



OMEGA SP-006 Layer N Pressure Monitoring and Control Smart Probe User Guide

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Notes Cautions and Warnings

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: Provides information that is important to successfully set up and use the SP-006.

Caution or Warning: Informs about the risk of electrical shock. **Caution, Warning, or Important:** Informs of circumstances that can affect the functionality of the instruments and must refer to accompanying documents.

Introduction

The Layer N SP-006 Pressure Monitoring Smart Probe provides an easy way to integrate Absolute or Gauge pressure readings and ambient temperature readings into the Layer N Ecosystem. The SP-006 accepts Layer N Smart Interfaces through its M12 8-pin connector. See Figure 1.

For additional functionality, the Layer N SP-006 features 2 configurable discrete I/O pins which can be used for a myriad of applications including driving relays, physical alarms, or sensing dry contacts like door switches. The SP-006 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. 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 M12.8-S-M-FM mating connector can be utilized to easily connect wire leads to the SP-006 or Sensor Splitter. See Figure 2.

Included with your SP-006

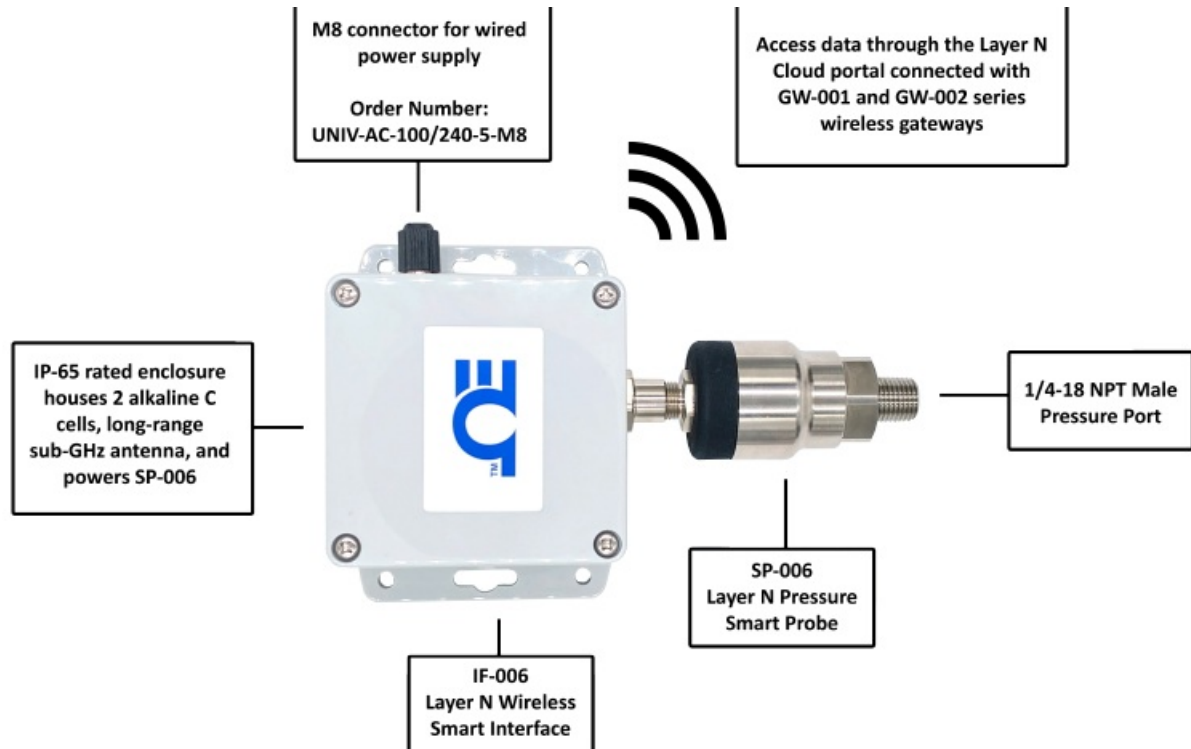
- SP-006 Unit
- Quick Start Guide

Additional Material Needed

- Layer N Smart Interface (wired IF-001 or wireless IF-006)
- Computer with Windows OS
- SYNC configuration software

Optional Materials

- M12.8-S-M-FM screw terminal connector (needed for discrete I/O)
- DM12CAB extension cable



Specifications

• INPUT POWER

Voltage: 2.8 VDC – 3.3 VDC

• DIO DISCRETE INPUTS

VinHighThreshold = 2.2 VMAX

VinLowThreshold = 0.3 VMIN

VinMAX = 30 VDC

• DIO DISCRETE OUTPUTS

2x Open Drain 100 mA max

VMAX = 30 VDC

• PRESSURE

Range: (See Ordering Guide below)

