7700 ION™

Installation & Operation Manual

Contents

POWER MEASUREMENT

DANGER

During normal operation of this device, hazardous voltages are present which can cause severe injury or death. These voltages are present on the terminal strips of the device and throughout the connected potential transformer (PT), current transformer (CT), status input, relay, and control power circuits. Installation and servicing should be performed only by qualified, properly trained personnel. See Chapter 2 for additional warnings.

WARNING

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area may cause interference in which case the operator will be required to take whatever measures may be required to correct the interference.

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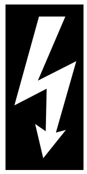
POWER MEASUREMENT

For further information or technical assistance, please contact your local Power Measurement representative, or Customer Service at one of the following locations:

Worldwide Headquarters	Europe & Middle East	Asia & Pacific	India
POWER MEASUREMENT LTD. 2195 Keating Cross Rd., Saanichton, B.C., Canada V8M 2A5 Tel: 1-250-652-7100 Fax: 1-250-652-0411	POWER MEASUREMENT EUROPE Zaventem Business Park, Ikaroslaan 5 B-1930 Zaventem (Brussels), Belgium Tel: 32-2-720-1919 Fax: 32-2-720-9586	POWER MEASUREMENT AUSTRALIA 7/16 Ledgar Road, Balcatta, Perth Western Australia 6021 Tel: 61-9-354-3866 Fax: 61-9-354-3899	POWER MEASUREMENT INDIA 12-G, Gopala Tower, 25 Rajendra Place, New Delhi - 110008, India Tel: 91-11-5724196 Fax: 91-11-6881738

Preface

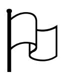
This manual uses various symbols to direct your attention to important information.



This symbol warns of the potential for severe injury or death. Use extreme caution when following any instructions that are accompanied by this symbol.

This symbol warns of the potential for equipment damage. Use caution when following any instructions that are accompanied by this symbol.

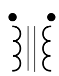
This symbol is used for information of which you should take special note.



This symbol indicates non-critical, but nevertheless useful information.

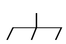
In addition, the wiring diagrams and product labels use symbols to denote the following objects:

Fuse



Potential Transformer (PT)

Current Transformer (CT)

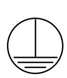


Switchgear chassis (earth) ground

Alternating current

Direct current

Three-phase alternating current



Protective conductor terminal

Table of Contents

1 Introduction to the 7700 ION

The 7700 ION is a highly advanced microprocessor controlled digital power monitor ideally suited for industrial, commercial and utility applications. All of the popular and powerful features of previous Power Measurement devices — which have been forming the leading edge of power instrumentation for over a decade — have been brought together into one fully customizable device. The 7700 ION offers unparalleled features and functionality, and defines the next generation of power monitoring and control solutions.

This chapter describes some of the major benefits you can enjoy using the 7700 ION for real-time power SCADA, energy management, demand management, cost control, power quality monitoring and correction, and more. Furthermore, the underlying principles of our patented Integrated Object Network (ION™) architecture and how this architecture is implemented in the 7700 ION are described. This clarifies some of the advantages that this revolutionary object-oriented approach has for your power monitoring and control application.

High Performance Power Instrumentation

An ION-compliant Intelligent Electronic Device (IED), the 7700 ION can be seamlessly integrated with the many advanced features of the PEGASYS software from Power Measurement. This allows the 7700 ION to become part of a fully networked SCADA or Energy Management System taking the place of numerous individual transducers, meters and control circuits. The new Modular Graphics Terminal, or MGT, from Power Measurement also provides an intuitive user interface for local monitoring and control, or for standalone applications.

The 7700 ION supports a variety of power system configurations: 4-wire Wye, 3-wire Delta and Single Phase. Three voltage inputs and four current inputs can be directly connected to systems up to 347 VAC line-to-neutral/600 VAC line-to-line.

The outstanding accuracy and reliability of the 7700 ION is assured by a high-speed 32-bit microprocessor and on-board Digital Signal Processor. This allows a very high level of sophistication and customization for advanced real time monitoring and control. A flexible communication allows rapid and accurate distribution of all acquired data. Ample nonvolatile memory retains setup and logged information during power failures and permits the 7700 ION to operate independently from any other system for long spans of time.

Flexible Interface

The 7700 ION can communicate with any ION capable system through a built in RS-485 or RS-232C communications interface. Using Power Measurement's new Windows NT based PEGASYS software, a comprehensive PC-based system may be configured using advanced client/server object oriented technology. The PEGASYS software can manage and store all device information obtained from the 7700 ION, as well as provide a graphical interface for interactive control and data acquisition.

The 7700 ION can also communicate directly with Power Measurement's new Modular Graphics Terminal, or MGT, for standalone installations. The MGT offers extensive graphic and text based data display for most 7700 ION parameters, and features a durable user-friendly front panel.

Real-Time SCADA

The combination of a 32-bit microprocessor and high-accuracy simultaneous sampling of all inputs makes the 7700 ION ideal for **real-time Supervisory Control and Data Acquisition** (SCADA) applications. Hundreds of parameters that clearly characterize the condition of the power system are made available in real time. These can be used internally by the 7700 ION or used by any large scale SCADA system for fully customized installations.

Energy Management

The 7700 ION has enough internal processing power to be used as a complete stand-alone power monitoring and control station. Alternatively, it may be used as a **smart RTU** in a large energy management system to provide distributed and highly responsive management of the power system.

Offering **revenue accurate** readings of all important power parameters, flexible and expandable I/O, comprehensive demand calculations, and powerful data logging, the 7700 ION is also ideal for **cost allocation** application.

Demand Side Management

The 7700 ION can perform continuous demand calculations (sliding window, predicted and thermal) on any programmed parameter. When combined with the comprehensive setpoint capabilities and extensive I/O control features, highly **responsive demand control** is easy to achieve.

Power Quality Analysis

An internal Digital Signal Processor (DSP) allows the 7700 ION to calculate continuously up to the 63rd harmonic of any input, as well as the K-factor for current inputs. This provides the data for **accurate analysis of power quality**, and can be combined with internal setpoint and control features to automatically address these problems.

Flexible waveform recording capabilities allow you to store and analyze up to 96 cycles of any line input, with a resolution of up to 128 samples per cycle. Disturbance and fault recording is easy to accomplish.

The 7700 ION provides data for detailed and historical analyses of voltage quality. It also provides pulse outputs that can be used to control external equipment for a more proactive approach to managing voltage quality problems.

Trend Analysis

The 7700 ION has a fully programmable, nonvolatile data storage area that can be used for **precise, high speed data logging.** The 7700 ION can automatically store readings of any parameter off-line at fully programmable intervals, timestamped to millisecond accuracy. When the communication link to a database system (such as the PEGASYS Log Server) is established, the data is automatically uploaded and made available for comprehensive trend analysis using popular analysis software.

Custom Analysis

The 7700 ION allows you to analyze aspects of your power system using any parameters and calculations you wish, providing you with the tools to fully **customize your power system analysis**. The 7700 ION can take values from any parameter in your system, and run analysis calculations that you create.

Time of Use

The 7700 ION provides you with the tools to monitor your energy usage and peak demand during intervals you specify. You are able to compare utility rate scales directly to time of use data, allowing you to **predict and verify your energy consumption costs**.

These are just a few of the many situations in which the 7700 ION excels. Please contact your local sales representative or Power Measurement directly for further information on using the 7700 ION in your particular application.

The ION Architecture

The ION architecture describes the characteristics of an *integrated object network* and defines the internal operation of the 7700 ION. The ION architecture is based on object-oriented principles. In terms of SCADA systems, an object may be the value of a voltage or current measurement, the status of a digital input, a setpoint threshold value, or any other parameter used in the system.

The Integrated Object Network (ION) defines the logical pathways for control information and data to pass between individual functional blocks within an IED, and between IEDs and other nodes in the SCADA system (workstations, databases, and so on). The two fundamental types of object that are required to store and process this information are *ION registers* and *ION modules*.

ION Registers

ION registers are simply data storage locations for numeric values, event log entries, waveform data, setup information, and so on. These might contain the RMS readings for three-phase current, for example, or perhaps the high speed digitized data points for 32 cycles of a single voltage phase. They might contain the maximum values that certain parameters reached or they may contain Boolean ON or OFF conditions. The 7700 ION has thousands of registers to store information about many aspects of the power system. You can look at this information through the PEGASYS software or the MGT.

There are two basic types of ION registers: output registers and setup registers. Output registers contain information that has been calculated or manipulated by ION modules (see below). Setup registers contain information that configures how ION modules will operate.

Registers are categorized in several different classes. The class of a register determines what kind of information it can store. For example, numeric registers can contain numbers, Boolean registers contain either ON or OFF, enumerated registers contain a list of options, and so on. A complete description of all the different register classes and the kinds of data they contain is given in Chapter 5.

Register Handles

When communicating with the 7700 ION using the MGT, you must use the *hexadecimal register handles* to refer to the registers.

A handle is like the address of a register and it is indicated by a hexadecimal number. It tells the MGT what part of the 7700 ION's internal memory contains the information it is looking for. Every ION register has a unique handle.

To retrieve the data stored in the 7700 ION and display it on the MGT, you need to refer to the handles of the corresponding registers. Refer to Appendix B for a complete list of register handles for the 7700 ION.

ION Modules

Each ION-complaint IED contains a selection of ION modules. An ION module is analogous to a single-purpose device or mechanism that may be found in conventional power monitoring and SCADA systems. Each of these "black boxes" has setup registers and output registers in addition to connection points for data and control inputs. The module reads the data at the inputs, manipulates this data in some fashion using the values stored in the setup registers, and writes the result to output registers.

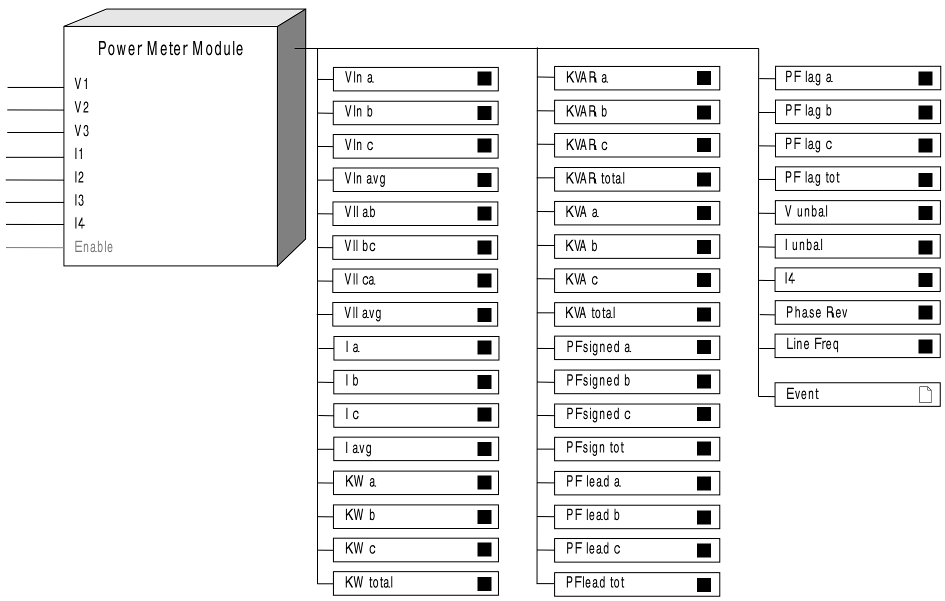
Following are a few examples of ION modules. Many more ION modules are available; the number and type of modules depend on the IED. See Chapter 5 for complete details on all the modules available in the 7700 ION. It provides an introduction to their rules of operation and detailed descriptions of each individual module.

Power Meter Module

This is analogous to a discrete power measuring instrument, such as a conventional kW meter or a multi-functional meter like the 3300 ACM. The inputs are the raw digitized data from the power line, and the outputs are a large number of measured values (Volts, Amps, kW, PF, and so on).

NOTE

This diagram shows all the inputs and the output registers of the Power Meter module. The symbols appearing in each register indicate the register class. See Chapter 5 for a detailed description of individual ION modules and the different register classes.



Maximum Module

This is analogous to a peak meter, which may keep track of the peak demand, for example. A Maximum module in the ION architecture, however, has the flexibility to monitor the maximum value for any parameter simply by linking the input to an appropriate output register from another module. This makes it very easy to measure any peak value, such as the hourly maximum harmonic distortion on a current input, for example.

Data Recorder Module

This is analogous to a conventional strip chart recorder, which may be used to track variations in current flow in a power system, for example. This module stores the values digitally so they can be uploaded to a computer via communications and displayed on the computer screen, retained on computer disk, or printed on paper. The Data Recorder may also be used for high-speed harmonics analysis and fault detection.

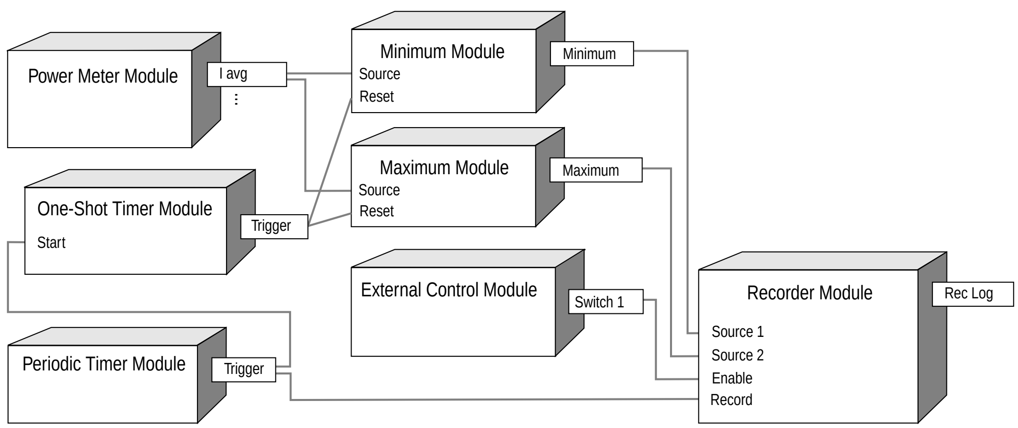
Module Links

The ION architecture is particularly useful because of the flexibility provided by the ION modules. Virtually any application related to SCADA and EMS can be implemented by linking different ION modules together. The input links can be programmed for all types of ION modules; the output registers and setup registers are part of the ION module. This structure allows data to flow from one module to the next, where the inputs for each subsequent module are linked to the output registers of previous modules.

A module can have output registers from several different modules as its inputs. You do not need to link all of one module's outputs to all of another module's inputs. You can pick and choose, selecting output registers from whatever modules provide the data you need. This allows you to interconnect your ION modules and build sophisticated functions. Note also that one output register from a module can be linked to many inputs of other modules. This allows you to program a whole series of actions that are initiated by a single condition.

NOTE

This diagram only shows the registers directly involved in the process of Min/Max recording. See the module descriptions in Chapter 5 for a complete listing of each module's registers.



The example shown here represents daily Min/Max recording on a 7700 ION. Every day at a specified time (determined by the Periodic Timer module), the minimum and maximum values attained by I avg (measured by the Power Meter module) are recorded (with the Data Recorder module) into a log. After a delay (introduced by the One-shot Timer module), the minimum and maximum values are reset.

What Follows in this Manual

Chapter 2 explains how to install the 7700 ION. Chapter 3 discusses the fundamentals of the ION architecture, and details the default configuration of the 7700 ION. The installation and configuration of the MGT display unit is discussed in Chapter 4. Each module available in the 7700 ION is described in detail in Chapter 5.

In Appendix A you will find technical specifications for the 7700 ION and detailed ordering information. Appendix B provides the register handles for all of the modules in the 7700 ION.

2 Installation

This chapter describes all procedures necessary to install the 7700 ION.

In this Chapter

DANGER

During normal operation of this device, hazardous voltages are present which can cause severe injury or death. These voltages are present on the terminal strips of the device and throughout the connected potential transformer (PT), current transformer (CT), status input, control power and external I/O circuits. Installation and servicing should be performed only by qualified, properly trained personnel, and the meter base should not be user-accessible after installation.

WARNING

The 7700 ION offers a range of hardware options that affect input ratings. The serial number label of the 7700 ION lists all equipped options. Appendix A lists all options and associated ratings. This chapter provides detailed installation instructions applicable to each hardware option.

Location & Mounting

Environmental Conditions

The 7700 ION should be mounted in a dry, dirt free location. Once installed, no cleaning of the device is necessary. To operate properly and effectively, environmental conditions should fall within the guidelines listed below.

NOTE

The 7700 ION-TRAN model does not provide an MGT. All data must be accessed via the communications port of the 7700 ION.

The 7700 ION-TRAN has an operating temperature range of -20°C (-4°F) to 50°C (122°F); the MGT is rated for 0°C (32°F) to 50°C (122°F).

Environmental Condition	Acceptable Range
Operating Temperature	0°C (32°F) to 50°C (122°F)
Storage Temperature	-30°C (-22°F) to +70°C (158°F)
Relative Humidity	5 to 95% non-condensing

For environments where high humidity may be a problem, the 7700 ION is available with a TROP (tropicalization) option which provides a conformal coating on all circuit boards inside the device.

Enclosure Considerations

The enclosure the 7700 ION is mounted in (typically a switchgear cabinet) should protect the devices from atmospheric contaminants such as oil, moisture, dust, and corrosive vapors, or other harmful airborne substances.

The mounting enclosure should be positioned such that the doors may be opened fully for easy access to the 7700 ION wiring and related components to allow for convenient troubleshooting. When choosing the enclosure size, allow for extra space for all wiring, intermediate terminal strips, shorting blocks, or any other required components. The mounting enclosure should not impede ventilation.

7700 ION Mounting

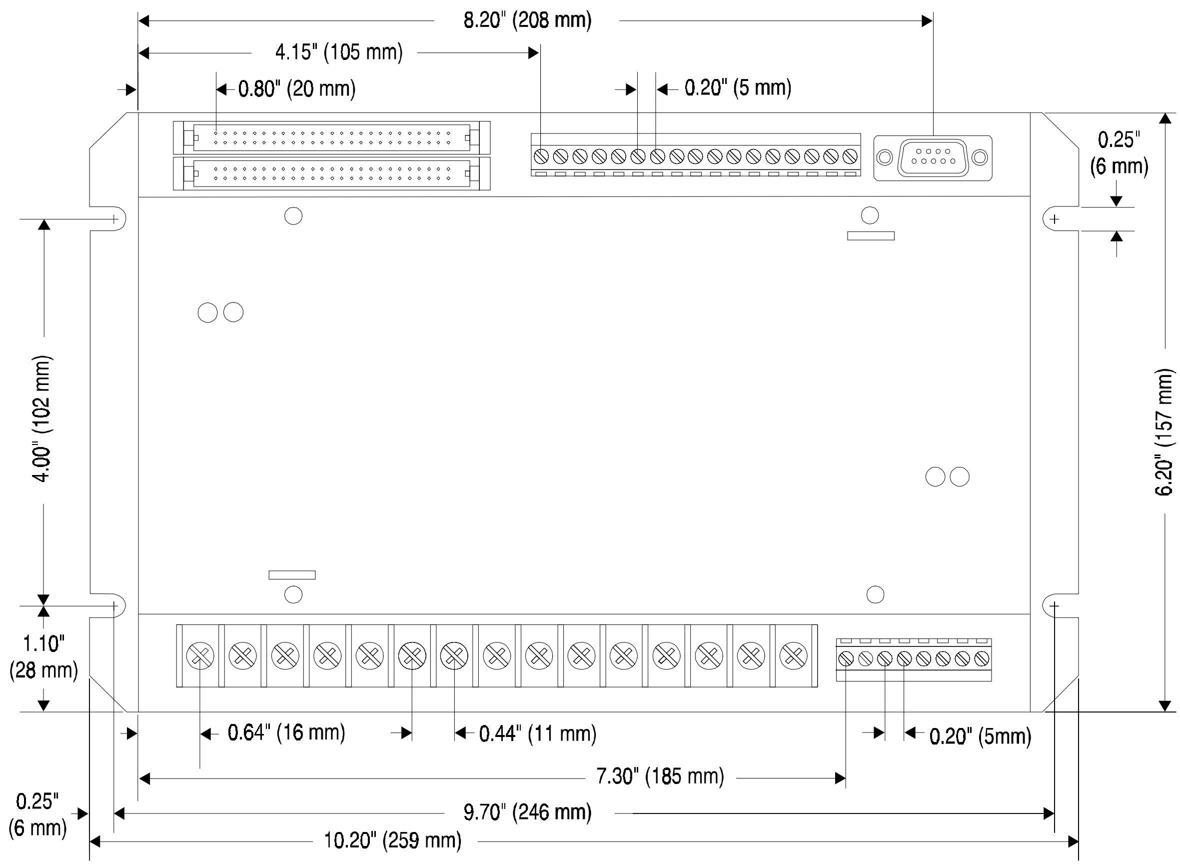
CAUTION

A switch or circuit breaker should be included in the installation, in close proximity to the unit and within easy reach to the operator. This switch or circuit breaker should be marked as the disconnecting device for the unit.

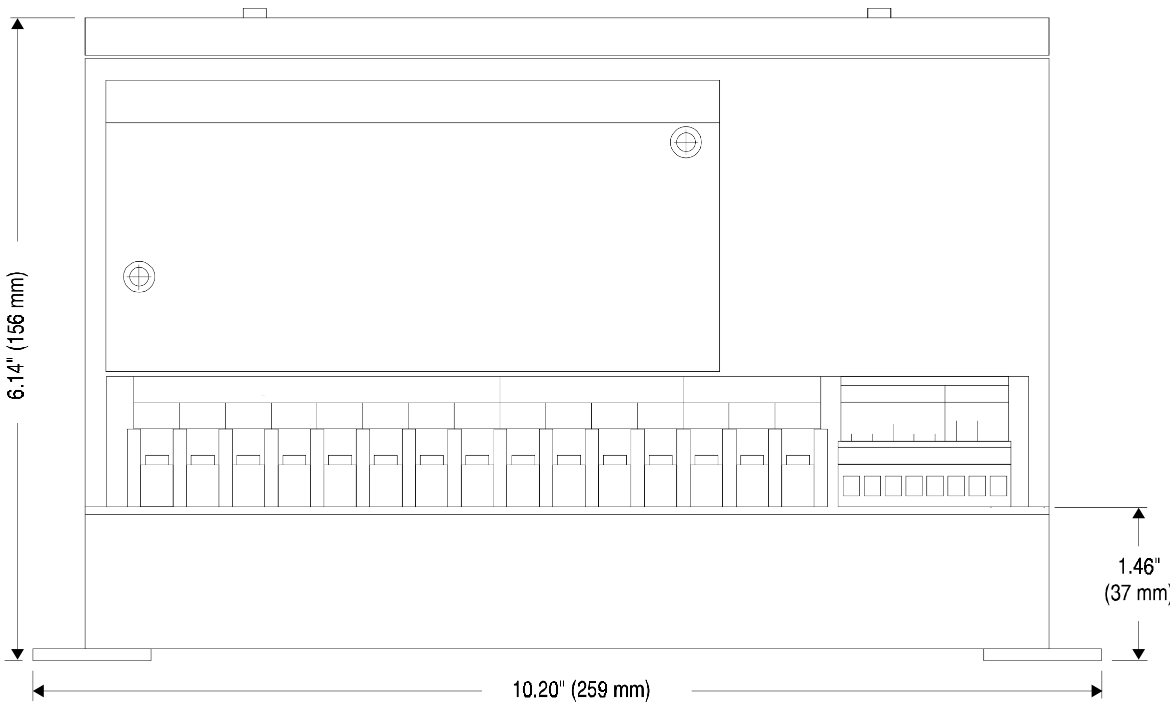
The 7700 ION can be mounted flush against any flat surface. The unit provides four slots on its mounting flange for this purpose. The 7700 ION is typically mounted inside the switchgear cabinet. It can be mounted in whichever orientation is most convenient.

The 7700 ION can also be mounted on the door of the switchgear cabinet; however, some electrical codes may prohibit extending voltages greater than 120 VAC line-to-neutral or 208 VAC line-to-line to the door. If this is the case, for higher system voltages a 7700 ION equipped with 120 VAC inputs (120 option) can be used with PTs that provide 120 VAC secondaries (see the section Phase Voltage and Phase Current Input Connections).

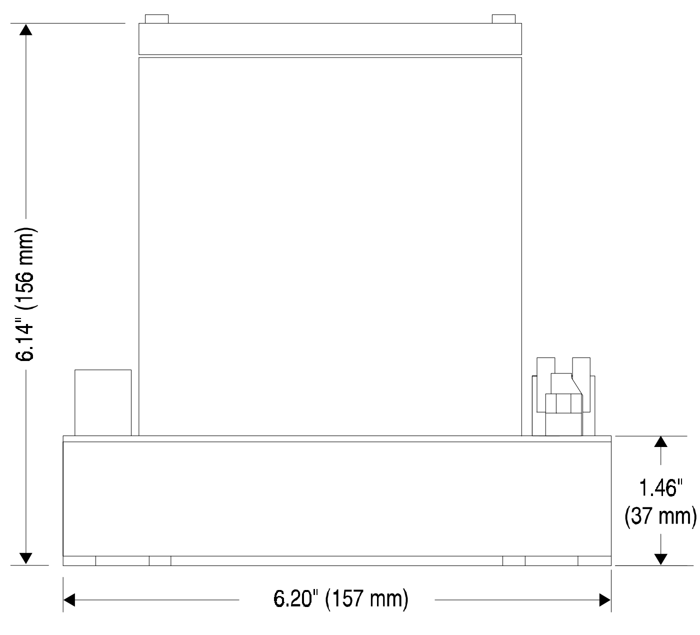
Top View with Mounting Hole Locations



Side View



End View



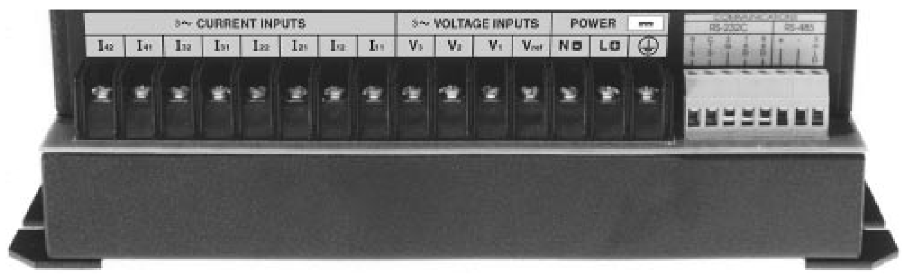
General Wiring Considerations

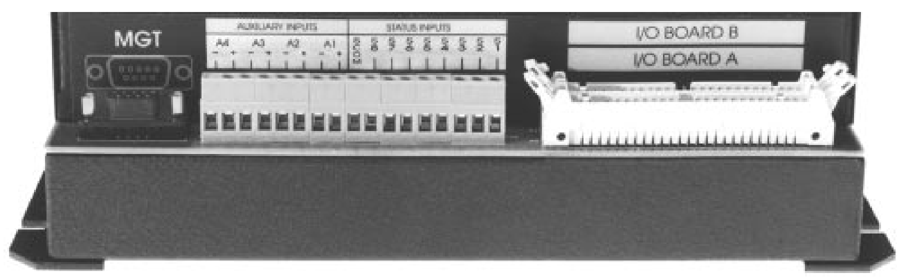
Terminal Strips

CAUTION

The 7700 ION must be installed in compliance with all local codes and standards, and device terminals (once installed) should not be user-accessible.

All connections to the 7700 ION are made to terminal strips and cable headers at either side of the unit. The terminal strip for phase *voltage/current* and supply *power* input is a barrier-type for which ring or spade terminals may be used to simplify connection. The *status/auxiliary input* terminal strip and communications terminal strip are both captured-wire type which accept stripped wire ends. Connections between the 7700 ION and the two external I/O expansion boards (optional) are made via two ribbon cable headers.





Field Service

If the 7700 ION requires servicing or field upgrading, you may need to disconnect and remove the unit from its mounting. The initial installation should be done in a way which makes this as convenient as possible:

- All phase voltage sense leads should be protected by breakers or fuses at their source such that the 7700 ION can be safely disconnected.
- A CT shorting block should be provided so that the 7700 ION current inputs can be safely disconnected without open circuiting the CT's. The shorting block should be wired so that protective relaying is not affected.
- All wiring should be routed to allow easy removal of the connections to the 7700 ION terminal strips, the 7700 ION cover, and the 7700 ION itself.
- If control relays are used with the external I/O modules, there should be a bypass mechanism installed (see page 2-36).

DANGER

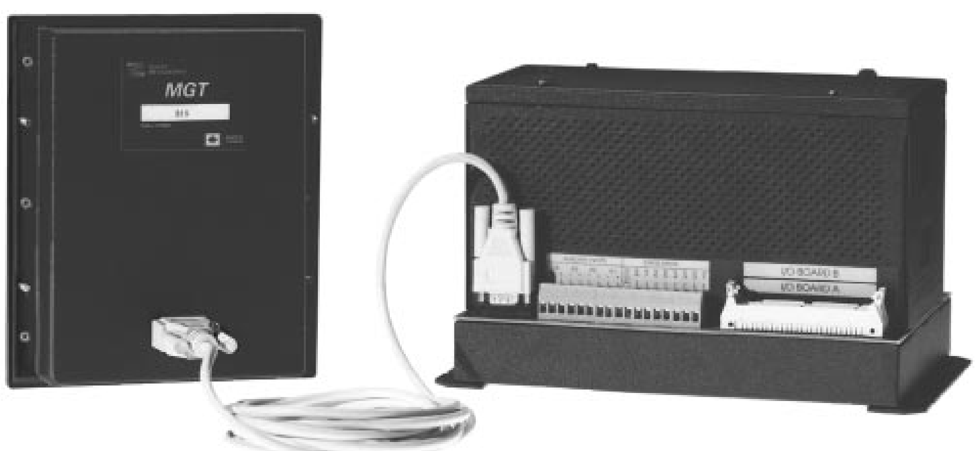
PT secondary circuits are capable of generating lethal voltages and currents with their primary circuit energized. Follow standard safety precautions while performing any installation or service on the device (i.e. removing PT fuses, etc.)

CT secondary circuits are capable of generating lethal voltages and currents when open circuited with their primary circuit energized. Follow standard safety precautions while performing any installation or service on the device (i.e. shorting CT secondaries, etc.)

Refer all questions regarding proper working procedures to qualified personnel.

MGT Connection

The MGT is connected to the 7700 ION by the supplied DB9 cable. The cable connects to the single connector on the rear panel of the MGT, and to the MGT connector on the 7700 ION. Hand tighten the securing screws on each cable connector. Refer to Chapter 4 for MGT configuration details.



Power Supply Connections

The following sections describe the various power supply options available for the 7700 ION and how to connect them.

Power Supply Considerations

The 7700 ION can be powered either from the voltage source it is monitoring, or from an independent supply. The 7700 ION requires a constant power supply to maintain monitoring, analysis, data logging, control and communications operations. Powering the device from the voltage source it is monitoring is not suitable for applications where these operations must be maintained in the event of a power outage.

If the 7700 ION is used to perform control functions or monitor power quality and power disruption events, an Uninterruptable Power Supply (UPS) should be used for supply power.

Power Supply Options

Basic Model

The basic model 7700 ION has a nominal power supply range of 100 to 240 VAC, but will operate correctly from 85 VAC up to 264 VAC. Applying power above 264 VAC can cause permanent damage to the power supply. The unit can also be powered by 110 to 300 VDC. Supply current can be as high as 1 Amp (56 W), dependent on whether an MGT unit and/or one or more external I/O expansion boards have been connected.

P24/48 Option

This option can be powered by 20 to 60 VDC. Supply current can be as high as 1.5 Amp (30 W), dependent on whether an MGT unit and/or one or more external I/O expansion boards have been connected. The label on the 7700 ION indicates if the unit is equipped with this option.

Power Sources and Connections

NOTE

Do not power the 7700 ION from the voltage source it is monitoring if the frequency is less than 50 Hz. Use a dedicated power supply that conforms to the power supply specifications listed in Appendix A.

The basic model can be powered from a dedicated feed, or from the voltage source which it is monitoring, as long as it is within the supply range. The P24/48 option must be powered from a dedicated fused feed.

The 7700 ION is internally protected on the L/+ terminal by a 3A IEC Type T fuse. If the unit is powered from a dedicated feed, and your power system consists of a grounded neutral, no other protection is required. If your power system does not have a grounded neutral, the installation of a 3A IEC Type T fuse (or equivalent circuit protector) on the N/- terminal is recommended. This may be installed in the breaker or fuse panel.

If an AC power supply is being used, connect the line supply wire to the 7700 ION L/+ terminal and the neutral supply wire to the N/- terminal. If a DC power supply is being used, connect the positive supply wire to the 7700 ION L/+ terminal and the negative (ground) supply wire to the N/- terminal.

Chassis Ground Connection

CAUTION

The 7700 ION chassis ground must be properly connected to the switchgear earth ground for the noise and surge protection circuitry to function correctly. Failure to do so will void the warranty.

The G or ⏚ terminal of the 7700 ION provides the chassis ground connection. This terminal must be connected to earth ground. A good, low impedance chassis ground connection is essential for the 7700 ION surge and transient protection circuitry to function effectively. It should be made to the switchgear earth ground using a dedicated AWG 14 (2.08 square mm) or larger wire to a point where there will be no voltage error due to distribution voltage drops. Do not rely on metal door hinges as a ground path. Ensure that the ⏚ terminal screw is tightened down securely onto the ground wire.

Phase Voltage and Phase Current Input Connections

Phase Voltage Inputs

Maximum Terminal Voltages

The maximum constant voltage levels the phase voltage inputs can withstand are presented in the following table.

