

Digital and Analog I/O

This document discusses the application and configuration of digital and analog inputs/outputs (I/O). Details are for both onboard I/O and external I/O boards.

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Additional Information:

- ◆ *ION Reference*
- ◆ Your ION product documentation
- ◆ *Modbus and ION Technology* technical note
- ◆ *Grayhill OpenDAC and ION Technology* technical note
- ◆ www.grayhill.com

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Introduction

Analog and digital I/O ports on PowerLogic™ ION™ meters let you bring in a variety of data into a common system. This simplifies data gathering and provides the following capabilities. Meter analog and digital I/O ports let you:

- ◆ Interface the I/O ports with relays as well as transducers for gas, steam, air, and water metering.
- ◆ Use the inputs to count transducer pulses and breaker trips, or measure flow rates, rotations, fuel levels, oil pressures, and transformer temperatures.
- ◆ Use the outputs for equipment control to transfer any value (e.g. energy) to remote terminal units (RTUs).
- ◆ Monitor equipment status.

There is a range of I/O solutions available depending on your application. Onboard I/O provides fast and robust performance for time-critical applications. Configuration is simple and integration is seamless.

For extensive I/O requirements with the ION8600 meter, you can use the I/O Expander — this device was designed and tested with the ION8600 meter, and provides reliable performance.

You can use meters with Modbus™ master capability (ION8600, ION7550, and ION7650 meters) for extensive I/O requirements; when communication speed is not required, you can use the Grayhill OpenDAC I/O system. Other ION meters also use Grayhill I/O products, such as the ION7300 relay extension board and the ION7700 expansion boards.

I/O Solutions

ION meters offer you a range of onboard I/O. For expanded I/O applications, you can use Grayhill products. Configuring onboard and expanded I/O is the same using ION software.

Every ION meter has a set of ION modules that control its analog and digital onboard I/O ports. There is one module that corresponds to each hardware input or output port, for example, one Digital Input module corresponds to one hardware input port.

Onboard I/O requires minimal setup using the Designer component of ION Enterprise™. The I/O Expander for the ION8600 meters and expansion boards for the ION7700, ION7300 series, ION7550, and ION7650 require similar setup to the onboard I/O with Designer software.

Refer to your meter User's Guide or technical documentation or the *ION Reference* for complete details on how to link and configure these ION modules using Designer software.

Onboard I/O for ION Meters

The number of digital and analog inputs and outputs on each ION meter is listed below.

Meter	Digital Inputs*	Digital Outputs*	Analog Inputs*	Analog Outputs	Modbus Master
ION6200	0	2	0	0	
ION7300	0	4	4	4	
ION7330	4	4	4	4	
ION7350	4	4	4	4	
ION7550	16	7	4	4	yes
ION7650	16	7	4	4	yes
ION7700	8	0	4	0	
ION8600 C	3	4	0	0	
ION8600 B	3	4	0	0	yes
ION8600 A	3	4	0	0	yes

* Some digital inputs/outputs and all analog inputs require the installation of an optional circuit board inside the meter. See the meter's data sheet for complete details.

I/O Expander for ION8600 Meters



To get enhanced analog or digital I/O with the ION8600 meters, you can use an external I/O Expander. Complete information for the I/O Expander is available in the *I/O Expander Installation Guide*.

The I/O Expander equips the ION meter with eight digital inputs, four Form A digital outputs, and four Form C digital outputs, or four analog outputs (0 to 20 mA, -20 to 20 mA, or -1 to +1 mA) in place of the four Form A digital outputs. The I/O Expander also provides a convenient location for the ION meter's RS-232 and RS-485 communications wiring.

The I/O Expander is mounted separately, no more than 15 feet away from the meter. It connects to the meter via a standard Molex Micro-Fit 3.0 connector. RS-232 and RS-485 links are made via standard DB9 and captured-wire connectors located on the I/O Expander. The analog output version of the I/O Expander must be powered by an external source, a standard AC/DC supply.

As the I/O Expander board is external, you can install and configure I/O points without affecting the meter's operation. Terminal strips simplify connections to external equipment. Furthermore, the low-profile connectors between the meter and the I/O board let you easily remove the meter without disconnecting all the attached I/O wiring.

External I/O with Grayhill Products

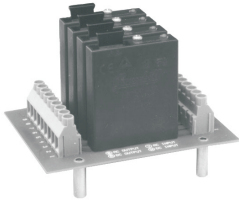
You can change the number of inputs and outputs available for ION meters, or extend the functionality of the standard digital outputs, through external I/O boards. Just plug Grayhill analog or digital I/O hardware modules into the boards. For more information on Grayhill, visit their website at www.grayhill.com.

Meter	Digital Inputs	Digital Outputs	Analog Inputs	Analog Outputs
ION7300	0	4†	0	0
ION7330	0	4†	0	0
ION7350	0	4†	0	0
ION7700	30	30	14	30
ION8600 C	8	8	0	4
ION8600 B	8	8	0	4
ION8600 A	8	8	0	4

† The ION7300 series meter relay expansion board is used to extend the functionality of the standard onboard digital outputs.

As with onboard I/O, the functionality of these external Grayhill hardware modules are controlled by ION modules inside the meter. Digital Output, Analog Output, Pulser, and Calibration Pulser modules specify output signal characteristics, while the Digital Input or Analog Input modules define incoming signals.

Digital Output Boards for ION7300 Series Meters



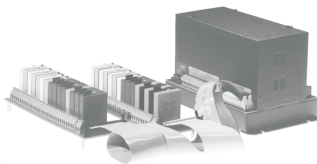
You can extend the capability on the ION7300, ION7330 and ION7350 with an optional relay extension board (REB). The relay extension board provides four slots where you can plug Grayhill digital output hardware modules. There are nine Grayhill hardware modules of varying functionality available.