Accuracy: $\pm 0.5\%$ full-scale

Resolution: 0.1 kPa

Absolute Maximum Pressure: 1.5 time full-scale for each range

Caution: Do not exceed 500 psi

• TEMPERATURE

Range: -10 to 80°C (14 to 176°F)

Accuracy: $\pm 1.5^{\circ}\text{C}$

Resolution: 0.1°C

- **ENVIRONMENTAL**

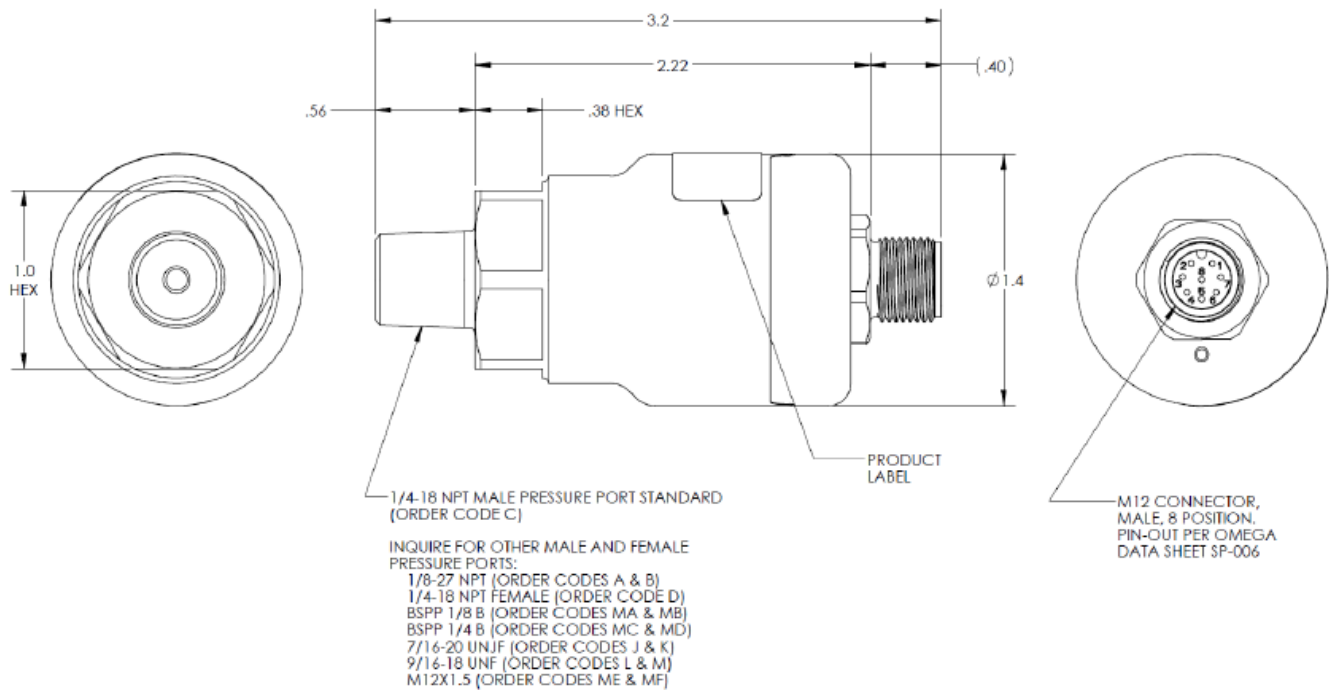
Storage Temperature: -40 to 85°C (-40 to 185°F) less than 95% RH, non-condensing

Environmental Rating: IP50

- **GENERAL**

Configuration: Configurable via Layer N Smart Interface and SYNC configuration software

Software: Compatible with OEG, SYNC, and OMEGA Cloud



Ordering Guide

Model Number	
SP-006-1-C-050G	Layer N pressure monitoring and control smart probe with discrete I/O – 50 psi 350 kPa Gauge
SP-006-1-C-050A	Layer N pressure monitoring and control smart probe with discrete I/O – 50 psi 350 kPa Absolute
SP-006-1-C-100G	Layer N pressure monitoring and control smart probe with discrete I/O – 100 psi 700 kPa Gauge
SP-006-1-C-250G	Layer N pressure monitoring and control smart probe with discrete I/O – 250 psi 1700 kPa Gauge

Notes:

- Model Numbers above have a 1/4 – 18 NPT male pressure port (i.e. ordering code C)
- Inquire with Omega Engineering for other pressure port options. Refer to Figure 3.