Voltage Option	Maximum Terminal Voltage
120	150 VAC line-to-neutral or 260 VAC line-to-line
277	346 VAC line-to-neutral or 600 VAC line-to-line
347	434 VAC line-to-neutral or 750 VAC line-to-line

V1 Input Connection

The 7700 ION uses the V1 input as the reference for frequency for all power and energy related measurements. For any system configuration, the V1 input must be connected to ensure accurate readings and correct operation of the 7700 ION.

Direct Connection

Whether or not potential transformers (PTs) are required depends on the nature of the system being monitored, the voltage levels to be monitored, and the phase voltage input option of the 7700 ION.

Voltage Option	Direct Connection to Wye Systems up to:	Direct Connection to Single Phase Systems up to:
120	120 VAC line-to-neutral or 208 VAC line-to-line	120 VAC line-to-neutral or 240 VAC line-to-line
277	277 VAC line-to-neutral or 480 VAC line-to-line	277 VAC line-to-neutral or 554 VAC line-to-line
347	347 VAC line-to-neutral or 600 VAC line-to-line	

Using Potential Transformers

NOTE

PTs are always required for Delta systems.

For Wye systems over 347 VAC line-to-neutral/600 VAC line-to-line, Single Phase systems over 277 VAC line-to-neutral/554 VAC line-to-line, and all Delta systems, potential transformers (PTs) are required. PTs are used to scale down the line-to-neutral or line-to-line voltage to the rated input scale of the 7700 ION.

The inputs of devices equipped with the 120 option can be used with PTs that have secondaries rated at 120 VAC or less. This can include 100/√3, 110/ √3, 100, 110, or 120 VAC secondaries. Devices equipped with the 277 option can be used with PTs that have secondaries rated up to 277 VAC, such as 220 VAC.

For proper monitoring, correct selection of PTs is critical. For Wye systems, the PT primary rating should equal the system line-to-neutral voltage or nearest higher standard size. For Delta systems, the PT primary rating should equal the system line-to-line voltage. For all system configurations, the PT secondary rating must be within the rated full scale range of the 7700 ION voltage inputs.

PT quality directly affects system accuracy. The PTs must provide good linearity and maintain the proper phase relationship between voltage and current in order for the voltage, kW, and power factor readings to be valid. Instrument Accuracy Class 1 or better is recommended.

Phase Current Inputs

The 7700 ION uses CTs to sense the current in each phase of the power feed and (optionally) in the neutral or ground conductor. The selection of the CTs is important because it directly affects accuracy.

Using Current Transformers

NOTE

Refer to Appendix C for Revenue Metering CT and PT selection.

Depending on the options purchased, the 7700 ION is compatible with CTs with 1 Amp, 5 Amp or 10 Amp full scale secondaries. The current input ratings of all three phase inputs and the I4 input are equivalent.

WARNING

Applying current levels incompatible with the current inputs will permanently damage the 7700 ION.

The CT secondary should have a burden capacity greater than 3 VA.

The CT primary rating is normally selected to be equal to the current rating of the power feed protection device. However, if the peak anticipated load is much less than the rated system capacity, you can improve accuracy and resolution by selecting a lower rated CT. In this case the CT size should be the maximum expected peak current +25%, rounded up to the nearest standard CT size.

Other factors may affect CT accuracy. The length of the CT cabling should be minimized because long cabling contributes to inaccuracy. Also, the CT burden rating must exceed the combined burden of the 7700 ION plus cabling plus any other connected devices (burden is the amount of load being fed by the CT, measured in Volt-Amps). The 7700 ION burden rating is given in Appendix A.

Overall accuracy depends on the combined accuracies of the 7700 ION, the CTs, and the PTs (if used). Instrument accuracy Class 1 or better is recommended.

Overrange Capability

NOTE

The optional 10 Amp phase current inputs do not provide current over-range capability.

The 1 Amp and 5 Amp phase current inputs provide 25% overrange capability which allows current readings to be accurately displayed up to 125% of full scale. For example, if the CT Primary setup register in the Power Meter module has been set at 2000A full scale, the 7700 ION allows for readings up to 2500A.

The 1 Amp and 5 Amp phase current inputs also allows for up to 2000% of full scale for a maximum duration of 1 second. This provides a 20X fault capture capability. The 10 Amp phase current inputs allow for up to 1000% of full scale for a maximum duration of 1 second, providing a 10X fault capture capability.

PT & CT Connection

AWG 12 to 14 wire (3.31 to 2.08 square mm) is recommended for all phase voltage and current connections.

DANGER

PT secondary circuits are capable of generating lethal voltages and currents with their primary circuit energized. CT secondary circuits are capable of generating lethal voltages and currents when open circuited with their primary circuit energized. Follow standard safety precautions while performing any installation or service on the device (e.g. removing PT fuses, shorting CT secondaries etc.)

Refer all questions regarding proper working procedures to qualified personnel.

Phasing and polarity of the AC current and voltage inputs and their relationship is critical to the correct operation of the unit. All phase voltage sense leads should be protected by breakers or fuses at their source. In cases where PTs are required, if the power rating of the PTs is over 25 Watts the secondaries should be fused.

CTs should be connected to the device via a shorting block or test block to facilitate the safe connection and disconnection of the CTs.

Voltage Reference Connection

The voltage reference terminal, Vref, of the 7700 ION serves as the zero voltage reference for voltage readings. A good, low impedance Vref connection is essential for accurate measurement. It should be made using a dedicated 14 gauge wire to a point where there will be no voltage error due to distribution voltage drops.

The connection point for Vref depends on the system configuration.

I4 Current Input Connections

The 7700 ION is equipped with a fourth current input, named I4. This input is typically used to measure the current flow in the neutral or ground conductor. The use of this input is optional. The secondary rating of the CT connected to the I4 input must be identical to that of the three phase current inputs.

The primary rating for the CT connected to the I4 input can be different from the three phase inputs, since the I4 input scaling can be programmed independently.

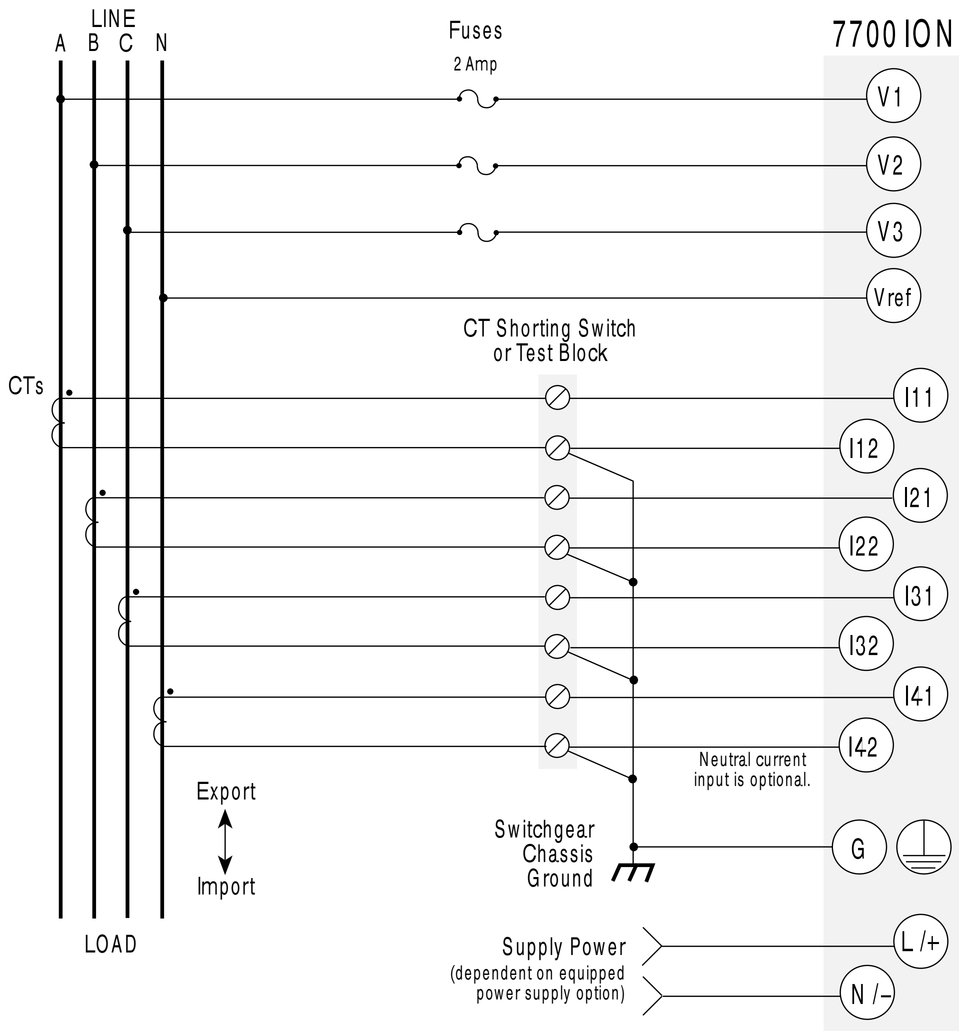
Connection for Three Phase WYE (Star) Systems

4-Wire Wye: 3-Element Direct Connect

For a 4-wire Wye system, the 7700 ION senses the line-to-neutral (or ground) voltage of each phase and current of each phase, making for an equivalent 3 element metering configuration.

NOTE

VOLTS MODE should be set to 4W-WYE.



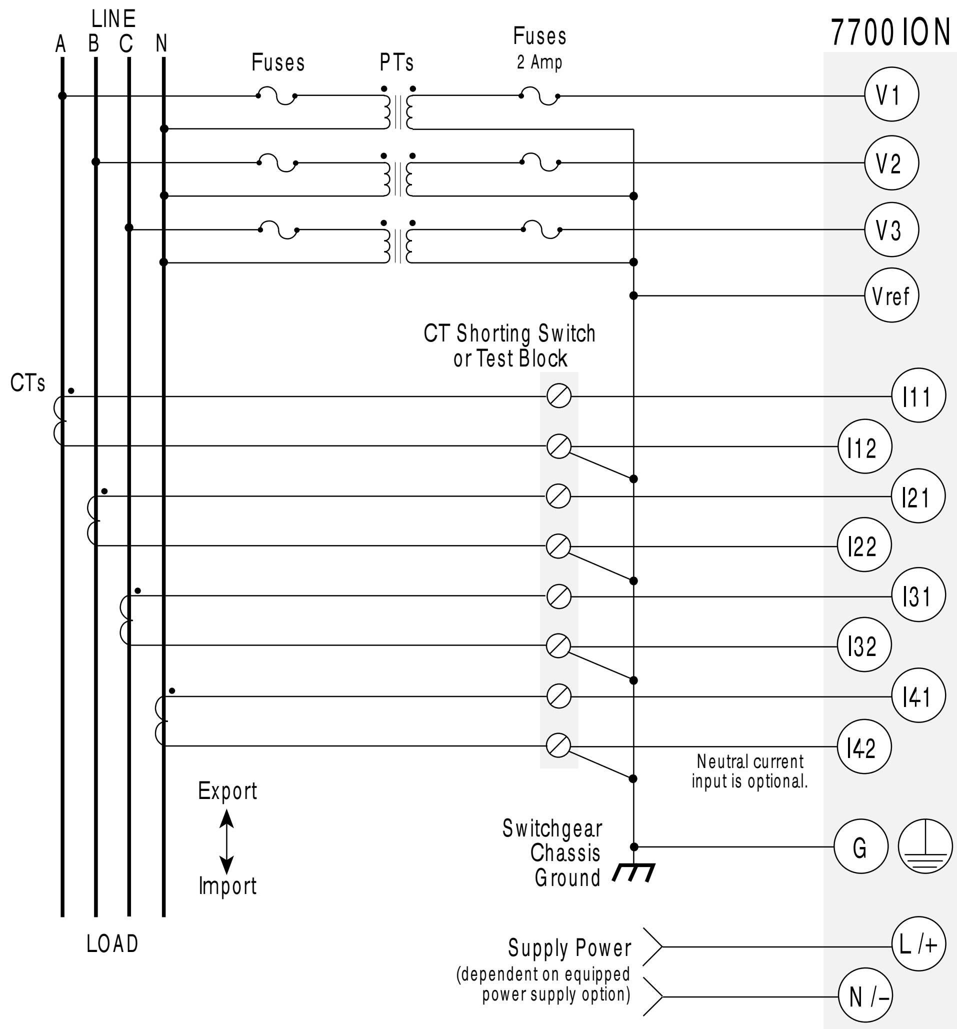
Maximum System Voltage	Voltage Input Option
≤ 120 VAC line-to-neutral / 208 VAC line-to-line	120 option
≤ 277 VAC line-to-neutral / 480 VAC line-to-line	277 option
≤ 347 VAC line-to-neutral / 600 VAC line-to-line	347 option

4-Wire Wye: 3-Element Connection Using 3 PTs

For 4-wire Wye system voltages over 347 VAC line-to-neutral / 600 VAC line-to-line, PTs must be used. When PTs are used, both the PT primary and secondary must be wired in a Wye (Star) configuration. Voltage sense leads should be protected by breakers or fuses at their source. Wiring must be exactly as shown for correct operation.

NOTE

VOLTS MODE should be set to 4W-WYE.



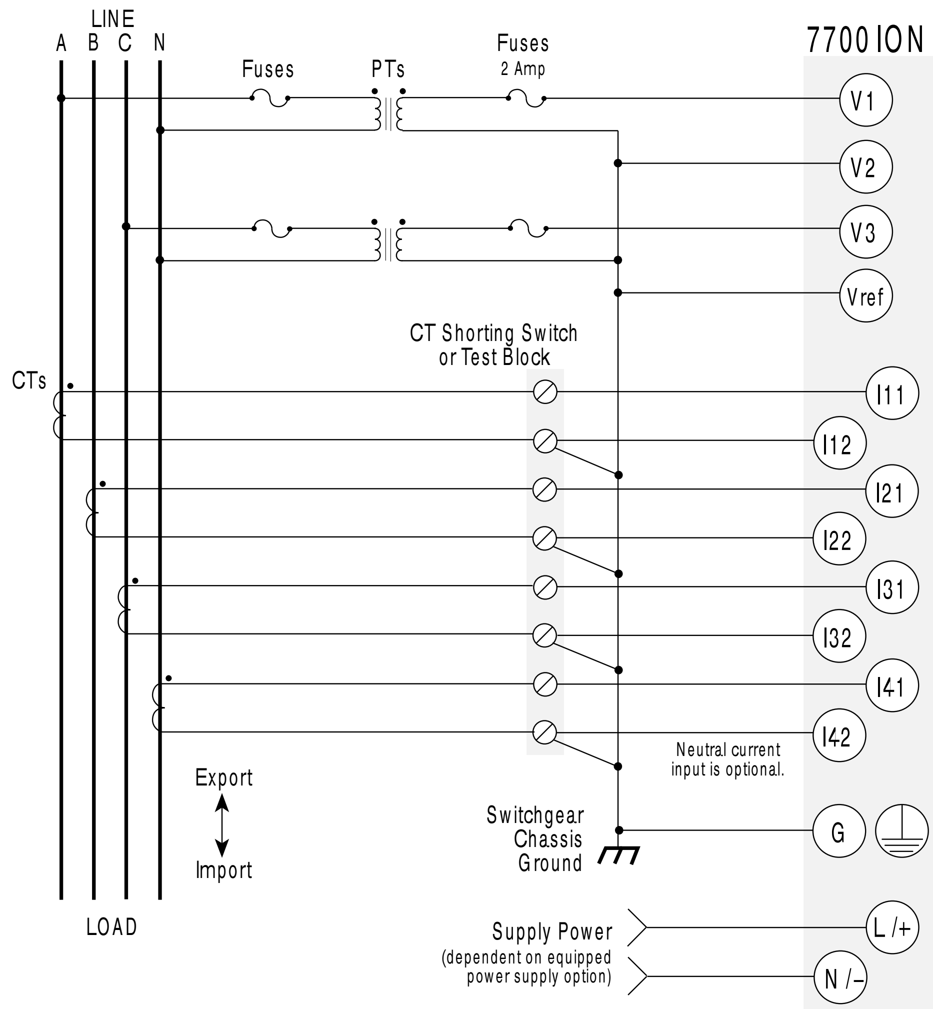
PT Secondary Voltage	Voltage Input Option
≤ 120 VAC line-to-neutral / 208 VAC line-to-line	120 option
≤ 277 VAC line-to-neutral / 480 VAC line-to-line	277 option
≤ 347 VAC line-to-neutral / 600 VAC line-to-line	347 option

4-Wire Wye: 2½-Element Connection Using 2 PTs

The 7700 ION also supports a 2½-element connection scheme which requires only two PTs. In this mode, the phase B voltage displayed on the front panel is derived from the available voltages.

NOTE

VOLTS MODE should be set to 3W-WYE.



CAUTION

VOLTS MODE = 3W-WYE only provides accurate power measurement if the voltages are balanced. If the phase B voltage is not equal to the phase A and C voltages, the power readings may not meet the 7700 ION accuracy specifications.

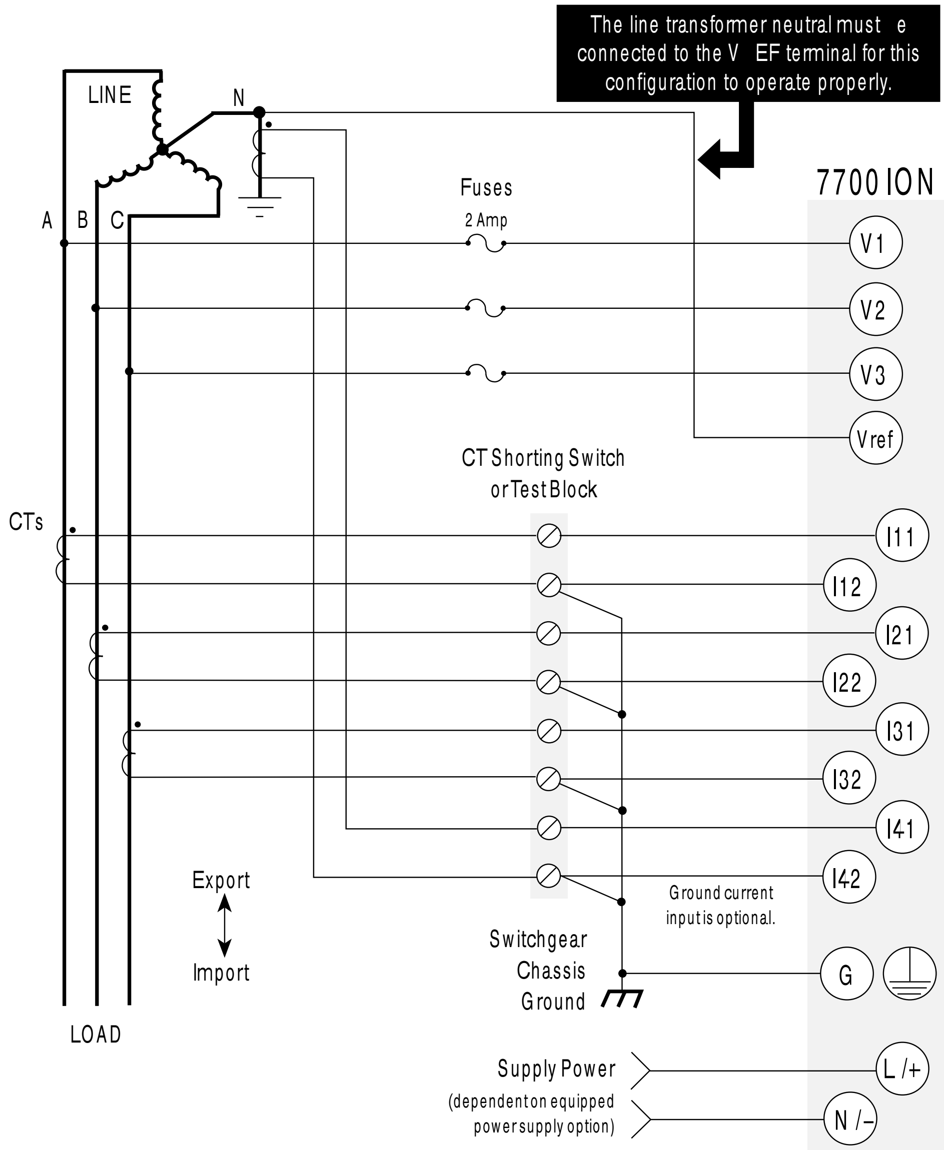
PT Secondary Voltage	Voltage Input Option
≤ 120 VAC line-to-neutral / 208 VAC line-to-line	120 option
≤ 277 VAC line-to-neutral / 480 VAC line-to-line	277 option
≤ 347 VAC line-to-neutral / 600 VAC line-to-line	347 option

3-Wire Grounded Wye: 3-Element Direct Connection

When the common or *star* point of a 3 wire Wye system is grounded, the 7700 ION may be connected directly without the use of PT's (provided the voltages are within the input range of the unit).

NOTE

VOLTS MODE should be set to 4W-WYE.



Maximum System Voltage	Voltage Input Option
≤ 120 VAC line-to-neutral / 208 VAC line-to-line	120 option
≤ 277 VAC line-to-neutral / 480 VAC line-to-line	277 option
≤ 347 VAC line-to-neutral / 600 VAC line-to-line	347 option

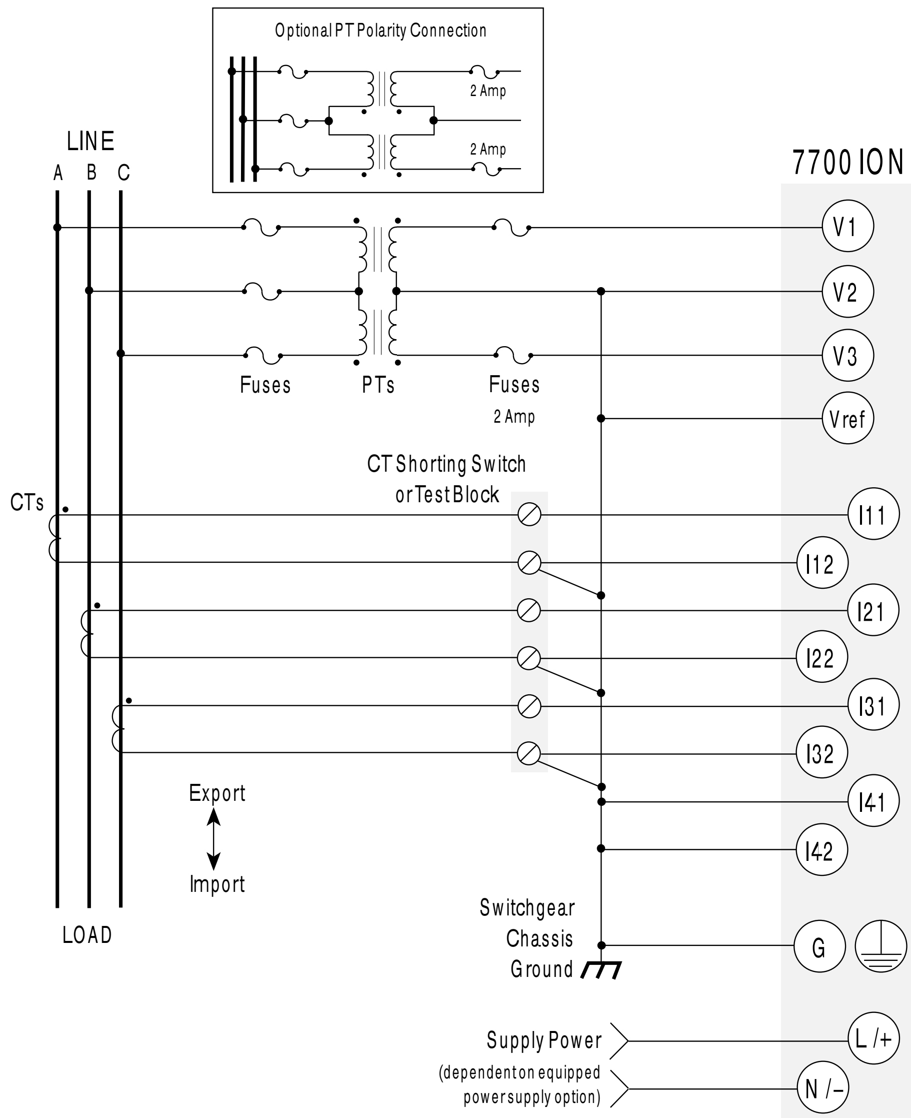
Connection for Three Phase Delta Systems

For ungrounded (floating) 3-wire open Delta systems, the 7700 ION always requires PTs and senses the line-to-line voltages between each of the phases. The 7700 ION may be connected in either of two ways: using 2 or 3 CTs.

3-Wire Delta: 2½-Element Connection Using 2 PTs & 3 CTs

NOTE

VOLTS MODE should be set to DELTA.

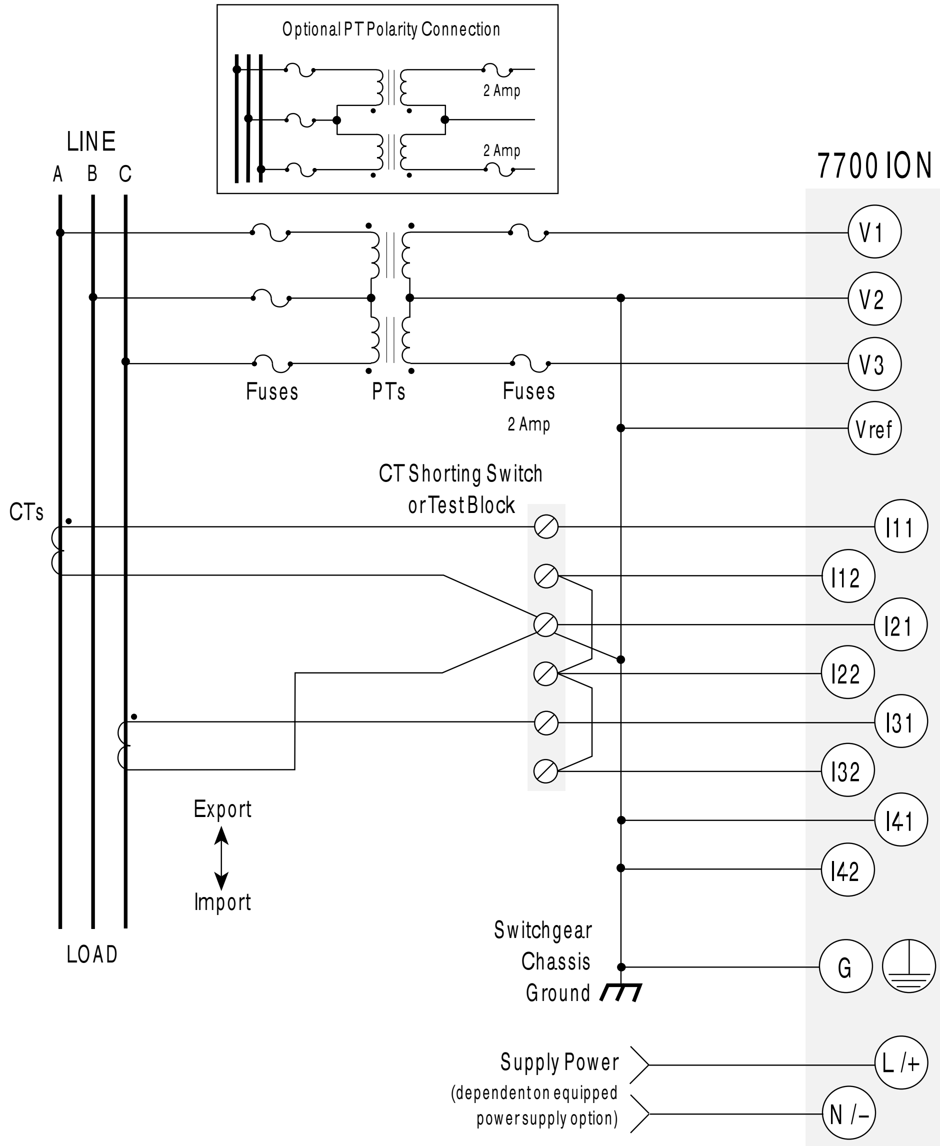


PT Secondary Voltage	Voltage Input Option
≤ 120 VAC line-to-neutral / 208 VAC line-to-line	120 option
≤ 277 VAC line-to-neutral / 480 VAC line-to-line	277 option
≤ 347 VAC line-to-neutral / 600 VAC line-to-line	347 option

3-Wire Delta: 2-Element Connection Using 2 PTs and 2 CTs

NOTE

VOLTS MODE should be set to DELTA.



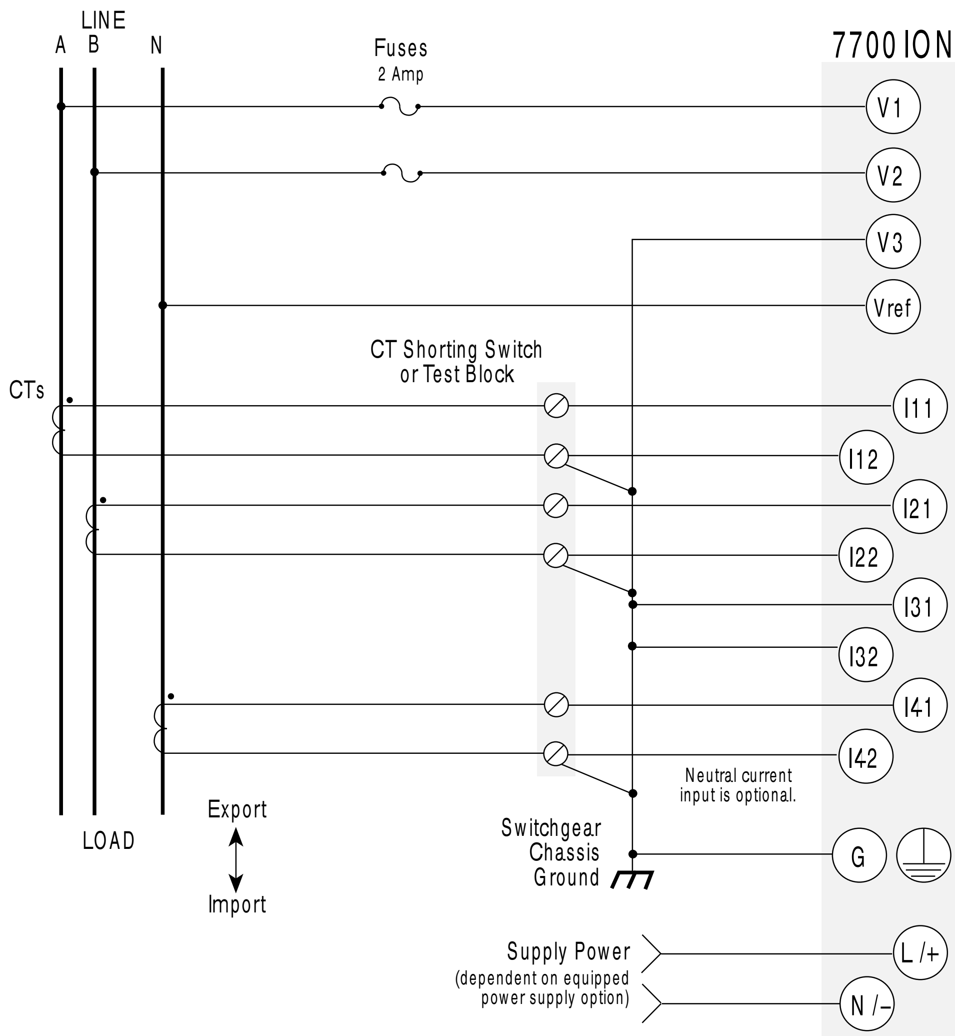
PT Secondary Voltage	Voltage Input Option
≤ 120 VAC line-to-neutral / 208 VAC line-to-line	120 option
≤ 277 VAC line-to-neutral / 480 VAC line-to-line	277 option
≤ 347 VAC line-to-neutral / 600 VAC line-to-line	347 option

Connection for Single Phase Systems

Wiring for Single Phase systems is performed by connecting the two voltage phases (each 180 degrees with respect to each other) to the V_1 and V_2 inputs of the 7700 ION, and the outputs of the two corresponding current transformers to the I_1 input pair and I_2 input pair. Note that the V_3 input and I_3 input pair are unused and should all be grounded.

NOTE

VOLTS MODE should be set to SINGLE.



Maximum System Voltage	Voltage Input Option
≤ 120 VAC line-to-neutral / 240 VAC line-to-line	120 option
≤ 277 VAC line-to-neutral / 554 VAC line-to-line	277 option

Communications Connections

For the 7700 ION to communicate with other devices and with a computer, you must select a communications standard and correctly connect all the devices on the communications network. The following sections describe the different communications standards and their connection requirements.