You can use Digital Output, Pulsar, or Calibration Pulsar modules to control the functions of the Grayhill relay. Set the module's *Port* setup register to the digital output port (D1 to D4) that the Grayhill relay is connected to. Refer to "Configuring ION Modules for Digital and Analog I/O" on page 24. For wiring instructions, see your *ION7300 Series Installation Guide* for more information.

Expansion Boards for the ION7700



The ION7700 expansion boards provide multiple analog and digital inputs, analog outputs, digital inputs, and/or digital outputs. Up to two expansion boards can be connected to the ION7700 meter, though the second board requires its own power supply. (The first expansion board connected to the meter is powered by the meter itself.) Each expansion board offers 15 slots where you can plug Grayhill I/O hardware modules. Some restrictions to the use of analog I/O Grayhill hardware modules are listed below.



Grayhill analog hardware module restrictions—power supplies

Power requirements and hardware restrictions limit the number and placement of Grayhill analog hardware modules on I/O expansion boards. To install the maximum number of Grayhill analog I/O hardware modules, you must have two power supplies (one for each expansion board). These power supplies are purchased separately.

If you only need to install a maximum of six Grayhill analog hardware modules, you can power Expansion Board A directly from the ION7700. Note that if you have a separate power supply for Expansion Board A, then you must remove the associated jumper from the board. Failure to remove the jumper voids the ION7700's warranty. See the *ION7700 Installation and Basic Setup Instructions* for jumper location. Expansion Board B always requires a separate power supply, no matter what the configuration.

Grayhill analog hardware module restrictions—direction of installation

The direction of all modules in slots 0 through 7 and slots 8 through 14 must be the same. Slots 0 through 7 support digital input, digital output and analog output Grayhill hardware modules only (not analog input modules). Slots 8 through 14 support digital input, digital output, analog input and Grayhill analog output hardware modules. Slot 15 is not supported.

As noted above, only slots 8 through 14 support analog input hardware modules, so you can have a maximum of 7 per board. Analog output hardware modules can populate both slot groups on the expansion board, so you can install a maximum of 15 analog output hardware modules per board. The following table summarizes the restrictions on analog I/O devices.

Description	Maximum # of Analog Inputs	Maximum # of Analog Outputs	Maximum # of Analog Devices	Possible Maximum Configurations
Board A WITHOUT Optional Power Supply	6	6	6	Any combination up to 6 total
Board A WITH Optional Power Supply	7	15	15	Board full
Board A WITHOUT Optional Power Supply + Board B	13	21	21	A: 6 AI; B: 7 AI, 8 AO A: 6 AO; B: 7 AI, 8 AO A: 6 AO; B: 15 AO A: 6 AI; B: 15 AO
Board A WITH Optional Power Supply + Board B	14	30	30	Both boards full

Expansion Boards for Meters with Modbus Master Capability

For ION meters that have Modbus master capability, the Grayhill OpenDAC I/O system provides extended functionality. The Grayhill OpenDAC system provides serial Modbus RTU connections to the ION meter. Extended analog and digital I/O capability are provided by the Grayhill OpenDAC rack.

OpenDAC controllers provide network connections but do not perform local control, and are used most often with ION meters that have Modbus master capability. OpenLine hardware modules fit into an OpenDAC rack to make up the system. OpenLine hardware modules are dual-point modules, for example, one digital input module has two input channels. The Series 73L modules are analog, and measure or control voltage, current, or temperature. The Series 70L modules are digital and are discrete — either on or off.

Grayhill OpenDAC controllers and hardware modules let you stack up two racks for a total of 32 I/O points. You can also mix analog and digital inputs and outputs on the same rack. You must have a power supply for each expansion board. These power supplies are purchased separately.

In general, you require the following to use the OpenDAC system with an ION meter that has Modbus master capability:

- ◆ ION meter with Modbus master capability
- ◆ OpenDAC controller
- ◆ One or two OpenDAC racks
- ◆ Up to eight OpenLine hardware modules (per rack) up to 16 I/O points per rack
- ◆ Five-volt, 5-Amp DC power supply (you may need more amperage if you are using current output modules)
- ◆ OpenDAC Modbus Configuration Installation and Troubleshooting Guide, Bulletin #812

Power Requirements

The Modbus controller requires 1 Amp at 5 Vdc. The I/O modules require between 10-150 mA depending on module type.

Description	Maximum draw per channel for I/O
Controller	1 A
Rack	40 mA
Digital Inputs	20 mA
Digital Outputs	20 mA
Analog Voltage Input	75 mA
Analog Current Input	75 mA
Analog Voltage/Current Outputs	200 mA
Thermocouple Modules	75 mA

The 5-Amp power supply can support the Modbus controller (1 Amp) plus two full racks of digital I/O that fit on a DIN rail rack.

Communications Considerations

The OpenDAC controller provides four wire RS-485 with the Modbus RTU protocol. For two wire RS-485, connect a jumper wire between the two negative and positive terminals.

The Unit ID is set with two dial switches. One switch sets the low word of the ID (0x0 to 0xF) and the other sets the high word. Protocol and baud rate are set with the third dial switch. Common settings are as follows:

Switch Setting	Parameters
0	9600 baud Modbus RTU
1	19 200 baud Modbus RTU
Remaining settings are for higher baud rates or ASCII protocol	

NOTE

Detailed setup information for the Grayhill OpenDAC system is available at www.grayhill.com and in Bulletin #812, OpenDAC Modbus Configuration, Installation and Troubleshooting manual. Part numbers are available on the PowerLogic order form.

