also be configured for low-level mV input signals. The four selectable ranges determine the **turn-on threshold (TH)** and the **turn-off threshold (TL)** which are used to set the ACTIVE level of the digital input.

Setting	High Threshold (ON)	Low Threshold (OFF)
100 mV	75 mV	37.5 mV
500 mV	375 mV	187.5 mV
1.0 V	0.75 V_{DC}	0.375 V_{DC}
2.0 V	1.5 V_{DC}	0.75 V_{DC}

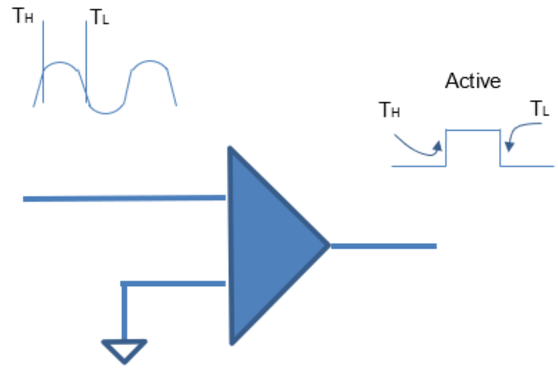


Figure 16: Active High/Low Threshold example

5.3.2 Mixed Input Interface

When set to the mixed input mode, the SP-013 can accept one process signal and one digital pulse input. To configure the digital pulse and process inputs, follow these steps:

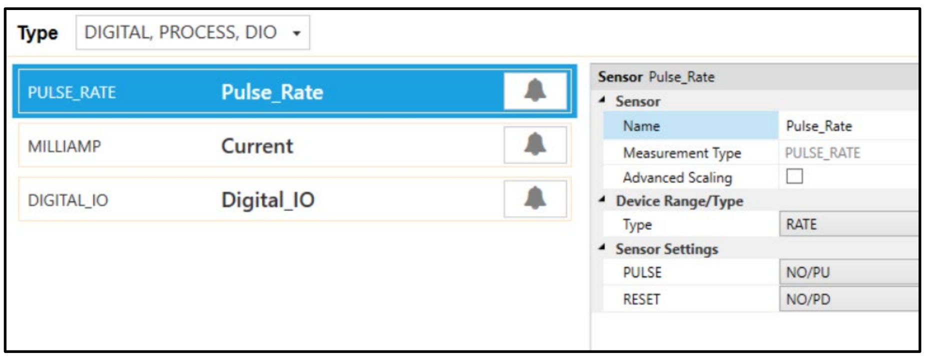


Figure 17: SYNC interface digital and process configuration with general DIO

Step 1: Click the **Inputs** configuration tab on SYNC and choose the **Digital, Process** or **Digital, Process, DIO** type from the **Type** drop-down.

Step 2: For each respective channel, select the type of digital or process input in the **Device Range/Type** drop-down. Click **Apply Settings** when done.

For additional information regarding pin wiring for the single digital and single process mixed mode, refer to the wiring diagrams on page 8.

5.3.2.1 *Digital Inputs (Mixed Mode)*

The following table lists the available digital input configuration options available when in mixed mode. Some options available in digital-only mode are not available in mixed mode. Descriptions and example diagrams are provided starting in section **5.3.1.1 Pulse Measurements**.

Selection	Measurement	Description
DIN	Digital Input	2-bit binary digital input
RATE	Frequency	Measures the frequency of rising edges
WIDTH	Pulse Width	Measures the active time of a signal
DUTY	Duty Cycle	Measures the % of active time of a signal
COUNT	Up Counter / Totalizer	Counter with Enable and Reset

Important: Digital input signals (pulse inputs) ***must*** be referenced to ground when *Mixed Mode* is used. Negative offsets at pulse inputs may cause interference and noisy/incorrect readings in analog (mA/V) process input signals.

The table below shows the binary-weighted values for the 2-bit Digital Input (DIN) function in mixed mode.

Input 1	Input 0	Reading
Inactive	Inactive	0
Inactive	Active	1
Active	Inactive	2
Active	Active	3

5.3.2.2 *Process Inputs (Mixed Mode)*

The following process input configuration options are available in mixed input mode: 4-20 mA current loop, 0-1.0 V voltage input, 0-2.0 V voltage input. Current loop readings are rounded to the nearest 0.1 mA and voltage readings are rounded to the nearest 10 mV.

5.3.2.2.1 *4-20 mA Device Connection*

The Current Loop interface measures the current into the selected input by converting it to a voltage measurement across a fixed 49.9-ohm resistor.

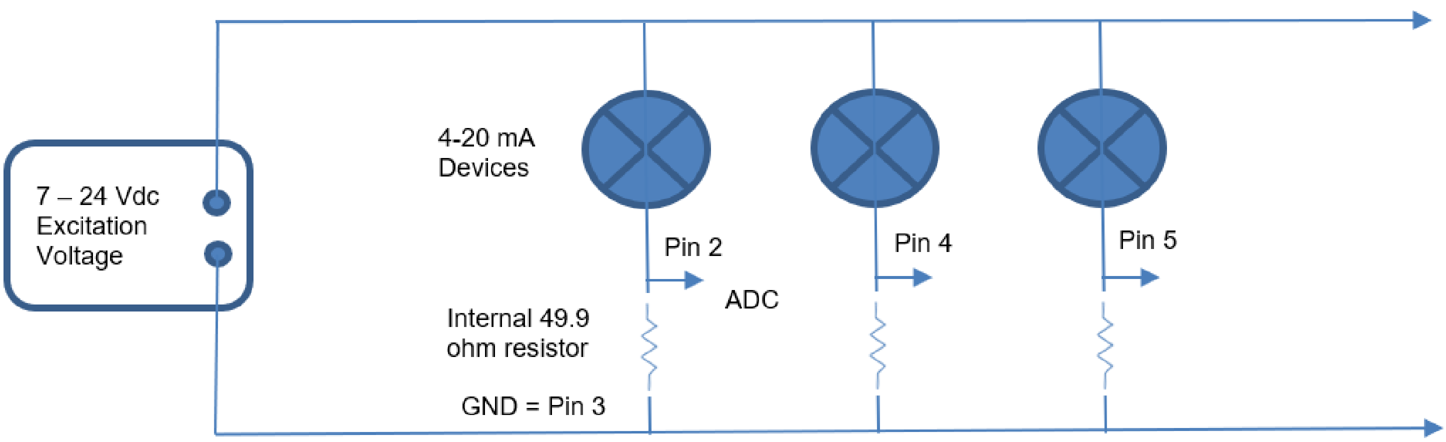


Figure 18: 4-20 mA device connection diagram

5.3.3 Discrete Input/Output (DIO)

The Layer N SP-013 features 2 configurable discrete I/O pins. These can be used for a myriad of applications including driving relays, physical alarms, or sensing dry contacts like door switches. The user may configure the polarity of the inputs (active **HIGH** or active **LOW**) or **Disable** the DIO to utilize the outputs (ON/OFF, PWM, SERVO).

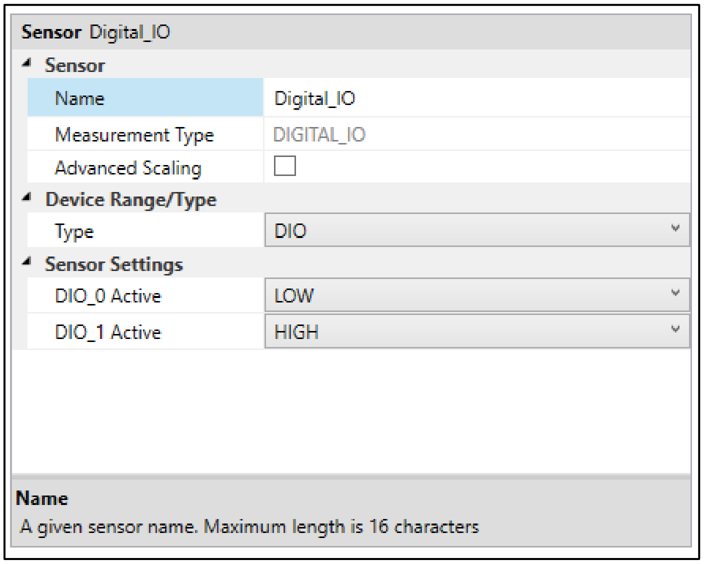


Figure 19: SYNC interface discrete I/O input configuration

The Discrete I/O input shares the output circuitry. The internal process drives the output control signal to turn on the output driver which will force the output low. When the state of the DIO input signal is to be read the processor applies 3.3 V_{DC} to the Input Bias signal and reads the level detected at the Input Sense. If the output is inactive an external signal may be used to force the input level low. A diode protects external positive voltages, allowing the output driver to activate loads greater than the internal 3.3 V_{DC}.