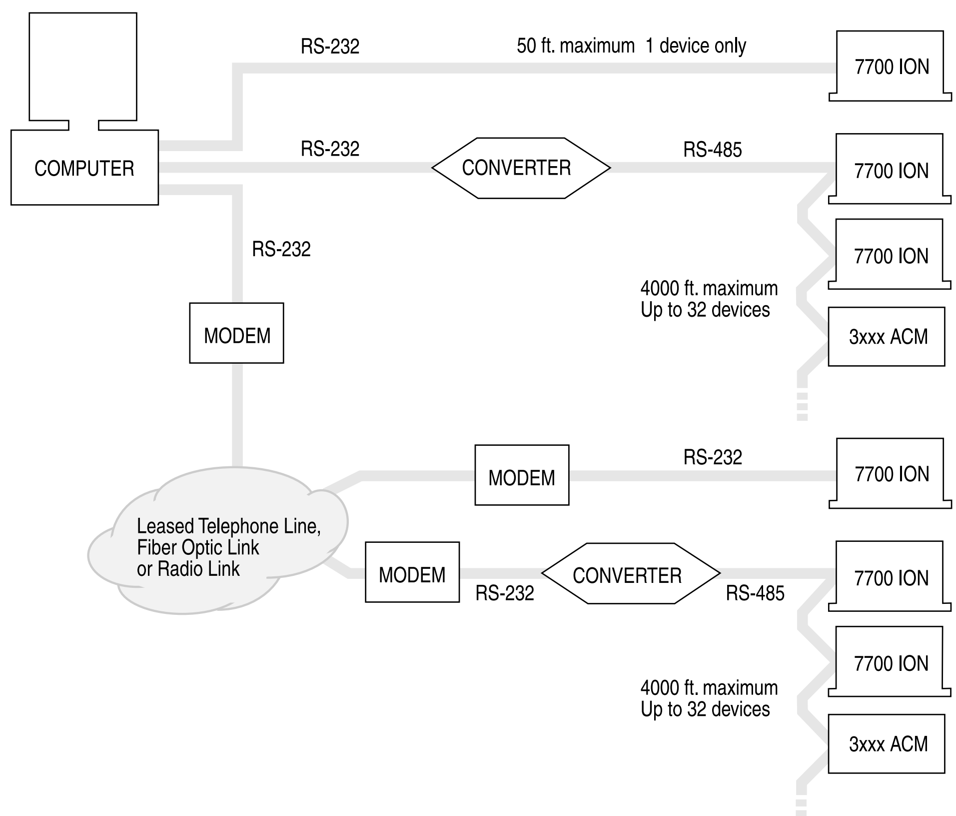
Choosing a Communications Standard

RS-232C

RS-232C is commonly used for short distance, point-to-point communications. The RS-232C standard allows only one 7700 ION to be connected directly to the serial port of another device (computer, PLC, etc.) Connection length must be less than 50 feet (15.2 m). For communication to a remote site, connection to a modem (telephone, radio, fiber optic) is also possible.

RS-485

RS-485 is used when multiple devices are installed at a local or remote site. RS-485 communication can be used to connect up to thirty-two devices on a single communications loop. The total distance limitation on a single RS-485 communication network is 4000 feet (1220 m). An RS-232C to RS-485 converter, such as Power Measurement's COM32™ or COM128™, is required between the RS-232C port of the computer/PLC or modem and the RS-485 network.



Communications Card

The communications card supplied with the basic model 7700 ION allows communication using either the RS-232C or RS-485 standard at baud rates up to 19,200. Configuration is performed via the ION Communications module. Refer to Chapter 3 for more details regarding communications setup parameters.

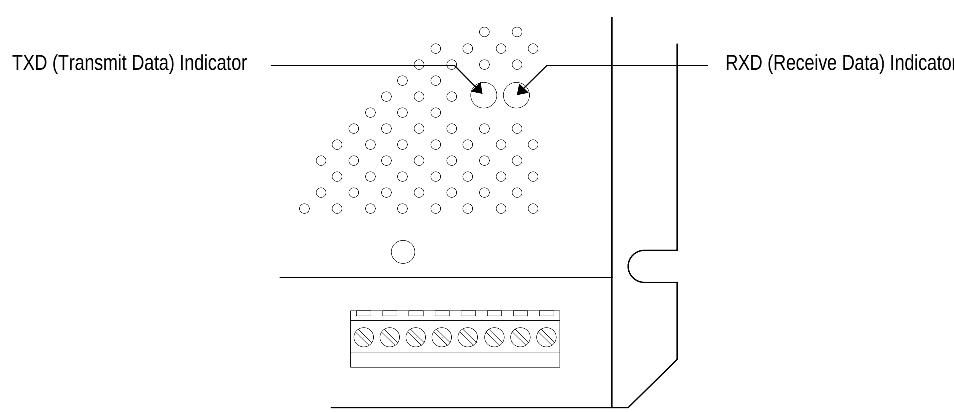
The communications card is designed with optical coupling that provides full isolation between the RS-232C or RS-485 communication lines and the 7700 ION internal circuitry. Protection circuitry provides protection from common mode voltages and incorrect connection. All inputs pass the ANSI/IEEE C37.90-1989 surge withstand and fast transient tests.

Terminal and LED Functions

Communications connections are made via a *captured-wire* type terminal strip. Terminal functions include:

RS-485	SHLD	RS-485 Shield (electrically connected to chassis ground)
	–	RS-485 Data Minus
	+	RS-485 Data Plus
RS-232C	RXD	RS-232C Receive Data (i.e. data into device)
	TXD	RS-232C Transmit Data (i.e. data out of device)
	SG	RS-232C Signal Ground (isolated)
	RTS	RS-232C Request To Send
	CTS	RS-232C Clear To Send

Two LED indicators on the top of the unit above the COMMUNICATIONS terminal strip show activity on the RS-485 or RS-232C communications lines and can be used to verify correct communications operation. The TXD indicator flashes when data is being sent out by the device. The RXD indicator flashes when data is being received by the device.



RS-232C Connections

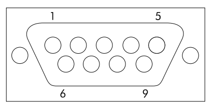
NOTE
Use of the RTS and CTS lines is optional. Some types of modems (e.g. radio modems) may require the use of these lines.

The cable used between a computer and modem (if used) is a standard straighthrough RS-232C communications cable with a maximum length of 50 feet (15.2 m). Refer to the installation manuals for both the computer and modem for cable requirements.

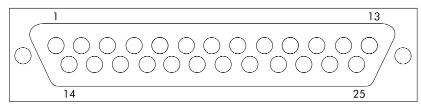
The cables used between a computer and the 7700 ION, or a modem and the 7700 ION are each custom RS-232C cables. In each case, one end is equipped with a DB25 or DB9, male or female connector. The connector required depends on the mating connector of the computer or modem serial port. The other end of the cable consists of discrete wires which connect to the RS-232C terminals of the 7700 ION. Cable length is 50 feet (15.2 m) maximum.

RS-232C Serial Cable Wiring Connections

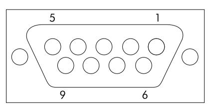
DB9 Pins (Male)



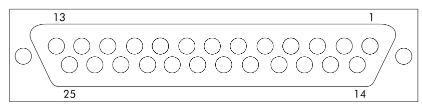
DB25 Pins (Male)



DB9 Pins (Female)



DB25 Pins (Female)



Always jumper RTS to CTS at computer end.

Always jumper DSR to DTR at modem end.

Computer				*7700 ION RS-232C Port*
DB9	DB25	Function		Function
3	2	TX	→	RXD
2	3	RX	←	TXD
5	7	Signal Ground	—	SG
7	4	RTS	jumper to CTS	RTS (jumper to CTS)
8	5	CTS		CTS
6	6	DSR	jumper to DTR	
4	20	DTR		

Jumper RTS to CTS at modem end if not used.

Always jumper DSR to DTR at modem end.

Modem				*7700 ION RS-232C Port*
DB9	DB25	Function		Function
2	3	TX	→	RXD
3	2	RX	←	TXD
5	7	Signal Ground	—	SG
7	4	RTS	←	RTS
8	5	CTS	→	CTS
6	6	DSR	jumper to DTR	
4	20	DTR		

RS-485 Connections

RS-485 communications allows multiple devices to be connected on the same bus. Up to 32 devices can be connected on a single RS-485 bus, which consists of a shielded twisted pair cable. The overall length of the RS-485 cable connecting all devices cannot exceed 4000 ft. (1219 m).

To connect an RS-485 communications bus to a computer or other RS-232C equipped device, an RS-232C to RS-485 converter is required, such as Power Measurement's COM32™ or COM128™. The COM32 offers a single RS-485 port, while the COM128 offers a total of four RS-485 ports that can each support up to 32 devices.

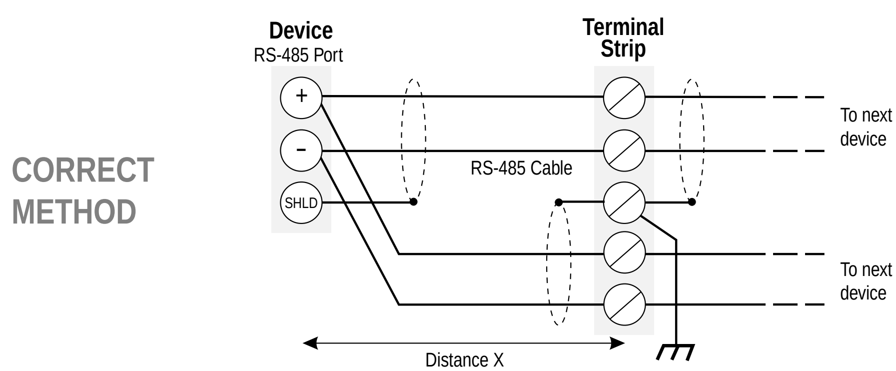
General Bus Wiring Considerations

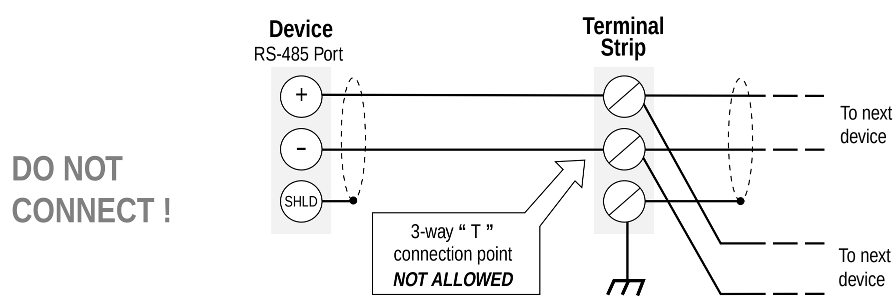
CAUTION

Do not connect ground to the shield at both ends of a segment. Doing so allows ground loop currents to flow in the shield, inducing noise into the communications cable.

Devices connected on the bus, including the 7700 ION, converter(s) and other instrumentation, must be wired as follows:

- Use a good quality shielded twisted pair cable for each RS-485 bus. It is recommended that AWG 22 (0.33 square mm) or larger conductor size be used.
- Ensure that the polarity is correct when connecting to the RS-485 port (+) and (-) terminals of each device.
- The shield of each segment of the RS-485 cable must be connected to ground at *one end only*.
- Isolate cables as much as possible from sources of electrical noise.
- Use an intermediate terminal strip to connect each device to the bus. This allows for easy removal of a device for servicing if necessary.





Recommended Topologies

Devices on an RS-485 bus are connected in a point-to-point configuration, with the (+) and (-) terminals of each device connected to the associated terminals on the next device. While there are many topologies that can be used to connect devices on an RS-485 communication bus, the two recommended methods are the *straight-line* and *loop* topologies.

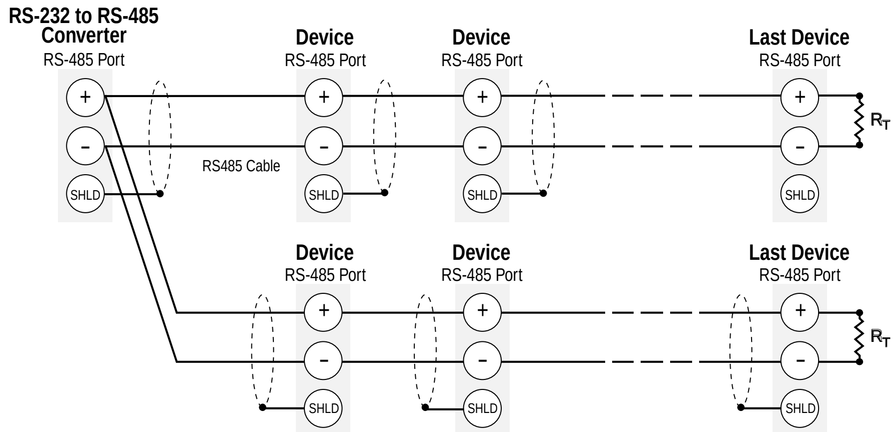
Straight-Line Topology

NOTE

The COM128 can support up to four RS-485 buses simultaneously.

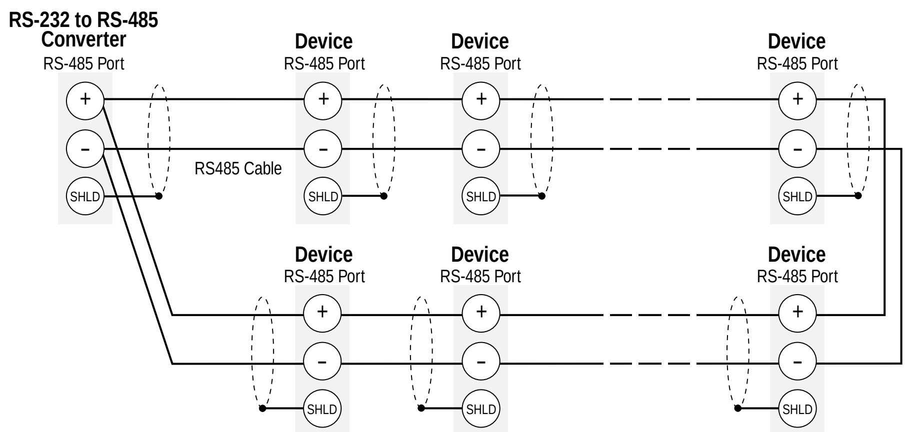
The converter can exist at any position on the RS-485 bus, including an end point.

Terminate each device at the end point of a straight-line bus with a 1/4 watt resistor connected between the (+) and (-) terminals. These *termination resistors* reduce signal reflections that may corrupt data on the bus. The resistor should match the line impedance of the cable being used. For AWG 22 (0.33 square mm) shielded twisted pair cable, values between 150 and 300 ohms are typical. Consult the cable manufacturer's documentation for the exact impedance of your cable.



Loop Topology

One advantage of the loop topology is that a single open circuit fault condition anywhere on the loop will not result in the loss of communication between the computer station and any of the remote devices. The loop topology does not require termination resistors at any point on the bus.



Calculating Overall Cable Length

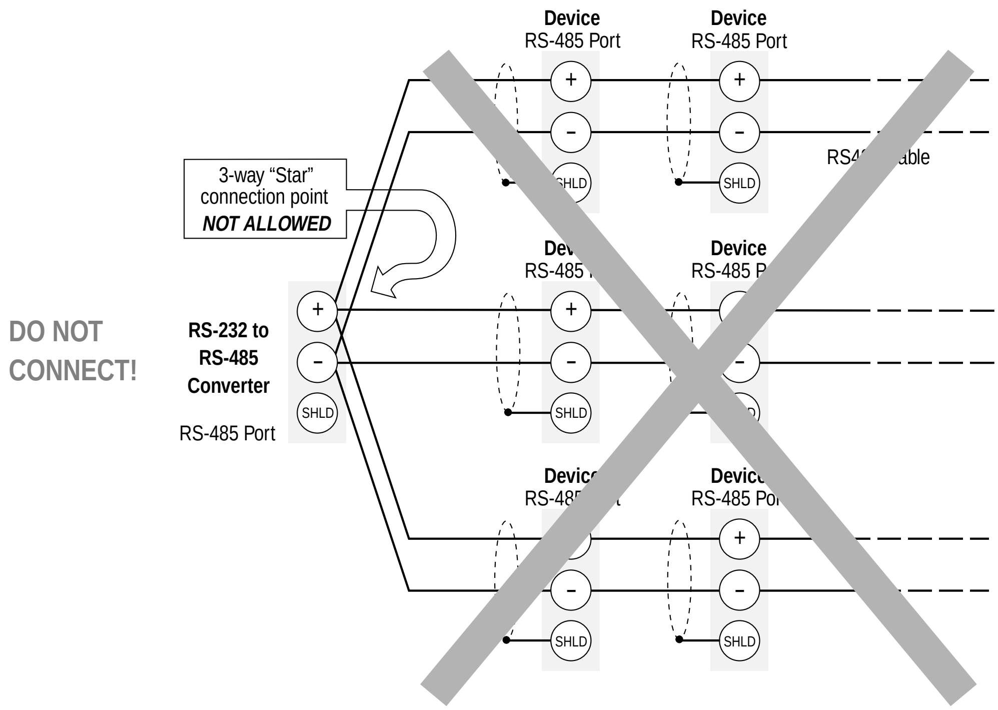
When determining the overall length of an RS-485 communication straight-line or loop connection, it is important to account for all cable segments. For example, when RS-485 connections to the device are made via an intermediate terminal block, the lengths of cable between the device and the terminal block must be added to the total cable distance.

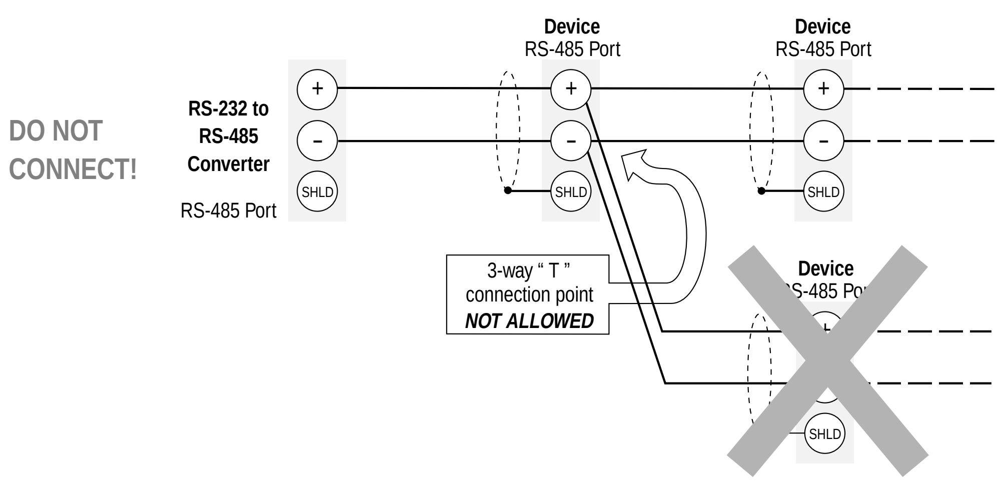
Connection Methods to Avoid

Any device connection that causes a branch in the main RS-485 bus should be avoided. This includes *star* and *tee (T)* methods. These wiring methods cause signal reflections that may cause interference.

RULE OF THUMB

At any connection point on the RS-485 bus, no more than two cables should be connected. This includes connection points on instruments, converters, and terminal strips. Following this guideline ensures that both star and tee connections are avoided.





Status Input Connections

The 7700 ION on-board status inputs can be used to monitor the condition of an external contact, or for pulse counting applications.

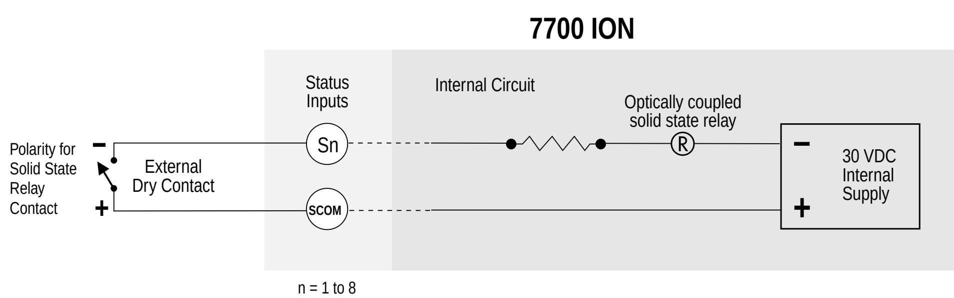
Connections to the status inputs are made via a captured-wire type terminal block on the 7700 ION. AWG 12 to 14 (3.31 to 2.08 square mm) wire is recommended for all status input connections.

The 7700 ION uses a current sensing technique to monitor contact status by providing an internal 30 VDC supply for *self-excitation*. These inputs can be used for *dry* contact sensing applications, but *not* for voltage sensing applications. Note that no ground or external voltage connections are required.

WARNING

The 7700 ION status inputs can only be used for dry contact sensing applications. Connection of an external voltage source to the any of the status inputs of a standard equipped 7700 ION can cause permanent damage to the 7700 ION.

The assignment and configuration of each input is user-programmable via the ION Digital Input modules. Refer to Chapter 5 for details about these modules.



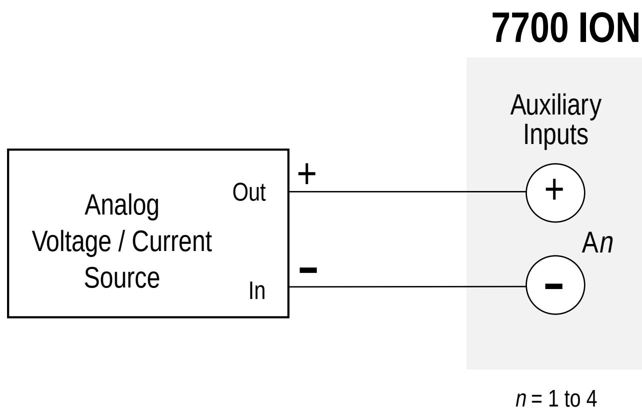
Auxiliary Analog Input Connections

The 7700 ION can be ordered with an optional internal analog input board that provides 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.

CAUTION

Ground all unused inputs to prevent incorrect readings.

Connections to the analog inputs are made via a captured-wire type terminal block on the 7700 ION. AWG 12 to 14 (3.31 to 2.08 square mm) wire is recommended for all on-board auxiliary input connections. Assignment and input scaling for each input is user-programmable via the ION Analog Input modules. See Chapter 5 for details.



Option	Input Impedance	Max Common Mode Voltage
0 - 1mA	49.9 Ω	8 V
0 - 20mA	100 Ω	20 V
0 - 1V	>= 50 kΩ	12 V
0 - 10V	>= 50 kΩ	25 V

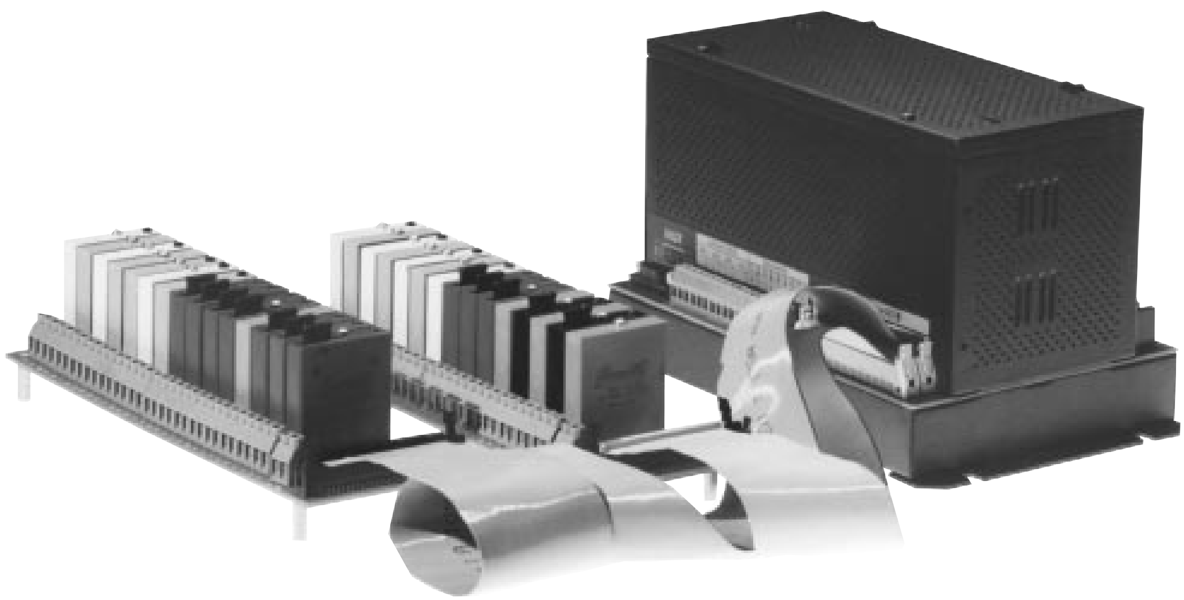
I/O Expansion Boards

CAUTION

The I/O expansion boards and their associated power supply equipment are external devices to the 7700 ION. It is the user's responsibility to ensure installation takes local codes and standards into account.

The external input and output capabilities of the 7700 ION can be expanded using up to two plug-in *I/O expansion boards*. Each expansion board can provide multiple analog inputs, analog outputs, digital inputs, and/or digital outputs. A list of the I/O devices supported by the 7700 ION is available in Appendix A under the section *Ordering Options*.

Assignment and configuration of the inputs and outputs is user-programmable via the ION Analog Input, Analog Output, Digital Input, Digital Output, and Pulser modules.



Expansion Board Assembly and Configuration

NOTE

To install an I/O device, simply plug it into an appropriate slot and screw down the fastening screw.

You can purchase and plug in Power Measurement-approved I/O devices to configure each expansion board with the number of desired inputs and outputs. There are no restrictions on how many of these devices can be digital, but there are restrictions on the number of analog devices you can use (see next page).

Each expansion board offers 15 slots into which you can plug I/O devices. These 15 slots are divided into one group of 7 slots and one group of 8 slots. The 7-slot group can accept digital input, digital output, analog input, and analog output devices. The 8-slot group can accept digital input, digital output and analog output devices only (analog input devices are not supported).

NOTE

Slots 0-7 comprise the 8-slot group; slots 8-14 comprise the 7-slot group. Note that slot 15 is not used.

Analog Device Restrictions

Power requirements and hardware restrictions limit the number and placement of analog devices on I/O expansion boards. The following paragraphs detail the different restrictions.

TIP

Because the analog devices can generate heat, try to alternate your analog and digital devices, or leave empty slots between analog devices whenever possible.

Power Supplies

The allowable number of analog devices the 7700 ION can support increases significantly when an external power supplies are used to power the expansion boards.

The default configuration of Expansion Board A does not include a power supply; it has to be purchased separately. If Expansion Board A does not use a separate power supply (i.e. it is powered directly from the 7700 ION), then a maximum of 6 analog devices can be installed on it.

A separate power supply is required for Expansion Board B in any configuration.

To use the maximum number of analog I/O devices, 2 power supplies must be used (one for each expansion board). Note that if a separate power supply is used with Expansion Board A, then the jumper (JMPR) must be removed from the board. Failure to remove the jumper will void the 7700 ION's warranty.

Direction (Input or Output)

The direction of all of the slots in a group must be the same. As noted on the graphic above, only the 7-slot group supports analog input devices, thereby limiting the maximum number of these devices to 7 per board. Analog Output devices can populate both slot groups on the expansion board, so a maximum of 15 of these devices can be used per board.

If Expansion Board A is used without a separate power supply, only 6 analog devices can be used in total, regardless of direction restrictions.

Maximum Analog Devices per Expansion Board - Separate Power Supplies Used

The following maximums apply to expansion boards that are powered by separate power supplies. A separate power supply is required for each expansion board. These restrictions apply to Expansion Board A or B, and the maximums stated are doubled if both boards are used.

- A single expansion board can support a maximum of 7 analog input devices. This leaves 8 slots open for other devices.
- A single expansion board can support a maximum of 15 analog devices in total; either 7 analog inputs and 8 analog outputs, or 15 analog outputs.

Maximum Analog Devices on Expansion Board - No Separate Power Supply

If Expansion Board A is used without a separate power supply (its default configuration), then only 6 analog devices can be used in total. The remaining 9 slots can be populated with digital devices.

The following table summarizes the restrictions on analog I/O devices.

	Max # of Inputs	Max # of Outputs	Max # of Devices	Possible Max Configurations
Board A WITHOUT Optional Power Supply (default configuration)	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 (default configuration) + 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

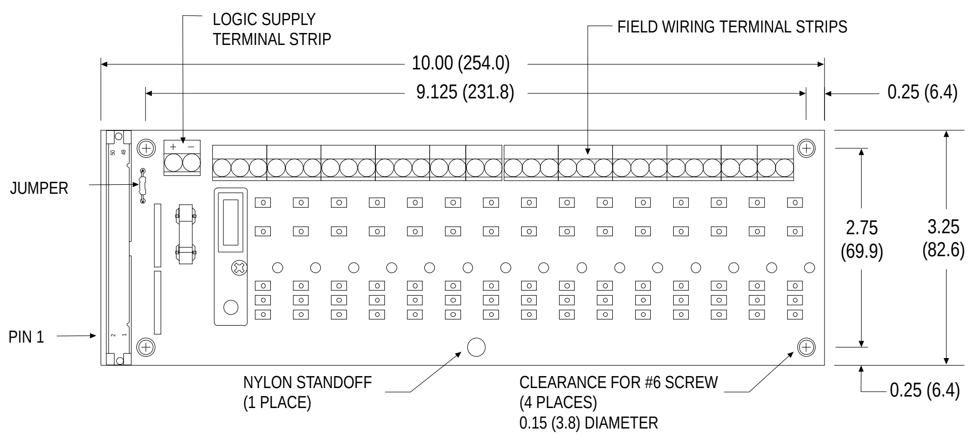
Expansion Board Installation

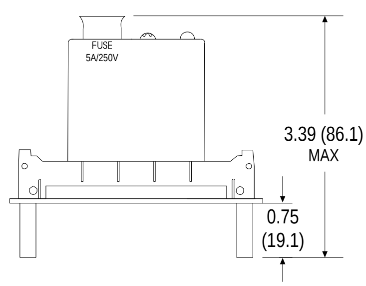
NOTE

An external power supply is required if you are using Expansion Board A with a custom cable. See the section 'Using Custom Cables with I/O Expansion Boards' on page 2–34 for more details.

The I/O expansion boards should be mounted against a flat surface to provide easy access for plugging in or removing the I/O devices. If you are installing two boards, or you are installing one board with a custom cable, ensure there is enough space to mount the external power supply.

Mounting requires four holes (no cutout is necessary). A minimum depth of 3.4 inches (8.6 cm) clearance is required behind the board to allow for cable connection and for the I/O devices. Refer to the following mounting diagrams:





All measurements given in inches (with millimeters in brackets).

Connecting I/O Expansion Boards to the 7700 ION

Connections between the 7700 ION and the optional I/O expansion boards are made via 50-conductor ribbon cables to two lockable, 50-pin headers on the 7700 ION named I/O BOARD A and I/O BOARD B. The connectors are keyed to protect against incorrect orientation.

If only one expansion board is used, it must be connected to the I/O BOARD A port. If you use a second expansion board, it must be connected to the I/O BOARD B port.

Supply Power for I/O Expansion Boards

NOTE

If possible, the same power source should be used to power the 7700 ION and the external I/O board so that external I/O devices and the meter all react the same way if the system is powered down.

If a single expansion board and the supplied cable are used, power to the board can be supplied entirely by the 7700 ION and no external power supply is necessary. An external power supply is required if two expansion boards are used, or if one expansion board is used with analog devices (as discussed earlier), and it is connected with a custom cable. See page 2-35 for details on using custom cables.

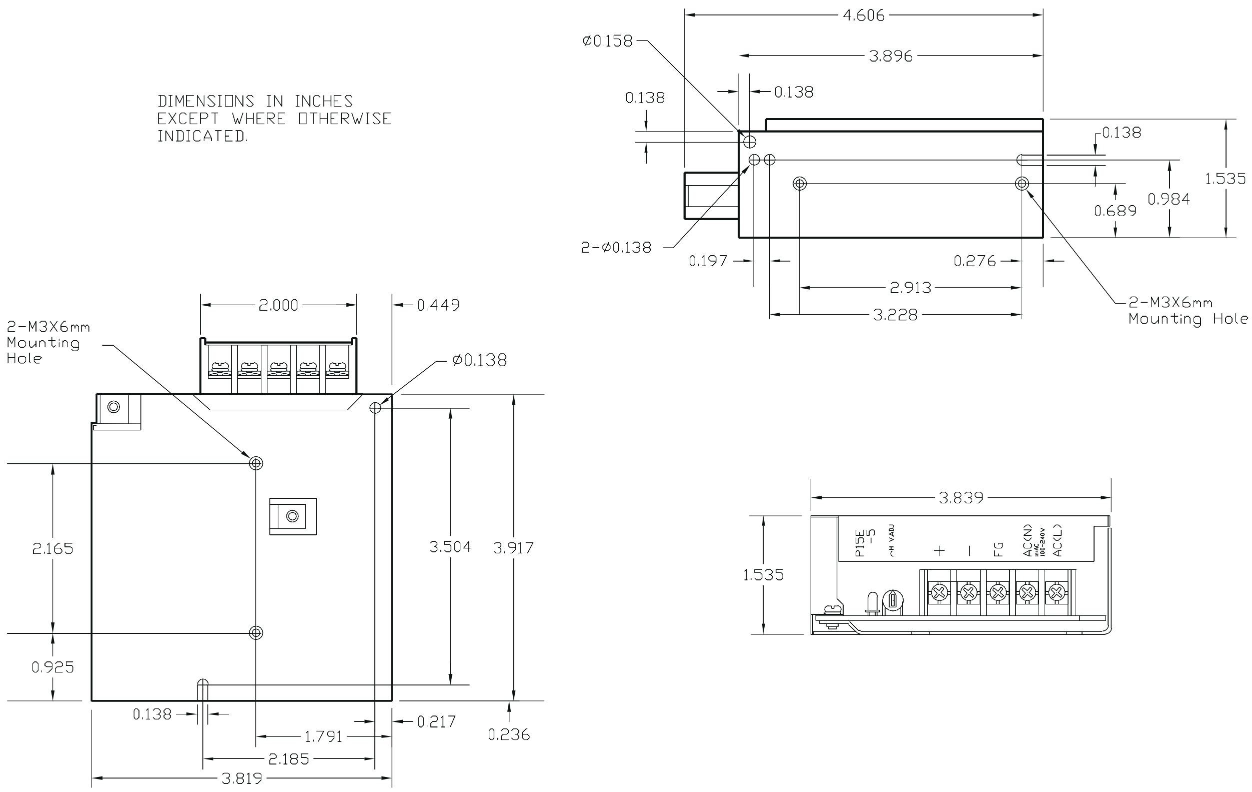
Like the 7700 ION itself, there are two power supply options for the external I/O board; the P240 and the P24/48 option.