Grayhill OpenLine I/O Modules

OpenLine I/O modules can be used as a component within an OpenDAC system. Adding Grayhill OpenLine I/O modules to your ION meter extends the conditions you can monitor even further, to include transformer temperatures, generator fuel levels, equipment status, or other utilities like water and steam.

For more information, see the *Grayhill OpenDAC and ION Technology* technical note, which provides an overview of the Grayhill OpenDAC control system, including OpenLine modules. It also provides instructions for configuring the system with ION technology. Also, refer to Grayhill's support documentation at http://grayhill.com/support/docs_openline.htm.

Configuring Digital and Analog I/O

With the exception of Modbus master control of I/O, ION meters require the setup of ION modules for digital and analog I/O capabilities.

Digital Input: Digital (status) inputs can be used for monitoring external contacts or pulse counting applications, and are controlled by Digital Input modules. This module tells the meter how to interpret incoming signals.

Digital Output: Digital outputs are used for hardware relay control or pulse counting applications. The outputs can be controlled by Digital Output modules, Pulser modules, or Calibration Pulser modules, depending on the application (relay switching or energy pulsing). An example of a commonly used application for each module is listed below.

- ◆ Digital Output module: monitors a change of state to control relay operation via a hardware output device.
- ◆ Pulser module: transfers high-speed pulses to a hardware pulse counting device that is used to track energy usage.
- ◆ Calibration Pulser module: integrates instantaneous power inputs, then outputs high-speed pulses to an LED that can be monitored to verify revenue meter calibration.

All of these modules can act as intermediaries between the hardware port and the other modules in the meter. They define the characteristics of outgoing signals.

Analog Input: Analog inputs can measure DC signals from transducers. They are controlled by Analog Input modules.

Analog Output: Analog outputs can deliver a continuous DC signal, and are controlled by the Analog Output modules.

The following sections describe how the modules provide digital and analog data exchange among ION meters and devices that measure and collect various types of information.

Configuring Digital Input

Digital inputs are necessary for status monitoring or pulse counting applications. Status monitoring can help you prevent equipment damage, improve maintenance, or track security breaches. Some common status monitoring applications are: monitoring the closed/open positions of breakers, on/off status of generators, armed/unarmed conditions in a building alarm system, and over/under pressures of transformers.

NOTE

If you want to confirm the status of a breaker, it should have an auxiliary circuit that indicates whether it is open or closed. If you want to check for the over/under conditions of a transformer, you have to interface the meter's digital input to a transducer that monitors the transformer and turns on if such a condition exists.

You can also have the digital inputs count transducer pulses to indicate, for example, the number of times a breaker has tripped, or the number of rotations completed by a device. Another option is to have the inputs read pulses from gas, water, steam, or other electricity meters.

Digital Input Module

Digital inputs are used to monitor the status of a sensor such as limit, pressure or temperature switches, and to monitor the status of loads. The source connected to the Digital Input module provides a logic-level signal that describes the state of device that is monitored. The device state is interpreted as either a complete pulse or a KYZ transition (half of a pulse) and is made available as an output. Each state change is determined by the amount of time (debounce time) that the external signal remains in a state.

Digital Input Module Setup Registers

Setup Register	Description
Input Mode	Specifies if the external signal is pulse or KYZ
Event Log Mode	Specifies whether events are logged or not (LOG ON, LOG OFF)
Polarity	Determines if the signal from the hardware is inverting or non-inverting
Debounce	Specifies how long the external signal must remain in a state to be considered a valid state change
Port	Defines which hardware port provides the signal

Specifying a Debounce Time

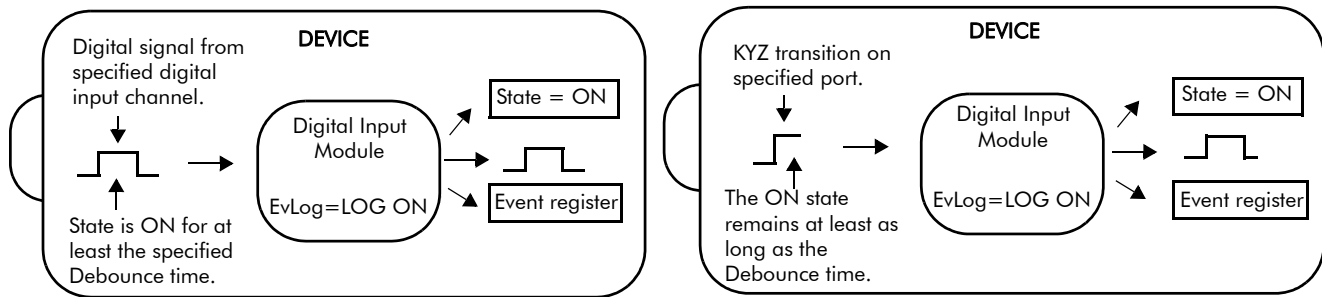
The value specified for the Debounce setup register depends on the kind of signal and the input devices being monitored. A typical value for solid state, dry contacts is 0 to 5 milliseconds. For mechanical dry contacts, a value between 1 and 80 milliseconds is typical. Some input devices may already have a built-in debounce time, often referred to as a *Turn On* or *Turn Off* time.

NOTE

The ION7300 series, ION7550 / ION7650 and ION7700 meters have factory preconfigured Digital Input modules, as well as Counter modules for counting status changes, and External Pulse modules for resetting counter modules.

Detailed Operation: Pulse or KYZ Input Mode

Digital inputs can be set in either a pulse or KYZ configuration. In pulse applications you specify the module registers to change (on or off) when a signal occurs for the specified debounce time (usually between 0-5ms for solid state dry contact, and 1-80ms for mechanical dry contacts). In KYZ applications, a transition occurs when a signal is received and the transition remains at least as long as the debounce time. When the next transition occurs, the input module state changes again. This type of redundancy is important in utility applications where the pulses correspond to energy consumption.