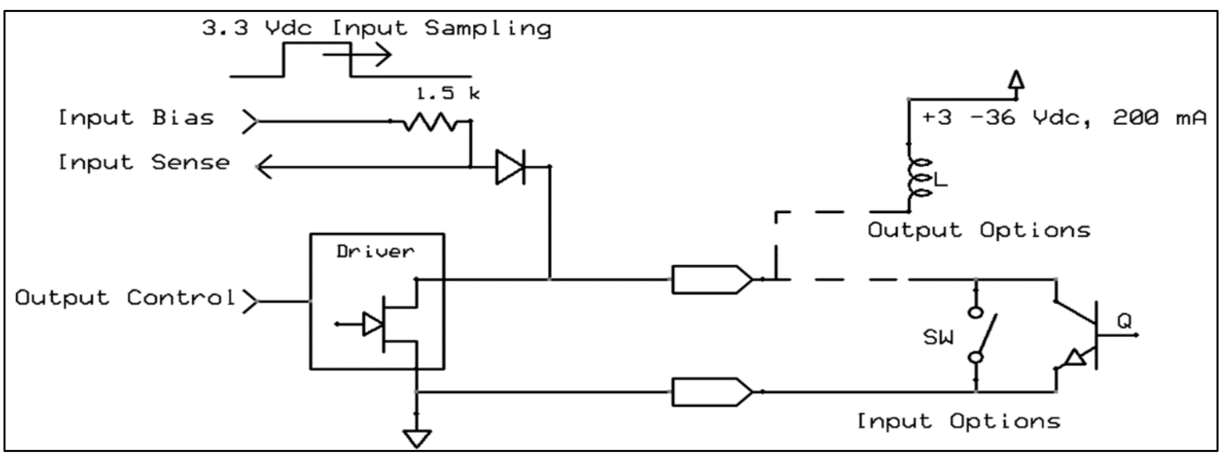


Figure 20: Digital/Discrete I/O circuitry

5.3.3.1 *Setting DIO as an Input*

To use a DIO pin as an input, make sure it is set to **Active Low** (default) in the **Output Tab** in SYNC.

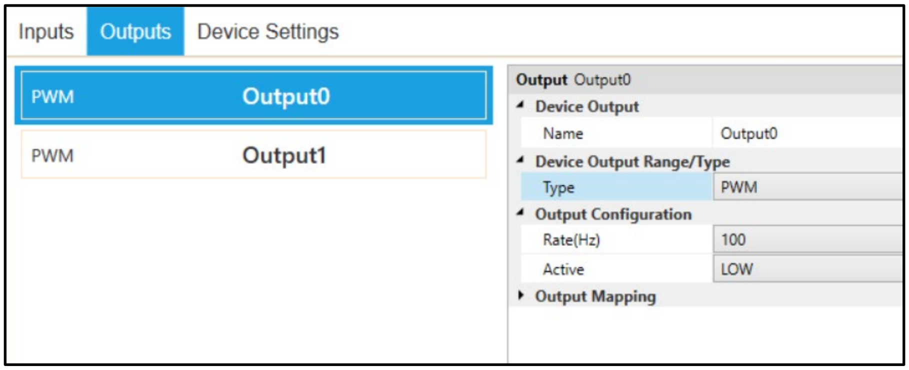


Figure 21: SYNC interface outputs tab

Then, in the **Input Tab**, select a **Type** from the drop-down which includes DIO. Each DIO pin has an internal pull-up, but to save power, the internal pull-up is only active when the unit takes a reading.

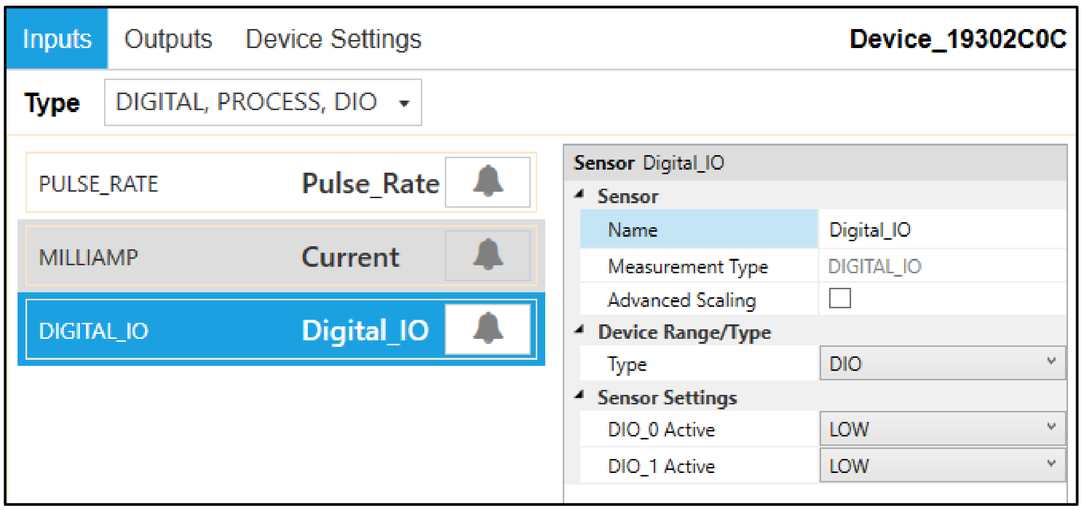


Figure 22: SYNC interface Digital_IO

5.3.4 Advanced Scaling Options

The Layer N SP-013 allows for advanced scaling options on process and pulse inputs only. The **Advanced Scaling** checkbox can be selected to expand additional configuration options. A gain and/or offset can be applied to the input reading and the displayed unit can be changed.

To apply a gain or offset to the input, expand the **Scaling** menu and ensure that **Apply Scaling** is checked. There, the gain and offset values can be adjusted. Both positive and negative values may be entered as well as decimal numbers. The equation for the scaled input value is given below.

$$\boldsymbol{Input_{Scaled} = (Input_{Raw} \times Gain) + Offset}$$

The displayed units can be changed by entering a new value in the **Unit** field and clicking **Apply Settings**. This field is limited to a maximum of 4 characters. Note that changing the Unit field does not change the base unit type, only the display name. The **Lock** checkbox must be selected to use the user-defined Unit field. Unchecking the Lock checkbox and clicking **Apply Settings** will revert the unit display back to the default setting.