WARNING

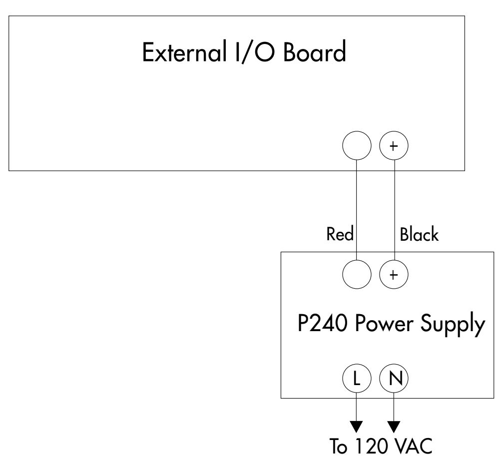
When using an external power supply with Expansion Board A, you must remove the jumper (JMPR) on the board. Failure to do so will void the 7700 ION warranty.

P240 Option

The P240 external power supply must be mounted within 5.5 inches (14 cm) of the external I/O board. The following diagrams illustrates all the dimensions required for mounting:

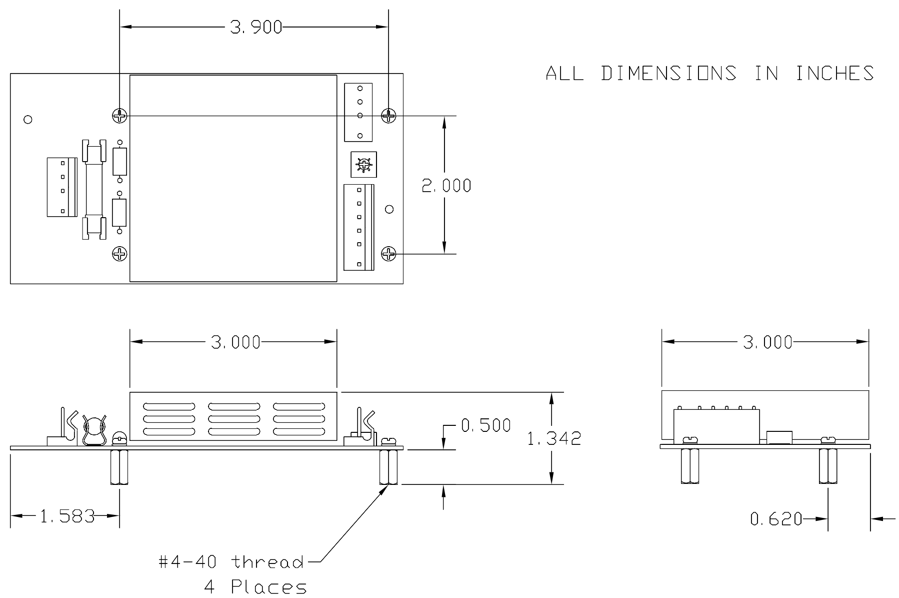


The P240 external power supply can be powered by 100 to 240 VAC, but will operate correctly from 85 VAC up to 264 VAC. Applying power above 264 VAC can cause permanent damage to the power supply. The unit can also be powered by 110 to 300 VDC. This can be with a dedicated fused feed or the same voltage source that powers the 7700 ION. Refer to the following:

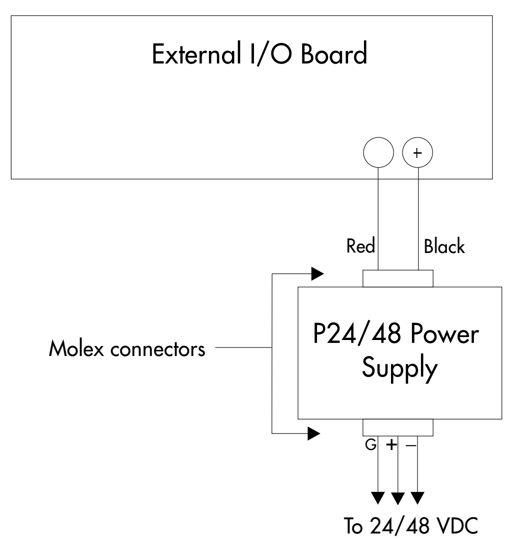


P24/48 Option

The P24/48 external power supply must be mounted within 18 inches (45 cm) of the external I/O board.



The P24/48 external power supply can be powered by 20 to 60 VDC. It must be a dedicated fused feed. Refer to the following wiring diagram:



Using Custom Cables with I/O Expansion Boards

When using Expansion Board A with a custom connecting cable longer than the standard 3 feet (0.9m), you cannot use any analog I/O modules unless you use an external power supply. The power supply options available are the same as those listed for Expansion Board B.

When using an external power supply with Expansion Board A, you must remove the jumper (JMPR) on the board. Failure to do so will void the 7700 ION warranty.

Note that the same power source should be used to power the 7700 ION and Expansion Board A so that external I/O devices and the meter all react the same way if the system is powered down.

Connecting to Expansion Board I/O Devices

This section describes how to connect to each of the I/O devices that are plugged into the external I/O board.

Relay Application Precautions

DANGER

Primary Protection

Do not use digital output devices for primary protection functions. These include applications where the device provides:

a) Protection of people from injury. If failure of the device can cause injury or death, do not use the 7700 ION.

b) Energy limiting. If failure of the device will cause sufficient energy to be released that a fire is likely, the 7700 ION should not be used. In electrical systems, energy limiting is normally provided by circuit breakers or fuses.

Secondary Protection

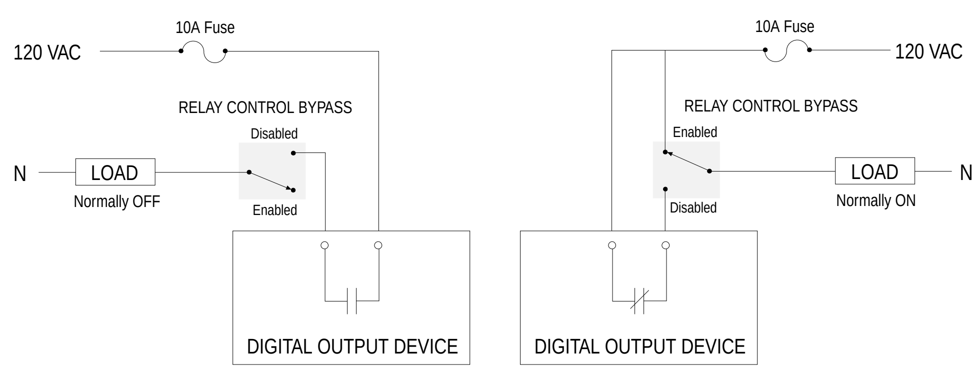
The 7700 ION can be used for secondary protection functions. Secondary protection includes situations where:

a) The 7700 ION is backing up a primary protection device (shadow protection), such as an overcurrent relay.

b) The 7700 ION is protecting equipment, not people. This includes applications such as over/ under voltage, voltage unbalance, over/under frequency, reverse power flow, or phase reversal protection, etc.

In applications where the digital output devices are used to perform critical equipment control operations (for example, breaker trip, etc.):

1. Make connections to the external equipment via an intermediate mechanism which allows relay control to be completely disabled for commissioning and servicing (for example, firmware upgrades). See the following figure:



2. Anytime the 7700 ION has powered down and powered back up, test the digital outputs of the 7700 ION to ensure that all your control condition(s) are occurring as expected.

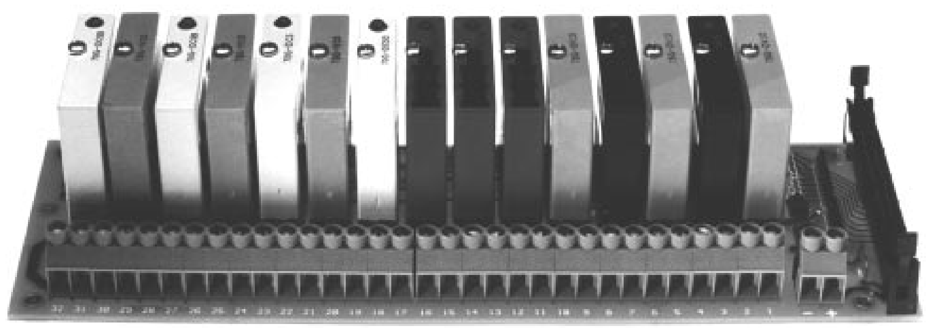
3. When you have verified all control operations, relay control of the external equipment can be enabled.

NOTE

All digital output devices supplied by Power Measurement are asserted low.

I/O Input Terminals

Expansion boards provide captured-wire type terminal strips for connection to each I/O device. AWG 12 to 14 (3.31 to 2.08 square mm) wire is recommended for all connections. Assignment and scaling for each device is programmable via the Analog Input, Analog Output, Digital Input and Digital Output ION modules which are described in Chapter 4. For detailed information about the specifications of each I/O device option, refer to Appendix A.



The I/O expansion board slots correspond to the input terminals as follows:

Slot Number	Input Terminals + & −
0	1 & 2
1	3 & 4
2	5 & 6
3	7 & 8
4	9 & 10
5	11 & 12
6	13 & 14
7	15 & 16

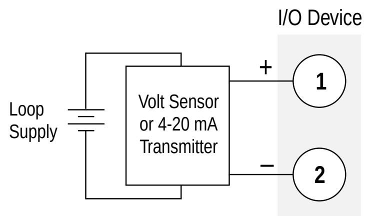
Slot Number	Input Terminals + & −
8	17 & 18
9	19 & 20
10	21 & 22
11	23 & 24
12	25 & 26
13	27 & 28
14	29 & 30

I/O Device Connections

In the connection diagrams that follow, the I/O device input terminals shown are input 1 and input 2. For connection to modules in other slots, substitute the *odd* numbered input for input 1 and the *even* numbered input for input 2. (For example, if you are connecting to a module in slot 6, substitute input 13 for input 1 in the diagram, and input 14 for input 2 in the diagram).

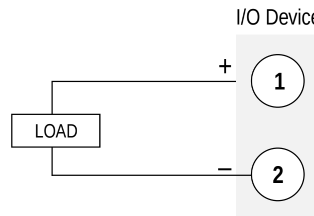
Analog Inputs

GAIVDC1, GAIVDC5, GAIVDC10, GAIIDC420



Analog Outputs

GAOVDC5, GAOVDC10, GAOIDC420



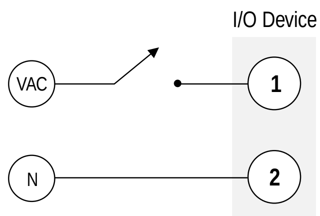
NOTE

The external I/O devices are color-coded as follows:

Analog Inputs	Blue
Analog Outputs	Orange
Digital Inputs (AC)	Yellow
Digital Inputs (DC)	White
Digital Outputs (AC)	Black
Digital Outputs (DC)	Red

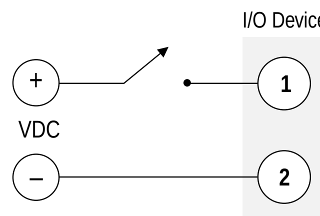
Digital Inputs (AC)

GDIAC120, GDIAC240



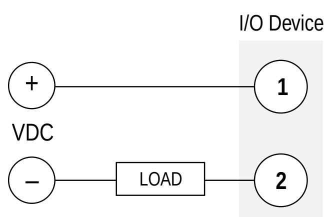
Digital Inputs (DC)

GDIDC32, GDIDC32H



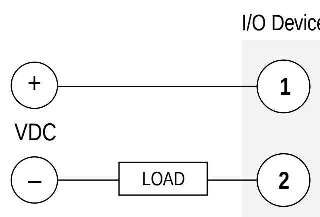
Digital Outputs (DC) - Solid State

GDODC60, GDODC200, GDODC60L



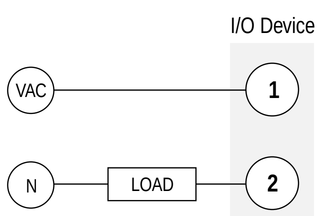
Digital Outputs (DC) - Mechanical

GDODC100M



Digital Outputs (AC)

GDOAC120, GDOAC240



Maintenance

The following circumstance describes the only regular maintenance that the 7700 ION may require.

Battery Replacement

The 7700 ION non-volatile memory (NVRAM) and real-time clock (RTC) circuit contain integrated battery backup systems.

NVRAM

NOTE

When the NVRAM is replaced, setup parameters and historic data may be lost. It is recommended that setup parameters and all critical logged data is backup up to the hard drive of a computer prior to servicing. Calibration of the unit is not affected.

The rated life of the NVRAM battery is seventy years at 50°C (122°F), 28 years at 60°C (140°F), and 11 years at 70°C (158°F). If the unit operates at less than 50°C for 60% of the time, less than 60°C for 90% of the time, and less than 70°C for 100% of the time, the expected life of the NVRAM battery is 35 years. If the meter is operating in an environment where the temperatures regularly exceed 60°C, the NVRAM battery should be replaced every ten years.

Real-Time Clock

The battery system for the RTC may exhibit a somewhat shorter lifespan than the NVRAM backup, due to the fact that it remains active (i.e. the clock continues to run) when the meter is powered down.

Cleaning

Once the 7700 ION is properly installed in a suitable enclosure, no cleaning is required.

Calibration

The calibration interval for the 7700 ION depends on your accuracy requirements. Contact Power Measurement for information regarding the required calibration procedure.

3

ION Implementation

This chapter describes how the ION architecture is implemented in the 7700 ION.

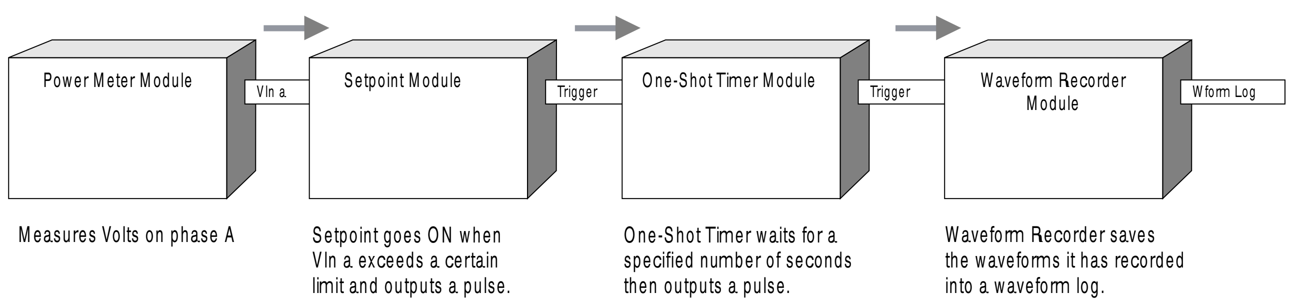
In this Chapter

Overview of ION Modules

As its name implies, an ION module is an independent object that performs an operation, analogous to a discreet function in a conventional power meter. ION modules are the basic building blocks of the 7700 ION system. For example, the Maximum module identifies a maximum value, the Setpoint module triggers an action in response to a specific condition and the Waveform Recorder module performs a waveform recording when triggered. Every module accepts a variety of *inputs*, and depending how you set it up, generates a variety of *outputs*. By combining or *linking* different modules, making the output of one module the input of another, you can create whatever custom features you need. This revolutionary architecture offers you the flexibility to tailor the functions of the device to your own unique requirements.

ION modules operate as black boxes. The details of how they operate internally are secondary to the more important questions of "what information is going into the module?" and "what information is coming out?". Most modules do have some setup parameters offering configuration options but the basic function of each module is fixed; a module's primary strength lies in its inter-connectivity rather than the individual function it performs.

In this example, a combination of modules (also referred to as a *framework*) records waveforms in response to an over-voltage condition.



Modules are linked together using the ION Designer graphic user interface. Refer to the *ION Designer User Guide* for details.

ION Managers

An ION manager regulates the number of ION modules available in an ION device. There is an ION manager for each type of ION module. For example, in one IED, you can use up to 8 AND/OR modules. When that limit is reached, the AND/OR manager will not let you add any more AND/OR modules to your frameworks.

Overview of ION Registers

Because ION modules can be combined together, the output of one module must be stored so that the next module can use this information. To allow ION modules to pass information between themselves, the ION architecture uses objects called *registers*. ION registers are simply data storage locations for numeric values, event log entries, waveform data and so on. They are passive objects that hold data so that multiple modules can use the information.

There are two basic types of registers:

Setup	These registers control how the module operates. For example, you can control if the Setpoint module evaluates a variable on a "Less Than" or "Greater Than" basis. Several setup registers may be required to completely define the operation of the module. The values of these registers can be left at their default or changed via communications.
Output	These registers contain the results of the operation of the ION module. Often, they also contain information about changes in the module. The information stored in one module's output register can become the *input* to another module.

Module Links

For all types of ION modules, the links to inputs can be programmed; the links to output registers and to setup registers are fixed. This structure allows data to flow from one module to the next, where the inputs for each subsequent module are linked to the output registers of previous modules.

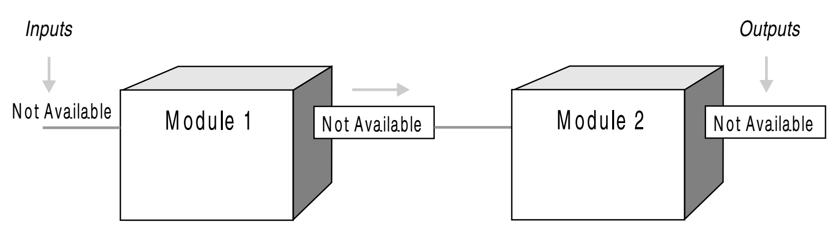
The Not Available Value

NOTE

The Not Available value does not propogate through linked Arithmetic modules as described on the right. Refer to the ION Arithmetic module description in Chapter 5 for details.

If a module is not linked to anything, its output registers will not contain any values and are set to Not Available. In addition, if a module has an input that is invalid (for example a line-to-neutral measurement for a 3-wire Delta system) its output register is also set to Not Available. This helps distinguish between cases where a register contains a value like 0 or OFF, and cases where there is actually no value stored.

If the inputs of a module are Not Available, its output registers are also Not Available. The setting of Not Available propagates through linked modules.



Register Classes

Not all output registers can serve as input registers for all modules. There are different *classes* of registers and each is capable of holding different types of information. To combine two ION modules together, the output registers of the first module must contain the kind of information that the next module can use.

To see if you can link ION modules, check the class of the module's input and output registers to ensure they are the same. The following list describes the various register classes available. Note that each class is represented by a small graphic. You can use these graphics as a quick reference when linking modules:

■ *Numeric*
These registers contain a single numeric value. It can be any value within the range capabilities of the device.

Numeric Array
These registers contain an array of numeric values.

◑ *Boolean*
These registers contain a logical ON or OFF (1 or 0).

Pulse
These registers "contain" a pulse, or instantaneous signal. They are normally used for resetting, pulsing or triggering functions.

Waveform
These registers contain formatted waveform data (an array of points that define a waveform). The information is formatted on the basis of:

#samples per cycle X #cycles

Enumerated
These registers are used for storing one value from a list of several options. For example, the Setpoint module has an Evaluate Mode setup register that can be set to either LESSTHAN or GREATERTHAN. Typically only setup registers are of the enumerated class.

▣ *Numeric Bounded*
These registers contain a number bounded by a high and low limit. For example, in the Thermal Demand (TD) module, the setup register that specifies the period length is numeric bounded because the value must be a number higher than 1 but less than 100. Typically only setup registers are of the numeric bounded class.

Calendar
The Calendar register holds the setup information in the Scheduler module.

String
These registers contain text strings. Text strings can consist of any combination of numbers, letters and spaces, excluding double-quote characters ("). In addition, the text must not end with a backslash character (\ ). (Backslashes elsewhere in the text are permissible, as is a backslash at the end of the string if it is followed by a space character.)

String register applications include formulas (Arithmetic module) and device information (Factory module).

Event
Almost every ION module has an output called an event register that records all the *events* produced by the module. An event is simply any occurrence in the system that warrants logging (for example, changing a setup register or a Setpoint module going active). The contents of an event register include:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause
- The effect of the event.
- Any values or conditions associated with the effect.

The Event Log Controller module takes all the event registers from all the modules in the device and assembles them to provide an Event Log.

Event Log
These registers contains the assembled contents of all the event registers of other modules. The Event Log Controller module uses this class of register to provide a log of all the events occurring on the device.

Log
These registers can contain a timestamped list of numeric, Boolean or waveform data. Typically, modules that record data (e.g. Data Recorder, Waveform Recorder) have Log output registers.

ION Register Names and Labels

Every register in the ION architecture has a name and a programmable label that identify what information the register contains. The name of each register appears in the link symbols (see the *ION Module Link Symbols* section) and the default label for each register is the same as its name.

You can change the label via communications to be more descriptive for your application. For example, the name (and thus the default label) of the Maximum module's output register is *Maximum*. If you are using that particular module to record maximum values on Vunbal, you may want to change the "Maximum" label to "Max Vunbal" to make it more apparent what the contents of the register represent. The length of the label is limited to 15 characters.

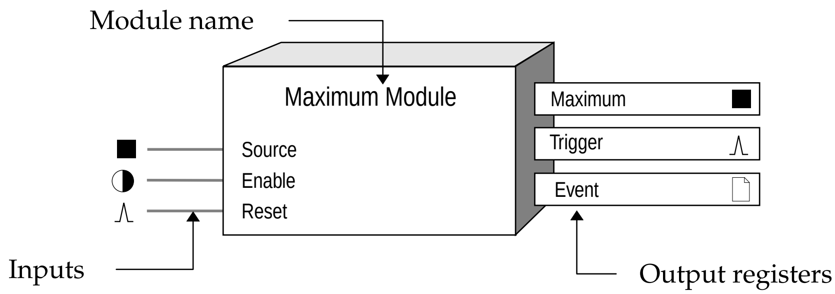
You can also specify labels for the two states of a Boolean register. The default labels are ON and OFF, but you can customize them for different functions. For example, in the Digital Output register, the State output register is a Boolean register that may describe the state of some external device. You may want to change the ON and OFF labels to FAN RUNNING and FAN NOT RUNNING to be more specific.

See the *ION Designer User Guide* for details about programming new labels.

ION Module Link Symbols

In the sections that follow, each ION module description contains a link symbol that indicates the inputs and the output registers used by the module. You can use these symbols as a quick reference for implementing the module on a stand-alone basis or in combination with other modules.

In the figure below, the link symbol for the Maximum module is shown. The inputs (shown on the left) depend on what register you connect. The output registers appear on the right. By simply looking at the register class symbols of a module's inputs and outputs, you can determine which registers are compatible.



Note that you can use the outputs from multiple modules and link them all to one module's inputs. In other words, not all module's inputs must come from the outputs of a single module. For the module shown above, you can link the Source input to the output of the Power Meter module, the Enable input to the output of External Control module and the Reset input to the output of the Periodic Timer module.

NOTE

An example of linking modules to perform daily min/max recording is given in Chapter 1 in the section *ION Modules*. The example given there illustrates how a complex function can be performed by linking ION modules.

In addition, you can link a single module's output register to the inputs of multiple modules. For example, you may have the Vln a output register of the Power Meter module linked to both the Source input of a Setpoint module and the source input of a Data Recorder module.

This ability to interconnect modules provides additional flexibility and allows you to use your modules more efficiently.

Unless otherwise noted in a module description, all ION modules must have all their inputs linked for the module to operate.

ION Event Priority Groups

Events produced by the various ION modules are prioritized and grouped to facilitate custom logging. Each event has a priority group number assigned to it, based on its type and severity. There are 8 event priority groups in total, as shown in the table below.

Event Group	Description	Priority Number
Reset	Module reset or resynchronized	5
Setup Change	Module setup changes (setup register cahnges, label changes, input handle changes)	10
Input Register Change	Inputs of certain modules change value (i.e. input to And/Or module changes)	15
I/O State Change	I/O state changes (i.e. relay closes)	20
Information	Module produces important user information	25
Warning	Module produces a warning	30
Failure	A failure has occurred	255
Setpoint	Setpoint condition goes Active or Inactive (i.e. Sag/Swell module detects a disturbance)	programmable via module setup

The Event Log Controller module allows you to set a priority cutoff for event logging. Any events with a priority number greater than the cutoff value are logged, and events with lower priorities are discarded. Refer to the individual module descriptions and the Event Log Controller module description in Chapter 5 for more details.

External ION events

Some events are not produced by a specific module; they are generated internally by the 7700 ION. These events and their associated priority levels are shown in the table below.

Event Group	Description	Priority Number
Warning	Factory initialize performed	30
	Firmware upgrade performed	
	Memory upgrade performed	
	Device power-up	
	Device power-down	
Failure	Communications fail to allocate required memory	255

Timing Considerations in the 7700 ION

NOTE
For a 60 Hz system, one cycle is 16.67 milliseconds.

The standard, high-accuracy update rate of the modules in the 7700 ION is 1 second. Many modules can also be configured to operate as high-speed, and as such are updated every cycle. When programming, or linking ION modules, it is important to keep in mind whether you want the framework you are creating to be a high-speed or high-accuracy framework. If you link three modules together to perform a function, the update rate of the first module in the framework defines the speed of the whole framework. For example, if you link:

Power Meter (high-speed) ⇒ Maximum ⇒ Recorder

the whole framework will operate at high-speed (1 cycle update rate), including the Maximum and Recorder modules. If you used an Analog input module (which all have a 1 second update rate) instead of the high-speed Power Meter module, the framework would operate as high-accuracy (1 second update rate).

In most cases, the number of high-speed-capable modules is limited so you should only use them when necessary.

Time-Sensitive Modules

NOTE
The modules that have time-sensitive setup registers include:

- Setpoint
- Periodic Timer
- One-shot Timer
- Digital Input
- Digital Output
- Pulser
- Communications

In addition, both the Sliding Window Demand module and the Thermal Demand module have definable time intervals.

Many modules in the 7700 ION have setup registers requiring you to specify a time interval. Typically, these registers are specified in seconds and you can enter any value that is within the allowable range. Due to the update rate of the module however, the time that you specify cannot always be supported. If you specify a time that is shorter than the update rate of the module (or falls in-between update cycles), the module will round up to the shortest time possible.

For high-accuracy modules, it is advisable to specify time values in the various setup registers in multiples of the update rate.

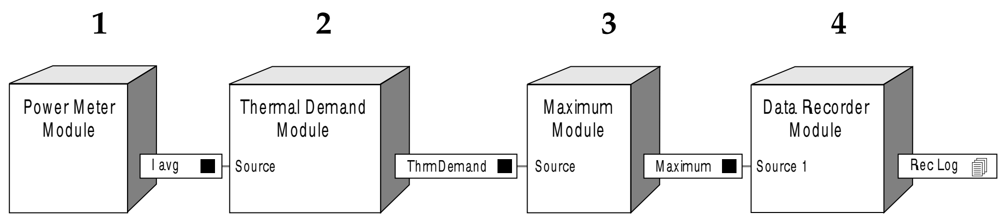
For high-speed modules, it is still advisable to restrict your time values to multiples of the update rate (e.g. 1 cycle, 2 cycles, 3 cycles, etc.); however, because you are required to specify time in milliseconds, these modules should be addressed slightly differently.

Since the frequency of the system defines how many milliseconds there are in a cycle, and the frequency of the system can drift slightly, specifying an exact number of milliseconds may not always correspond with the number of cycles you expect. For example, if you specify a value in milliseconds that exactly corresponds to 3 cycles, your event may sometimes occur every 3 cycles and sometime every 4 if there has been any drift.

You can take advantage of the fact that some modules always round time values up to the closest update rate they can support to ensure that your time value results in the number of cycles you wish. For example, in a 60 Hz system, if you specify 13 instead of 16.67 milliseconds, the module will automatically update every cycle, even if the frequency has drifted and the number of milliseconds in a cycle has changed to 15.

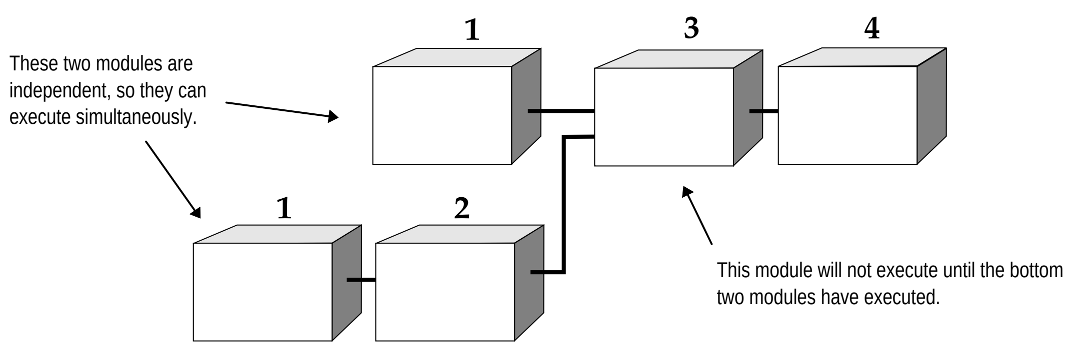
Sequence of Module Execution

ION modules are executed in the order in which they are logically linked, rather than the order in which you actually linked them. In other words, modules are executed in the same order in which the data flows from one module to the next. For example, say you have created a group of modules, or framework, that records the maximum thermal demand value for I avg. The modules would be executed in the following order:



This allows you to link a framework in any order you wish and maintain a logical execution order. For example, you can link the Data Recorder, the Maximum and the Thermal Demand modules together first, and then later link them to the Power Meter module. It does not affect the execution order; the Power Meter module will still execute first.

In more complex frameworks, the relationship between modules may not be as linear as in the previous examples. In these cases, modules are still executed in the order of information flow but some modules may be executed simultaneously if they do not depend on each other for data. For example:



Note that execution order and update rate are not the same thing. Update rate refers to how frequently a module performs its operation and updates its output registers (every second for high accuracy, every cycle for high speed). Execution order refers to the order in which modules execute *within* the update period. For example, if the framework above was high-speed, the whole thing would execute within the 1 cycle update period; it would not take 4 cycles to execute.

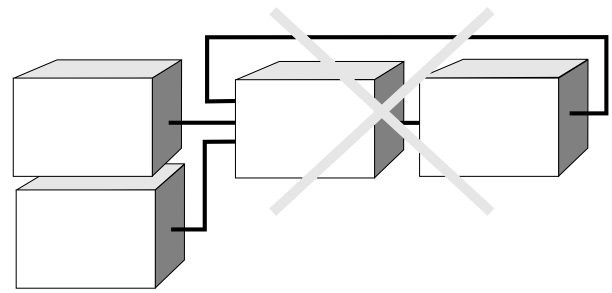
Restrictions on Linking Modules

NOTE

There is no restriction on the number of branches you can have in a framework (as long as no branch exceeds 8 modules).

The maximum number of modules that can be linked in a row is 8. This is referred to as the framework's *depth*. Only modules that are part of a contiguous chain contribute to the depth of a framework. Modules that branch off or branch into the chain do not affect the depth. For example, in the figure above, the depth of the framework is 4 even though there are 5 modules.

Another restriction concerns "circular" linking of modules. You cannot link a module's output register to its own input or to the input of any module that precedes it in the chain. This protects you from creating infinite loops that can waste system resources.



7700 ION Module Summary

Refer to Chapter 5 for a table that shows which modules are included in the 7700 ION and how many of each are available for programming. The table in Chapter 5 also indicates the supported ranges for all the setup parameters as well as any pre-defined defaults.

I/O Ports Available on the 7700 ION

NOTE

The 8 status inputs are part of the basic 7700 ION. The external I/O expansion boards and auxiliary analog inputs are all optional.

Many of the ION modules in the 7700 ION allow you to specify a port to which a signal is sent (in particular, the Analog Input, Analog Output, Digital Input, Digital Output and Pulser modules). When you access any of these module's Port setup register, all expansion board ports will be available selections, even if there is no expansion board connected to the 7700 ION. Ensure that you do not configure a module to send a signal to an expansion board port that is not physically available. The AUX inputs will only appear in the Port setup registers if the auxiliary analog input card is installed.

The following tables indicate what ports selections are available with the different I/O options of the 7700 ION.

NOTE

On both external I/O expansion boards, ports 0 through 7 can support Digital Input, Digital Output and Analog Output devices. Ports 8 through 14 can support Digital Input, Digital Output and Analog Input and Analog Output devices.

1st I/O Expansion Board	2nd I/O Expansion Board	Status Inputs	Auxiliary Analog Inputs
Port A-0	Port B-0	Status 1	AUX1/*optional*DC
Port A-1	Port B-1	Status 2	AUX1/*optional*AC
Port A-2	Port B-2	Status 3	AUX2/*optional*DC
Port A-3	Port B-3	Status 4	AUX2/*optional*AC
Port A-4	Port B-4	Status 5	AUX3/*optional*DC
Port A-5	Port B-5	Status 6	AUX3/*optional*AC
Port A-6	Port B-6	Status 7	AUX4/*optional*DC
Port A-7	Port B-7	Status 8	AUX4/*optional*AC
Port A-8	Port B-8		
Port A-9	Port B-9		
Port A-10	Port B-10		
Port A-11	Port B-11		
Port A-12	Port B-12		
Port A-13	Port B-13		
Port A-14	Port B-14		

Auxiliary analog options include:

0-20mA, 0-1mA, 0-1V and 0-10V

Note that there are four optional internal auxiliary analog inputs and each can be configured to monitor AC or DC signal; however, all four inputs must be configured with the same input rating. In other words, if you ordered the AUX 20mA option, all four inputs must be configured as 0-20mA but some can be AC and some can be DC.