Configuring Digital Output

Digital output ports provide access to external relays and control capabilities. For example, an ION meter's digital outputs can provide on/off control signals for capacitor banks, generators, and other equipment.

ION meter digital output ports can also send out status signals or kWh pulses if the receiving device determines energy usage by counting pulses.

Different ION modules are used to control the hardware digital output ports in different ways. For relay and control, the Digital Output module is used. For pulsing applications, the Pulser and Calibration Pulser modules are generally used.

Each hardware digital output consists of a dry contact relay (switch) that is either open or closed. An external power supply may be required to sense whether the relay is open (no current) or closed (flowing current).

CAUTION

The digital relay outputs should never be used for primary protection functions.

For additional information regarding using the digital output ports for energy pulsing, refer to "Energy Pulsing from ION Meters" on page 26.

Digital Output Module

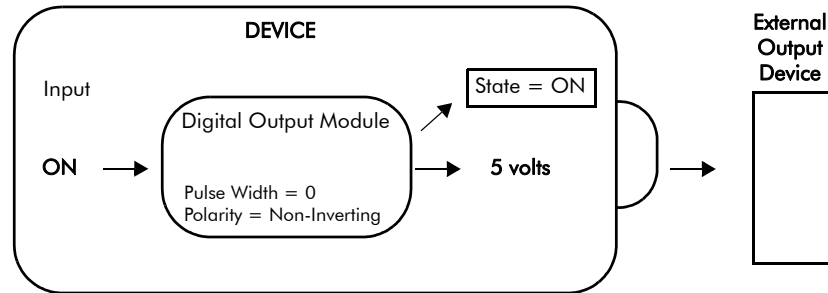
The Digital Output module acts as an intermediary between another module in the device and the hardware port. It takes a Boolean input and sends that out a hardware channel as a constant level or pulse. With the module setup registers, you must specify what kind of output that the module produces, and on what hardware port.

Digital Output Module Setup Registers

Setup Register	Description
Event Log Mode	Specifies whether events are logged or not (LOG ON, LOG OFF)
Polarity	Determines if the signal from the hardware is inverting or non-inverting
Pulse Width	Specifies the width of the output pulse
Ports	Defines the hardware port where the pulse or (continuous) output is sent

Detailed Operation

The following example illustrates the basic operation of a Digital Output module. The input in the figure could be any of the *Source*, *Force ON*, *Force OFF*, or *Normal* inputs. The *EvLog Mode* and the *Port* setup registers could be set to whatever is appropriate (they do not affect the output values of the module). Similarly, the *Mode* and *Event* output registers contain whatever is appropriate.



When specifying the *Polarity* setup register, you must consider the characteristics of the external output device. If you have defined different ON or OFF labels for the *State* output register, you should consider the characteristics of the output device and the *Polarity* setting.

Calibration Pulser Module

The Calibration Pulser module is a highly accurate energy pulser often used for verifying calibration on revenue meters. This module can serve as an intermediary between the power (kW, kVAR or kVA) outputs of the Meter Units Power Meter module and an ION meter's hardware output channel.

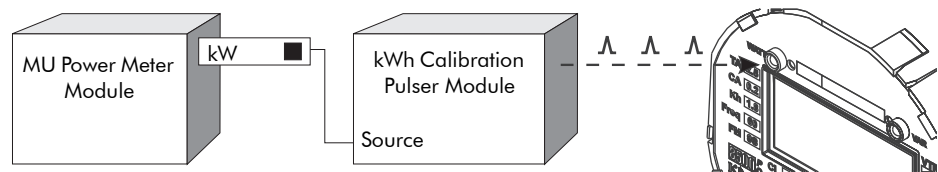
The module integrates the instantaneous power inputs and then outputs complete pulses or KYZ transitions to a hardware channel. Using the Calibration Pulser module setup registers, you must specify the output mode, output rate (Kt), the output pulse width or minimum duration between KYZ transitions, and the hardware port where the pulses appear.

Calibration Pulser Module Setup Registers

Setup Register	Description
Output Mode	Specifies whether the output is a complete pulse (PULSE) or a change of state transition (KYZ)
Pulse Width	Specifies the width (on-time) of the output pulse (e.g. how long an LED is lit or relay is open)
Kt	Defines how much energy is accumulated by the module before an output is sent to the hardware channel
Integration Mode	Defines the mode of integration
Ports	Defines the hardware port where the output appears

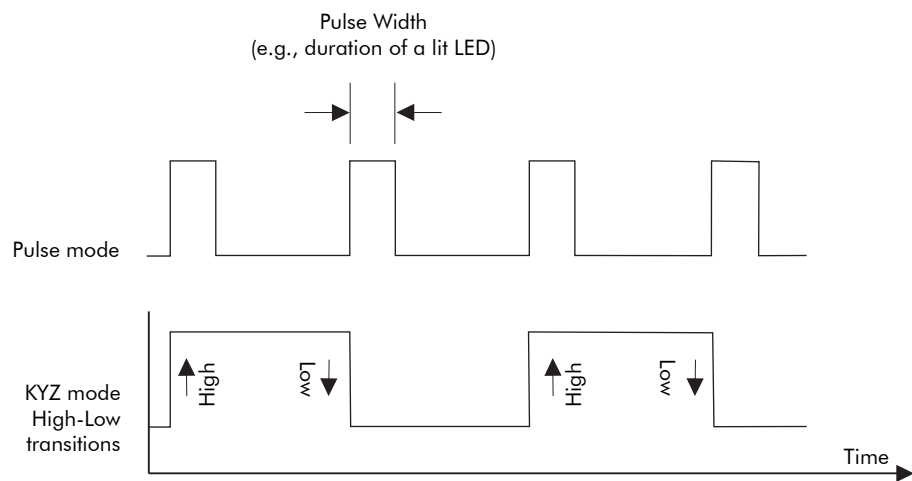
Detailed Module Operation

The Calibration Pulser module integrates the *Source* input, determines how many KYZ transitions or complete pulses it must generate from the *Kt* setup register, and sends the output to the hardware channel specified in the *Port* setup register.