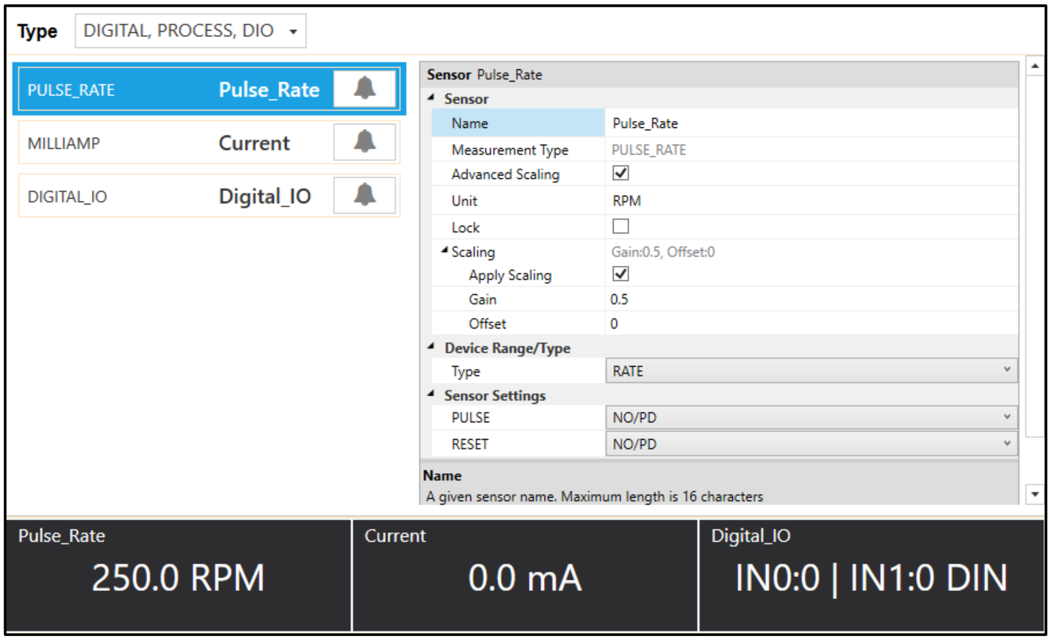


Figure 23: Advanced Scaling Example

The screenshot above shows an example application for advanced scaling with changed units. A fan tachometer with a 500 Hz signal is connected to the Pulse Rate input. The fan outputs 2 pulses per revolution, so to convert to rotations per minute (RPM) the reading must be divided by 2 which is accomplished by setting the Gain to 0.5. The units can then be renamed to RPM and will display as such.

5.4 Output Configuration

The SP-013 offers two discrete outputs that share circuitry with the discrete inputs. If an output is to be used then the corresponding input pin must be set to **Disable**. See section ***5.3.1 Discrete Input/Output (DIO)*** for more information.

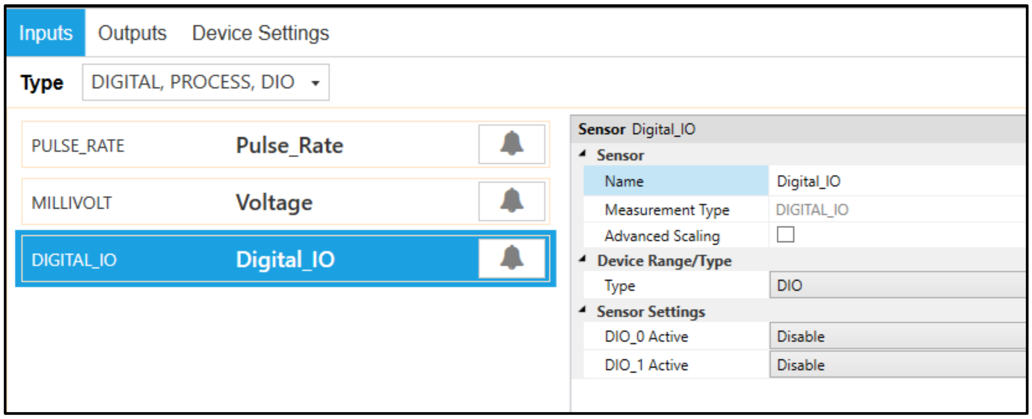


Figure 24: SYNC interface SP-013 DIO_0 and DIO_1 set to Disable

There are three types of output options – On/Off, Pulse-Width Modulation (PWM), or Servo. See section **5.4.1** for more information on each type.

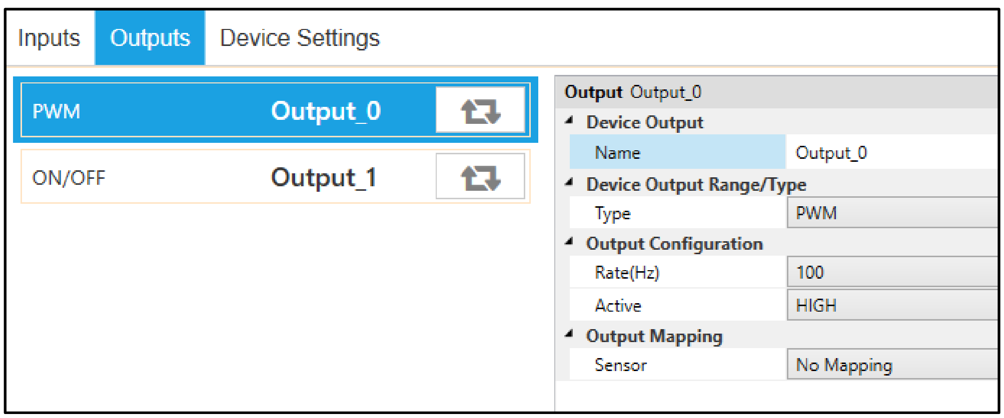


Figure 25: SYNC interface Output Configuration

Outputs may be configured as either *Active High* or *Active Low*. When configured as Active High the output conducts normally and becomes high impedance when activated. When configured as Active Low the Open-Drain output is high impedance normally and will conduct when activated.

Option	Value	Description
Active	LOW	When the output is inactive, it is in a high impedance state.
	HIGH	When the output is active, it is in a high impedance state.

An output may be controlled in one of three ways – a scaled mapping to an input, an on/off control from an input setpoint, or as an input alarm. Sections **5.4.2** through **5.4.4** describe these output control methods.

5.4.1 Device Output Range/Types

There are three types of output options – On/Off, Pulse-Width Modulation (PWM), or Servo. This section describes these output options.

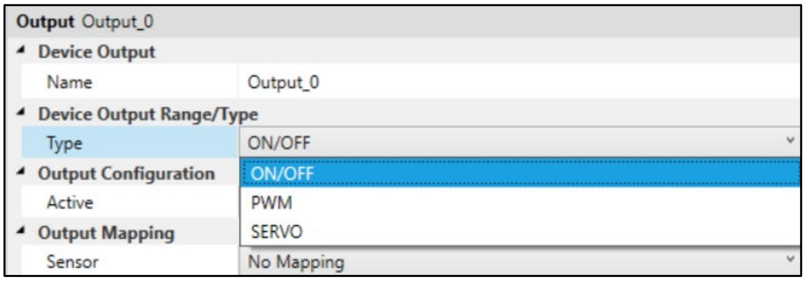


Figure 26: SYNC interface output type selection

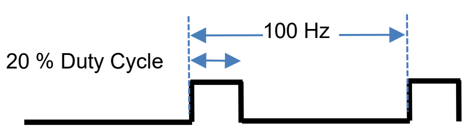
5.4.1.1 ON/OFF Output Type

The ON/OFF output mode switches the output to be a binary ON or OFF. Depending on if the output is configured as Active Low or Active High, the ON/OFF mode can correspond to different polarities.

5.4.1.2 Pulse-Width Modulation (PWM) Output Type

Pulse-Width Modulation (PWM) controls the amount of power given to a device by cycling the on/off phases of a digital signal. PWM consists of a duty cycle and frequency. The Duty Cycle measures the amount of time a signal is in the ON state as a percentage. The frequency controls how fast the PWM cycle is repeated. Users can select between the following settings:

Option	Value	Description
Rate	100 Hz	Signal has a constant 100 Hz frequency with 0-100% Duty Cycle
	10 Hz	Signal has a constant 10 Hz frequency with 0-100% Duty Cycle
	1 Hz	Signal has a constant 1 Hz frequency with 0-100% Duty Cycle
	0.1 Hz	Signal has a constant 0.1 Hz frequency with a 0-100% Duty Cycle
Signal Type	Active LOW	When the output is active, it is pulled to ground (LOW)
	Active HIGH	When the output is active, it is in a high impedance state



Example shows a PWM output signal configured with a 100 Hz frequency and active HIGH outputs. The duty cycle has been set to 20%.

Figure 27: PWM function diagram

5.4.1.3 SERVO Output Type

The SERVO output allows driving servo motors that control position. A Servo output is a special case of the PWM output, where the ON time varies between 1.0 msec and 2.0 msec or between 0.5 msec and 2.5 msec, with the lower bound representing 0 degrees and the upper bound representing 180 degrees of angular travel. The typical non-critical frequency is 50 or 100 Hz. Servo outputs are always active high.