Configuring the 7700 ION

For most applications, you must first setup the Power Meter module and the Communications module before you can implement other features in the 7700 ION. These modules control how the 7700 ION measures data from the power system it is connected to and how it communicates.

If your installation requires settings that differ from the defaults, you must change them either through the MGT or via PEGASYS. For detailed information about using the PEGASYS software, refer to the *PEGASYS User's Guide*. For information about the MGT, refer to Chapter 4 of this manual. Both describe the steps involved in changing the value of an ION setup register.

In general, you should use PEGASYS to configure the 7700 ION as it offers security and a more powerful interface. The only exceptions are the communications mode and the communication baud rate, which you may need to configure from the MGT if the defaults do not match your system.

Communications Module Configuration

This module controls how the 7700 ION communicates with other devices and with a computer running PEGASYS. In most cases, only the following two setup registers must be configured for the 7700 ION to operate.

NOTE

Each meter connected to a com port must have a unique Unit ID. By default, the 7700 ION's Unit ID is factory set to the last 4 numbers of the serial number (letters are excluded). It is advisable to check the value of this register when setting up your meter to ensure it is unique on the network.

Comm Mode — The default for this register is RS485, the mode used when multiple devices are connected at a local or remote site. If you are connecting a single 7700 ION to the serial port of another devices (for example, a computer), you must use the MGT to specify RS232. The handle for this register is 7986.

Baud Rate — The default for this register is 9600. If the computer running PEGASYS has a different baud rate, you must use the MGT to set this register to match the baud rate of the computer. The handle for this register is 7987.

The remaining setup registers of the Communications module and their default settings are given in the table at the beginning of Chapter 5.

Power Meter Module Configuration

For the 7700 ION to measure and calculate data properly, the following setup registers in the Power Meter module must be configured:

Volts Mode — The default for this register is 4W-WYE. If your power system is not 4 wire -Wye, select the option that matches your system. The handle for this register is 7800.

PT Prim — The default for this register is 1200. Set this to a value that corresponds to the PT primary rating of the power system. The handle for this register is 7000.

PT Sec — The default for this register is 120. Enter PT secondary rating of the power system. The handle for this register is 7001.

CT Prim — The default for this register is 5000. Set this to a value that corresponds to the CT primary rating of the power system. The handle for this register is 7002.

CT Sec — The default for this register is 5. Set this to a value that corresponds to the CT secondary rating of the power system. The handle for this register is 7003.

The remaining setup registers of the Power Meter module and their default settings are given in the table at the beginning of Chapter 5. In most cases you can leave them at their default settings and the 7700 ION will function properly.

The 7700 ION Default Configuration

NOTE

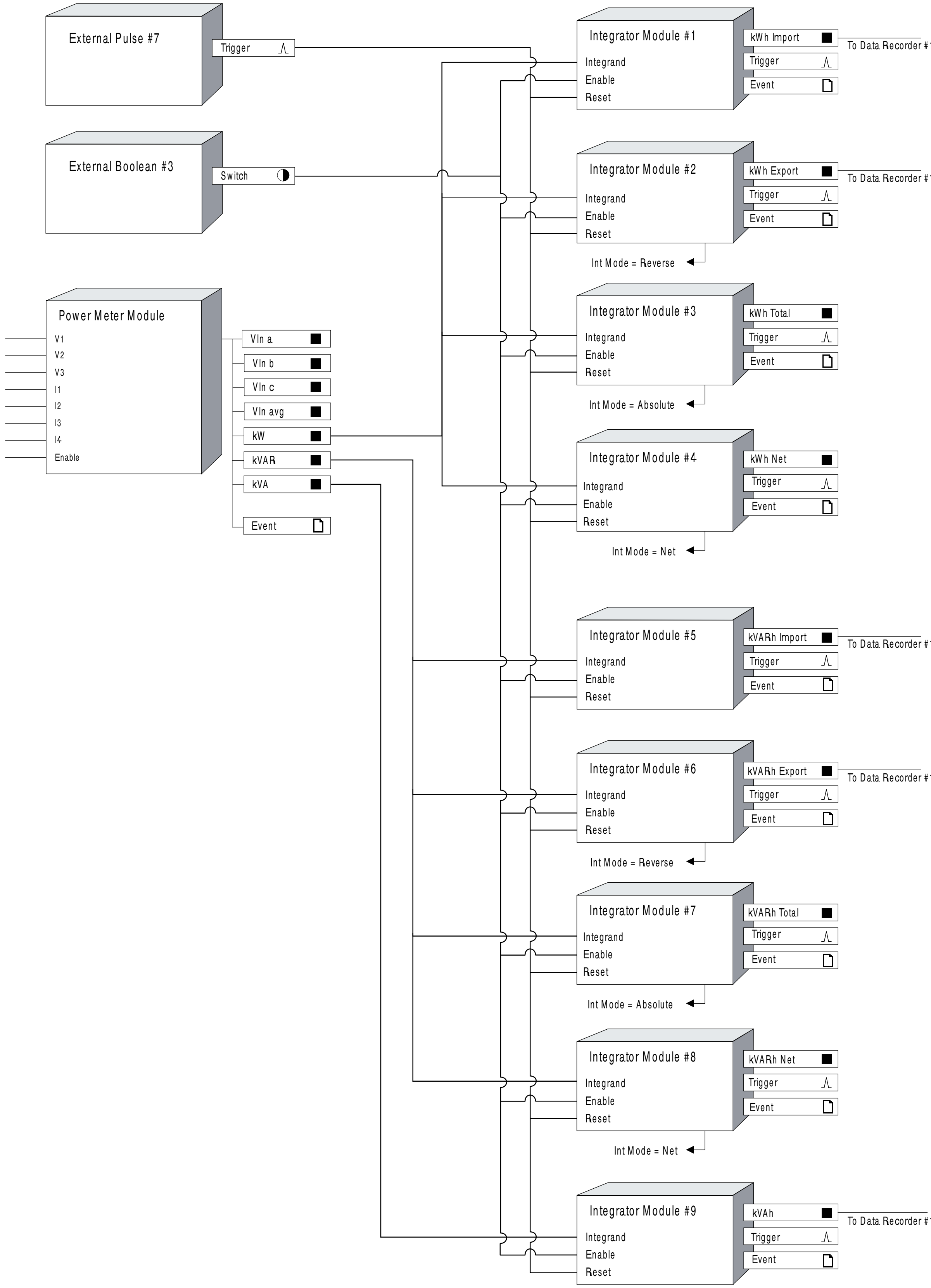
Unless otherwise noted in the sections that follow, the setup registers for all modules used in the pre-configured frameworks have been left at their default values.

The 7700 ION has some module links pre-configured at the factory to provide many common monitoring and recording functions. These module links use only a fraction of the 7700 ION's available resources; however, if you want to direct more resources to other functions or if you want to use a module elsewhere, you can unlink them as necessary.

Energy

Integrator modules #1 through #9 are linked to the high-accuracy Power Meter module according to the following table. External Pulse module #7 is linked to the Reset input of each of the Integrator modules, allowing you to reset all of the Result values simultaneously. External Boolean #3 is linked to each Integrator module's Enable input. Some of the Integrator's Result outputs are linked to Data Recorder #1 (see *Recording* later in this section).

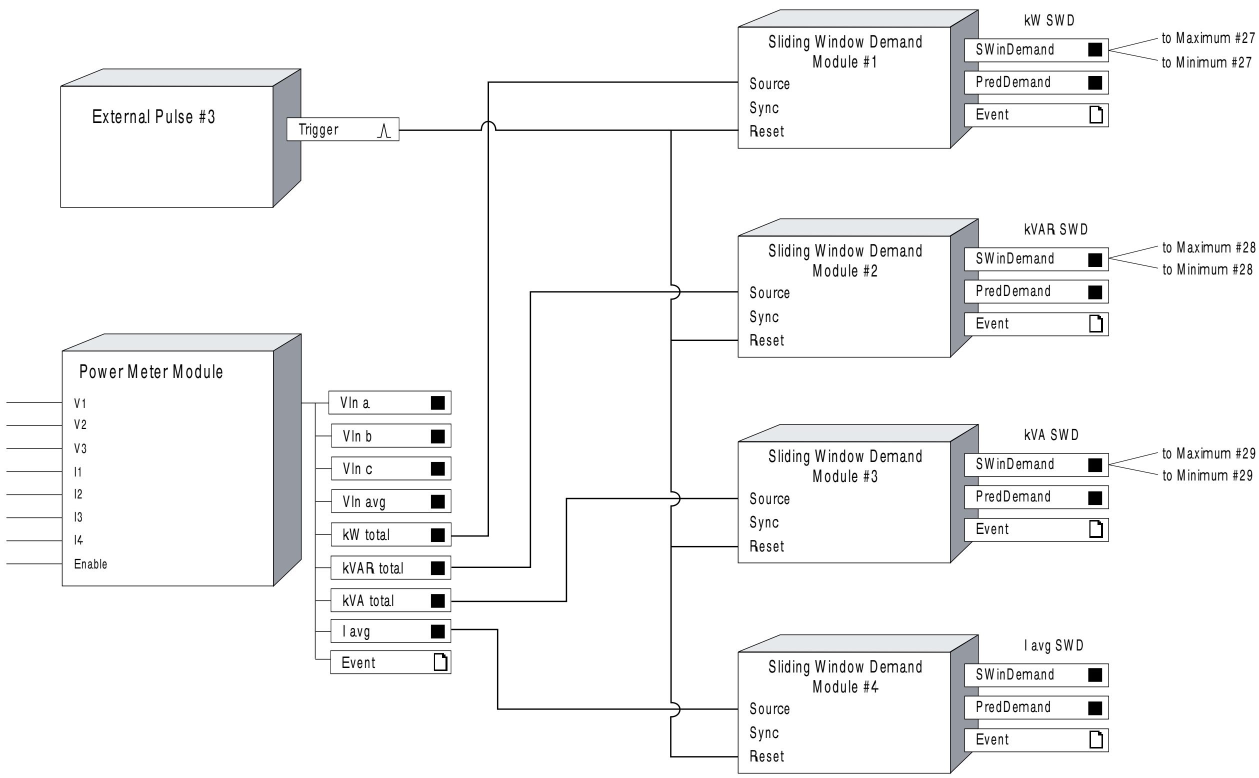
Inputs			*Outputs*
Integrand (from Power Meter module)	**Module #**	**Int Mode**	**Result**
kW	Integrator #1	Forward	kWh import
kW	Integrator #2	Reverse	kWh export
kW	Integrator #3	Absolute	kWh total
kW	Integrator #4	Net	kWh net
kVAR	Integrator #5	Forward	kVARh import
kVAR	Integrator #6	Reverse	kVARh export
kVAR	Integrator #7	Absolute	kVARh total
kVAR	Integrator #8	Net	kVARh net
kVA	Integrator #9	Forward	kVAh


External Pulse #7
Trigger
External Boolean #3
Switch
Power Meter Module
V1
V2
V3
I1
I2
I3
I4
Enable
Vln a
Vln b
Vln c
Vln avg
kW
kVAR
kVA
Event
Integrator Module #1
Integrand
Enable
Reset
kWh Import
Trigger
Event
To Data Recorder #1
Integrator Module #2
Integrand
Enable
Reset
kWh Export
Trigger
Event
To Data Recorder #1
Int Mode = Reverse
Integrator Module #3
Integrand
Enable
Reset
kWh Total
Trigger
Event
Int Mode = Absolute
Integrator Module #4
Integrand
Enable
Reset
kWh Net
Trigger
Event
Int Mode = Net
Integrator Module #5
Integrand
Enable
Reset
kVARh Import
Trigger
Event
To Data Recorder #1
Integrator Module #6
Integrand
Enable
Reset
kVARh Export
Trigger
Event
To Data Recorder #1
Int Mode = Reverse
Integrator Module #7
Integrand
Enable
Reset
kVARh Total
Trigger
Event
Int Mode = Absolute
Integrator Module #8
Integrand
Enable
Reset
kVARh Net
Trigger
Event
Int Mode = Net
Integrator Module #9
Integrand
Enable
Reset
kVAh
Trigger
Event
To Data Recorder #1

Demand

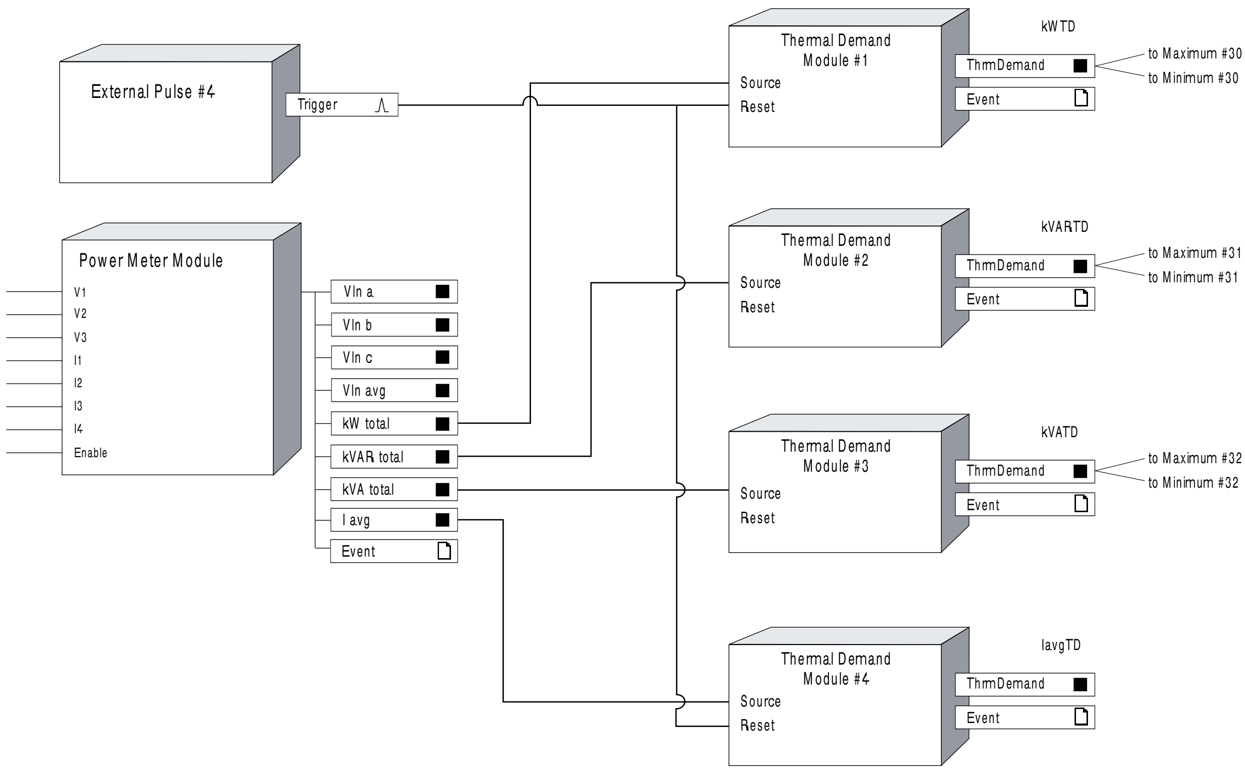
Sliding Window/Predicted Demand modules #1 through #4 are linked according to the following table. External Pulse module #3 is linked to the Reset input of each of the Sliding Window / Predicted Demand modules, allowing you to reset all of the SWinDemand and PredDemand values simultaneously. The kWSWD, kVARSWD and kVASWD outputs are linked to Minimum and Maximum modules (see *Minimums and Maximums* later in this section).

Inputs		*Outputs*	
Source (from Power Meter module)	**Module #**	**SWinDemand**	**PredDemand**
kW total	Sliding Win Demand #1	kWSWD	kWPD
kVAR total	Sliding Win Demand #2	kVARSWD	kVARPD
kVA total	Sliding Win Demand #3	kVASWD	kVAPD
I avg	Sliding Win Demand #4	IavSWD	IavPD



Thermal Demand modules #1 through #4 are linked according to the following table. External Pulse module #4 is linked to the Reset input of each of the Thermal Demand modules, allowing you to reset all of the ThrmDemand values simultaneously. The kWTD, kVARTD and kVATD outputs are linked to Minimum and Maximum modules (see *Minimums and Maximums* later in this section).

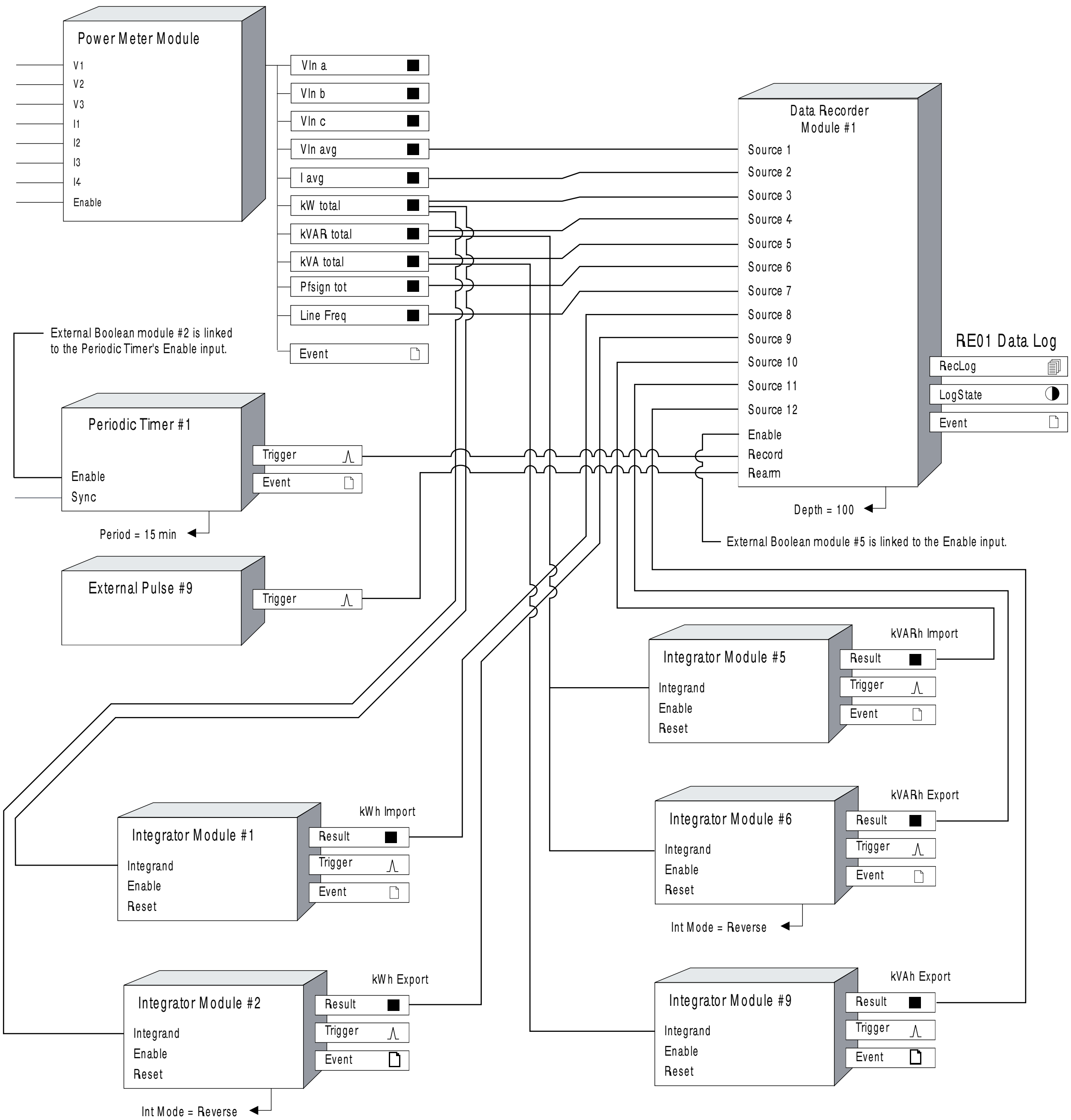
Inputs		*Outputs*
Source (from Power Meter module)	**Module #**	**ThrmDemand**
kW total	Thermal Demand #1	kWTD
kVAR total	Thermal Demand #2	kVARTD
kVA total	Thermal Demand #3	kVATD
I avg	Thermal Demand #4	IavTD



Data Recording

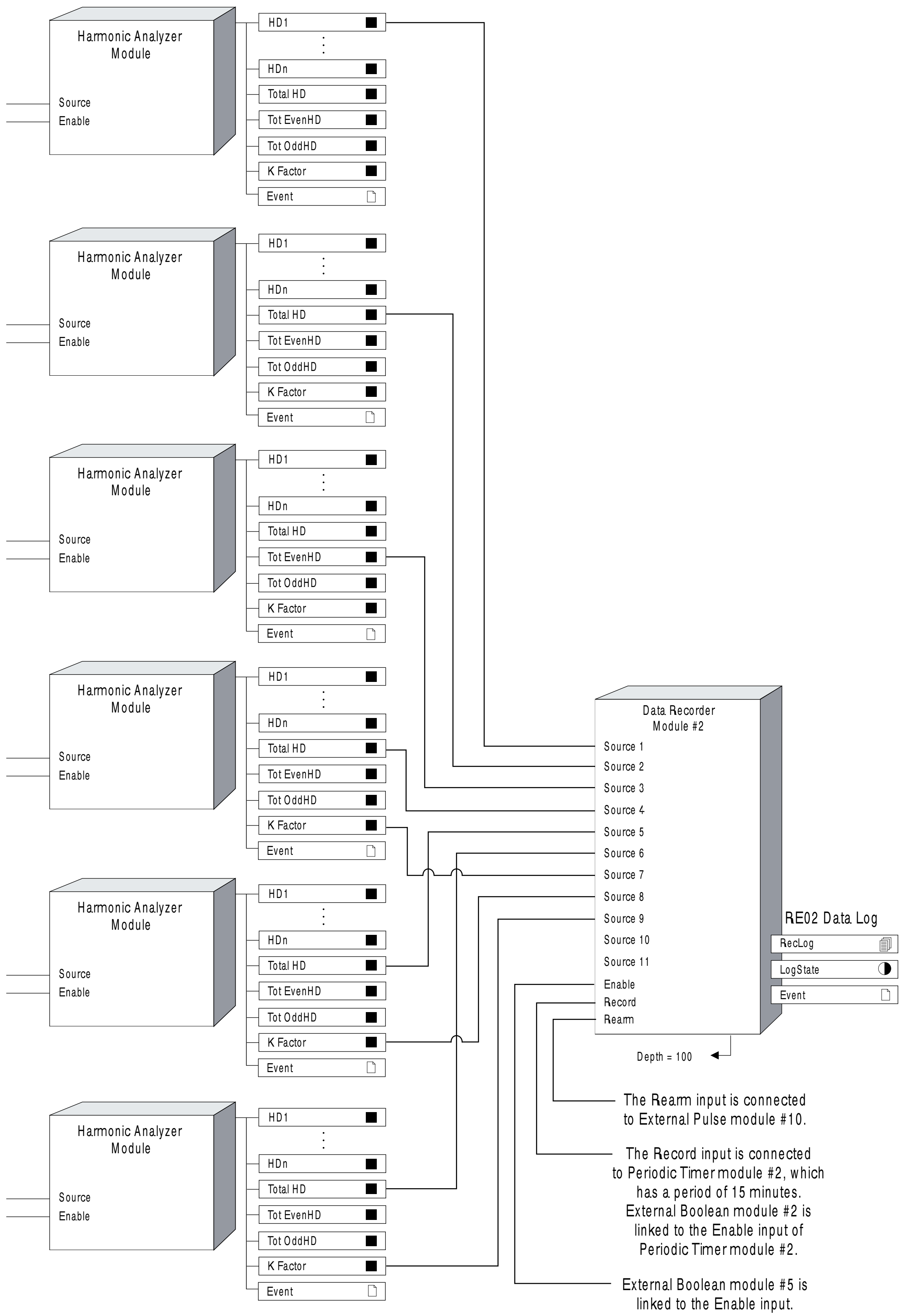
Data Recorder module #1 is linked as shown below. Note that its Record input is linked to Periodic Timer module #1 (with a Period of 15 minutes), and the Enable input of Periodic Timer #1 is linked to External Boolean #2. External Boolean #5 is linked to the Data Recorder's Enable input, and the Data Recorder's Rearm input is linked to External Pulse module #9. The Data Recorder module's Depth setup register is set to 100.

Inputs		*Outputs*
Source 1-12		**Rec Log**
Power Meter	Vln Avg	RE01 Data Log
Power Meter	I avg	
Power Meter	kW total	
Power Meter	kVAR total	
Power Meter	kVA total	
Power Meter	Pfsign tot	
Power Meter	Line Freq	
Integrator #1	kWh import	
Integrator #2	kWh export	
Integrator #5	kVARh import	
Integrator #6	kVARh export	
Integrator #9	kVAh	


Power Meter Module
V1
V2
V3
I1
I2
I3
I4
Enable
Vln a
Vln b
Vln c
Vln avg
I avg
kW total
kVAR total
kVA total
Pfsign tot
Line Freq
Event
Data Recorder Module #1
Source 1
Source 2
Source 3
Source 4
Source 5
Source 6
Source 7
Source 8
Source 9
Source 10
Source 11
Source 12
Enable
Record
Rearm
Depth = 100
RE01 Data Log
RecLog
LogState
Event
External Boolean module #2 is linked to the Periodic Timer's Enable input.
Periodic Timer #1
Enable
Sync
Trigger
Event
Period = 15 min
External Pulse #9
Trigger
External Boolean module #5 is linked to the Enable input.
Integrator Module #5
Integrand
Enable
Reset
kVARh Import
Result
Trigger
Event
Integrator Module #1
Integrand
Enable
Reset
kWh Import
Result
Trigger
Event
Integrator Module #6
Integrand
Enable
Reset
kVARh Export
Result
Trigger
Event
Int Mode = Reverse
Integrator Module #2
Integrand
Enable
Reset
kWh Export
Result
Trigger
Event
Int Mode = Reverse
Integrator Module #9
Integrand
Enable
Reset
kVAh Export
Result
Trigger
Event

Data Recorder module 2 is linked as shown on the following page. Note that its Trigger input is linked to Periodic Timer module #2 (with a Period of 15 minutes) and the Enable input of Periodic Timer #2 is linked to External Boolean #2. The Data Recorder's Enable input is linked to External Boolean #5, and its Rearm input is linked to External Pulse module #10. The Data Recorder module's Depth setup register is set to 100.

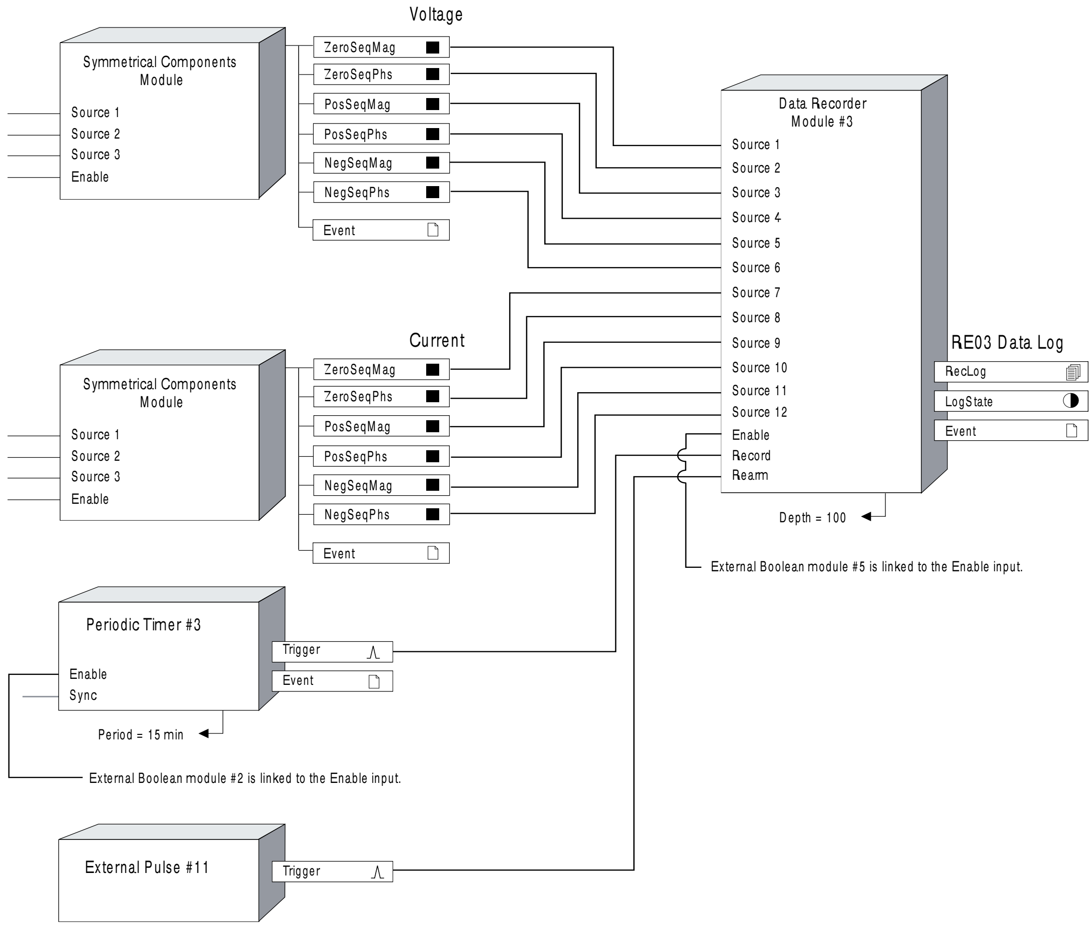
Inputs	*Outputs*
Source 1-9 (from Harmonics Analyzer module)	**Rec Log**
V1 Total HD	RE02 Data Log
V2 Total HD	
V3 Total HD	
I1 Total HD	
I2 Total HD	
I3 Total HD	
I1 K Factor	
I2 K Factor	
I3 K Factor	



Harmonic Analyzer Module
Source
Enable
HD1
HDn
Total HD
Tot EvenHD
Tot OddHD
K Factor
Event
Data Recorder Module #2
Source 1
Source 2
Source 3
Source 4
Source 5
Source 6
Source 7
Source 8
Source 9
Source 10
Source 11
Enable
Record
Rearm
Depth = 100
RE02 Data Log
RecLog
LogState
Event
The Rearm input is connected to External Pulse module #10.
The Record input is connected to Periodic Timer module #2, which has a period of 15 minutes. External Boolean module #2 is linked to the Enable input of Periodic Timer module #2.
External Boolean module #5 is linked to the Enable input.

Data Recorder module 3 is linked as shown below. Note that its Record input is linked to Periodic Timer module #3 (with a Period of 15 minutes), and the Enable input of Periodic Timer #3 is linked to External Boolean #2. The Data Recorder's Enable input is linked to External Boolean #5, its Rearm input is linked to External Pulse #11, and its Depth setup register is set to 100.

Inputs	*Outputs*
Source 1-12 (from Symmetrical Components module)	**Rec Log**
VZeroSeqMag	RE03 Data Log
VZeroSeqPhs	
VPosSeqMag	
VPosSeqPhs	
VNegSeqMag	
VNegSeqPhs	
IZeroSeqMag	
IZeroSeqPhs	
IPosSeqMag	
IPosSeqPhs	
INegSeqMag	
INegSeqPhs	

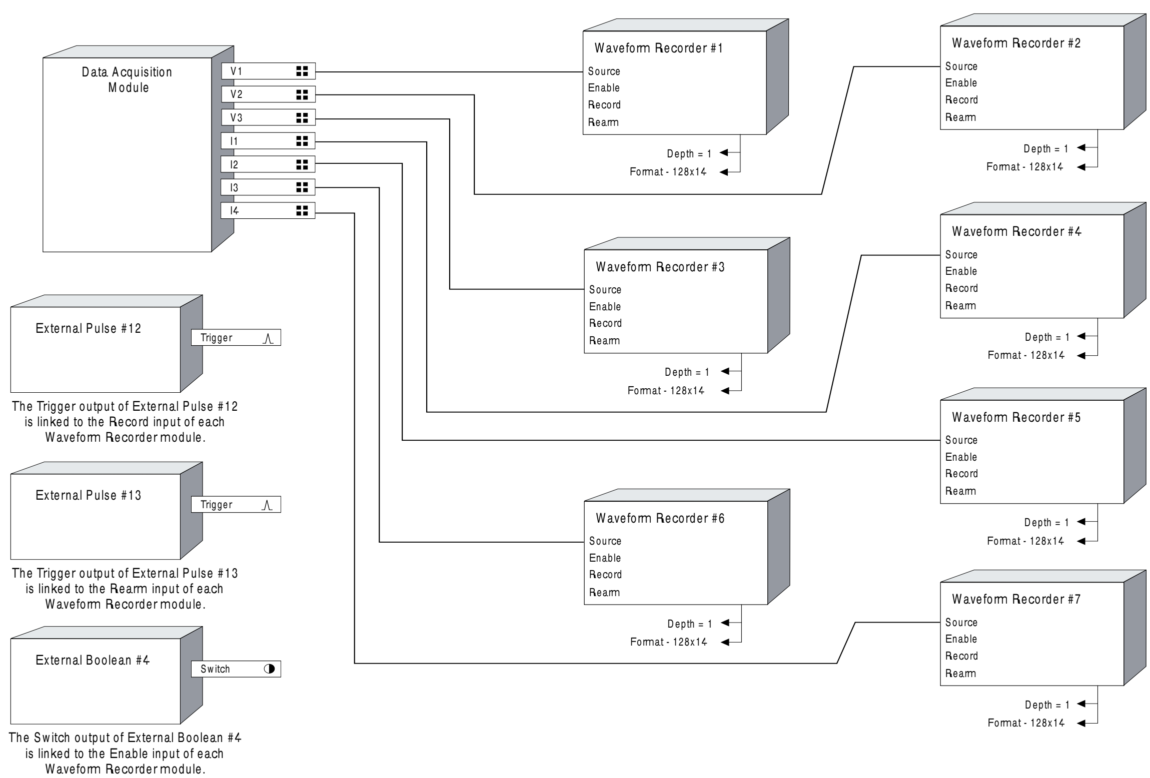


Voltage
Symmetrical Components Module
Source 1
Source 2
Source 3
Enable
ZeroSeqMag
ZeroSeqPhs
PosSeqMag
PosSeqPhs
NegSeqMag
NegSeqPhs
Event
Data Recorder Module #3
Source 1
Source 2
Source 3
Source 4
Source 5
Source 6
Source 7
Source 8
Source 9
Source 10
Source 11
Source 12
Enable
Record
Rearm
RE03 Data Log
RecLog
LogState
Event
Current
Symmetrical Components Module
Source 1
Source 2
Source 3
Enable
ZeroSeqMag
ZeroSeqPhs
PosSeqMag
PosSeqPhs
NegSeqMag
NegSeqPhs
Event
Depth = 100
External Boolean module #5 is linked to the Enable input.
Periodic Timer #3
Enable
Sync
Trigger
Event
Period = 15 min
External Boolean module #2 is linked to the Enable input.
External Pulse #11
Trigger

Waveform Recording

Waveform Recorder modules #1 through #7 are linked to the Data Acquisition module as shown below. External Pulse module #12 links to the Record input of each Waveform Recorder module, allowing you to begin recording with all modules simultaneously. Similarly, External Pulse module #13 links to the Rearm input of each Waveform Recorder module, allowing you to reset all of the modules simultaneously. The Enable inputs of all Waveform Recorders are linked to External Boolean #4.