Depending on the number of KYZ transitions or complete pulses output, the Calibration Pulser module operates in a normal, maximum, or an overload state.

Normal State

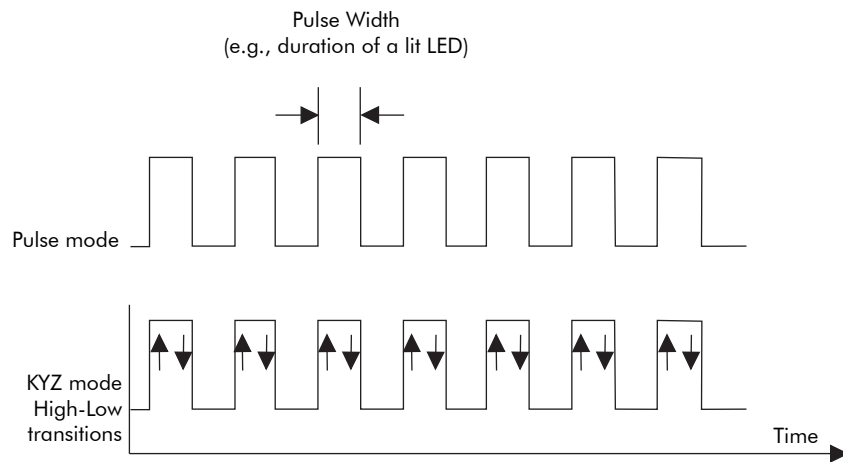


A value entered into the *Pulse Width* register describes the on-time of the pulse (i.e. the time period that an LED is lit or relay is closed). In normal operation, the on-time of the pulse is significantly shorter than the off-time.

KYZ mode indicates a transition (from high to low or vice versa), so Pulse Width typically has no effect, except in an overload state. The on-time and off-time of a KYZ transition is equal in normal and maximum states.

The diagram above shows four complete pulses for the Calibration Pulser module in PULSE mode, and four transitions for the Calibration Pulser module in KYZ mode. If the *Kt* register was set up to send a pulse or KYZ transition for 1.8 energy-hours on each module respectively, then both modules have equal energy-hours output.

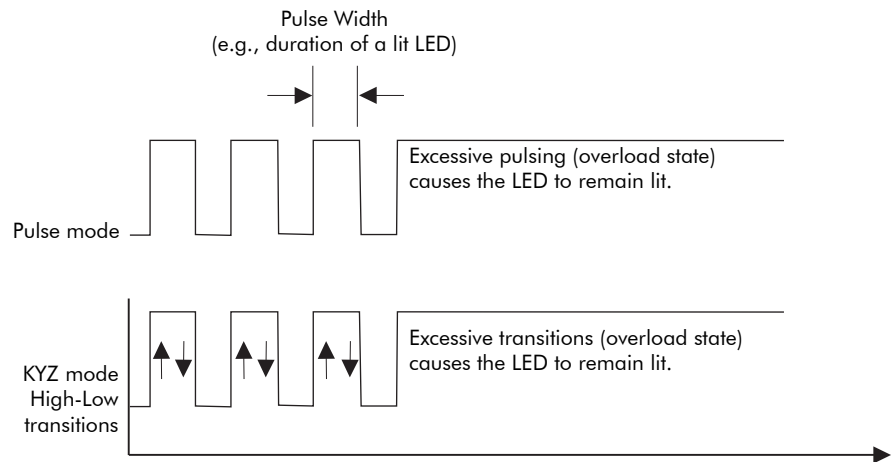
Maximum State



In PULSE mode during maximum operation, the *Source* input increases so the on-time and off-time of the pulses are equal.

The diagram above shows seven complete pulses for the Calibration Pulser module in PULSE mode, and fourteen transitions for the Calibration Pulser module in KYZ mode. If the *Kt* register was set up to send a pulse or KYZ transition for 1.8 energy-hours on each module respectively, then the module in KYZ mode has output twice as much energy-hours than the module in PULSE mode.

Overload State



If the *Source* input increases so that an excessive number of state changes appear at the hardware channel, the *Overload* Boolean output is turned ON, and pulsing stops (i.e. the LED or digital output remains on) until the energy values return to a nominal level. The *Overload* Boolean output is available for Calibration Pulser modules in PULSE or KYZ mode.

The diagram above shows three complete pulses for the Calibration Pulser module in PULSE mode, and six transitions for the Calibration Pulser module in KYZ mode. For both modules, the *Overload* output has turned on, causing the LED to remain lit.