Option	Value	Description
Rate	100 Hz	Signal has a constant 100 Hz frequency
	50 Hz	Signal has a constant 50 Hz frequency
Pulse Width Range	1.0-2.0 msec	On time varies between 1 and 2 msec
	0.5-2.5 msec	On time varies between 0.5 and 2.5 msec

Example: For the percent of angular travel, if the pulse width range is set to a range of 1.0-2.0 msec, then selecting 50% of angular travel represents 1.5 msec or 90 degrees of travel.

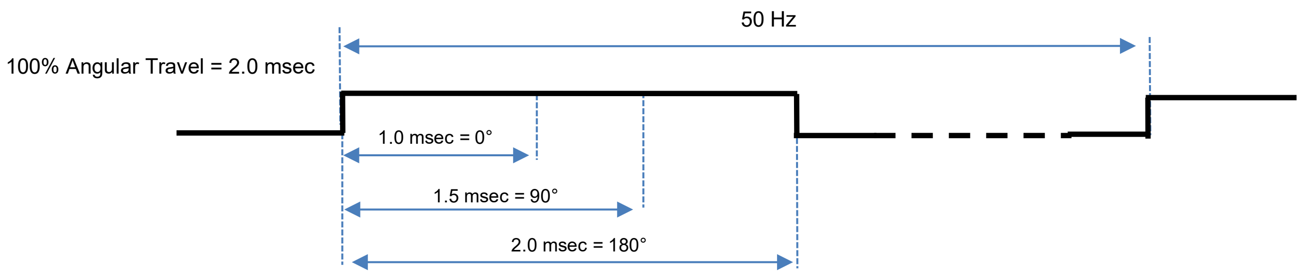


Figure 28: SERVO output example

5.4.2 Sensor Output Mapping

The SP-013 allows mapping a scaled copy of any of the input values to any of the outputs. To set a mapped output, it must not be associated with any alarm or ON/OFF control module. Two user-defined values, **Scaling Minimum** and **Scaling Maximum**, define the sensor range that is mapped to the output. A *Factory Reset* sets the Input Minimum to 0 and the Input Maximum to 100.

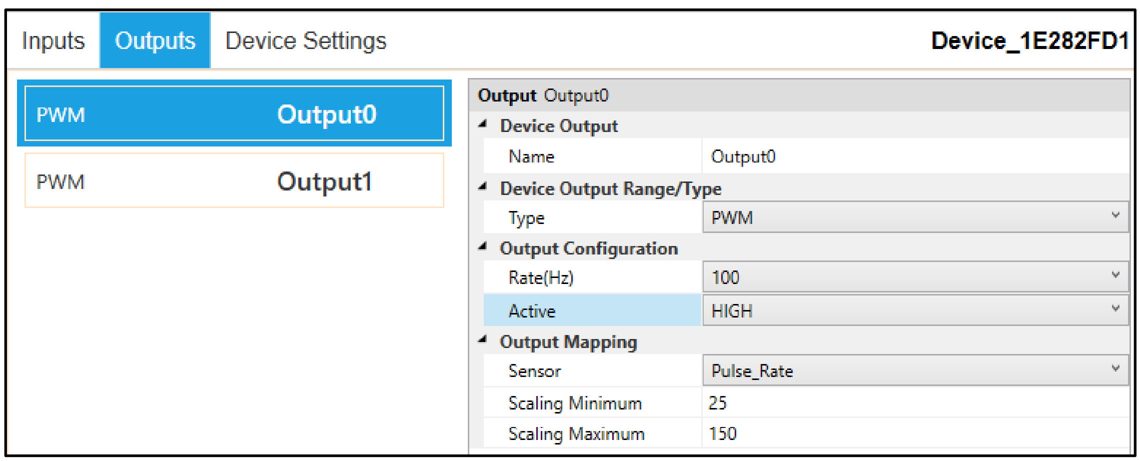


Figure 29: Sensor output mapping configuration example

The scaling equations for direct and reverse output percentages are given below.

$$Output\ Percent_{Direct} = \left(\frac{Scaling\ Maximum - Input\ Reading}{Scaling\ Maximum - Scaling\ Minimum}\right) \times 100\%$$

$$Output\ Percent_{Reverse} = \left(\frac{Scaling\ Minimum - Input\ Reading}{Scaling\ Minimum - Scaling\ Maximum}\right) \times 100\%$$

Example: The figures below and above display a PWM output direct-mapped to a Rate input. The minimum expected input rate is 25 Hz and the maximum expected rate is 150 Hz. A value of 50 Hz read at the input is then mapped to a PWM output with an 80% duty cycle.

$$Output\ Percent_{Direct,Example} = \left(\frac{150\ Hz - 50\ Hz}{150\ Hz - 25\ Hz}\right) \times 100\% = 80\%$$

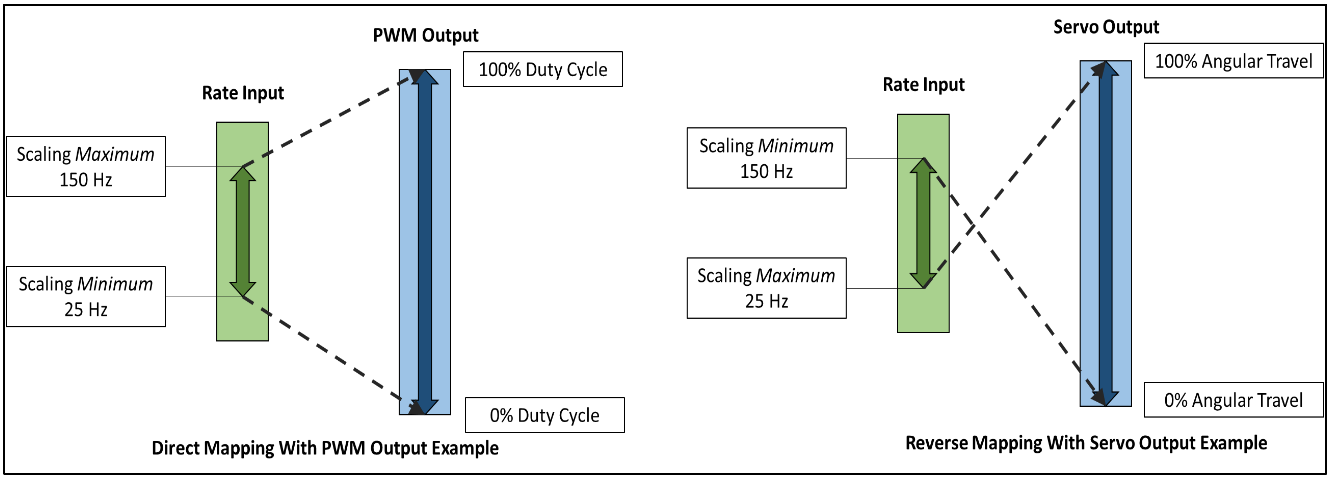


Figure 30: Sensor output mapping diagram

5.4.3 ON/OFF Control Module

To configure an ON/OFF control module on a device, first ensure that the desired output pin is not associated with any input alarms and that it is set as **No Mapping** in the Output Mapping menu in the **Outputs** tab. The ON/OFF control module can be used with any selected output type including ON/OFF, PWM, and SERVO. When enabled in PWM mode, ON corresponds to 100% duty cycle. When enabled in SERVO mode, ON corresponds to 100% angular travel.

In the **Outputs Tab** in SYNC click on the icon located to the right of the available outputs. Clicking the icon will open the **Define ON/OFF Control** dialog box as seen below.

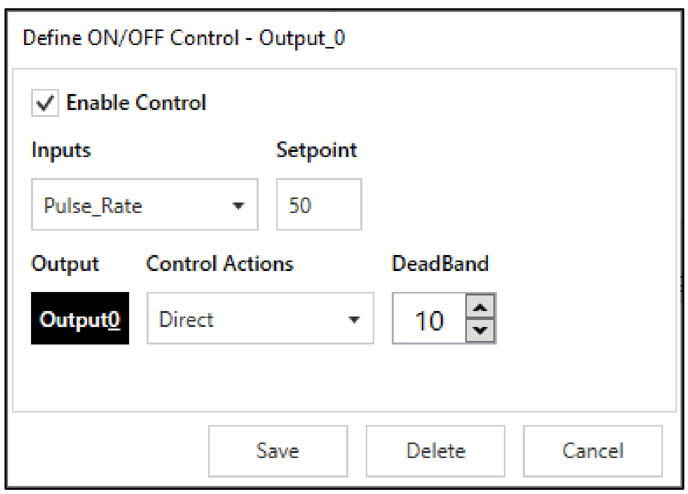


Figure 31: SYNC interface ON/OFF control module functions

The **Enable Control** checkbox enables the ON/OFF control module. If this box is unchecked, the output will be disabled but the module with all its settings will remain available to be enabled at a later time.