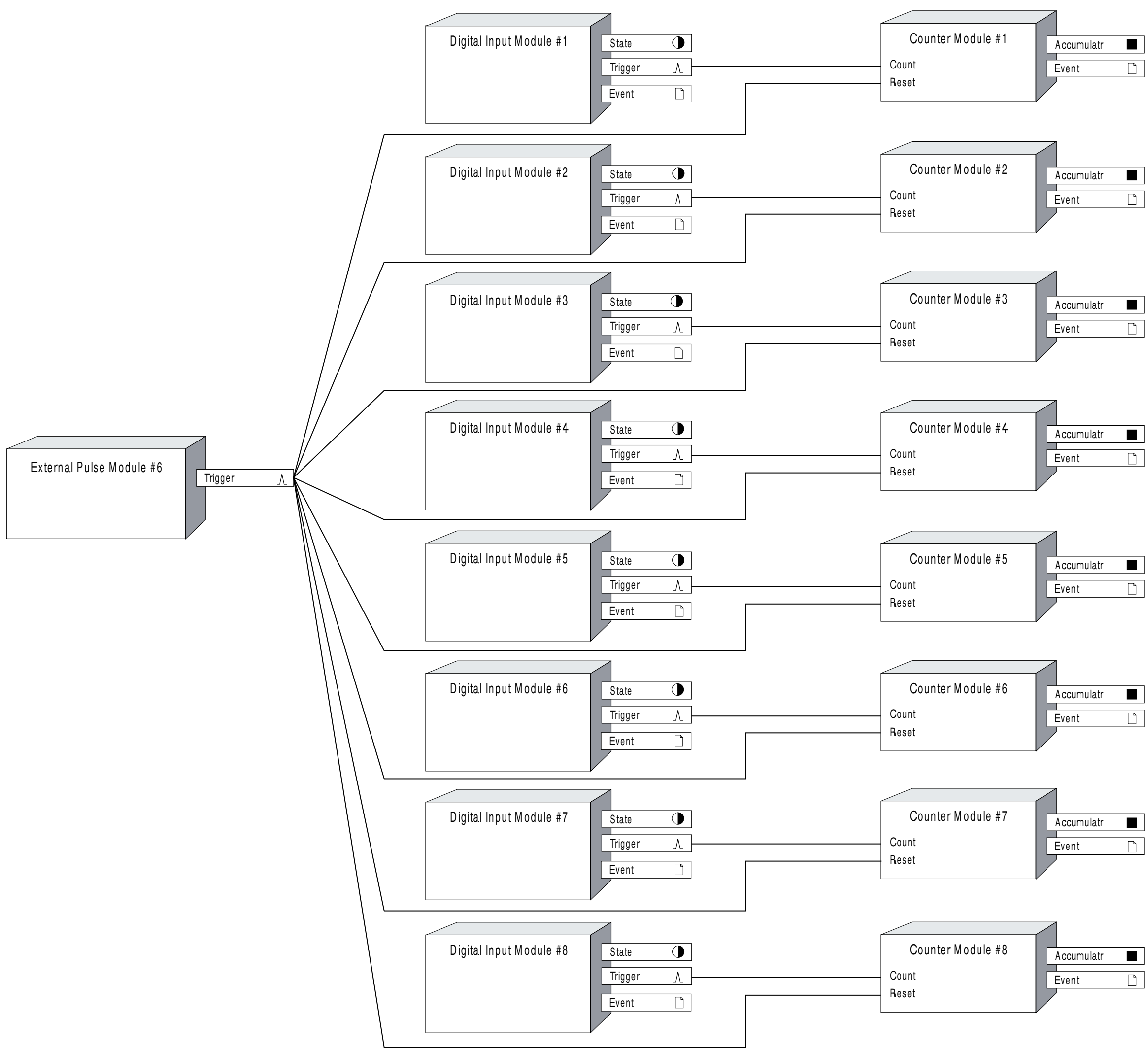
Inputs Source 1-7 (from Data Acquisition module)	*Outputs* Wform Log
V1	WR01
V2	WR02
V3	WR03
I1	WR04
I2	WR05
I3	WR06
I4	WR07



Status Inputs

Digital Input modules #1 through #8 are linked to Counter modules #1 through #8 as shown below. The Trigger output of External Pulse module #6 is linked to the Reset input of each of the Counter modules, allowing you to reset all of the Counter modules simultaneously.

Port	Digital Input Module #	State	Trigger	Counter Module #	Count
STAT1	1	Status In 1	DI01 Trigger	1	Stat CNT 1
STAT2	2	Status In 2	DI02 Trigger	2	Stat CNT 2
STAT3	3	Status In 3	DI03 Trigger	3	Stat CNT 3
STAT4	4	Status In 4	DI04 Trigger	4	Stat CNT 4
STAT5	5	Status In 5	DI05 Trigger	5	Stat CNT 5
STAT6	6	Status In 6	DI06 Trigger	6	Stat CNT 6
STAT7	7	Status In 7	DI07 Trigger	7	Stat CNT 7
STAT8	8	Status In 8	DI08 Trigger	8	Stat CNT 8



Minimums and Maximums

All Minimum and Maximum modules are linked as follows:

Inputs			*Outputs*	
Source		**Module #**	**Maximum**	**Minimum**
Power Meter	Vln a	1	Vln a MAX	Vln a MIN
Power Meter	Vln b	2	Vln b MAX	Vln b MIN
Power Meter	Vln c	3	Vln c MAX	Vln c MIN
Power Meter	Vln Avg	1	Vln Avg MAX	Vln Avg MIN
Power Meter	Vab	2	Vab MAX	Vab MIN
Power Meter	Vbc	3	Vbc MAX	Vbc MIN
Power Meter	Vca	4	Vca MAX	Vca MIN
Power Meter	Vll Avg	5	Vll Avg MAX	Vll Avg MIN
Power Meter	Ia	6	Ia MAX	Ia MIN
Power Meter	Ib	7	Ib MAX	Ib MIN
Power Meter	Ic	8	Ic MAX	Ic MIN
Power Meter	I Avg	9	I Avg MAX	I Avg MIN
Power Meter	kW	10	kW MAX	kW MIN
Power Meter	kVAR	11	kVAR MAX	kVAR MIN
Power Meter	kVA	12	kVA MAX	kVA MIN
Power Meter	PF	13	PF MAX	PF MIN
Power Meter	Freq	14	Line Freq MAX	Line Freq MIN
Harmonics Analyzer	Va Total HD	15	Va THD MAX	Va THD MIN
Harmonics Analyzer	Vb Total HD	16	Vb THD MAX	Vb THD MIN
Harmonics Analyzer	Vc Total HD	17	Vc THD MAX	Vc THD MIN
Harmonics Analyzer	Ia Total HD	18	Ia THD MAX	Ia THD MIN
Harmonics Analyzer	Ib Total HD	19	Ib THD MAX	Ib THD MIN
Harmonics Analyzer	Ic Total HD	20	Ic THD MAX	Ic THD MIN
Harmonics Analyzer	Ia KF	21	Ia KF MAX	Ia KF MIN
Harmonics Analyzer	Ib KF	22	Ib KF MAX	Ib KF MIN
Harmonics Analyzer	Ic KF	23	Ic KF MAX	Ic KF MIN
Sliding Win Demand	kW SWD	24	kW SWD MAX	kW SWD MIN
Sliding Win Demand	kVAR SWD	25	kVAR SWD MAX	kVAR SWD MIN
Sliding Win Demand	kVA SWD	26	kVA MAX SWD	kVA MIN SWD
Thermal Demand	kW TD	27	kW TD MAX	kW TD MIN
Thermal Demand	kVAR TD	28	kVAR TD MAX	kVAR TD MIN
Thermal Demand	kVA TD	29	kVA TD MAX	kVA TD MIN

NOTE

External Pulse module #1 is linked to the Rest input of all Minimum and Maximum modules.

External Boolean module #1 is linked to the Enable input of all Minimum and Maximum modules.

Default Modbus Links

The 7700 ION ships with its Modbus Slave modules linked to real- time power measurements, demand values and energy calculations, as shown in the tables below. These linkages allow you to read data from the 7700 ION using any Modbus Master device.

Modbus Slave Module #1

Setup Register	Value
Format	unsigned 16 bit
Base Address	40011
Scaling	YES
In Zero	0
In Full	6553
Out Zero	0
Out Full	65530

NOTE

Refer to the Modbus Slave module description in Chapter 5 for detailed descriptions of setup register ranges and defaults.

Source Input #	Source / Parameter		Modbus Register
1	Power Meter	Vln a	40011
2	Power Meter	Vln b	40012
3	Power Meter	Vln c	40013
4	Power Meter	Vln Avg	40014
5	Power Meter	Vll ab	40015
6	Power Meter	Vll bc	40016
7	Power Meter	Vll ca	40017
8	Power Meter	Vll Avg	40018
9	Power Meter	Ia	40019
10	Power Meter	Ib	40020
11	Power Meter	Ic	40021
12	Power Meter	I Avg	40022
13	Power Meter	V unbal	40023
14	Power Meter	I unbal	40024
15	Power Meter	Line Freq	40025
16	Power Meter	I4	40026

Modbus Slave Module #2 Source Inputs

Setup Register	Value
Format	signed 32 bit
Base Address	40027
Scaling	YES
In Zero	-214748364
In Full	214748364
Out Zero	-2147483640
Out Full	2147483640

Source Input #	Source / Parameter		Modbus Register
1	Power Meter	kWa	40027-40028
2	Power Meter	kWb	40029-40030
3	Power Meter	kWc	40031-40032
4	Power Meter	kW tot	40033-40034
5	Power Meter	kVARa	40035-40036
6	Power Meter	kVARb	40037-40038
7	Power Meter	kVARc	40039-40040
8	Power Meter	kVAR tot	40041-40042
9	Power Meter	kVAa	40043-40044
10	Power Meter	kVAb	40045-40046
11	Power Meter	kVAc	40047-40048
12	Power Meter	kVA tot	40049-40050
13	Power Meter	PF signed a	40051-40052
14	Power Meter	PF signed b	40053-40054
15	Power Meter	PF signed c	40055-40056
16	Power Meter	PF signed avg	40057-40058

NOTE

Refer to the Modbus Slave module description in Chapter 5 for detailed descriptions of setup register ranges and defaults.

Modbus Slave Module #3 Source Inputs

Setup Register	Value
Format	signed 32 bit
Base Address	40059
Scaling	YES
In Zero	-214748364
In Full	214748364
Out Zero	-2147483640
Out Full	2147483640

Source Input #	Source / Parameter		Modbus Register
1	Maximum	Vll avg MAX	40059-40060
2	Maximum	I avg MAX	40061-40062
3	Maximum	kW tot MAX	40063-40064
4	Maximum	kVAR tot MAX	40065-40066
5	Maximum	kVA tot MAX	40067-40068
6	Maximum	Line Freq MAX	40069-40070
7	Minimum	Vll avg MIN	40071-40072
8	Minimum	I avg MIN	40073-40074
9	Minimum	Line Freq MIN	40075-40076
10	SW Demand	kW SWD	40077-40078
11	SW Demand	kVA SWD	40079-40080
12	SW Demand	kVAR SWD	40081-40082
13	Maximum	kW SWD MAX	40083-40084
14	Maximum	kVA SWD MAX	40085-40086
15	Maximum	kVAR SWD MAX	40087-40088

Modbus Slave Module #4 Source Inputs

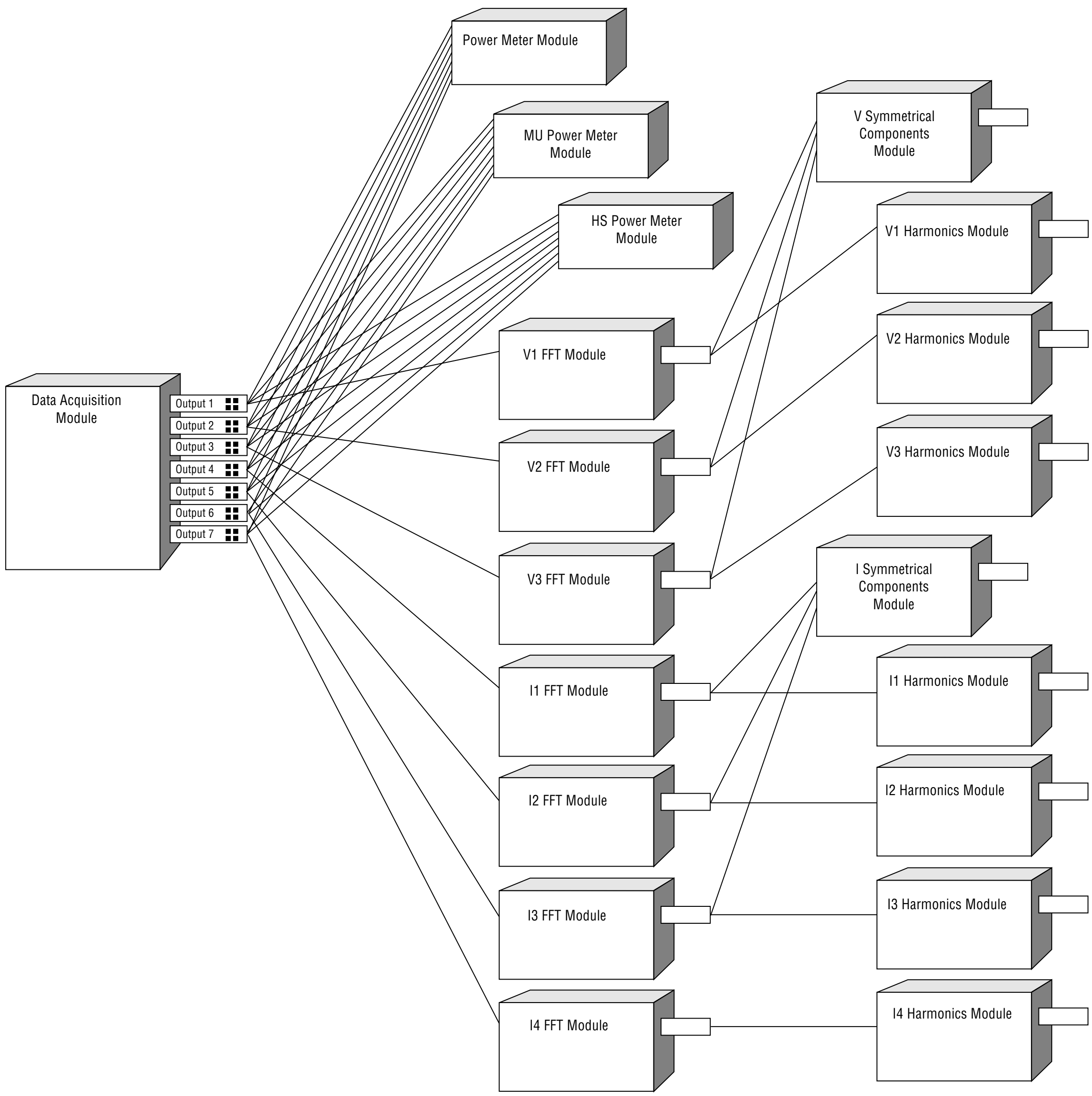
Setup Register	Value
Format	signed 32 bit MFP
Base Address	40089
Scaling	NO

Source Input #	Source / Parameter		Modbus Register
1	Integrator	kWh import	40089-40090
2	Integrator	kWh export	40091-40092
3	Integrator	kWh tot	40093-40094
4	Integrator	kWh net	40095-40096
5	Integrator	kVARh import	40097-40098
6	Integrator	kVARh export	40099-40100
7	Integrator	kVARh tot	40101-40102
8	Integrator	kVARh net	40103-40104
9	Integrator	kVAh tot	40105-40106

Fixed Module Links

The 7700 ION's default configuration includes several fixed module links that cannot be deleted. They are required for the normal operation of the 7700 ION. Output registers that are connected in fixed links can still be connected to other modules as required.

The FFT module provides a good example of fixed links: its inputs are connected to the Data Acquisition module and its outputs are linked to both Harmonics Analyzer modules and Symmetrical Components modules. These links cannot be deleted. Data Acquisition and FFT output registers can still be linked to other module's inputs as required. The following diagram summarizes the fixed module links in the 7700 ION's default configuration.



4 Modular Graphics Terminal

This chapter describes the installation, configuration and operation of the MGT.

In this Chapter

Introduction to the MGT

The MGT, or Modular Graphics Terminal, is an ION-compliant unit that provides a detailed graphics and text display for the 7700 ION and other ION devices. The MGT features an easy-to-read back-lit liquid crystal display with adjustable contrast and a programmable backlight time-out.

The MGT has two basic functions:

- Displaying the values of various ION registers in the connected device.
- Providing basic setup capabilities for the connected device.

To perform these functions, the MGT offers an extremely flexible interface that you can customize to suit your needs. You can select what data you wish to display, as well as the format of the display. Formats include alphanumeric displays in a number of font sizes, as well as bar graphs, harmonics histograms, waveform displays and trending graphs of many of the parameters measured by the connected device. You can specify your own button labels and you can create titles for your display screens.

Installation

The following sections describe how to install the MGT and the MGT Switchbox, and include details about environmental conditions and mounting dimensions. Since the MGT will always be connected to the 7700 ION, you should also refer to Chapter 2 for installation instructions for the 7700 ION.

Environmental Conditions

The MGT should be mounted in a dry, dirt free location. To operate properly and effectively, environmental conditions should fall within the guidelines listed below.

Environmental Condition	Acceptable Range
Operating Temperature	0°C (32°F) to 50°C (112°F)
Storage Temperature	-20°C (-22°F) to +70°C (158°F)
Relative Humidity	5 to 95% non-condensing

The enclosure the MGT is mounted in (typically a switchgear cabinet) should protect it from atmospheric contaminants such as oil, moisture, dust, and corrosive vapors, or other harmful airborne substances.

The mounting enclosure should be positioned such that the doors may be opened fully for easy access to the MGT and the connected device's wiring. This will allow for convenient troubleshooting.

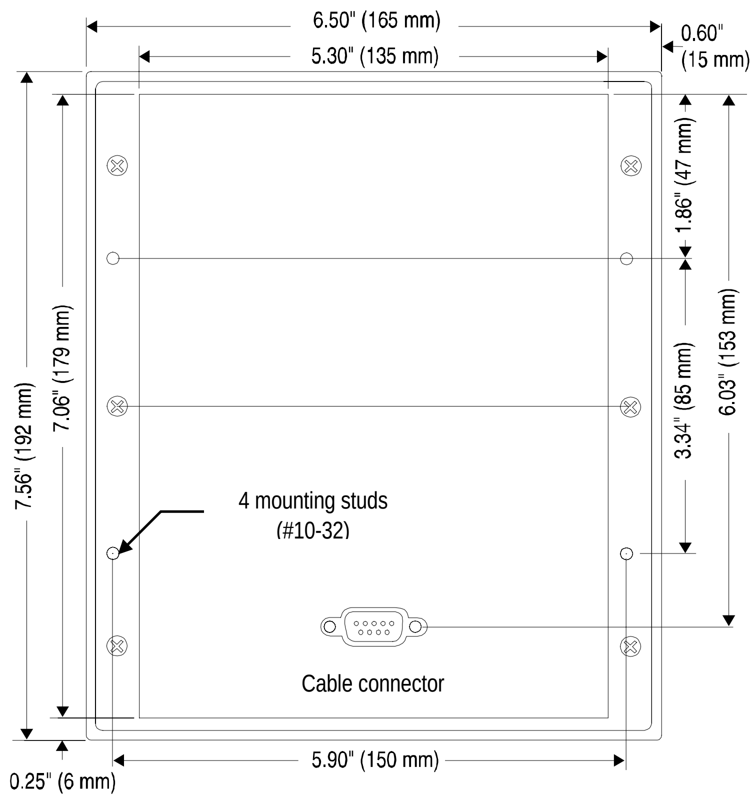
MGT Mounting

NOTE

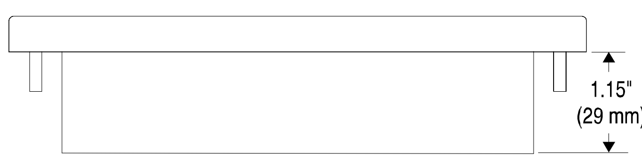
The distance between the mounting locations of the MGT and the 7700 ION will be limited by the length of the interconnecting display cable supplied. The maximum cable length is 61 m (200 ft.)

The MGT can be panel mounted for easy access and viewing. It is typically mounted on the switchgear cabinet door. Panel mounting requires four holes and one cutout. A minimum of 10 cm (4 in.) depth of clearance is required behind the panel to allow for cable connection.

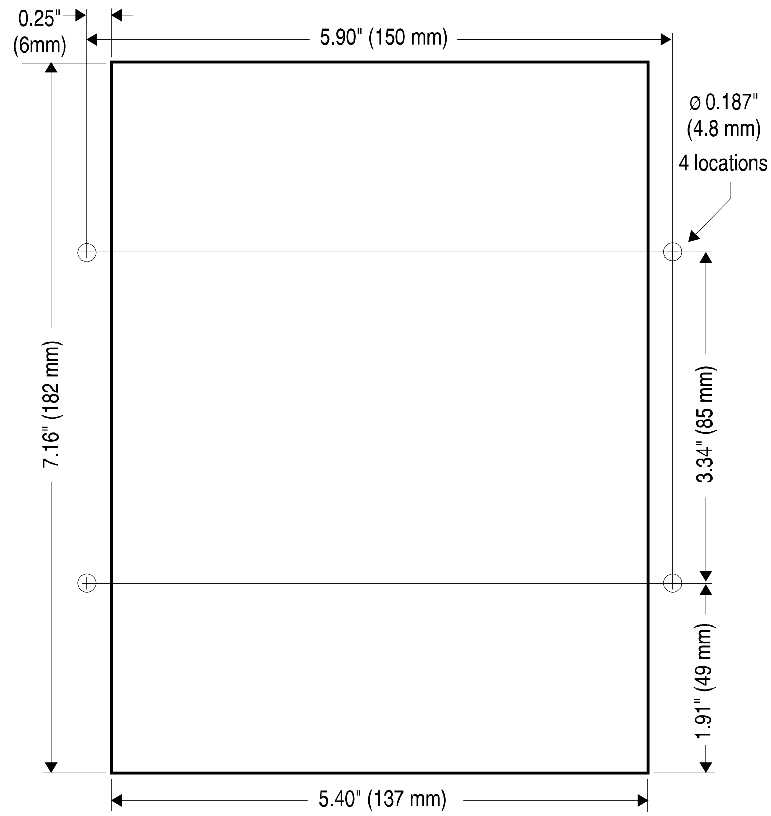
Rear View



Top View



Mounting Holes and Panel Cutout

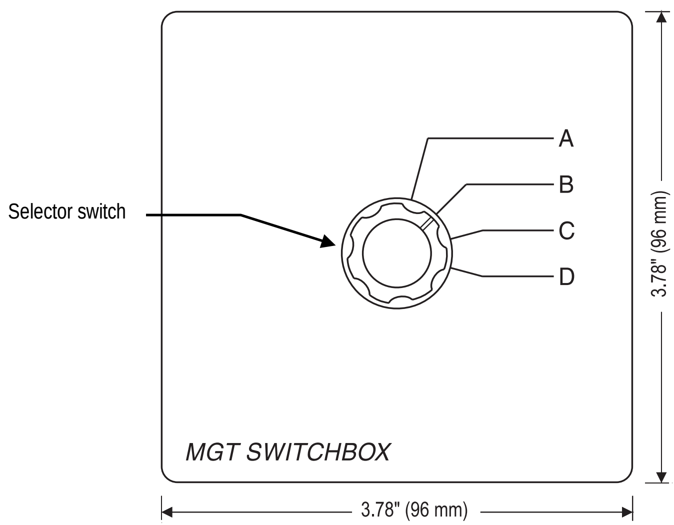


The MGT Switchbox

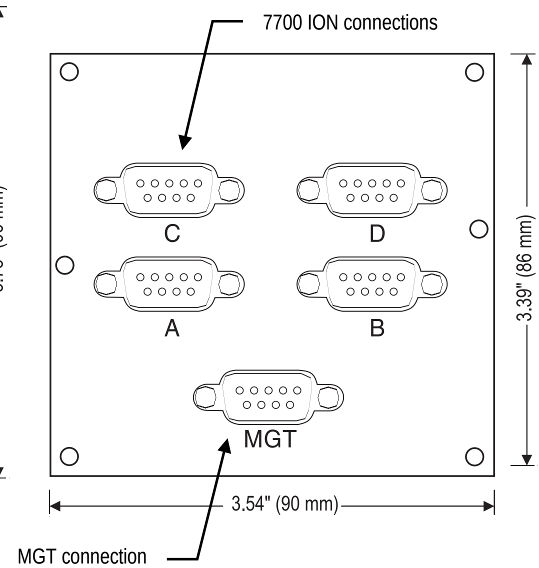
The MGT Switchbox allows you to connect up to 4 7700 IONs to a single MGT. The Switchbox allows you to access any of the connected devices by toggling the selector switch on the front of the unit.

The 4 7700 IONs and the MGT are connected to the back of the Switchbox with standard 9-pin serial cables.

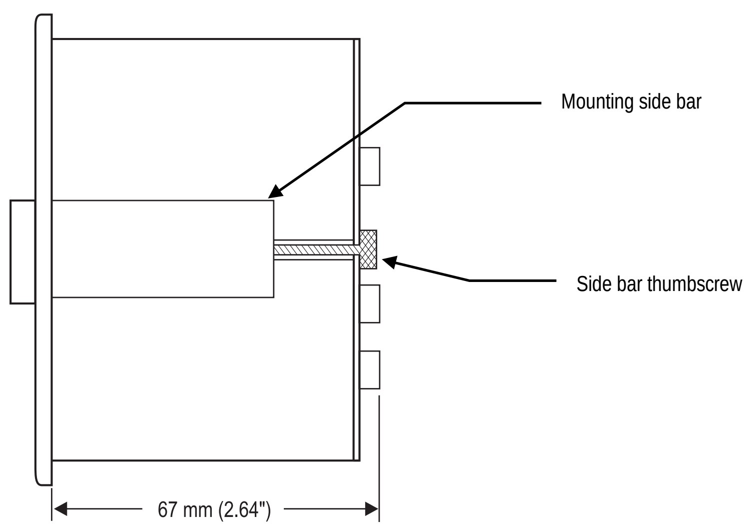
Front View



Rear View



Side View

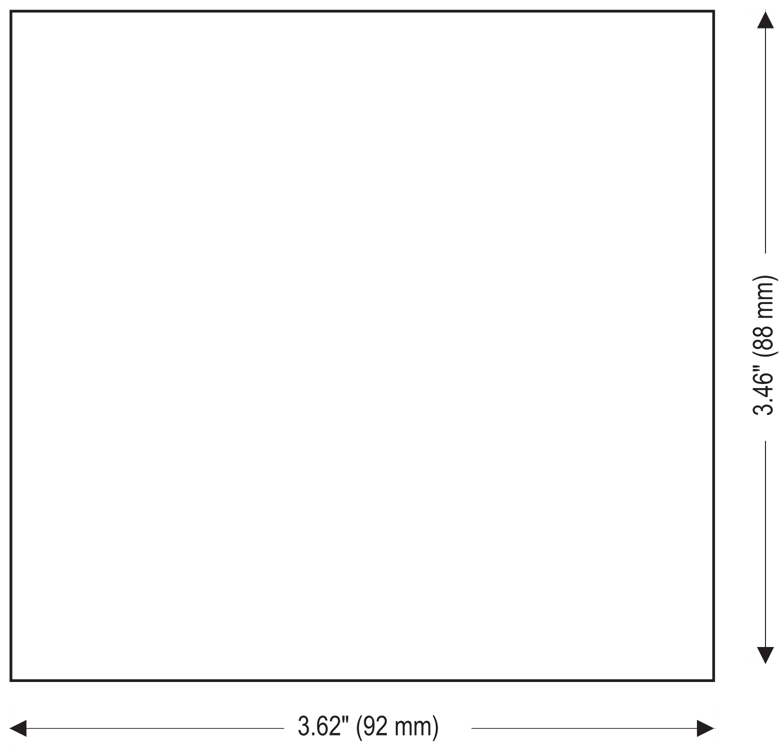


MGT Switchbox Mounting

The MGT Switchbox can be panel mounted for easy access. It is typically mounted on the switchgear cabinet door. Panel mounting requires a single 92 mm x 88 mm (3.62 in. x 3.46 in.) cutout. A minimum of 13 cm (5 in.) depth of clearance is required behind the panel to allow for cable connections.

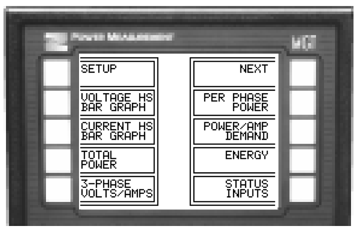
To mount the Switchbox, fit it into the cutout then slide the supplied slide bars into the grooves on either side on the unit. Insert the thumbscrews and tighten them until the slide bars securely anchor the unit to the cabinet door.

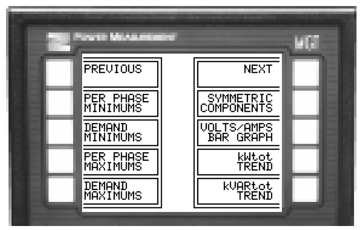
Mounting Cutout

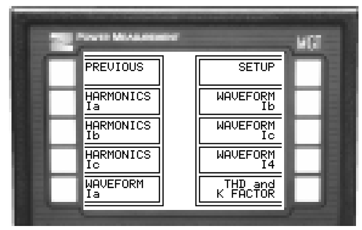


The MGT Menu System

The MGT offers 24 programmable buttons that provide access to various data display screens. The label beside each button on the MGT screen indicates the button's function. The MGT is pre-programmed at the factory with default displays, as shown below, that you can change to suit your particular application (see page 4–19 for more information about configuring the MGT buttons). These three screens comprise the main menu of the MGT, and from them you gain access to all the data display screens as well as the configuration menus.







The top two buttons in each screen are reserved either for scrolling back and forth through the main menu screens or for accessing the setup functions of the MGT.

Password Protection

The MGT provides two levels of password protection; a *user* password and a *backdoor* password. The user password is configured by the user to provide security access to the setup of the connected 7700 ION and the configuration of the MGT's function buttons.

The backdoor password provides access to all of the configurable options of the MGT and the connected ION device. It also provides access to user and backdoor password revision. This password is contained in the MGT when it is shipped from the factory, and does not need to be changed for regular operation. However, if the default backdoor password is maintained, the MGT could be accessed by Power Measurement. If you wish to change the backdoor password, contact Power Measurement with the 7700 ION's serial number, and obtain the backdoor password key. Note that once the backdoor password is changed, Power Measurement will no longer be able to access the MGT; if you forget your new password there will be no way to access the MGT's setup unless the 7700 ION is returned to Power Measurement.

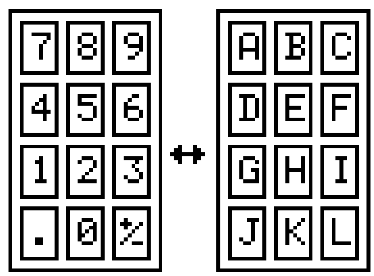
Using the MGT Buttons

The MGT has several different kinds of buttons, some with fixed functions, some with variable functions and some with user-programmable functions. This section describes the basic button functions you will need to program the MGT.

The MGT Keypad Buttons

Most of the functions of the MGT require you to enter alphanumeric information. For example, to specify what parameters in the connected device that you wish to display on the MGT screen, you must enter the appropriate hexadecimal register handles. In other cases, you may have to enter a password, or you may wish to create a title that describes one of the screens that you have set up. The MGT keypad is the means by which you enter all digits and letters.