Pulser Module

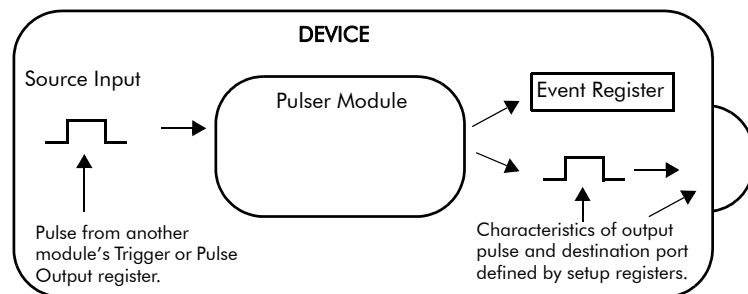
The Pulser module serves as an intermediary between other modules' pulse output registers and a hardware output channel on the device. It converts the instantaneous pulses to pulses or transitions on a hardware output channel. With the module setup registers, you must specify whether the output is a transition or complete pulse, if it pulses high or low, and the hardware port where the pulses appears. For each pulse received at the *Source* input, a single pulse is sent to the specified hardware output channel.

Pulser Module Setup Registers

Setup Register	Description
Output Mode	Specifies whether the output is a complete pulse (PULSE) or a change of state transition (KYZ)
Pulse Width	Specifies the width (on-time) of the output pulse (e.g. how long an LED is lit or relay is open)
Polarity	Defines the output polarity of the pulses if you have selected a complete pulse as the Output Mode. It has no effect if you selected transition mode
Ports	Defines the hardware port where the output appears

Detailed Operation

The figure below illustrates the operation of the Pulser module.



Each second, the Pulser module determines how many pulses it has received on its *Source* input and outputs an equal number of pulses to the specified hardware output channel. Because the *PulseWidth* setup register limits the output pulse to a minimum width, the Pulser module may not always be able to output a pulse for every pulse it receives on its *Source* input. In these cases, the extra pulses are sent to the hardware output channel in the next second. In cases where the Pulser module can output the correct number of pulses, these pulses are spread evenly throughout the second.

Configuring Analog Input

Analog inputs can measure and store analog information such as electrical signals from transducers; transducers derive the electrical signals from flow rates, temperatures, pressures, rotations, and fluid levels. Analog inputs require the installation of an optional circuit board inside the meter.

Analog Input Module

The Analog Input module takes an analog signal from a hardware port, scales it, and makes the scaled result available in its output register.

ION meters with analog input connections have two types of analog input ports available when you order a meter (refer to your meter's label to determine what type you ordered):

Analog Input Option	Input Impedance	Max Common Mode Voltage
0 to 1 mA	475 Ω	8 V
0 to 20 mA (scalable to 4 - 20 mA)	25 Ω	20 V

The accuracy of these analog inputs is $\pm 0.3\%$ of full-scale.

Connecting Auxiliary Analog Inputs (ION7700 Meters)

The optional internal analog input boards for ION7700 meters provide four double-ended current or voltage inputs for direct interface with transducers or thermocouples. The option ordered determines the configuration and maximum input range for all four analog input pairs (refer to the label on the ION7700 for the AUX rating). All four must have the same input rating (e.g. 0 - 20 mA). Analog inputs receive DC signals only. Options include:

ION7700 Analog Input Option	Input Impedance	Max Common Mode Voltage
0 to 1 mA	49.9 Ω	8 V
0 to 20 mA	100 Ω	20 V
0 to 1 V	≥ 50 k Ω	12 V
0 to 10 V	≥ 50 k Ω	25 V

Analog Input Module Setup Registers

An Analog Input module corresponds to each hardware input port. This module takes signals from an input port, scales it, and makes the result available to the meter. The register settings let you determine the value that appears in the output register when the lowest and highest possible values from the hardware are applied, and determine the hardware port that the module controls.

To learn more about the Analog Input module scaling, refer to the section "Setting Analog Zero and Full Scale Values" on page 21.

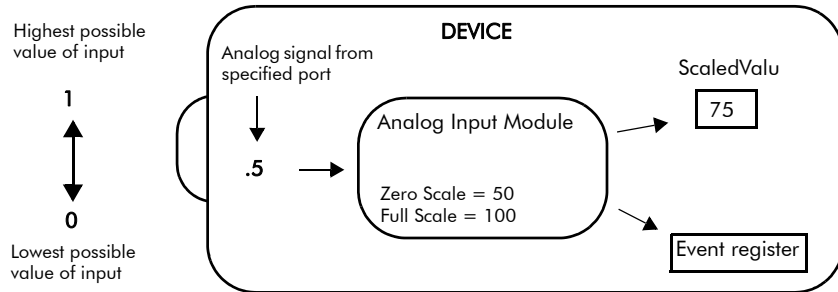
Setup Register	Description
Zero Scale	Defines the value that appears in the <i>ScaledValu</i> output register when the lowest value from the hardware port is applied
Full Scale	Defines the value that appears in the <i>ScaledValu</i> output register when the highest value from the hardware port is applied
Port	Defines the hardware port that provides the signal

NOTE

Once you have set the *Port* setup register to the appropriate analog input port on the meter, link the *ScaledValu* output register to another software module or framework for analysis.

Detailed Operation

The following example illustrates the Analog Input module with an input coming from 50% of the highest possible input value. The Analog Input module takes the input value and calculates what it corresponds to on the new scale, which is defined by the *Zero Scale* and *Full Scale* registers. In this case, 50% on the new scale is a value of 75. This value is written into the *ScaledValu* output register.



Configuring Analog Output

An ION meter's analog outputs act as transducers. The meter measures power and energy, and then sends that information via the analog outputs to a remote terminal unit (RTU). The analog outputs issue industry standard 0 to 20 mA current signals.

Analog Output Module

Analog outputs allow you to control external devices by delivering a specific current or voltage that is proportional to your source point. The Analog Output module takes an input value and scales it to the appropriate values for output to an analog hardware port. It also provides the scaled value as an output register that can be accessed by other modules.