Hardware Setup

Connecting your Layer N Smart Interface

The SP-006 requires a Layer N Smart Interface to connect to a computer. Omega offers a variety of Layer N Smart Interfaces such as the wired IF-001 (USB) and IF-002 (Modbus) or the wireless IF-006. Use the M12 8-Pin Connector diagram below to connect the SP-006 to a Layer N Smart Interface.

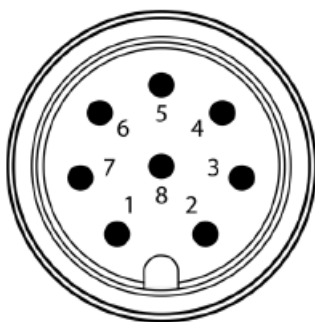


Figure 4: M12 8-Pin Connector front view

Figure 4: M12 8-Pin 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

SYNC Configuration

Layer N Smart Probe products are easily configurable through Omega's SYNC configuration software. Ensure SYNC is running on a Windows OS computer before continuing. Connect the SP-006 to a computer running SYNC through your Layer N Smart Interface to begin.

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

Connecting to SYNC – Automatic Detect

Once the SP-006 and Layer N Smart Interface are connected to a computer, SYNC will automatically detect the device and display readings.

Note: If live readings from the SP-006 are displayed on SYNC, skip ahead to the section titled Input Configuration.

Connecting to SYNC – Manual

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

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

Communication Interface

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

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

- Connection Type: Select the type of connection you have between your SP-006 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 unchanged to avoid communication errors.

- Device Address: The default device address is 1. The numerical value will automatically increase to the next available device address for every new device added to prevent duplicate addresses.
- Device IP or Port: The COM port number that your device is connected to on your computer.
- Baud Rate: Controls bits per second
- Data Bits: The number of bits in each character sent.
- Parity: A means of checking the correctness of a character by adding an extra bit to the character and setting

the value based on all the other bits in the character.

- **Stop Bits:** 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.

Input Configuration

The SP-006 provides readings for pressure, temperature, and discrete I/O (DIO). To use these features, click the Inputs configuration tab on SYNC and choose your preferred input mix from the Type dropdown. The SP-006 allows selecting pressure and discrete I/O only or pressure, temperature, and discrete I/O.

Pressure

The SP-006 Pressure readings are fixed based on the specific model. The user may calibrate the Pressure sensor using Single or Dual-Point calibration by clicking the Calibration button.

Add Device Wizard

Select Communication Interface
Please ensure the device parameters correctly match the settings below

USB Note: physical connection type must match selected

Command Timeout	500
Device Address	1
Device IP or Port	COM3

Command Timeout
The maximum time in millisecond for waiting response.

< Back Finish Cancel

Figure 7: SYNC interface pressure input

Pressure User Calibration

After clicking the Calibration button, the user must follow the onscreen directions to calibrate the device.

Add Device Wizard

Select Communication Interface
Please ensure the device parameters correctly match the settings below

USBSerial Note: physical connection type must match selected

BaudRate	38400
Command Timeout	500
DataBits	8
Device Address	1
Device IP or Port	COM3
Parity	Even
StopBits	One

BaudRate
The baud rate: 115200, 4800, 9600, 19200, 38400, 57600

< Back Finish Cancel

Figure 8: SYNC pressure user calibration

Temperature

The SP-006 Temperature readings may be configured under the advanced scaling options which include Gain and Offset.

InputsOutputsDevice Settings

TypeP, T, DIO

PRESSUREPressure

TEMPERATURETemperature

DIGITAL_IODigital_IO

Sensor Pressure

Sensor

NamePressure

Measurement TypePRESSURE

Advanced Scaling

Device Range/Type

Type350

Sensor Settings

TypeAbsolute

Figure 9: SYNC interface temperature input

5.3.3 Discrete Input/Output (DIO)

The Layer N SP-006 features 2 configurable discrete I/O pins DIO_0 and DIO_1. These DIO pins 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). The Advanced Scaling option does not apply to the DIO input reading.

Pressure User Calibration

Single PointDual Point

Lo Rdg0

Capture

Lo Act0

A Single Point Calibration will provide a fixed offset for the entire measuring range and is best used to optimize the accuracy at a single point. To perform: (1) Set process to a known value and enter this value into "Lo Act". (2) Press "Capture" to record the sensor reading. (3) Press "Calibrate" to complete the calibration process. "Clear Calibration" resets the device back to factory calibration.