The **Inputs** dropdown lists the available input sources and will depend on how the device is configured in the Inputs tab.

The **Setpoint** field sets the threshold for activating the ON/OFF control module. The unit of the Setpoint field will be the same as the unit of the chosen Input.

The **Control Actions** dropdown has options for direct or reverse control. In direct mode, once the Setpoint value is reached then the output will be set to ON. In reverse mode, once the Setpoint value is reached then the output will be set to OFF.

The **DeadBand** field together with the direct or reverse control action configures a deadband range around the Setpoint where the ON/OFF control does not toggle. The unit of the DeadBand field will be the same as the unit of the chosen Input.

- **Example 1:** the setpoint is configured for a 50 Hz rate input with a deadband of 10 Hz with direct control action. The output will activate if the input rises above 60 Hz. Conversely, the output will become inactive if the input falls below 50 Hz.
- **Example 2:** the setpoint is configured for a 50 Hz rate input with a deadband of 10 Hz with reverse control action. The output will activate if the input falls below 40 Hz. Conversely, the output will become inactive if the input rises above 50 Hz.

The **Save** button saves and applies the configurations settings to the ON/OFF control module. The **Delete** button only appears for a previously saved ON/OFF control module and it removes the module and allows other output types to be configured such as an alarm or mapping.

5.4.4 Setting an Alarm

Alarms are set by clicking the  icon in SYNC on the desired input signal found in the **Input Tab**.

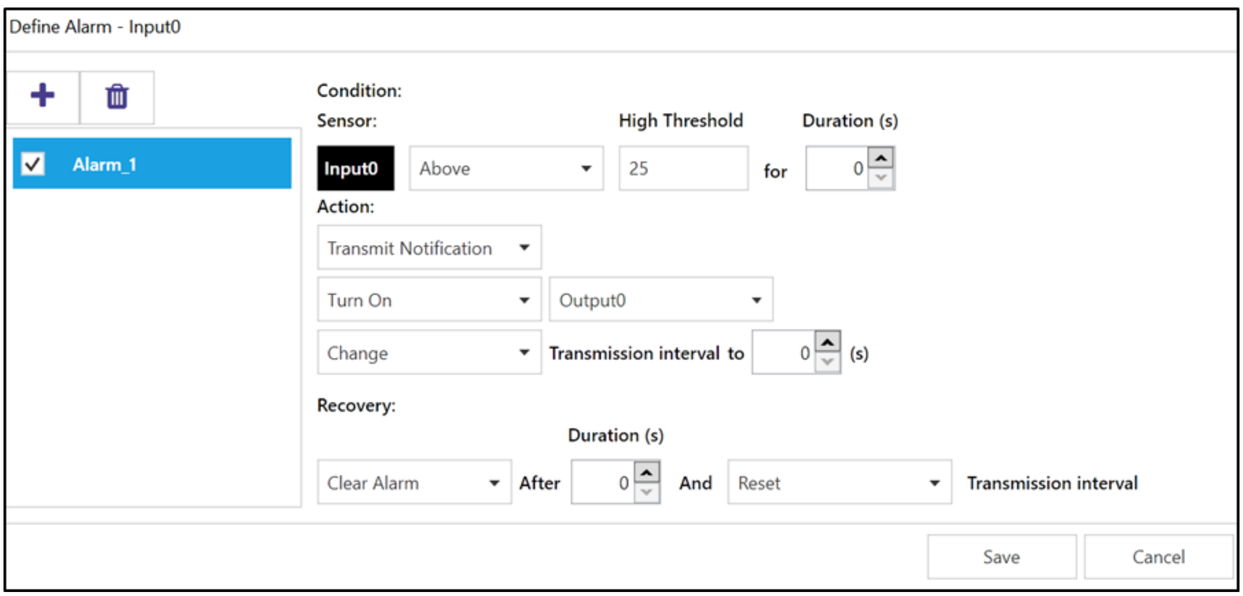


Figure 32: SYNC alarm configuration interface

Configure the **Condition** that triggers the alarm by selecting an option from the drop down such as Above or Below. The **Threshold** field(s) will change to display whatever is appropriate for the option chosen such as a High Threshold for an Above condition or a Low Threshold for a Below condition. A **Duration** can be set for the trigger as well where the condition must be met for a certain amount of time before the alarm flags.

Under the **Action** menu, the option to transmit or not transmit a notification can be set. The option to enable an output can also be set. The output chosen must not be currently used in a sensor mapping or ON/OFF control module. The data transmission interval may also be changed upon triggering an alarm, e.g. increate the rate of transmission if an excessive value is detected.

The **Recovery** menu allows the option to clear the alarm after a certain **Duration** once the trigger condition is no longer met. The transmission interval can also be reset to the normal system setting once the alarm is cleared.

To create a new alarm, click the plus icon and a new alarm will be added. To remove an alarm once it is created, select the alarm in question on the left side of the alarm panel and click the delete icon .

6 Pairing a Sensing Device to a Layer N Gateway

Refer to either the Wired or Wireless instructions to pair a Layer N Smart Probe & Interface to a Layer N Gateway. Before continuing to the pairing instructions, ensure the following prerequisites are met:

- Ensure that the Layer N Gateway has been properly setup, powered on, and in close physical proximity.
- (*For Wired pairing*) Ensure the user has access to a PC and the internal Gateway UI (*refer to the Layer N Gateway manual for instructions on how to access the internal Gateway U*I).

6.1 Wireless Pairing

Pairing a wireless Smart Interface (IF-006) with probe attached is made easy with a one-button pairing system between the IF-006 and the Layer N Gateway.

Step 1: When the Smart Probe and relevant accessories have been securely connected to the IF-006, push the pairing button once on the IF-006. The LED status indicator will blink green indicating the device is in Pairing Mode.

Step 2: Quickly push the pairing button on the Layer N Gateway. The LED on the Gateway will blink green indicating the Gateway is in Pairing Mode.

When the IF-006 or Smart Sensor has been successfully paired to the Layer N Gateway, the LED will stop blinking on both devices. Readings for the newly added device will then appear on the Layer Cloud or OEG interface.

6.2 Wired Pairing

Wired Smart Probes connected directly to a Layer N Gateway with an IF-001 cable or IF-002 will need to be added to the Gateway Internal User Interface.

The **Connected Devices** tab is the default page set once you are signed in to the internal gateway UI. From here, you can add devices to your gateway to have them appear in your Layer N Cloud account.

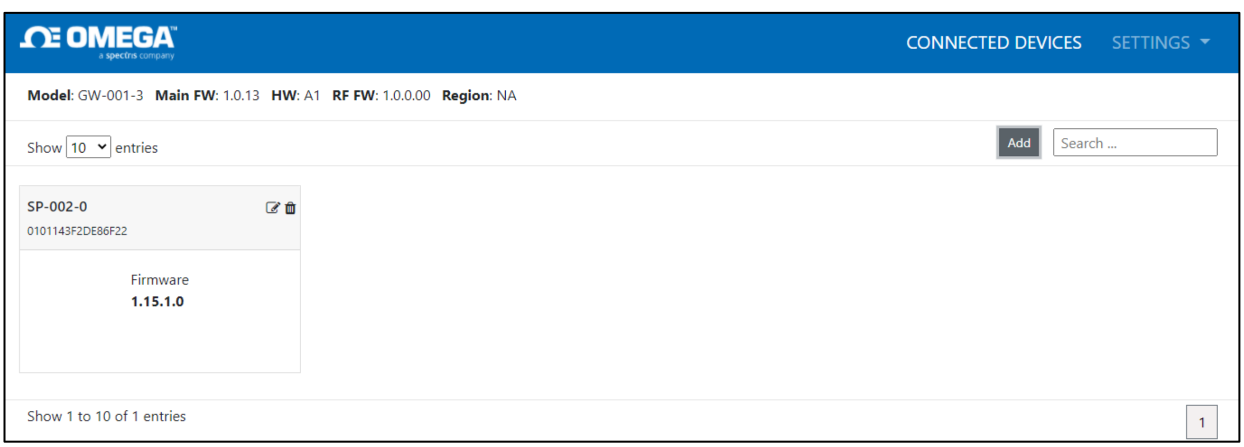


Figure 33: Gateway Internal User Interface

To add a device to your gateway from the internal gateway web UI, begin by clicking the Add button at the top right of the web page. Fill out the Add Device menu with the parameters of the Smart Probe connection.