Ordering options on some ION meters provide analog outputs that can deliver a continuous DC signal. The accuracy of analog outputs for ION meters is $\pm 0.3\%$ of full scale. The following varieties are available—be sure to check the device label to determine your option:

Analog Output Option	Maximum Load
-1 to 1 mA (scalable to 0 to 1 mA)	10 Ω
0 to 1 mA	10 Ω
0 to 20 mA (scalable to 4 - 20 mA)	500 Ω
-20 mA to 20 mA	500 Ω

Analog Output Module Setup Registers

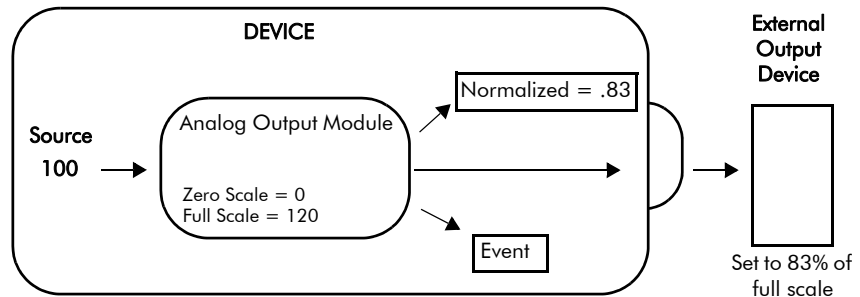
An Analog Output module corresponds to each hardware output port. This module takes a numeric value and scales it for output to an analog hardware port, allowing you to control external devices by delivering a specific current or voltage. The register settings let you determine the value that appears in the output register when the lowest and highest possible values from the hardware are applied, and determine the hardware port that the module controls.

To learn more about the Analog Output module scaling, refer to the section "Setting Analog Zero and Full Scale Values" on page 21.

Setup Register	Description
Zero Scale	Should be set to the value on the <i>Source</i> input that will create the minimum possible output on the analog hardware port
Full Scale	Should be set to the value on the <i>Source</i> input that will create the highest possible output on the analog hardware port
Port	Defines the hardware port where the output appears

Detailed Operation

The following illustration shows the operation of an Analog Output module. The *Source* input falls between the *Zero Scale* and *Full Scale* values. It is scaled and the result is then sent to the specified hardware port. (The port is specified in the *Port* setup register.) The *Normalized* output register provides information about the state of the hardware: the output on the hardware port in this instance is at 83%.



If at any point the input rises above the value specified in the *Full Scale* setup register, the output remains at the *Full Scale* value and the maximum possible value is sent to the hardware port. Likewise, if the input falls below the value specified in the *Zero Scale* register, the output remains at the *Zero Scale* value and the lowest possible value is sent to the hardware port. If the input becomes NOT AVAILABLE, the *Normalized* output register is also NOT AVAILABLE and the lowest possible value is sent to the hardware port.

Setting Analog Zero and Full Scale Values

You control or monitor external analog devices by delivering or receiving a specific current or voltage that is proportional to a source. This is done by setting the *Full Scale* and *Zero Scale* setup registers and defining the hardware port that receives (Input) or delivers (Output) current. Use the Designer component of ION Enterprise to configure the setup registers in the Analog Input or Output modules.

When scaling values to current, the *Full Scale* value is always set to the highest value you expect. The *Zero Scale* value depends on the actual current that drives the input/output and the type of information that the current represents. The following information steps through scaling an Analog Output module that receives kW as a source and passes the kW value to an analog device whose range is different than the range for the analog output.

NOTE

The general behavior of *Full Scale* and *Zero Scale* is such that: if the input rises above the *Full Scale* value, the output remains at the *Full Scale* value and the maximum possible value is sent to the hardware port. Likewise, if the input falls below the *Zero Scale* value, the output remains at the *Zero Scale* value and the lowest possible value is sent to the hardware port.

Considerations when scaling

1. Set the *Full Scale* value that you expect. For example, consider scaling an Analog Output module whose *Source* input is linked to kW values; if the highest Watt value that you expect is 10 kW enter 10,000 as the *Full Scale* value.
2. Consider the output type you have (-1 to 1 mA, -20 to 20 mA, 0 to 20 mA) and then consider the output range you want (0 to 1 mA, 0 to 20 mA or 4 to 20 mA). For example, the Analog output on an I/O Expander may be 0 to 20 mA, and the analog device connected to the I/O Expander may support a range of 4 to 20 mA.
3. Calculate the *Zero Scale* setting according to the table below. The table assumes the *Source* input varies between *Zero Scale* and the *Full Scale* settings.

Output Type	Desired Range	Zero Scale Setting*	Full Scale Setting
-1 to 1 mA	0 to 1 mA	negative value of Full Scale (e.g. -1000)	e.g. 1000
-20 to 20 mA	0 to 20 mA	negative value of Full Scale (e.g. -1000)	e.g. 1000
	4 to 20 mA	-1.5 times value of Full Scale (e.g. -1500)	e.g. 1000
0 to 20 mA	4 to 20 mA	-0.25 times value of Full Scale (e.g. -250)	e.g. 1000

* To determine the *Zero Scale* multiplier, calculate the ratio of minimum desired output to the desired range:

$$\text{ZeroScaleMultiplier} = \frac{\text{MinimumDesiredOutput}}{\text{MaximumDesiredOutput} - \text{MinimumDesiredOutput}}$$

For example, assume output type is 0 to 20 mA and desired range is 4 to 20 mA:

$$0.25 = \frac{4\text{mA}}{20\text{mA} - 4\text{mA}}$$

NOTE

The *Zero Scale* setting is *minus* 0.25 times the *Full Scale* value as explained in the following section "Determining the Zero Scale setting for output ranges below zero". Although the section describes setting for ranges below zero, the calculation proves the multiplier is negative for output ranges starting at zero.