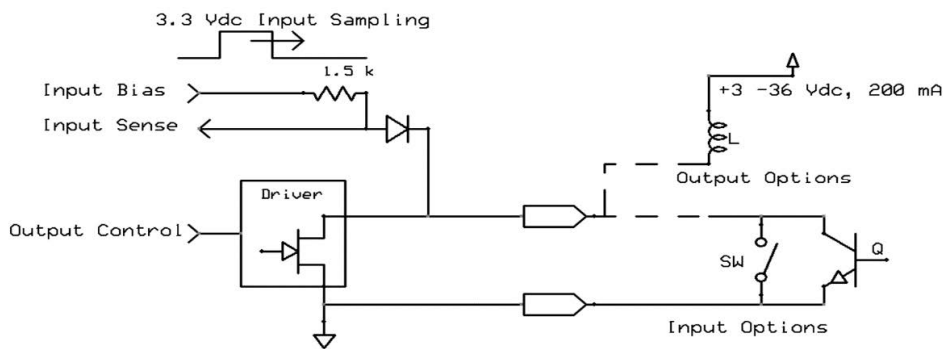
Calibrate

Clear Calibration

Close

Figure 10: SYNC interface discrete I/O input configuration

The Discrete I/O input shares the same circuitry as the output. 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 VDC 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 VDC.



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.

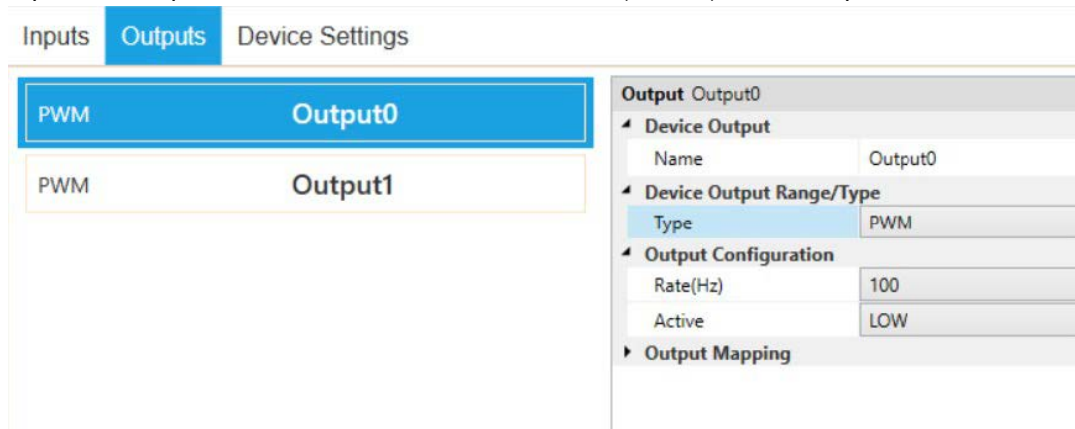


Figure 12: SYNC interface outputs tab

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.

Advanced Scaling Options

The Layer N SP-006 allows for advanced scaling options on the pressure and temperature inputs. 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 Advanced Scaling menu and ensure that both Apply Scaling and Lock are checked. Under Scaling, 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.

$$= (\times) +$$

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.

Output Configuration

The SP-006 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 5.3.3 Discrete Input/ Output (DIO) for more information.

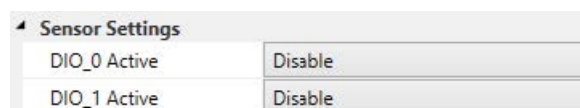


Figure 13: SYNC interface SP-006 DIO_0 and DIO_1 set to Disable

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

information on each type.