7 Appendix: SP-013 Registers

The following Appendix provides the registers and list index for the Layer N SP-013 Digital Input Smart Probe. This information is intended to aid users who will be making configurations and adjustments to their Layer N SP-013 Digital Input Smart Probe through the Command Line Interface or other custom interfaces.

Smart Probe devices share a common platform architecture that provides extensive monitoring and control capabilities through a set of platform generic registers. These registers may be accessed using I2C based commands directly to the Smart Probe devices or through a set of Modbus-based registers when using Omega Interface devices.

When powered on or after a device reset each Smart Sensor-based device will enumerate 1 or more sensor instances which are described by the device-specific Sensor Descriptors which include configuration options, measurement type, and units of measure for the corresponding sensor values. Additional sensor information is provided in sensor-specific IPSO object descriptions which include extended measurement type, precision, and tracking of minimum/maximum readings.

Each enumerated Sensor has a Descriptor Base address location and a Sensor IPSO /Configuration structure address location based on the sensor mix selected.

Sensor	Descriptor Base	IPSO/Configuration	Enumerated Sensor	
			Digital	Mixed Mode
0	0x0060 (0xf030)	0x08a8 (0xf454)	DIN, RATE, WIDTH, DUTY_CYCLE, or COUNT	DIN, RATE, WIDTH, DUTY_CYCLE, OR COUNT
1	0x0068 (0xf034)	0x09a8 (0xf4d4)	DIO	Process 0
2	0x0070 (0xf048)	0x0aa8 (0xf554)	Not Used	DIO
3	0x0078 (0xf03c)	0x0ba8 (0xf5d4)	Not Used	Not Used

7.1 Digital Descriptor

The SP-013 configures the sensors based on the factory device list and user-specified list index. The Sensor Configuration and Sensor Device fields may be written to provide control of the overall function of the channel and the signal types used.

7.1.1 Digital Descriptor

Offset	Name	Value	Description
0x00	Sensor Type	0x??	DIO, FREQUENCY, WIDTH, DUTY_CYCLE, DELAY, or COUNT – set by Sensor Type field in Configuration byte.
0x01	Data Type/Format	0x46	Float, Writeable
0x02	Configuration	0x??	Determines channel and Measurement Type
0x03	Sensor Device	0x??	Determines DIO signal types
0x04	UOMR	“??”	Units of measure

7.1.1.1 *Digital Measurement Types*

The Digital interface provides a measurement dependent on the input range/type selected. The units of measure may be changed by the user.

Sensor Type	Measurement	SI Derived Units	Measurement
0x18	DIN	DIN	DIN (Digital Inputs)
0x19	FREQUENCY (RATE)	Hz	RATE
0x1a	PUSLE WIDTH	msec	PULSE WIDTH
0x1b	DUTY CYCLE	%	DUTY CYCLE
0x1d	COUNTER	CNT	COUNTER

7.1.1.2 *Digital Data Type/Format*

Digital Data Type/Format							
7	6	5	4	3	2	1	0
Smart Sensor	Writeable	Factory Calibrate	Reserved	Data Type			
0	1	0	0	6 == Floating point			

7.1.1.2.1 *Data Type*

The 4-bit Data Type field determines the type of data of the specific sensor.

7.1.1.2.2 *Factory Calibrate*

No Factory calibration is used on the digital pulse inputs.

7.1.1.2.3 *Writeable*

The writeable bit is set, indicating that the sensor values may be overwritten. This allows values to be preset, such as setting a counter value to 0.

7.1.1.3 *Digital Configuration*

Digital Configuration							
7	6	5	4	3	2	1	0
Available	Assigned	Apply Scaling	Lock	Sensor Range / Type			
0	0	?	?	(See Below)			

7.1.1.3.1 *Sensor Range / Type*

Range / Type		Measurement Type	Units of Measure	Signals		
				DIO2	DIO1 **	DIO0
0x00	DIO	0x18	DIN	INPUT 2	INPUT 1	INPUT 0
0x01	RATE	0x19	Hz	RESET	ENABLE	PULSE
0x02	PULSE WIDTH	0x1a	msec	RESET	ENABLE	PULSE
0x03	DUTY CYCLE	0x1b	&	RESET	ENABLE	PULSE
0x05	COUNTER	0x1d	CNT	RESET	ENABLE	PULSE

*** When configured for Mixed-mode operation (Digital pulse + Process) the DIN1 signal is used for the Process input signal. The Pulse Delay and Up/Down counter functions are not available.*

7.1.1.3.2 Lock

If set, the user-specified units of measure string (4 character maximum) will be used in place of the default**.**

7.1.1.3.3 Apply Scaling

If set, the user-defined Offset and Gain values will be used to adjust the sensor reading:

Result = (Raw Reading * Gain) + Offset

7.1.1.3.4 Assigned

The Assigned bit will always read as 0.

7.1.1.3.5 Available

The Available bit will always read as 0.

7.1.2 Digital Input Device Byte

For digital input types, the Device Byte field determines the signal types for each of the channel bits.

Digital I/O Device Byte										
	SIG 2 (ENABLE)			**SIG 1 (RESET)**				**SIG 0 (PULSE)**		
7	**6**	**5**	**Description**	**4**	**3**	**Description**	**2**	**1**	**0**	**Description**
0	0	0	N.O. SINK (DRY)	0	0	N.O. SINK (DRY)	0	0	0	N.O. SINK (DRY)
0	0	1	N.C. SINK (DRY)	0	1	N.C. SINK (DRY)	0	0	1	N.C. SINK (DRY)
0	1	0	N.O. SOURCE (WET)	1	0	N.O. SOURCE (WET)	0	1	0	N.O. SOURCE (WET)
0	1	1	N.C. SOURCE (WET)	1	1	N.C. SOURCE (WET)	0	1	1	N.C. SOURCE (WET)
							1	0	0	COMPARATOR (100 mV)
							1	0	1	COMPARATOR (500 mV)
							1	1	0	COMPARATOR (1.0 V)
							1	1	1	COMPARATOR (2.0 V)

7.1.3 Digital Sensor Parameters

There are no Digital Sensor Parameters.

7.1.3.1 IPSO Digital Definition

The IPSO Digital definition provides signal range, measured min/max values, IPSO object type information.

<table>
<tr><th>Offset</th><th>Name</th><th>Value</th><th>Description</th></tr>
<tr><td>0x08a8</td><td>Sensor Type</td><td><table></td><td><table><tr><td>Value</td><td>Description</td></tr><tr><td>3318</td><td>Frequency</td></tr><tr><td>33005</td><td>Pulse Width</td></tr><tr><td>33006</td><td>Pulse Delay</td></tr><tr><td>33007</td><td>Duty Cycle</td></tr><tr><td>33002</td><td>Counter</td></tr><tr><td>33003</td><td>Up/down Counter</td></tr></table></td></tr>
<tr><td>0x08aa</td><td>Precision</td><td>0</td><td>Provides reading of xxx</td></tr>
<tr><td>0x08ac</td><td>Sensor Trigger</td><td>??</td><td>See Below</td></tr>
<tr><td>0x08b0</td><td>Min Measured</td><td>??</td><td>Minimum reading since the last reset</td></tr>
<tr><td>0x08b4</td><td>Max Measured</td><td>??</td><td>Maximum reading since the last reset</td></tr>
<tr><td>0x08b8</td><td>Min Range</td><td>-8388607</td><td>Minimum reading</td></tr>
<tr><td>0x08bc</td><td>Max Range</td><td>+8388607</td><td>Maximum reading</td></tr>
</table>

7.1.3.2 Digital Resolution

The measured digital value provides +/- 1.0 resolution.