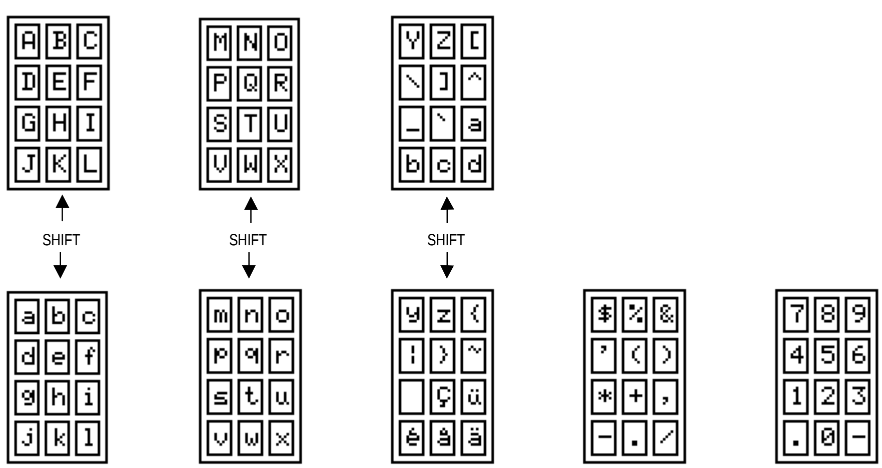
When the MGT requires your input, it displays the following keypad screen.

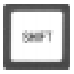


The left side of the above display represents the actual buttons on the front of the MGT. The right side of the display indicates which characters each of the buttons represent. In this case, to enter the character “G”, you would press 1 on the MGT keypad.

To access all the characters that the MGT is capable of displaying, press the right-arrow button to scroll to the next screen of characters. There are 8 keyboard screens in total, offering the following letters, digits and symbols:

Use the left and right arrow buttons to scroll back and forth through the various keypad screens.



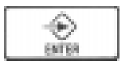


Use this button to toggle between the lower case and the upper case character screens.

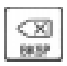
The SHIFT key offers a shortcut for accessing characters on another keypad screen. Similar to the SHIFT key on a computer keyboard, pressing SHIFT on the MGT switches the case of characters. This minimizes the amount of scrolling you have to do, particularly when you are entering mixed-case text.

The MGT Control Buttons

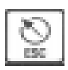
The control buttons of the MGT work very much like comparable keys on a computer keyboard.



After entering text or register handles, press the ENTER key to confirm or implement your selection. In some cases, the MGT will prompt you to press the ENTER key to keep a previous setting.



The BKSP key allows you to step back, one character at a time, to change what you have typed. If you make a mistake entering a register handle, or if you misspell a screen title or button label, you can press the backspace key to correct the mistake. You must press the BKSP key before pressing ENTER or you will have to completely re-enter the text.



The ESC key allows you to exit from any data display screen and return to the main menu. It also allows you to exit from all the device and button configuration screens and cancel any changes you made.

The ALARM display and the MUTE button are not supported in Version 1.0 of the MGT.

Note that the MGT also has a Status LED to indicate when it is operational.

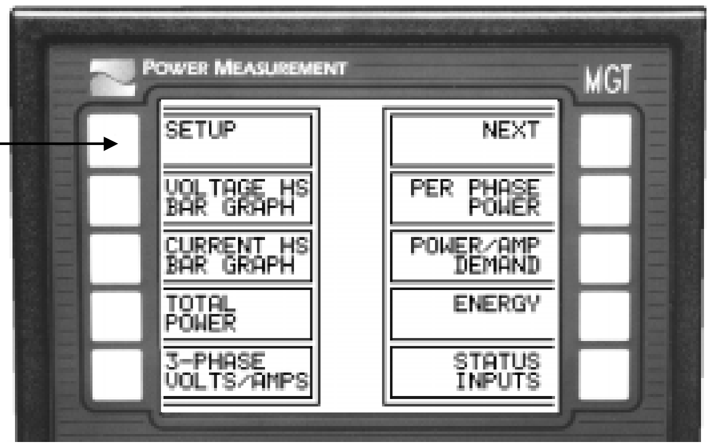
User-Programmable Buttons

Eight of the ten buttons aligned along the sides of the MGT screen are programmable. You can configure these buttons to display a variety of different screens and you can define your own labels for them. The two top-most buttons are reserved for moving back and forth through the main menu screens. Refer to page 4–19 for detailed information about configuring the MGT buttons.

Configuring the MGT and the 7700 ION

The MGT provides basic configuration functions to set up the connected device. It also has several configurable settings of its own. All of the configuration functions are accessed by pressing the SETUP key in the main menu screen. This section details configuring the MGT and the connected 7700 ION.

Pressing SETUP provides access to all the setup screens of the MGT.

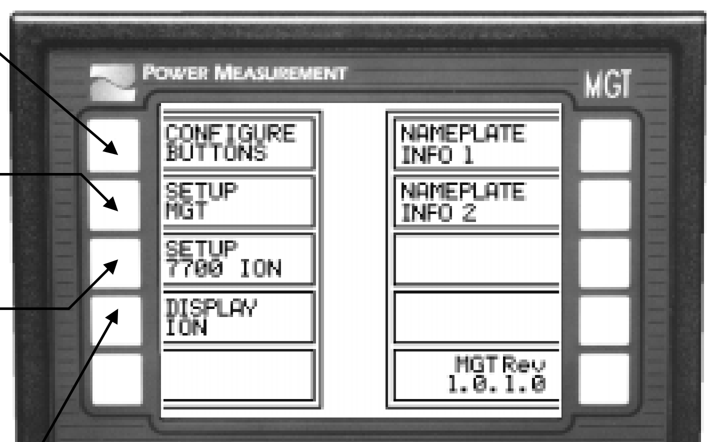


This button is used to customize the MGT's display (as detailed on page 4–19). Access is password protected.

This button provides access to the MGT configuration screens

This button provides access to all the configuration screens for the connected 7700 ION (access is password protected).

This button provides access to the display of register values and labels.



Configuring the MGT

The MGT has several configurable parameters that improve the readability and longevity of its display.

Adjusting the Contrast of the MGT Display

Depending on the angle from which you will view the MGT display, and depending on the surrounding light conditions, you may want to change the MGT's display contrast.

The Adjust Contrast screen previews the contrast setting you have selected so you can make the best choice before pressing ENTER.

To adjust the contrast of the MGT:

1. Press the SETUP button from the main menu, then press the button labeled SETUP MGT.

2. Press the ADJUST CONTRAST button.

3. The MGT has a contrast scale of 0 to 15 where 0 is the lowest contrast and 15 is the highest. Press either the right arrow key to increase contrast or the left arrow key to decrease contrast.

4. Press ENTER to confirm your choice or ESC to exit the screen and cancel your changes.

The contrast level you select affects the display when the back-lighting is both on and off. Be sure to select a contrast level that provides a legible display in both cases.

Setting the Backlight Timeout

The bulb that provides the back-lighting for the MGT has a limited life span. To prolong the life of the bulb, you should only have the back-lighting on when you are actively using the MGT (configuring parameters or displaying data). The MGT has a programmable timeout feature that turns off the back-lighting if the MGT is idle for more than a specified amount of time.

To specify the timeout setting:

1. Press the SETUP button from the main menu, then press the button labeled SETUP MGT.

2. Press the BACKLIGHT TIMEOUT button.

1. You can specify a timeout of 1 to 3599 seconds. Use the number pad to enter the number of seconds you wish.

2. Press ENTER to confirm your choice or ESC to exit the screen and cancel your changes.

NOTE

The longer a timeout period you specify, the longer the back-lighting will remain on when the MGT is left idle. This will decrease the lifespan of the bulb.

Selecting the Number Format

To conform to different world and industrial standards, the MGT allows you to specify what delimiter you wish to use when displaying numbers. To change this delimiter, press the SETUP button from the main menu, then press the button labeled SETUP MGT. The NUMBERS X.XXX button allows you to toggle between:

- 123.4 This is the default. A decimal point is used for the decimal delimiter.
- 123,4 A comma is used for the decimal delimiter.

Configuring the Connected Device

The ION device to which the MGT is connected can be configured, to a limited extent, via the MGT. Normally, initial device setup should be performed with Power Measurement's PEGASYS software, which offers a more powerful graphical user interface and a more global view of the system in which the device is a component. The MGT interface is ideal for field installation, quick device adjustments, and for use by maintenance personnel while at the installed location of the device.

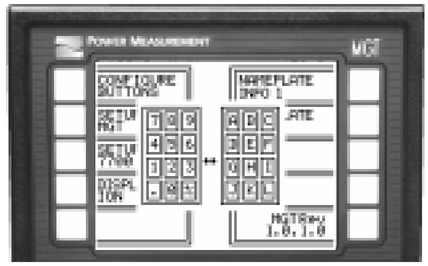
You can specify the values of the device's setup registers via the MGT; however, you cannot link its ION modules together. Typically, the first registers you should configure are the setup registers of the Power Meter modules on the connected device. This will allow the device to begin monitoring and measuring real-time values from the connected power system. Refer to Chapters 3 and 5 for specific information about all of the supported ION modules, what registers to set up, and module default settings. Appendix B provides all of the hexadecimal register handles for the ION modules.

The following sections provide general information about displaying and changing register values and labels on the connected device using the MGT. All the following functions are accessible via the following menu screens:

To gain access to SETUP 7700 ION, you must first enter the user password. The password is factory set at '0'. Immediately after you press SETUP 7700 ION, you will be presented with the keypad screen where you enter the password.

NOTE

The MGT's user password is factory set at 0.



Using the keypad, enter the password, then press ENTER.

To perform the tasks described below, you must enter hexadecimal register handles. Refer to Appendix B for a complete list of the 7700 ION's registers and register handles.

Displaying and Editing Register Values

The MGT allows you to display registers on the connected device, and it also allows you to edit any of the setup registers. With these two functions you can perform a basic configuration for the connected device. Note that not all register values can be displayed in this screen; for example, a log register or a waveform register has too much information and must be displayed via a data display screen instead. The table below lists the different register classes and indicates which ones can be displayed and edited in the device setup screens:

Register class	Abbreviation on MGT Screen	Symbol	Displayable/Editable on Display Register screen?
Numeric	NVReg	■	✓
Numeric Bounded	NBReg	▣	✓
Boolean	BVReg	◑	✓
Pulse	PLReg	⋀	✓
Enumerated	ENReg	≡	✓
Numeric Array			×
Waveform			×
Event			×
Event Log			×
Log			×

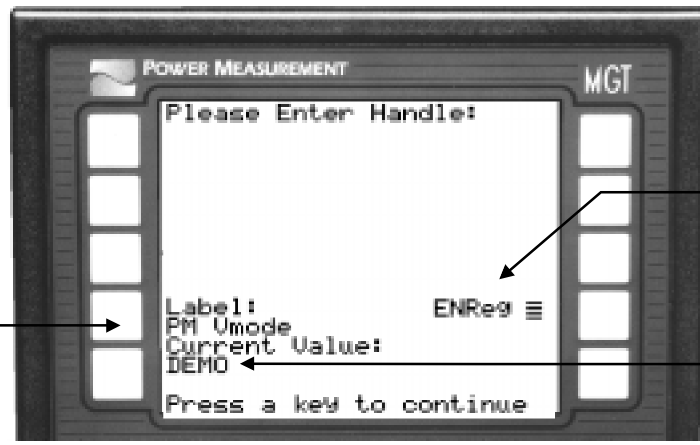
To display the value of a register in the connected device:

1. Press the SETUP button from the main menu, then press the button labeled DISPLAY ION.

2. Press the button labeled DISPLAY REGISTER.

3. Using the keypad, enter the handle of the register you wish to view, then press ENTER. The following screen appears:

The register label is displayed. In this example, the register displayed is the Volts Mode setup register of the Power Meter module.



The register class is indicated along with the

The value of the register is displayed. In this example the Power Meter module has been set to Demo mode.

The label displayed can be either the default name of the register, or a custom user label if one has been specified. The value of the register can contain text, or a number, depending on the class of the register. Pressing any button on the MGT will return you to the device setup screen.

To edit the value of a register in the connected device:

1. Press the SETUP button from the main menu, then press the button labeled SETUP 7700 ION.

2. Using the keypad, enter the password as described on page 4-13, then press ENTER.

3. Press the button labeled EDIT REGISTER.

4. Using the keypad, enter the handle of the register you wish to edit. Note that the only registers you are allowed to edit are setup registers, and if the connected device supports them, External Control module output registers. The following screen appears:

Again, the label displayed can be either the default name of the register, or a custom user label if one has been specified. The current value of the register can contain text, or a number, depending on the class of the register.

3. Using the keypad, enter the new value you wish the register to contain. For numeric bounded registers, this will involve entering numbers. For enumerated registers, it will involve selecting an option from a list using the Up and Down arrow keys on the MGT.

4. Press ENTER. Once you have entered your new value, the MGT indicates if the register was updated by displaying the message "Register Written...". Pressing any button on the MGT will return you to the device setup screen.

Displaying and Editing Register Labels

ION registers have labels that you can customize to suit the application in which the register is used. For example, you may want to identify the Status output register of one of your setpoint modules as "Over Voltage SP" to clearly indicate its function. If you don't specify a custom label for a register, its name is used by default.

To display the label of a register in the connected device:

1. Press the SETUP button from the main menu, then press the button labeled DISPLAY ION.

2. Press the button labeled DISPLAY LABEL.

3. Using the keypad, enter the handle of the register you wish to view, then press ENTER.

4. The current label is displayed; it can be either the default name of the register, or a previously defined custom user label. Pressing any button on the MGT will return you to the device setup screen.

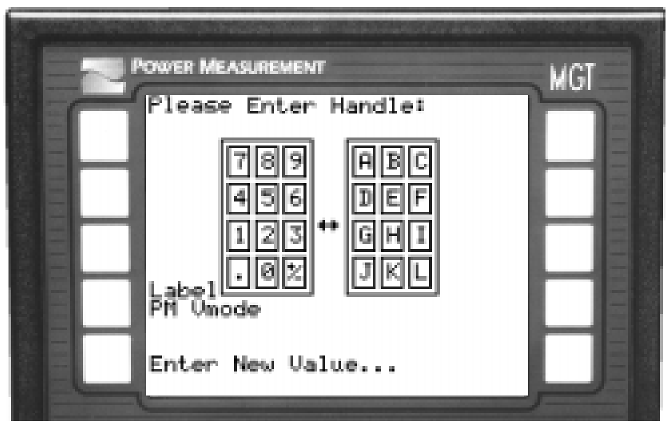
To edit the label of a register in the connected device:

1. Press the SETUP button from the main menu, then press the button labeled SETUP 7700 ION.

2. Using the keypad, enter the password as described on page 4-13, then press ENTER.

3. Press the button labeled EDIT LABEL.

4. Using the keypad, enter the handle of the register whose label you wish to edit. The following screen appears:



The current register label is displayed; it can be either the default name of the register, or a previously defined custom user label.

3. Using the keypad, enter the new label for the register. You can use any of the characters, numbers or symbols shown in the figure on page 4–9. The length of the new label must be limited to 15 characters.

4. Press ENTER. Once you have entered your new value, the MGT indicates if the label was updated by displaying the message “Register Written...”. Pressing any button on the MGT will return you to the device setup screen.

Displaying and Editing Boolean ON and OFF Labels

In addition to register labels, you can also specify labels for Boolean registers that are associated with the register’s ON and OFF conditions. These Boolean ON and OFF labels allow you to indicate what effect the current state of the register is having. For example, you may have a Boolean register controlling a relay that in turn controls a fan; when the Boolean register is OFF, the fan gets turned on and when the register is ON, the fan is turned off. By specifying an OFF label of “Fan Running” and an ON label of “Fan Off”, you can immediately see what effect the register is causing without having to retrace all the logic involved.

To display the ON or OFF label of a Boolean register in the connected device:

1. Press the SETUP button from the main menu, then press the button labeled DISPLAY ION.

2. Press the button labeled DISPLAY ON LABEL or DISPLAY OFF LABEL.

1. Using the keypad, enter the handle of the register whose ON or OFF labels you wish to view, then press ENTER.

2. The current ON or OFF label is displayed. Pressing any button on the MGT will return you to the device setup screen.

NOTE

Only registers of the Boolean class have ON and OFF labels. The MGT will display "Invalid Request" if you attempt to display or edit an ON or OFF label of a non-Boolean register.

To edit the ON or OFF label of a Boolean register in the connected device:

1. Press the SETUP button from the main menu, then press the button labeled SETUP 7700 ION.

2. Using the keypad, enter the password as described on page 4-13, then press ENTER.

3. Press the button labeled either DISPLAY ON LABEL or DISPLAY OFF LABEL.

4. Using the keypad, enter the handle of the register whose ON or OFF labels you wish to edit, then press ENTER. The current ON or OFF label is displayed (it may be partially hidden by the keypad).

5. Using the keypad, enter the new ON or OFF label for the register. You can use any of the characters, numbers or symbols shown in the figure on page 4–9. The length of the new ON or OFF label must be limited to 15 characters.

6. Press ENTER. Once you have entered your new ON or OFF label, the MGT indicates if it was updated by displaying the message "Register Written...". Pressing any button on the MGT will return you to the device setup screen.

Displaying Configuration Information

The MGT provides two screens that show details of the attached ION device's configuration; NAMEPLATE INFO 1 and NAMEPLATE INFO 2. These screens present the configuration information and the device options contained in the device's Factory module. To access the NAMEPLATE INFO screens, press SETUP, then NAMEPLATE INFO 1 or NAMEPLATE INFO 2. Refer to the Factory module description in Chapter 5 for details about this module and its registers.

Displaying Data on the MGT

The primary function of the MGT is to display data from the connected device. The MGT offers 11 different types of display screens, each designed to display specific register classes in a particular format. There are 24 configurable buttons on the MGT and you can assign one of the 11 display screen types to each of these buttons. The MGT is pre-programmed with default screens that you can keep if they are appropriate, or you can change some or all of them to suit an application.

This section details MGT button configuration, standard character screens, large character screens, bar graphs, harmonics, integrators, trending, waveform display and status display.

Configuring the MGT Buttons

All the user-configurable MGT buttons are set up as follows:

1. Press the SETUP button from the main menu, then press the button labeled CONFIGURE BUTTONS.

2. Using the keypad, enter the password.

NOTE

If the button you wish to configure is on another screen, use the buttons labeled NEXT and PREVIOUS to scroll back and forth between the screens of configurable buttons. Press the ESC button to return to the main menu.

1. Press the button that you wish to configure.

2. You will be prompted to enter the first line of the new button label you wish define. Use the keypad to enter the first line of your new button label, then press ENTER. (The first line of the label can be up to 10 characters long.) Pressing ENTER will keep the current button label.

3. Use the keypad to enter the second line of your new button label (again, up to 10 characters) then press ENTER. The following screen appears:

Use the arrow buttons to move up and down between the different screen selections.

3. Select the type of display screen you wish to use, then press ENTER. Depending on the screen type you have chosen, you will be prompted for different information. Setting up each of the display screens is described in detail in the sections that follow. Refer to these sections for instructions about setting them up.

4. When you have specified all the necessary information for the display screen you selected, press ENTER. You will return to the main menu screens and the new button you have specified will appear in the main menu.

Any time you wish to view the data in the screen you have setup, press its button in the main menu. To leave the screen and return to the main menu, press the ESC button.

Interpreting Numbers on the MGT

NOTE

To view data with more than 4 digits of resolution, you must use Power Measurement's PEGASYS software.

When displaying numeric values, the MGT can display 4 digits of resolution. If a value is too large, or too small to be displayed with 4 digits, the MGT uses an abbreviated engineering notation that displays 4 digits and uses standard metric prefixes to indicate the magnitude of the reading. For example,

MGT Display	Interpret Value As:
12m40	0.0124
12K40	12, 400
12M40	12, 400, 000
1G240	1, 240, 000, 000

Most of the numeric values the MGT displays are given in base units; voltages are measured and displayed in volts, current is measured and displayed in amps. There are however several exceptions:

- KW
- KVA
- KVAR

These values are displayed in "kilo" units rather than in base units since these are the units most frequently used. When viewing these parameters via the MGT, remember that the values are already multiplied by 1000. For example, the reading:

KW total... 120K0

indicates 120, 000 kilowatts, *not* 120, 000 watts.

INVLD and EXCEP Messages

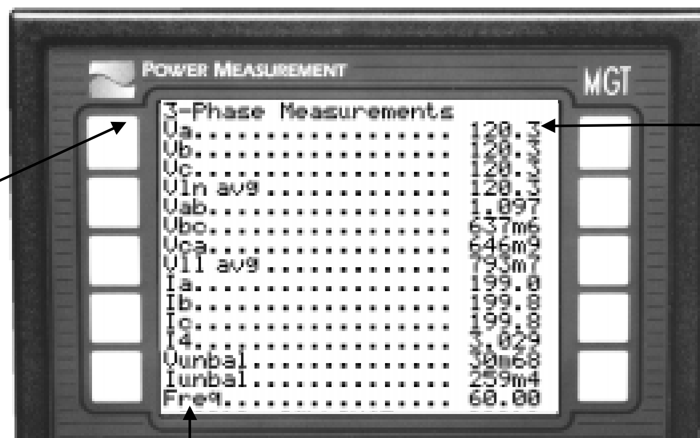
If the MGT is unable to read a value from the attached ION device, it will display either INVLD or EXCEP in place of the value. The INVLD message indicates that the value received cannot be displayed by the MGT, because it is either too large or too small. This will occur if the number is below 1m000 or above 9G999. The EXCEP message will appear if the register you are trying to view is Not Available, or if you have entered an invalid register handle when setting up a custom display screen.

The MGT Data Display Screens

The following sections describe the various data screens that the MGT offers. Depending on your connected device, not all these screens will be available. For example, if your device is not equipped with the Waveform Recorder feature, the MGT's waveform display screen will not be able to display data. Refer to the register class symbol at the start of each section to determine what register classes can be displayed in each screen. (See the table on page 4–14 that summarizes the different register classes and their symbols.)

Standard Character Screens

Standard character screens are used for displaying numeric register values. They present data in small enough characters to include 15 different numeric registers on one screen. These screens are best suited for viewing close-up. Data in standard character screens are updated once per second, regardless of the update rate of the register on the connected device.



The title is displayed here.

The value in the register is displayed and updated once per second.

The programmable register label is displayed (or the register name if no label has been setup).

NOTE

If you have already set up a standard character screen and you want to change some of the registers you are displaying but not all of them, use the button labeled KEEP PREVIOUS button to keep the old registers.

The KEEP PREVIOUS button is also available in most of the other MGT display screens.

To set up a standard character screen:

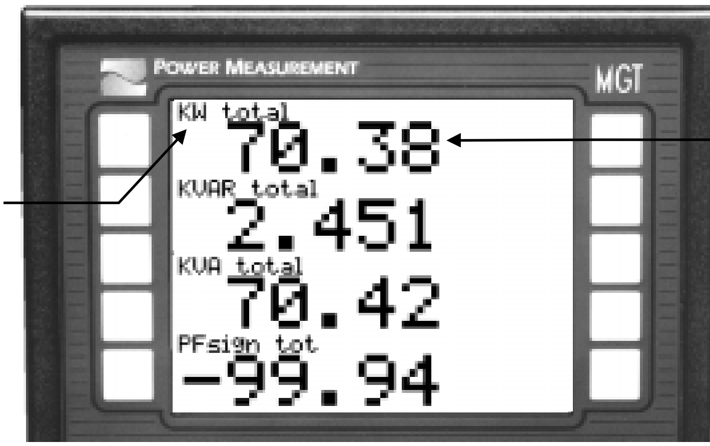
1. Enter the register handle of the first register you wish to display on the screen, then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

2. Repeat step 1 for the remaining 14 registers that you wish to display. If at any point you wish to return to the main menu and cancel your changes, press the ESC button. You do not have to specify a handle for every register if you do not want to use all 15 lines. Pressing ENTER will skip a line; in the display screen, that line will be left blank.

3. Once you have entered the register handles, you are prompted for a title for the display screen. Enter a title of up to 26 characters, then press the ENTER button. If you wish to keep the title that is currently in use, press the button labeled KEEP PREVIOUS.

Large Character Screens

Large character screens are also used for displaying numeric register values. They display up to four registers on one screen. The large character format is well- suited for viewing from a distance. Data in large character screens are updated once per second, regardless of the update rate of the register on the connected device.



The register label is displayed (or the register name if no label has been setup).

The value in the register is displayed and updated once per

To set up a large character screen:

1. Enter the register handle of the first register you wish to display on the screen, then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

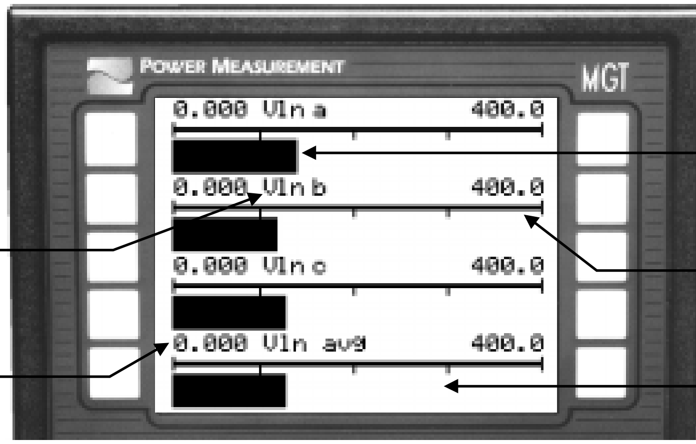
2. Repeat step 1 for the remaining 3 registers that you wish to display. If at any point you wish to return to the main menu, press the ESC button. You do not have to specify a handle for every register if you do not want to use all 4 lines. Pressing ENTER will skip a line; in the display screen, that line will be left blank.

Bar Graph Screens

The MGT offers two different kinds of bar graph screens to display numeric registers on the connected device (a 4-channel and a 6-channel display). These displays offer a graphical representation of fluctuations in the register values and they are suitable for viewing from a distance. For both the 4- and 6-channel displays, you can define a minimum and a maximum boundary of the bar graph and hence control the scale of the graph. If you have linked any of the registers you are displaying to a Minimum or Maximum module, you can also display the minimum and maximum values attained by the register.

4-Channel Bar Graph

The 4-channel bar graph displays four numeric register values in bar graph form. If you are displaying high-accuracy registers, the graph is updated every second. If you are displaying high-speed registers without minimum and maximum values indicated, the graph is updated every 100 msec (with the minimum and maximum values displayed, the update rate is 1 second).



The register label is displayed (or the register name if no label has been setup).

The low boundary of the scale is shown

The value in the register is represented by the position of the bar. No number is given

The high boundary of the scale is shown here.

If you have elected to show min and max bars, they are displayed as the symbols ▷ and ◁.

To set up a 4-channel bar graph screen:

1. Enter the register handle of the first register you wish to display on the screen, then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

1. Enter the minimum boundary for the bar graph scale, then press ENTER. Note that this value should be the lowest value you expect the register to attain. For example, if your bar graph is to display the voltage on phase a, and you expect the voltage to be around 1200 V, you may want to enter 1000 as your minimum boundary. If you wish to keep the value that is currently in use, press the button labeled KEEP PREVIOUS.

NOTE

The closer together your minimum and maximum values are, the more pronounced your graph's response will be to changes in the register value.

2. Enter the maximum boundary for the bar graph scale, then press ENTER. Note that this value should be the highest value you expect the register to attain. For example, if your bar graph is to display the voltage on phase a, and you expect the voltage to be around 1200 V, you may want to enter 1400 as your maximum boundary. If you wish to keep the value that is currently in use, press the button labeled KEEP PREVIOUS.

3. Repeat steps 1 to 3 for the remaining 3 registers that you wish to display. If at any point you wish to return to the main menu, press the ESC button.

1. The next value you are prompted for is the minimum value attained by the first register in the display. If you have linked the first register you are displaying to a Minimum module, you can display that minimum value on your bar graph. To do so, enter the handle of the appropriate Minimum module output register, then press ENTER. If you have not linked to a Minimum module, just press ENTER to continue.

Parameter		Function
5	=	*min for parameter 1*
6	=	*max for parameter 1*
7	=	*min for parameter 2*
8	=	*min for parameter 2*
9	=	*min for parameter 3*
10	=	*max for parameter 3*
11	=	*min for parameter 4*
12	=	*max for parameter 4*

NOTE
The minimum and maximum values attained by the register are not the same as the minimum and maximum boundaries of the scale.

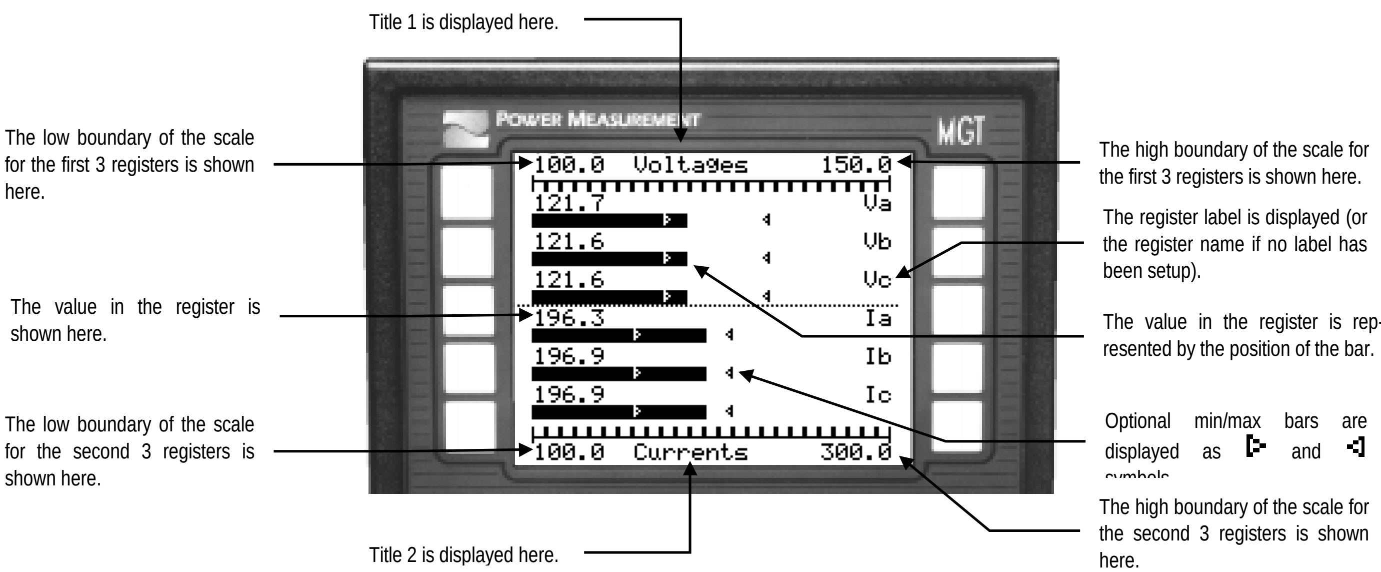
1. Next, you are prompted for the maximum value attained by the first register in the display. If you have linked the first register you are displaying to a Maximum module, you can display that maximum value on your bar graph. To do so, enter the handle of the appropriate Maximum module output register, then press ENTER. If you have not linked to a Maximum module, just press ENTER to continue.

2. Steps 5 and 6 are repeated for the remaining three registers to be displayed in the bar graph.

3. You are prompted to specify if you wish to display min and max bars on the bar graph. If you specified register handles in steps 5 or 6 and you wish to display these values, select 1, then press ENTER. If you have not linked to any Minimum or Maximum modules, or you do not wish to display these values, select 0 and press ENTER.

6-Channel Bar Graph

The 6-channel bar graph displays six numeric register values in bar graph form, and in number form. If you are displaying high-accuracy registers, the graph is updated every second. If you are displaying high-speed registers without minimum and maximum values indicated, the graph is updated every 100 msec (with the minimum and maximum values displayed, the update rate is 1 second).



To set up a 6-channel bar graph screen:

1. Enter the register handle of the first register you wish to display on the screen, then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

2. Repeat step 1 for the remaining 5 registers.

Parameter		Function
7	=	*min for parameter 1*
8	=	*max for parameter 1*
9	=	*min for parameter 2*
10	=	*min for parameter 2*
11	=	*min for parameter 3*
12	=	*max for parameter 3*
13	=	*min for parameter 4*
14	=	*max for parameter 4*
15	=	*min for parameter 5*
16	=	*max for parameter 5*
17	=	*min for parameter 6*
18	=	*max for parameter 6*

1. The next value you are prompted for is the minimum value attained by the first register in the display. If you have linked the first register you are displaying to a Minimum module, you can display that minimum value on your bar graph. To do so, enter the handle of the appropriate Minimum module output register, then press ENTER. If you have not linked to a Minimum module, just press ENTER to continue.

2. Next, you are prompted for the maximum value attained by the first register in the display. If you have linked the first register you are displaying to a Maximum module, you can display that maximum value on your bar graph. To do so, enter the handle of the appropriate Maximum module output register, then press ENTER. If you have not linked to a Maximum module, just press ENTER to continue.

3. Repeat steps 3 and 4 for the remaining 5 registers that you wish to display. If at any point you wish to return to the main menu, press the ESC button.

NOTE

The closer together your minimum and maximum values are, the more pronounced your graph's response will be to changes in the register value.

1. Enter the minimum boundary for the bar graph scale for the first three registers, then press ENTER. Note that this value should be the lowest value you expect any of these registers to attain. For example, if your bar graph is to display current on 3 phases, and you expect it to be around 4000 A, you may want to enter 3000 as your minimum boundary. If you wish to keep the value that is currently in use, press the button labeled KEEP PREVIOUS.

2. Enter the maximum boundary for the bar graph scale for the first three registers, then press ENTER. Note that this value should be the highest value you expect any of these registers to attain. For example, if your bar graph is to display current on 3 phases, and you expect it to be about 4000 A, you may want to enter 5000 as your maximum boundary. If you wish to keep the value that is currently in use, press the button labeled KEEP PREVIOUS.