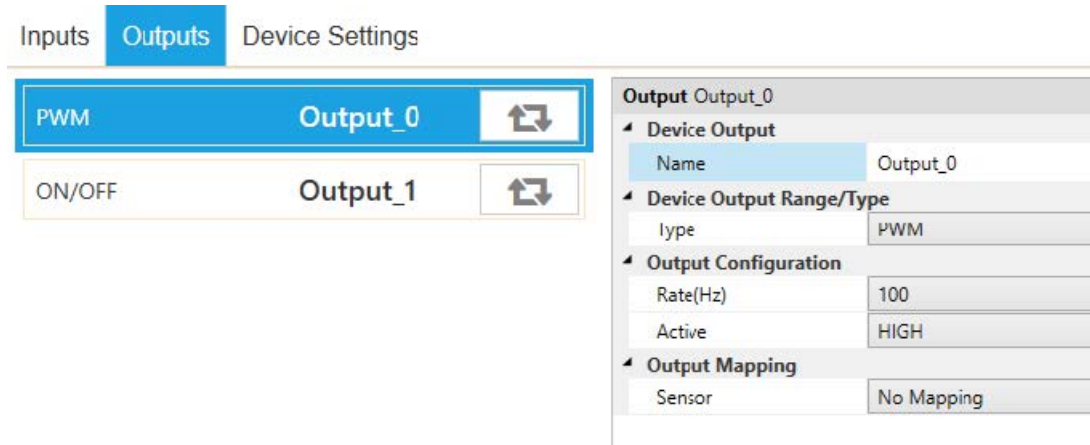


Figure 14: SYNC interface Output Configuration

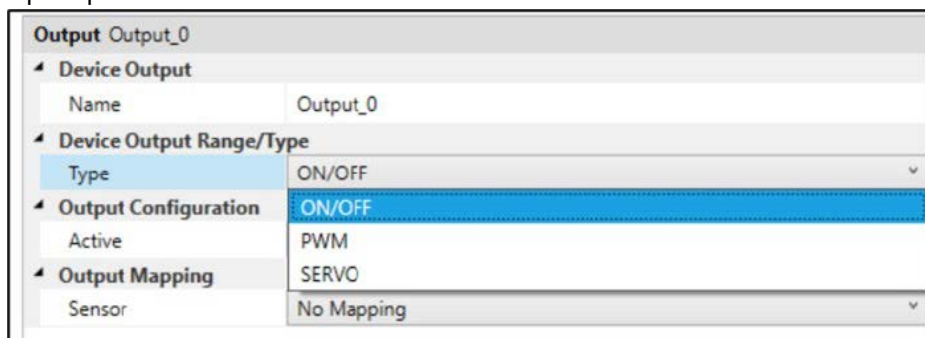
Outputs may be configured as either Active High or Active Low. When configured as Active High the output conducts normally and becomes high impedance when activated. When configured as Active Low, the Open-Drain output is high impedance normally and will conduct when activated.

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.

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.



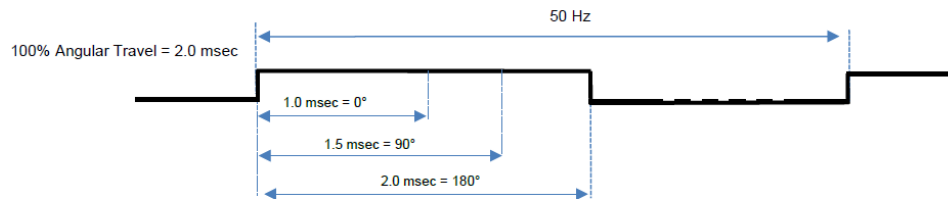
ON/OFF Output Type

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.

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 discrete 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%.

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

Sensor Output Mapping

The SP-006 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.

Inputs

Outputs

Device Settings

Device_1E282FD1

PWM

Output0

PWM

Output1

Output Output0

Device Output

Name

Output0

Device Output Range/Type

Type

PWM

Output Configuration

Rate(Hz)

100

Active

HIGH

Output Mapping

Sensor

Pulse_Rate

Scaling Minimum

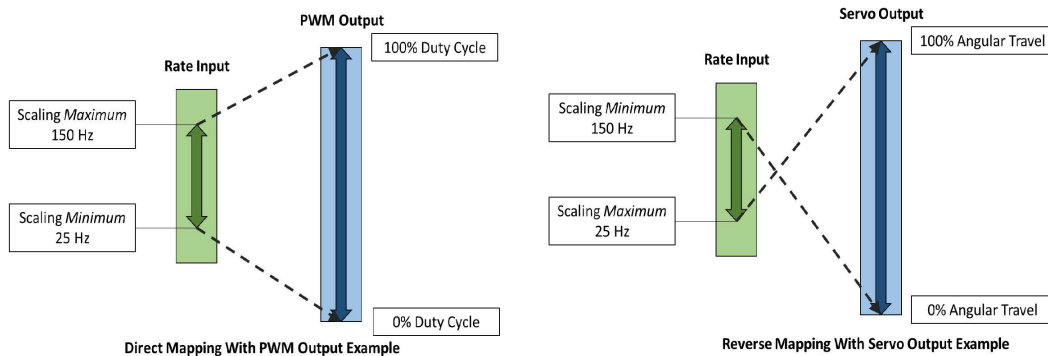
25

Scaling Maximum

150

Figure 18: Sensor output mapping configuration example

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



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.

The screenshot shows a dialog box titled 'Define ON/OFF Control - Output_0'. It has a section with a checked checkbox 'Enable Control'. Below this are two rows of controls. The first row has 'Inputs' with a dropdown menu showing 'Pulse_Rate' and a 'Setpoint' field with the value '50'. The second row has 'Output' with a dropdown menu showing 'Output0', 'Control Actions' with a dropdown menu showing 'Direct', and a 'DeadBand' field with the value '10' and up/down arrows. At the bottom are three buttons: 'Save', 'Delete', and 'Cancel'.

Figure 20: 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.