7.1.3.3 Sensor Trigger Function

The Sensor Trigger function is used to reset the IPSO min/max values as well as control the calibration process.

Sensor Trigger Function							
7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	Reset Min/Max
15	14	13	12	11	10	9	8
0	0	Calibration Reset	Calibration Status	Calibration Mode	Capture High	Capture Low	Calibration Start

Setting the Reset Min/Max bit to 1 will reset the Min/Max values recorded by the IPSO process. No User Calibration process is supported on the Digital inputs and all configuration bits should be written as 0.

7.2 Process Input

The Process Input interface provides single-ended voltage and current loop inputs. The Sensor Configuration and Sensor Device fields may be written to provide control of the overall function of the channel and the signal types used.

7.2.1 Process Descriptor

Offset	Name	Value	Description
0x00	Measurement Type	0x??	Analog Voltage and Current – set by Sensor Type field in Configuration byte.
0x01	Data Type/Format	0x06	Float,
0x02	Configuration	0x4?	Determines Process input type/range
0x03	Sensor Device	0x??	Determines AIO signal types
0x04..0x08	UOMR	“??”	Units of measure

7.2.1.1 *Process Measurement Types*

The Process interface provides a measurement dependent on the input range/type selected. The units of measure may be changed by the user.

Sensor Type	SI Derived Units	Measurement
0x11	mV	Process Voltage (0 - 1.0 V, 0 – 2.0 V)
0x13	mA	Process Current (0-24 mA current loop, common return)

7.2.1.2 *Process Input Data Type/Format*

Process Input Data Type/Format							
7	6	5	4	3	2	1	0
Smart Sensor	Writeable	Factory Calibrate	Reserved	Data Type			
0	0	?	0	0x06 = Float			

7.2.1.2.1 *Data Type*

The 4-bit Data Type field determines the type of data of the specific sensor.

7.2.1.2.2 *Factory Calibrate*

Factory calibration is available for the process inputs. Clearing this bit will disable the factory calibration values.

7.2.1.2.3 *Writeable*

The writeable bit is cleared, indicating that the sensor values may not be overwritten.

7.2.1.3 *Process Input Configuration*

Process Input Configuration							
7	6	5	4	3	2	1	0
Available	Channel	Scaling	Lock	Sensor Range / Type			
0	0*	?	?	(See Below)			

7.2.1.3.1 *Sensor Range / Type*

Sensor Range/Type	Sensor Input Type (Range)	Measurement Type	
0x01	0-24 mA	0x13	Current (mA)
0x03	0-1.0 Vdc	0x11	Millivolts (mV)
0x09	0-2.0 Vdc	0x11	Millivolts (mV)

7.2.1.3.2 *Lock*

If set, the user-specified units of measure string (4 character maximum) will be used in place of the default units of measure.

7.2.1.3.3 *Apply Scaling*

If set, the user-defined Offset and Gain values will be used to adjust the sensor reading:

Result = (Raw Reading * Gain) + Offset

7.2.1.3.4 *Assigned*

The Assigned bit will always read as 0.

7.2.1.3.5 *Available*

The Available bit will always read as 0.

7.2.2 Process Device Byte

The Sensor Device field determines the signal types for each of the channel bits.

Analog Inputs								
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**Description**
1	X	0	0	0	0	0	0	Single Ended

7.2.3 Process Sensor Parameters

There are no Process Sensor Parameters.

7.2.4 Process IPSO Definition

The IPSO process definition provides signal range, measured min/max values, IPSO object type information.

Offset	Name	Value	Description	
0x08a8	Sensor Type	Value	Description	
		3317	Current (mA)	
		3316	Voltage (mV)	
0x08aa	Precision	0-24 mA	1 - display as xx.x	
		0-1000 mV	-1 - display as xxx0.0	
		0-2000 mV	-1 - display as xxx0.0	
0x08ac	Sensor Trigger	??	Write any value to force a reset of min/max	
0x08b0	Min Measured	??	Minimum reading since the last reset	
0x08b4	Max Measured	??	Maximum reading since the last reset	
0x08b8	Min Range	Range	Minimum	Maximum
0x08bc	Max Range	0-24 mA	0	24 mA
		0 – 1 Vdc	0	1000 mV

7.2.4.1 Process Resolution

The measured mA value is rounded to provide +/- 0.1 mA resolution.
The measured mV value is rounded to provide +/- 10 mV resolution.

7.2.4.2 Process Sensor Trigger Function

The Sensor Trigger function is used to reset the IPSO min/max values as well as control the Calibration process.

Process Sensor Trigger Function							
7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	Reset Min/Max
15	14	13	12	11	10	9	8
0	0	Calibration Reset	Calibration Status	Calibration Mode	Capture High	Capture Low	Calibration Start

Setting the Reset Min/Max bit to 1 will reset the Min/Max values recorded by the IPSO process. No User Calibration process is supported on the Process inputs and all configuration bits should be written as 0.

7.3 DIO Interface

The DIO Interface provides 2 digital inputs which are hardwired to the Digital outputs. These may be used to detect the state of external switches (output off) or to monitor the state of the outputs.

7.3.1 DIO Descriptor

Offset	Name	Value	Description
0x00	Sensor Type	0x18	Digital Type (Bit mapped)
0x01	Data Type/Format	0x46	Configurable, Float type
0x02	Configuration	0x23	Scaling applied, Bits 0 and 1 enabled
0x03	Sensor Device	0x0f	DIN bits enabled / inverted
0x04	UOMR	"DIN"	Units of measure

7.3.1.1 DIO Sensor Type

The interface provides a bitmapped input of the 2 digital signal lines.

Sensor Type	SI Derived Units	Measurement
0x18	DIN	Bit mapped digital inputs

7.3.1.2 DIO Data Type/Format

DIO Data Type/Format							
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Smart Sensor	Sensor Value Writeable	Factory Calibrate	reserved	Data Type			
0	0	0	0	6 == Floating point			

7.3.1.2.1 Data Type

The 4-bit Data Type field determines the type of data of the specific sensor.

7.3.1.2.2 Factory Calibrate

The Factory Calibrate bit is not used for DIO types.

7.3.1.2.3 Sensor Value Writeable

This indicates that the sensor value may be overwritten. Not used on DIO inputs.

7.3.1.3 DIO Input Configuration

DIO Input Configuration							
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Available	Assigned	Apply Scaling	Lock	Sub Channel Selection			
0	0	1	?	0x03 == bits 0 and 1			

7.3.1.3.1 Lock

If set, the user-specified units of measure string (4 character maximum) will be used in place of the default **DIN.**

7.3.1.3.2 Apply Scaling

If set, the user-defined Offset and Gain values will be used to adjust the sensor reading:

Result = (Raw Reading * Gain) + Offset

7.3.1.3.3 Assigned

The Assigned bit will always read as 0.

7.3.1.3.4 Available

The Available bit will always read as 0.

7.3.1.4 DIO Device Configuration

The DIO Device Configuration allows enabling each of the 2 input bits and selecting whether the input is active HIGH (reads as 1 when input is not grounded) or active LOW (reads as 1 when input is grounded).

DIO Device Configuration							
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Reserved				DIN 1		DIN 0	
0	0	0	0	ENABLE	INVERT	ENABLE	INVERT
				1	1	1	1

7.3.1.4.1 Invert

If the Invert bit is set the input is active LOW.

7.3.1.4.2 Enable

If the Enable bit is set the input is enabled.

7.3.1.5 DIO IPSO Definition

The DIO input IPSO definition provides signal range, measured min/max values, IPSO object type information.

Offset	Name	Value	Description
0x08a8	Sensor Type	3349	Bit Mapped Digital
0x08aa	Precision	0	Provides reading of xxx
0x08ac	Reset Min/Max	??	Write 0x0001 force reset of min / max
0x08b0	Min Measured	??	Minimum reading since the last reset
0x08b4	Max Measured	??	Maximum reading since the last reset
0x08b8	Min Range	0	Minimum reading
0x08bc	Max Range	3	Maximum reading

7.3.1.6 Sensor Trigger Function

The Sensor Trigger function is used to reset the IPSO min/max values as well as control the calibration process.