Determining the Zero Scale setting for output ranges below zero

To determine the *Zero Scale* setting for any range of output (e.g. -1000 W to 1000 W) use the *Zero Scale* multiplier to calculate the portion of the entire range that falls below the lowest expected value. When you subtract this portion of the range from the lowest expected value the result is entered as the *Zero Scale* setting:

$$\text{ZeroScaleValue} = \text{MinimumValue} - \text{ZeroScaleMultiplier}(\text{Maximum} - \text{Minimum})$$

For example, assume the output type is 0 to 20 mA, the desired range is 4 to 20 mA, and the minimum and maximum expected values are -1000 W and 1000 W:

$$-1500 = -1000\text{W} - 0.25(1000\text{W} - (-1000\text{W}))$$

Enter -1500 in the *Zero Scale* register. When the value drops to its lowest expected value of -1000 W the current output is 4 mA as illustrated below:

+	-1500 W	0mA
+	-1000 W	4mA
+	1000 W	20mA

Configuring ION Modules for Digital and Analog I/O

Designer software lets you change the configuration of existing modules or create new modules. Below are general considerations for using Designer software:

- ◆ When using Designer software for configuration, ensure **Show Toolbox** is selected from the Tools menu.
- ◆ From the toolbox you can search for the module you want to create or modify and click on the icon.
- ◆ Right-click on the module to display existing modules. If you want to edit an existing module, click on that module to jump to its location.
- ◆ To create a new module, left-click its icon and drag it onto the workspace.
- ◆ Right-click on the module icon to access setup registers. You can read the input or output register owners by Shift Left-clicking on the either side of the module.

Configuring modules for digital or analog I/O

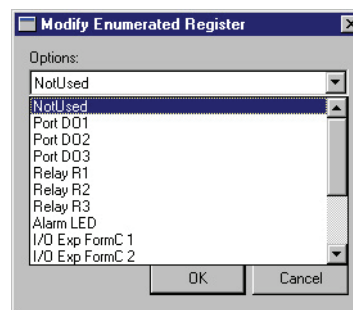
1. Once you have connected the external I/O field equipment to the appropriate input or output ports, run Designer software, and open the meter template.
2. If required, create the appropriate module for each input or output port you are going to use.
3. Link the *Source* input of these modules to a value you want to reflect through the desired outputs, **or** configure the input *Port* setup register to match the input port you want to monitor.
4. Configure the settings of the controlling module to match your requirements. The various module settings for each module are found under the appropriate Module Settings heading.

These software modules have *Port* registers that allow you to specify which port handles the incoming or outgoing signals.

Assigning a port to a module

1. Locate the appropriate module in Designer.
2. Right-click the module to open the Module Setup.
3. Modify the *Port* setup register by picking from the enumerated list.

The enumerated list only shows those ports which have not already been assigned to another module. Port DO4 has already been assigned to another module, so it is absent from the list.



Making a port available

1. Locate the module controlling the port in Designer.
2. Right-click that module to open Module Setup.
3. Set that *Port* setup register to NOT USED (or delete the module entirely). The port now appears in the enumerated list.

Energy Pulsing from ION Meters

To use one of the digital outputs on an ION7300 series, ION7550, ION7650, or ION8600 meter for energy pulsing applications (Wh, kVAh, kVARh), assign it any Pulser, Digital Output, or Calibration Pulser module.

NOTE

In the ION7300 series meters, ION7550, and ION7650, one of the solid-state relays (DO4) is preconfigured for calibration pulsing. It outputs a pulse for every 1.8 Wh measured and is controlled by the Calibration Pulser module. This default configuration can be disabled. Refer to the meter's User Manual to learn how to disable this default configuration.

On all these meters, an energy pulsing LED is preconfigured to pulse every 1.8 Wh (1.2 Wh on 35S socket meters). A Calibration Pulser module controls it. You can configure the LED for other energy pulsing applications (kVAh, kVARh) by disabling the default configuration and then assigning the LED to any Pulser, Digital Output, or Calibration Pulsar module.

On the ION6200 meter, two Pulser modules are pre-set to send pulses every 1 kWh and every 1 kVARh to the solid state relays on the meter.

The infrared port on the ION7300 series meters can also be used for energy pulsing. To do this, you must set the communications protocol to INFRARED I/O. Then choose one of the Pulser modules and specify the infrared port in its setup register.

One Digital Output, Calibration Pulser, or Pulser module corresponds to each physical output port.

Digital Output module: A Digital Output module takes a Boolean input and sends it out a hardware channel as a constant level or a complete pulse.

Calibration Pulser module: All ION meters have Calibration Pulser modules that allow you to generate high accuracy energy pulses for calibration testing. They integrate instantaneous power inputs. A Calibration Pulser module takes numeric input and sends a pulse out a hardware channel based on the calibration constant (Kt). This value defines how much energy accumulates before a pulse is sent to the hardware channel.

Pulser module: A Pulser module takes a pulse input from any other module's output register and sends a pulse to a specific hardware channel based on the pulse width. A Pulser module takes an instantaneous pulse and converts it to either a complete pulse or a transition pulse for a hardware channel.

 **NOTE**

By default, the Form C digital outputs are normally closed in the KY position upon power up. If a Form C output is used for Watt-Hour pulsing and the meter is powered down when the output is closed in the KZ position, then a false transition occurs as the output returns to its default (KY) position. To compensate for the extra pulse generated on power down, the first pulse after power up is ignored, i.e., there is no transition on the Form C output until the second Watt-Hour pulse is generated by the meter. This mechanism ensures that the correct number of Watt-Hour pulses are provided, regardless of the state the Form C outputs are in when the meter is powered down.