Setting an Alarm

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

The screenshot displays the 'Define Alarm - Input0' configuration window. On the left, a list of alarms includes 'Alarm_1' with a checkmark. The main configuration area is divided into three sections: Condition, Action, and Recovery. The Condition section shows 'Sensor' as 'Input0', 'Condition' as 'Above', 'High Threshold' as '25', and 'Duration (s)' as '0'. The Action section shows 'Transmit Notification' selected, 'Turn On' set to 'Output0', and 'Change' set to 'Transmission interval to 0 (s)'. The Recovery section shows 'Clear Alarm' selected, 'After' set to '0', 'And' set to 'Reset', and 'Transmission interval' set. At the bottom right, there are 'Save' and 'Cancel' buttons.

Figure 21: SYNC alarm configuration interface

Configure the Condition that triggers the alarm by selecting an option from the drop-down such as Above, Below, Outside the Range, or Within the Range. 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 “Turn On” 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. increase the rate of transmission if an excessive value is detected.

The Recovery menu allows the option to clear the alarm after a certain Duration (in Seconds) 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

Appendix: SP-006 Registers

The following Appendix provides the registers and list index for the Layer N SP-006 Pressure monitoring Smart Probe. This information is intended to aid users who will be making configurations and adjustments to their Layer N SP-006 Pressure monitoring Smart Probe through the Command Line Interface or other custom interfaces.

Register Base Addresses

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. Refer to the Smart Sensor Device Interface manual for further information.

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.

Sensors are always enumerated in the order Pressure, Temperature (T), and DIO.

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

Pressure Sensor

Sensor	Descriptor Base	IPSO/Configuration	Enumerated Sensor Mix	
			SP-006-0	SP-006-1
0	0x0060 (0xf030)	0x08a8 (0xf454)	Pressure	
1	0x0068 (0xf034)	0x09a8 (0xf4d4)	Temperature	Temperature
2	0x0070 (0xf038)	0x0aa8 (0xf554)		DIO
3	0x0078 (0xf03c)	0x0ba8 (0xf5d4)		

Pressure Descriptor

The SP-006 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.

Sensor	Descriptor Base	IPSO/Configuration	Enumerated Sensor Mix	
			SP-006-0	SP-006-1
0	0x0060 (0xf030)	0x08a8 (0xf454)	Pressure	
1	0x0068 (0xf034)	0x09a8 (0xf4d4)	Temperature	Temperature
2	0x0070 (0xf038)	0x0aa8 (0xf554)		DIO
3	0x0078 (0xf03c)	0x0ba8 (0xf5d4)		

Pressure Descriptor

The SP-006 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.

Offset	Name	Value	Description
0x00	Sensor Type	0x28	Pressure
0x01	Data Type/Format	0x06	Float type
0x02	Configuration Byte	??	See subsections below
0x03	Device Byte	0x00	Not Used
0x04..0x08	UOMR	"kPa"	Units of measure

Pressure Sensor Type

Sensor Type	SI Derived Units	Measurement
0x28	kPa	Pressure

Pressure Data Type/Format

Pressure Data Type/Format							
7	6	5	4	3	2	1	0
Smart Sensor	Configuration Enable	Factory Calibrate		Data Type			
0	0	0	0	6 == Floating point			

- **Data Type**

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

- **Factory Calibrate**

Factory calibration is available for the SP-006 process inputs. Clearing this bit will disable the factory calibration values.

- **Writeable**

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

Temperature Configuration Byte

Pressure Sensor Configuration							
7	6	5	4	3	2	1	0
Available	Assigned/Channel	Apply Scaling	Lock	Sensor Range/Type			
0	0	?	?	Read Only – Indicates pressure range			

- **Lock**

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

- **Apply Scaling**

For more information on Gain and Offset, refer to the Smart Sensor Manual. If set, the user-defined Offset, and Gain values will be used to adjust the sensor reading: $\text{Result} = (\text{Raw Reading} * \text{Gain}) + \text{Offset}$

- **Assigned**

The Assigned bit will always read as 0. Refer to the Smart Sensor Device Interface documentation for further information.

- **Available**

The Available bit will always read as 0. Refer to the Smart Sensor Device Interface documentation for further information.

• Sensor Range / Type

The lower 4-bits of the Range byte are read-only.

Sensor Type	Sensor Input Type (Range)	Measurement Type	
0x00	Reserved		
0x01	Reserved		
0x02	100 kPa (15 psi)	0x28	Pressure (Kilo Pascal)
0x03	200 kPa (30 psi)	0x28	Pressure (Kilo Pascal)
0x04	350 kPa (50 psi)	0x28	Pressure (Kilo Pascal)
0x05	700 kPa (100 psi)	0x28	Pressure (Kilo Pascal)
0x06	Reserved		
0x07	Reserved		
0x08	+/- 100 kPa (+/- 15 psi)	0x28	Pressure (Kilo Pascal)
0x09..0x0e	Reserved		
0x0f	Variable Pressure (special order)	0x28	Pressure (Kilo Pascal)

Pressure Sensor Device Byte

The Device byte is read-only.