Sensor Trigger Function							
7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	Reset Min/Max
15	14	13	12	11	10	9	8
0	0	Calibration Reset	Calibration Status	Calibration Mode	Capture High	Capture Low	Calibration Start

Setting the Reset Min/Max bit to 1 will reset the Min/Max values recorded by the IPSO process. No User Calibration process is supported on the DIO inputs and all bits should be written as 0.

7.4 Output Interface

Outputs share a common structure which consists of 3 fields mapped to a 16-bit unsigned integer, accessible in the Smart Sensor register map.

Output	Name	Modbus Address	I2C Address	Size	Typical Description
0	Output 0 Descriptor	0xf09a	0x0134	uint16	PWM 0 (see below)
1	Output 1 Descriptor	0xf09b	0x0136	uint16	PWM 1 (see below)
2	Output 2 Descriptor	0xf09c	0x0138	uint16	Phantom (non-configurable)
3	Output 3 Descriptor	0xf09d	0x013a	uint16	Phantom (non-configurable)

Refer to the specific output type for further information.

7.4.1 Scaling Minimum / Maximum Values

When Input Mapping is used the user may specify the input signal range through the Input Minimum and Input Maximum parameters. There is one pair of registers for each of the 4 possible outputs.

Sensor	Name	Modbus Address	I2C Address	Size	Description
0	Output 0 Low Scale	0xf1f0	0x03e0	float	Sets lower input range
	Output 0 High Scale	0xf1f2	0x03e4	float	Sets upper input range
1	Output 1 Low Scale	0xf1f4	0x03e8	float	Sets lower input range
	Output 1 High Scale	0xf1f6	0x03ec	float	Sets upper input range
2	Output 2 Low Scale	0xf1f8	0x03f0	float	Sets lower input range
	Output 2 High Scale	0xf1fa	0x03f4	float	Sets upper input range
3	Output 3 Low Scale	0xf1fc	0x03f8	float	Sets lower input range
	Output 3 High Scale	0xf1f2e	0x03fc	float	Sets upper input range

When either the Low Scale or High Scale value changes, an internal calculation is performed to calculate the linear transformation to be applied to the sensor reading.

7.4.2 Output Values

Outputs use *float* values which represent the percentage of full scale. If the output is not mapped, the value written (0 – 100%) is identical to the value that is read back. If the output is mapped, the scaling values are used to transform the minimum input value to 0% and the maximum input value to 100%.

Output	Name	Modbus Address	I2C Address	Size	Description
0	Output 0 Value	0xf078	0x00f0	float	Percent of full-scale value (0-100%)
1	Output 1 Value	0xf07a	0x00f4	float	Percent of full-scale value (0-100%)
2	Output 2 Value	0xf07c	0x00f8	float	Percent of full-scale value (0-100%)
3	Output 3 Value	0xf07e	0x00fc	float	Percent of full-scale value (0-100%)

7.4.3 Output Names

Each output has a name. The default names for the outputs are **Output_0** through **Output_3**. The default names may be overwritten, such as 'Stack_Lite' or 'Control_Valve'. Names are restricted to 16 characters.

Output	Name	Modbus Address	I2C Address	Size	Description
0	Output 0 Name	0xf720	0x0e40	char[16]	Defaults to **Output_0**
1	Output 1 Name	0xf728	0x0e50	char[16]	Defaults to **Output_1**
2	Output 2 Name	0xf730	0x0e60	char[16]	Defaults to **Output_2**
3	Output 3 Name	0xf738	0x0e70	char[16]	Defaults to **Output_3**

The Output names are retained until a factory reset occurs. It is strongly recommended that:

1) Spaces within the name should be replaced with the '_' character.

2) All output names on a particular device are unique – if duplicate functions are supported append a '_x' string, where x represents the instance. For example, *Stack_Lite_1* and *Stack_Lite_2* could be used if 2 stack lights are being connected.

7.5 Digital Output Configuration

Two output signals are available which may be configured for ON/OFF, PWM, or SERVO outputs through the Output Configuration registers (0x0124 and 0x0126). The remaining outputs are assigned as phantom devices which are non-configurable. The highlighted entries show typical default configurations.

Digital Output Configuration

7	6	5	4	3	2	1	0
Output Configuration							
		Servo Range	Active State		Rate		

Servo Range

1.0 – 2.0	0
0.5 – 2.5	1

Active State

LOW	**0**
HIGH	1

Rate

100 Hz	**0**	**0**	**0**
10 Hz	0	0	1
1 Hz	0	1	0
0.1 Hz	0	1	1
50 Hz	1	0	0
33 Hz	1	0	1
25 Hz	1	1	0
20 Hz	1	1	1

15	14	13	12	11	10	9	8
Output Type							
Sensor Mapping			Mapping Enable	Output Type			

Sensor Mapping

No Mapping	**0**	**-**	**-**
Sensor 0	1	0	0
Sensor 1	1	0	1
Sensor 2	1	1	0
Sensor 3	1	1	1

Mapping Enable

Not Enabled	0
Enabled	**1**

Output Type

Null	0	0	0	0
ON/OFF	**0**	**0**	**0**	**1**
PWM	0	0	1	0
Servo	0	0	1	1

7.5.1 Rate

The Rate determines the repetition rate, or frequency, of the Digital Output. For On/Off outputs the rate field is ignored.

7.5.1.1 PWM Rate

The SP-013 supports the following PWM frequencies:

PWM Rate	Name	Description
0	100 Hz	PWM signal has constant 100 Hertz frequency (10 msec repetition rate) with 0 – 100 % duty cycle
1	10 Hz	PWM signal has constant 10 Hertz frequency (100 msec repetition rate) with 0 – 100 % duty cycle
2	1 Hz	PWM signal has constant 1 Hertz frequency (1-second repetition rate) with 0 – 100 % duty cycle
3	0.1 Hz	PWM signal has constant 0.1 Hertz frequency (10-second repetition rate) with 0 – 100 % duty cycle

7.5.1.2 SERVO Rate

Smart Sensor probes support the following SERVO frequencies:

PWM Rate	Name	Description
0	100 Hz	PWM signal has a constant 100 Hertz frequency (10 msec repetition rate)
4	50 Hz	PWM signal has a constant 50 Hertz frequency (20 msec repetition rate)

7.5.2 Output Type

Smart Sensor probes support NULL (0), ON/OFF (1), PWM (2), and SERVO (3) outputs. When set to NULL the output signal will be left in a high impedance state. When set to ON/OFF the Rate and Servo Range controls have no effect. When the SERVO type is selected the Duty-Cycle is restricted so the output signal is either 0.5 – 2.5 msec or 1.0 to 2.0 msec based on the Servo Range bit.

7.5.3 Active State

Smart Sensor digital outputs may be configured as Active HIGH or Active LOW. When set to 1 (Active High), the output will be high impedance when active. When set to 0 (Active Low), the output will be low impedance (~ 0.0 volts) when active. The Factory reset value is 0 (Low).

7.5.4 Mapping Enabled

The read-only Mapping Enabled bit indicates that the output may be optionally directly mapped to a sensor input based on the Sensor Mapping field. If the Mapping Enabled bit is clear no mapping is supported, and the Sensor Mapping field is ignored.

7.5.5 Sensor Mapping

The Sensor Mapping value may select 'no mapping' or of any Sensor. If no mapping is selected the output may be directly controlled by writing a value from 0 – 100 % to the internal Output Value. If a Sensor is selected and the hardware supports the mapping the output will track the selected sensor value, scaled by the Input Minimum and Input Maximum values.

If Sensor Mapping is enabled for PWM outputs the scaling values are used such that a signal input at or below the Scaling Low-value results in a 0% output and a signal input at or above the Scaling High-value results in a 100% PWM duty cycle.

If Sensor Mapping is enabled for SERVO outputs the scaling values are used such that a signal input at or below the Scaling Low-value results in a minimum (0.5 or 1.0 msec) pulse width and a signal input at or above the Scaling High-value results in a maximum (2.0 or 2.5 msec) pulse width.

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