Pressure Sensor Device Byte							
7	6	5	4	3	2	1	0
Reserved						Type	
0	0	0	0	0	0		

Pressure User Calibration Parameters

The SP-006 provides four User Calibration registers that allow setting a 2-point calibration/linearization. The four parameters may only be set while the device is in the User Calibrate mode. When the calibration function is triggered the device will calculate the Gain and Offset used in the linearization process. The calibration process is performed by the following steps:

1. Send Sensor Function Calibrate Mode trigger to set the device to calibration mode.
2. Apply a known pressure and record in the User Calibration register 1 (Actual Low).
3. Record the measured value in User Calibration register 0 (Reading Low)
 - A Sensor Capture Low trigger function allows automatic capturing of the value.
4. Apply a 2nd known pressure and record in the User Calibration register 3 (Actual High)

5. Record the measured value of the 2nd weight in User Calibration register 2 (Reading High)
 - A Sensor Capture High trigger function allows automatic capturing of the value.
 6. Send the Sensor Function Start Calibrate trigger to generate the Gain and Offset value
- The four calibration parameters represent two sets of reading, where X = actual applied pressure and Y represents the reading captured by the device. After the calibration process:

Note: The device must be put into the Calibration Mode to access the User Calibration parameters. While in the Calibration mode, the raw Reading value will be displayed. To perform a single point calibration (Offset only), set the High Actual equal to the Low Actual (Gain) or the High Reading equal to the Low Reading value.

User Calibration Parameter	Name	Range	Factory Reset	Description
0	Low Reading (X1)	+/- 100000	0.0	Value read by SP-006 (lower value)
1	Low Actual (Y1)	+/- 100000	0.0	Actual applied load (lower value)
2	High Reading (X2)	+/- 100000	Full Scale	Value read by SP-006 (higher value)
3	High Actual (Y2)	+/- 100000	Full Scale	Actual applied load (higher value)

• IPSO Pressure Sensor Definition

The SP-006 IPSO pressure definition provides signal range, measured min/max values, IPSO object type information.

• Precision

The measured pressure value is rounded to provide +/- 0.5 kPa degree resolution.

• Sensor Trigger Function

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

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

Setting the Reset Min/Max bit to 1 will reset the Min/Max values recorded by the IPSO process. The Calibration mode is entered by writing a 1 to the Calibration Mode bit. While in the calibration mode the calibration registers may be accessed, the Capture High/Low may be used to capture real-time values and the Calibration Start may be set.

When the Calibration Start bit is set the Calibration Status bit will remain set until the calibration process is complete.

Setting the Calibration Reset bit will clear the calculated Gain and Offset values.

Max Range

The SP-006 allows pressures of 150% of the full range value.

Temperature Sensor

Temperature Descriptor

The SP-006 provides a discrete temperature sensor interface. The SP-006 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.

Offset	Name	Value	Description
0x00	Measurement Type	0x01	Temperature in °C
0x01	Data Type/Format	0x06	Float type
0x02	Configuration Byte	??	See subsections below
0x03	Device Byte	0x00	Not Used
0x04..0x08	UOMR	“oC”	Units of measure

Temperature Sensor Type

Sensor Type	SI Derived Units	Measurement
0x18	DIN	Bitmapped digital inputs

DIO Data Type/Format

The SP-006 supports extended configuration and provides factory calibration. All data values are returned as 32-bit floating-point values.

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

- **Data Type**

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

- **Factory Calibrate**

Factory calibration is available for the SP-006 process inputs. Clearing this bit will disable the factory calibration

values.

- **Writeable**

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

- **Temperature Configuration Byte**

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			

- **Lock**

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

- **Apply Scaling**

For more information on Gain and Offset, refer to the Smart Sensor Manual. If set, the user-defined Offset and Gain values will be used to adjust the sensor reading: $\text{Result} = (\text{Raw Reading} * \text{Gain}) + \text{Offset}$

- **Assigned**

The Assigned bit will always read as 0. Refer to the Smart Sensor Device Interface documentation for further information.

- **Available**

The Available bit will always read as 0. Refer to the Smart Sensor Device Interface documentation for further information.

- **Temperature Device Byte**

The Temperature Device Byte is not used.

- **Temperature Parameters**

There are no user-accessible parameters for the temperature sensor.

- **Temperature User Calibration**

There are no temperature user calibration registers assigned.

- **IPSO Temperature Sensor Definition**

The SP-006 IPSO temperature definition provides signal range, measured min/max values, IPSO object type information.

Offset	Name	Value	Description
0xa8	Sensor Type	3349	Bit Mapped Digital
0xaa	Precision	0	Provides reading of xxx
0xac	Sensor Trigger	??	Write 0x0001 force reset of min / max
0xb0	Min Measured	??	Minimum reading since the last reset
0xb4	Max Measured	??	Maximum reading since the last reset
0xb8	Min Range	0	Minimum reading
0xbc	Max Range	3	Maximum reading

Precision

The measured temperature value is rounded to provide ± 0.1 degree resolution.

Sensor Trigger Function

The Sensor Trigger function is used to reset the IPSO min/max values and to 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	0	0	0	0	0	0

Setting the Reset Min/Max bit to 1 will reset the Min/Max values recorded by the IPSO process. No user calibration is supported in the temperature sensor and all configuration bits should be written as 0.

Discrete I/O Interface

The SP-006 supports a DIO Interface that provides 2 discrete inputs that are hardwired to the outputs. These may be used to detect the state of external switches (output off) or to monitor the state of the outputs.

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

DIO Sensor Type

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

Sensor Type	SI Derived Units	Measurement
0x18	DIN	Bitmapped digital inputs

DIO Data Type/Format

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

- **Data Type**

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

- **Factory Calibrate**

The Factory Calibrate bit is not used for DIO types.

- **Writeable**

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

- **Smart Sensor**

Refer to the Smart Sensor Device Interface documentation.

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			

- **Lock**

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

- **Apply Scaling**

If set, the user-defined Offset and Gain values will be used to adjust the sensor reading: $\text{Result} = (\text{Raw Reading} * \text{Gain}) + \text{Offset}$

- **Assigned**

The Assigned bit will always read as 0. Refer to the Smart Sensor Device Interface documentation for further information.

- **Available**

The Available bit will always read as 0. Refer to the Smart Sensor Device Interface documentation for further information.

DIO Device Configuration

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

- **Invert**

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

- **Enable**

If the Enable bit is set the input is enabled.

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

Offset	Name	Value	Description
0xa8	Sensor Type	3349	Bit Mapped Digital
0xaa	Precision	0	Provides reading of xxx
0xac	Sensor Trigger	??	Write 0x0001 force reset of min / max
0xb0	Min Measured	??	Minimum reading since the last reset
0xb4	Max Measured	??	Maximum reading since the last reset
0xb8	Min Range	0	Minimum reading
0xbc	Max Range	3	Maximum reading

Sensor Trigger Function

The Sensor Trigger function is used to reset the IPSO min/max values as well as controlling 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	0	0	0	0	0	0

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 Configuration bits should be written as 0.

Output Configuration Registers

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.

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	0xf1fe	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.

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%)

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	0xf078	0xf720	char[16]	Defaults to Output_0
1	Output 1 Name	0xf07a	0xf728	char[16]	Defaults to Output_1
2	Output 2 Name	0xf07c	0xf730	char[16]	Defaults to Output_2
3	Output 3 Name	0xf07e	0xf738	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.

Output Configuration

The SP-006 provides two output signals which may be configured for ON/OFF, PWM, or SERVO outputs through the Output Configuration registers. The remaining outputs are assigned as phantom devices which are non-configurable.

The highlighted entries show typical default configurations.

Output Configuration										
7		6	5		4		3	2	1	0
Output Configuration										
			Servo Range		Active State		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				
No Mapping	0	-	-			Null	0	0	0	0
Sensor 0	1	0	0			ON/OFF	0	0	0	1
Sensor 1	1	0	1			PWM	0	0	1	0
Sensor 2	1	1	0			Servo	0	0	1	1
Sensor 3	1	1	1	Not Enabled	0					
				Enabled	1					

- **Rate**

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

- **PWM Rate**

The SP-006 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

- **SERVO Rate**

Smart Sensor probes support the following SERVO frequencies:

Servo Rate	Name	Description
0	100 Hz	PWM signal has constant 100 Hertz frequency (10 msec repetition rate) with 0 – 100 % duty cycle
4	50 Hz	PWM signal has constant 50 Hertz frequency (20 msec repetition rate) with 0 – 100 % duty cycle

- **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.

- **Active State**

Smart Sensor discrete 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).

- **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.

- **Sensor Mapping**

The Sensor Mapping value may select 'no mapping' or any of Sensor 0..3. 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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Documents / Resources

	<p>OMEGA SP-006 Layer N Pressure Monitoring and Control Smart Probe [pdf] User Guide SP-006 Layer N Pressure Monitoring and Control Smart Probe, SP-006, Layer N Pressure Monitoring and Control Smart Probe, Smart Probe, Probe</p>
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References

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