3. Enter the minimum boundary for the bar graph scale for the second three registers, then press ENTER

4. Enter the maximum boundary for the bar graph scale for the second three registers, then press ENTER.

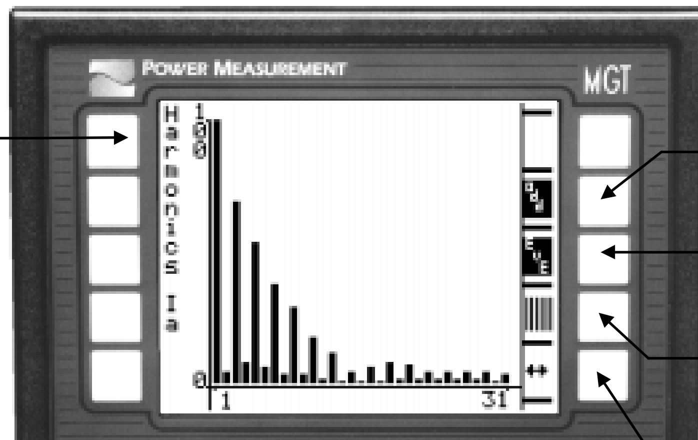
5. You are prompted to specify if you wish to display min and max bars on the bar graph. If you specified register handles in steps 2 or 3 and you wish to display these values, select 1, then press ENTER. If you have not linked to any Minimum or Maximum modules, or you do not wish to display these values, select 0 and press ENTER.

6. Next, you are prompted for a title for the top three bar graphs (Title 1). Enter a title of up to 9 characters, then press the ENTER button. If you wish to keep the title that is currently in use, press the button labeled KEEP PREVIOUS.

7. Next, you are prompted for a title for the bottom three bar graphs (Title 2). Enter a title of up to 9 characters, then press the ENTER button. If you wish to keep the title that is currently in use, press the button labeled KEEP PREVIOUS.

Harmonics Screens

The harmonics screens allow you to display the values calculated by the Harmonics Analyzer module. They appear in a histogram form to show the harmonic spectrum of the input for which harmonics are being calculated. To maximize the resolution of the display, the harmonic with the highest amplitude is scaled to the top of the screen. The display is updated every second.



To set up a harmonics screen:

1. Enter the handle of the first output register of the Harmonics Analyzer module you wish to view, then press ENTER. Note that the harmonics display depends on what register has been linked to the Harmonics Analyzer's input. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

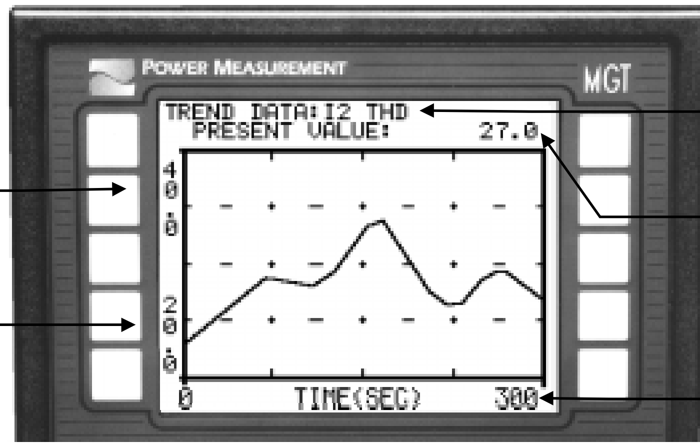
2. Enter a title of up to 15 characters, then press the ENTER button. If you wish to keep the title that is currently in use, press the button labeled KEEP PREVIOUS.

IMPORTANT

You only need to enter the register handle for the first harmonic; the MGT automatically reads the remaining harmonic registers. If you enter an incorrect handle for the first output register, the rest of the readings will be unpredictable.

Parameter Trending Screens

The parameter trending screens plot the value of a register over time. These real-time displays allow you to view a register value graphically. You can specify the scale for the Y-axis of the graph (the register value) and the X-axis (time). The maximum update rate for a parameter trending screen is 1 second.



The high boundary of the scale is shown here.

The low boundary of the scale is shown here.

The register label is displayed (or the register name if no label has been setup).

The value in the register is displayed and updated once per second.

This value depends on the number of seconds you specify between each point.

To set up a parameter trending screen:

1. Enter the handle of the register you wish to plot on the screen, then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

2. Enter the minimum boundary value you expect the register to attain, then press ENTER. This value becomes the minimum boundary of the Y-axis of the trending graph. If you wish to keep the value that is currently in use, press the button labeled KEEP PREVIOUS.

3. Enter the maximum boundary value you expect the register to attain, then press ENTER. This value becomes the maximum boundary of the Y-axis of the trending graph. If you wish to keep the value that is currently in use, press the button labeled KEEP PREVIOUS.

4. Enter the number of seconds you want to elapse between each point on the graph. This determines the scale of the X-axis of the graph. For example, if you specify 1 second between each point, the X-axis will span 150 seconds. If you specify 2 seconds between each point, the X-axis will span 300 seconds. If you wish to keep the value that is currently in use, press the button labeled KEEP PREVIOUS.

NOTE

The closer together your minimum and maximum bounds are, the more pronounced your graph's response will be to changes in the register value.

You do not need to specify a title for a parameter trending screen. It is pre-set to display the label of the selected register (or the register name if no label has been defined). The present value of the selected register is also displayed in numeric format at the top of the graph.

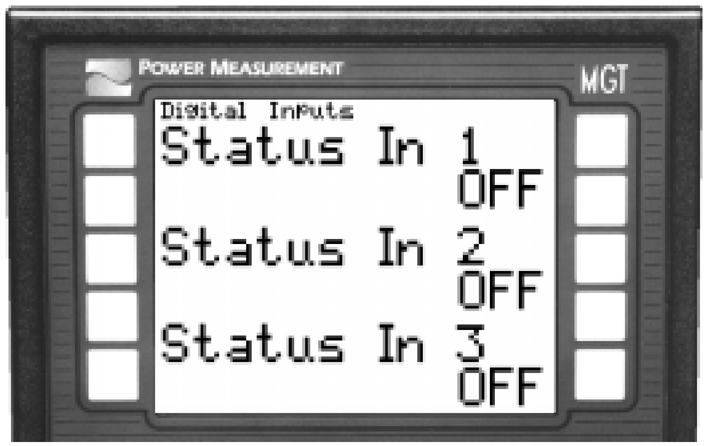
Status Display Screens

◑

Status display screens are used for displaying Boolean register values. They present data in small enough characters to include 3, 7, or 14 different Boolean registers on one screen. Data in status display screens are updated once per second, regardless of the updated rate of the register on the connected device.

Large Status Display

The status display screens with 3 values use large characters and are suitable for viewing from a distance.



To set up a large status display screen:

1. Enter the register handle of the first register whose status you wish to display on the screen, then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

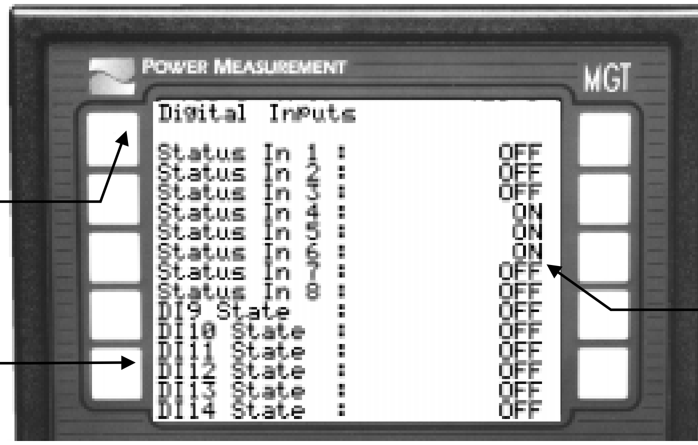
2. Repeat step 1 for the remaining 2 registers whose status you wish to display.

3. Once you have entered the register handles, you are prompted for a title for the display screen. Enter a title of up to 26 characters, then press the ENTER button. If you wish to keep the title that is currently in use, press the button labeled KEEP PREVIOUS.

When you view your status display screen, the labels of the selected registers are displayed; if no labels have been defined, the default register names appear. To the right of each label, the state of the register is displayed. This can be either the associated Boolean ON or OFF label, or, if no Boolean ON/OFF labels have been defined, simply ON or OFF.

7 and 14 Status Display Screens

The screens displaying 7 and 14 values are best suited for viewing close-up.



The screen title is shown here.

The register label is displayed (or the register name if no label has been setup).

The status of each Boolean register is shown. If Boolean ON or OFF label have been defined, these labels are displayed instead.

To set up a 7 or 14 status display screen:

1. Enter the register handle of the first register whose status you wish to display on the screen, then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

2. Repeat step 1 for the remaining 6 or 13 registers (depending on which display you selected) whose status you wish to display.

3. Once you have entered the register handles, you are prompted for a title for the display screen. Enter a title of up to 26 characters, then press the ENTER button. If you wish to keep the title that is currently in use, press the button labeled KEEP PREVIOUS.

When you view your status display screen, the labels of the selected registers are displayed; if no labels have been defined, the default register names appear. To the right of each label, the state of the register is displayed. This can be either the associated Boolean ON or OFF label, or, if no Boolean ON/OFF labels have been defined, simply ON or OFF.

Waveform Display Screens

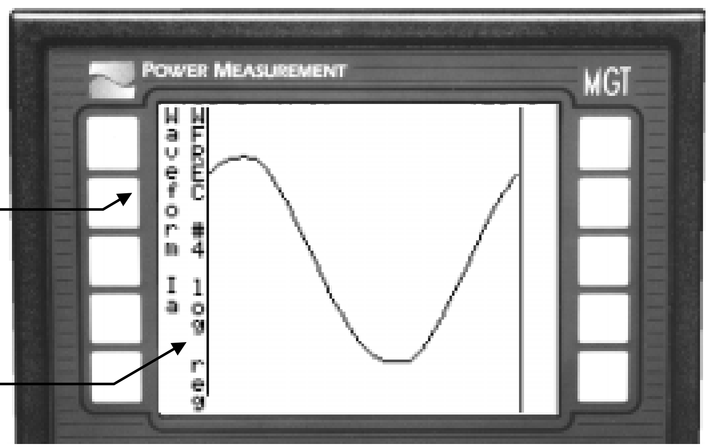
Waveform display screens allow you to display the output of a Waveform Recorder module. They read the data from this module's Wform Log output register and display it graphically based on the scale you define. Depending on how the waveform is formatted, your display may contain from 1 to 8 cycles of waveform data:

Waveform Format	Cycles Appearing on MGT	Resolution (samples/cycle)
128 x 14	1	128
64 x 14, 64 x 28	2	64
32 x 12, 32 x 26, 32 x 40, 32 x 54	4	32
16 x 22, 16 x 48, 16 x 72, 16 x 96	8	16

As the MGT can only display 128 points at a time, it takes the most recent set of waveforms in the Wform Log output register.

The title of the screen is displayed here.

The register label is displayed (or the register name if no label has been setup).



To set up a waveform display screen:

1. Enter the handle of a Waveform Recorder's Wform Log output register, then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

2. Enter a title of up to 15 characters, then press the ENTER button. To keep the title that is currently in use, press the button labeled KEEP PREVIOUS.

NOTE

The source of the waveform depends on which Data Acquisition module output register the Waveform Comb module is linked to. For example, in the 7700 ION, it could be V1, V2, V3, I1, I2, I3, I4, AUX1, AUX2, AUX3, or AUX4.

Integrator Screens

Integrator screens are allow you to display numeric outputs with greater resolution than other displays. They can display up to 4 output values on the MGT at one time, with up to 11 digits of resolution. By default, the MGT includes the ENERGY display; the outputs of Integrator modules #1 through #4.

To set up an integrator display screen:

NOTE

Any ION numeric register can be displayed on an Integrator screen.

1. Enter the handle of an Integrator's Result output register (or other numeric register if desired), then press ENTER. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

2. Repeat step 1 for the remaining 3 registers whose Results you wish to display. If you wish to keep the register that is currently in use, press the button labeled KEEP PREVIOUS.

When you view your Integrator display screen, the labels of the selected registers are displayed; if no labels have been defined, the default register names appear. To the right of each label, the value of the register is displayed.

5 ION Modules

This chapter describes each of the ION modules available in the 7700 ION.

In this Chapter

7700 ION Module Summary

The table that follows shows which modules are included in the 7700 ION and how many of each are available for programming. It also indicates the supported ranges for all the setup parameters as well as any pre-defined defaults.

Explanation of Symbols

◑	Boolean register	▣	Numeric Bounded register
⎍	Pulse register	∿	Waveform register
🗐	Log register	🕮	Event Log register
■	Numeric register	☰	Enumerated register
▪▪	Numeric Array register	🗋	Event register
▦	Calendar register	**T**	String register

Module Name	Total in 7700	High-Speed Capable	Inputs	Output Registers	Setup Registers	Setup Register Options or Ranges	Setup Registers Defaults
Analog Input	up to 10	*none*	*none*	ScaledValu	Zero Scale	-1×10^9 to 1×10^9	0
Optional: 4 internal,				Event	Full Scale	-1×10^9 to 1×10^9	1
up to 6 external†					Port	*variable*‡	NOT USED
Analog Output	up to 6	*none*	Source	Normalized	Zero Scale	-1×10^9 to 1×10^9	0
				Event	Full Scale	-1×10^9 to 1×10^9	1
Optional: up to 6					OutputMode	*not supported*	
external†					Port	*variable*‡	NOT USED
AND/OR	8	8	Source 1...8	Result	Mode	AND, OR, NAND, NOR	AND
				Trigger	EvLog Mode	LOG ON, LOG OFF	LOG OFF
				Event			
Arithmetic	2	*not applicable*	Source 1...8	Result 1...8	Formula		
			Enable	Event			
			Reset				
			Calc Now				
Clock	1		*fixed*	UTC	TZ Offset		
				Local Time	DST Offset		
				DST	DST Start		
				Event	DST End		
Communications	1	*not applicable*	*none*	Event	Comm Mode	RS232, RS485	RS485
					Baud Rate	300, 1200, 2400, 4800, 9600, 19200	9600
					HshakeMode	RTS/CTS, RTS WITH DELAY	RTS WITH DELAY
					RTS Level	NORMAL, INVERTED	NORMAL
					CTS Level	NORMAL, INVERTED	NORMAL
					RTS Delay	0 to 1 s	0.010
					Unit ID	1 to 9999	*last 4 digits of serial #*

Module Name	Total in 7700	High-Speed Capable	Inputs	Output Registers	Setup Registers	Setup Register Options or Ranges	Setup Registers Defaults
Counter	10	*none*	Count	Accumulatr	Multiplier	-1×10^9 to 1×10^9	1
			Reset	Event	Count Mode	DOWN, UP	UP
Data Acquisition	1	1*	*none*	V1, V2, V3, I1, I2, I3, I4, AUX1, AUX2, AUX3, AUX4			
Data Recorder	20	20	Source 1…16	Rec Log	Depth	0 to 4×10^9	0
			Enable	Log State	RecordMode	CIRCULAR, STOP-WHEN-FULL	CIRCULAR
			Record	Event	EvLog Mode	*not supported*	
			Rearm				
Digital Input	up to 38	38†	*fixed*	State	Input Mode	PULSE, KYZ	PULSE
				Trigger	EvLog Mode	LOG ON, LOG OFF	LOG OFF
Basic: 8 internal				Event	Polarity	NON-INVERTING, INVERTING	INVERTING
Optional: up to 30					Debounce	0 to 65.525 s	0
external†					Port	*variable*‡	NOT USED
Digital Output	30	30	Source	State	EvLog Mode	LOG ON, LOG OFF	LOG OFF
			Force ON	Mode	Polarity	NON-INVERTING, INVERTING	INVERTING
Optional: up to 30			Force OFF	Event	PulseWidth	0 to 2×10^6 s	0
external†			Normal		Port	*variable*‡	NOT USED
Event Log	1		Event 1…N	Event Log	Depth	0 to 20 000	500
Controller					Protection	128	128
External Boolean	32	0		Switch			
External Numeric	8	0		Numeric			
External Pulse	128	0		Trigger			

* These modules are factory-set as high-speed.
† See Chapter 3 for details about external I/O hardware modules.
‡ The ports available depend on the hardware options you have. See Chapter 3 for details.

Module Name	Total in 7700	High-Speed Capable	Inputs	Output Registers	Setup Registers	Setup Register Options or Ranges	Setup Registers Defaults
Harmonics Analyzer (1 for each voltage and current input)	7	*none*	Source§ Enable	HD1...HD63 Total HD Tot EvenHD Tot OddHD K Factor *(current inputs only)* Event			
Integrator	16	*none*	Integrand Enable Reset	Result Trigger Event	Divisor	1 to 1 000 000 seconds	3600 seconds
					Int Mode	FORWARD, REVERSE, ABSOLUTE, NET	FORWARD
					Valu/Pulse	0 to 1×10^9	0
					Rollvalue	0 to 1×10^9	0
Maximum	32	32	Source Enable Reset	Maximum Trigger Event			
Minimum	32	32	Source Enable Reset	Minimum Trigger Event			
One-shot Timer	12	12	Enable Start	State Trigger Event	Duration	0.010 to 2×10^6 s	1 s
Periodic Timer	20	20	Enable Sync	Trigger Event	Period	0.010 to 2×10^6 s	900 s
					Sync Mode	NO TRIG ON SYNC, TRIGGER ON SYNC	NO TRIG ON SYNC

§ When no register class symbol is given for an input, the input is pre-defined, or pre-linked at the factory.

Module Name	Total in 7700	High-Speed Capable	Inputs	Output Registers	Setup Registers	Setup Register Options or Ranges	Setup Registers Defaults
Power Meter	3	1	V1, V2, V3	Vln a,b,c,avg	Volts Mode	4W-WYE, 3W-WYE , DELTA, SINGLE, DEMO	4W-WYE
			I1, I2, I3, I4	Vll ab,bc,ca, avg	PT Prim	1 to 999999	1200
			Enable	I a,b,c, avg	PT Sec	1 to 999999	120
				KW a,b,c, total	CT Prim	1 to 999999	5000
				KVAR a,b,c, total	CT Sec	1 to 999999	5
				KVA a,b,c, total	I4 CT Prim	1 to 999999	5000
				PFsigned a,b,c, tot	I4 CT Sec	1 to 999999	5
				PFlead a,b,c, tot	V1 Polarity	NORMAL, INVERTED	NORMAL
				PFlag a,b,c, tot	V2 Polarity	NORMAL, INVERTED	NORMAL
				V unbal	V3 Polarity	NORMAL, INVERTED	NORMAL
				I unbal	I1 Polarity	NORMAL, INVERTED	NORMAL
				I4	I2 Polarity	NORMAL, INVERTED	NORMAL
				I residual *(not supported)*	I3 Polarity	NORMAL, INVERTED	NORMAL
				Phase Rev**	I4 Polarity	NORMAL, INVERTED	NORMAL
				Line Freq	PhaseOrder	ABC, ACB	ABC
				Event	Nom Freq	*not supported (factory ordering option)*	60 Hz
					Phase Lbls	ABC, RST, XYZ, RYB, 123	ABC
Pulse Merge	8	8	Pulse In 1…8	Pulse Out	EvLog Mode	LOG ON, LOG OFF	
			Enable	Event			
Pulser	up to 10	*none*	Source	Event	PulseWidth	0.020 to 2 x 10^6 ms	1 s
					OutputMode	PULSE, KYZ	PULSE
Optional: up to 10					Polarity	NON-INVERTING, INVERTING	INVERTING
external‡					Port	*variable*‡	NOT USED

** Not supported for the high-speed Power Meter module.

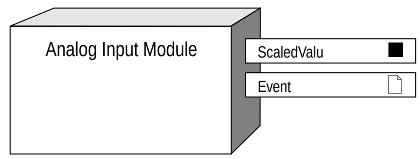
Module Name	Total in 7700	High-Speed Capable	Inputs	Output Registers	Setup Registers	Setup Register Options or Ranges	Setup Registers Defaults
Sag/Swell	1	1	V1-V3	Dist State	Swell Limit	100 to 1000	106
			Nominal	Dist Start	Sag Limit	0 to 100	88
			Enable	Dist End	Change Crit	0 to 100	10
				Dist Duration	Nom Voltage	1 to 1×10^6	1200
				V1, V2, V3 Dist Min	EvPriority	0 to 255	127
				V1, V2, V3 Dist Max			
				V1, V2, V3 Dist Avg			
				V1, V2, V3 Dist Ener			
				V1, V2, V3 SubTrig			
				V1, V2, V3 SubMag			
				V1, V2, V3 SubDur			
				Event			
Scheduler	1	*none*	Enable	Active 1...8			
				Start 1...8			
				End 1...8			
				Event			
Setpoint	24	24	Source	Status	High Limit	-1×10^9 to 1×10^9	0
			Enable	Trigger	Low Limit	-1×10^9 to 1×10^9	0
				Event	SusUntlON	0 to 3 600 s	0
					SusUntlOFF	0 to 3 600 s	0
					Input Mode	SIGNED, ABSOLUTE	SIGNED
					Eval Mode	GREATERTHAN, LESSTHAN	GREATERTHAN
					EvPriority	0 to 255	128
SWD	16	*none*	Source	SWinDemand	Sub Intvl	60 to 5940 s	1800 s
(Sliding Window/			Sync	PredDemand	#SubIntvls	1 to 15	1
Predicted Demand)			Reset	Event	Pred Resp	0 to 99	70

Module Name	Total in 7700	High-Speed Capable	Inputs	Output Registers	Setup Registers	Setup Register Options or Ranges	Setup Registers Defaults
Symmetrical Components (1 for Voltage 1 for Current)	2	*none*	Source 1 Source 2 Source 3 Enable	ZeroSeqMag ZeroSeqPhs PosSeqMag PosSeq Phs NegSeqMag NegSeqPhs Event	Harmonic††	*fixed at fundamental*	
Thermal Demand	16	*none*	Source Reset	ThrmDemand Event	Interval	60 to 5940 s	1800 s
					Time Const	1 to 99 %	90%
Waveform Recorder	14	14	Source Enable Record Rearm	Wform Log Log State Event	Depth	0 to 4 x 10^9	0
					RecordMode	CIRCULAR, STOP-WHEN-FULL	CIRCULAR
					EvLog Mode	*not supported*	
					Format	128X14, 64X14, 64X28, 32X12, 32X26, 32X40, 32X54, 16X22, 16X48, 16X72, 16X96, NOT USED	16x22

†† Not supported in the 7700 ION.

ION 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. This allows you to measure and store analog information (for example, the output of a transducer that is measuring temperature).



Inputs

Analog Input modules have no programmable inputs.

Output Registers

All Analog Input modules have the following output registers:

■ *ScaledValu*
This numeric register contains the scaled version of the hardware input (as defined by the Zero Scale and Full Scale setup registers.

Event
All events produced by an Analog Input are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.

Setup Registers

The setup registers allow you to define a scaling factor for the values taken from the hardware port. All Analog Input modules have the following setup registers:

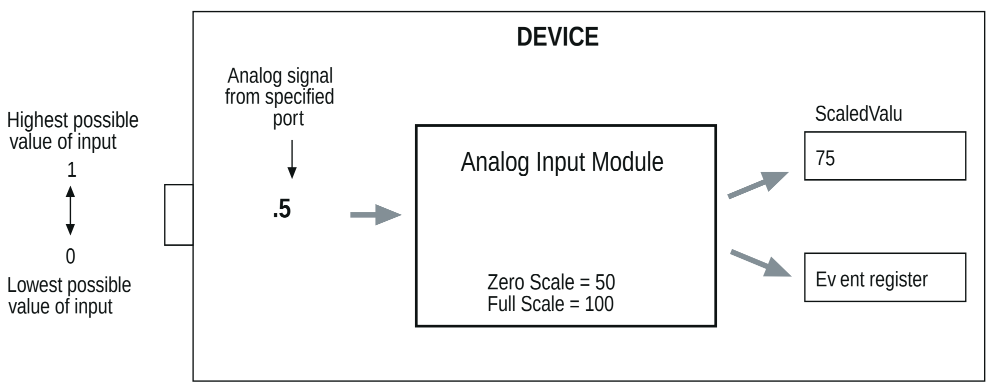
- *Zero Scale*
  This numeric bounded register defines what value appears in the ScaledValu output register when the lowest possible value from the hardware is applied.

- *Full Scale*
  This numeric bounded register defines what value appears in the ScaledValu output register when the highest possible value from the hardware is applied.

- *Port*
  This register defines which hardware port is providing the signal. Refer to the hardware options table in Chapter 3 for a list of available ports.

Detailed Operation

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



Responses to Special Conditions

The following table summarizes how the Analog input module behaves under different conditions.

Condition	Response of Output Register
When the device is started or powered-up (either the first time or after a shut-down)	The Output register's value matches the value at the Analog Input port on the connected device.

7700 ION Device Notes

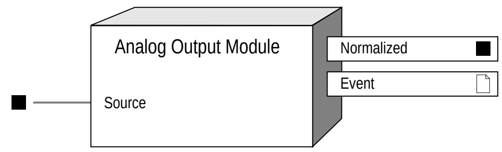
The 7700 ION supports a total of 10 Analog Input modules. Of these, 4 are for internal analog inputs, and up to 6 are provided for external analog inputs (i.e. expansion boards).

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Zero Scale	-1×10^9 to 1×10^9	0
Full Scale	-1×10^9 to 1×10^9	1
Port	The Port register's options are variable, and depend on the options ordered with the 7700 ION. There is no default port; the available ports will be presented when you enter this setup register.	

ION Analog Output Module

This module allows you to control external devices by delivering a specific current or voltage that is proportional to your source input. 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.



Inputs

All Analog Output modules have the following inputs:

■ *Source*
The Analog Output module takes the value of this input, scales it and sends it to a hardware port. It must be a numeric register from another module's output registers. Linking this input is mandatory.

Output Registers

All Analog Output modules have the following output registers:

■ *Normalized*
This numeric register contains a normalized value (i.e. between 1 and 0) proportional to the state of the output on the analog hardware port. For example, if the Source input is 50 and the Zero Scale and Full Scale setup registers are set to 0 and 200 respectively, the value in the Normalized output register will be 0.25.

🗋 *Event*
All events produced by an Analog Output module are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.

- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The setup registers of the Analog Output module define the scale to which the value in the Source input should be fit and select the hardware port to which the output is sent. All Analog Output modules have the following setup registers:

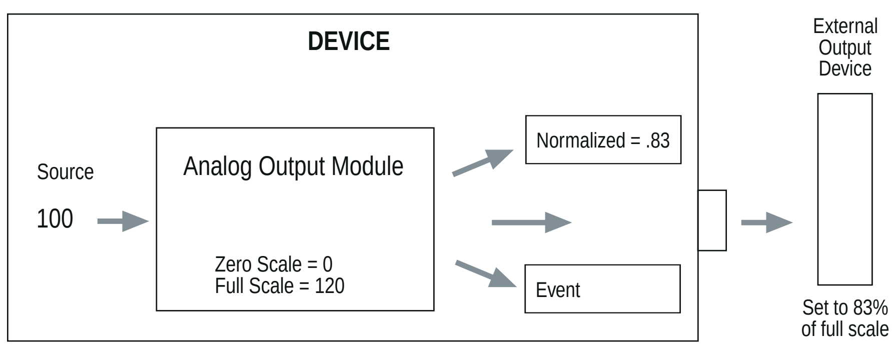
▣ *Zero Scale*
This numeric bounded register should be set to the value on the Source input that will create the minimum possible output on the analog hardware port.

▣ *Full Scale*
This numeric bounded register should be set to the value on the Source input that will create the highest possible output on the analog hardware port.

☰ *Port*
This register determines to which hardware port the output is sent. Refer to the hardware options table in Chapter 3 for a list of available ports.

Detailed Operation

The figure below illustrates the operation of the Analog Output module. The Source input falls between the Zero Scale and Full Scale values. It is scaled and the result is sent to the specified hardware port (the Port setup register can be set to whatever is appropriate). The Normalized output register provides information about the state of the hardware; in this case, the output on the hardware port 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.

Responses to Special Conditions

The following table summarizes how the Analog Output module behaves under different conditions.

Condition	Response of Output Register
If the Source input is *Not Available*	The Output register holds the last value obtained while the Source input was available.
When the device is started or powered-up (either the first time, or after a shut-down)	The Output register's value matches the hardware port's value. Supported analog output devices will hold the lowest values in their operating range at power-up. Refer to the Technical Specifications for the analog output device you are using.

7700 ION Device Notes

The 7700 ION supports a total of 6 Analog Output modules, for use with external analog outputs (i.e. expansion boards).

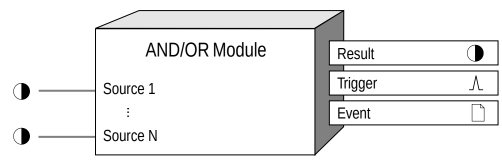
The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Zero Scale	-1×10^9 to 1×10^9	0
Full Scale	-1×10^9 to 1×10^9	1
Port	The Port register's options are variable, and depend on the options ordered with the 7700 ION. There is no default port; the available ports will be presented when you enter this setup register.	

ION AND/OR Module

AND/OR modules are flexible tools that allow you to logically link together Boolean registers. You can then initiate an action based on the condition of a combination of these registers. A common application for this module is "ORing" multiple setpoints to the same Digital Output module which may control a relay external to the device.

An AND/OR module monitors a number of Boolean registers and performs an AND/NAND or OR/NOR calculation on them. The calculation result, which is also a Boolean variable, is written into the Result register. For example, you may want to monitor the condition of three other Boolean registers and respond only if they are all ON at the same time. You can also control if the AND/OR modules produce events.



Inputs

NOTE
You only need to link the first Source input for the module to operate; linking the remaining inputs is optional.

◑ *Source*
All AND/OR modules have inputs called *Source* inputs. The AND/OR module uses these inputs to calculate the Result output register. You can have multiple Source inputs for each AND/OR module (see the Module Summary in Chapter 3 for the number of Source inputs supported). These inputs must be Boolean output registers from other modules.

Output Registers

All AND/OR modules have the following output registers:

◑ *Result*
This Boolean register contains the result of the AND, OR, NAND, or NOR calculation.

NOTE
Note that no pulse is generated for ON to OFF transitions.

⎍ *Trigger*
Every time the Result output register changes from OFF to ON, the Trigger output register generates a pulse.

Event
All events produced by the AND/OR module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
Input Register Change	15	Boolean input has changed. *
Information	25	*Not Available* input caused output to go *Not Available.*

* These events are only recorded if the EvLog Mode setup register is set to LOG ON.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

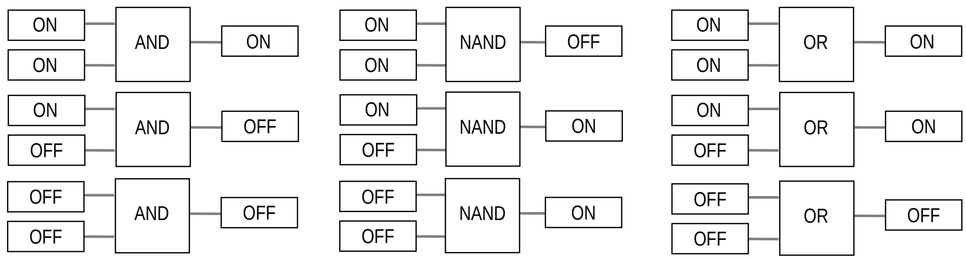
These registers control the operation of the module. All AND/OR modules have the following setup registers:

Mode
This register specifies the type of logical evaluation to be performed. It is an Enumerated register allowing you to select AND, OR, NAND or NOR.

EvLog Mode
This register specifies if changes in the Result output register are recorded as events in the Event output register. If you select LOG ON, these events are logged. If you select LOG OFF, these events are not included in the Event output register. (Note that in either case, linking the module and changing setup registers are still logged as events in the Event register.)

Detailed Operation

The figure below shows the results produced by each logical calculation given a variety of input conditions. Note that the logical calculations operate the same regardless of how many source inputs you have selected.



NOTE

When choosing Sources, ensure that they all have the same update rate. If you mix high-speed and high-accuracy inputs, the AND/OR module will give unexpected results.

Linking Source Inputs

You do not need to link all the source inputs on the AND/OR module; however, if you choose to use only a few you must link them consecutively, starting with the first register. The AND/OR module examines each source input and as soon as it comes to an unlinked input, it goes ahead and performs its logical evaluation, ignoring the rest of the source inputs. For example, if you skip the fourth input and link the fifth and sixth, they will not be evaluated.

Using the Module

The following steps outline how to use an AND/OR module. It is not necessary to do these steps in order; for example, you could set all the setup registers first and not actually link to another module until later.

1. The first step in using an AND/OR module is to determine what values you wish to compare. These will become your Source inputs.

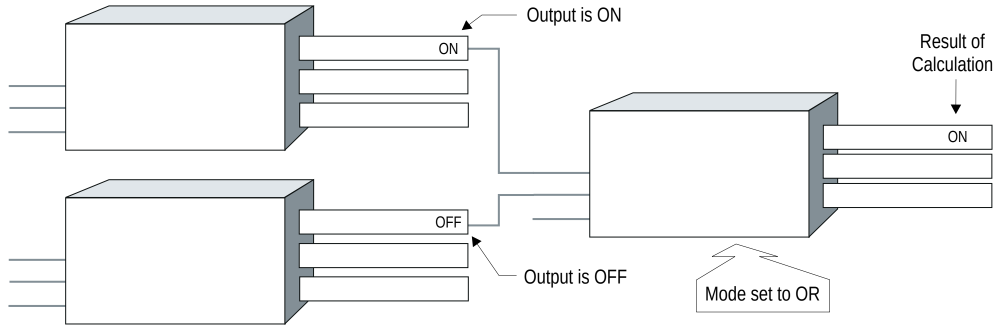
2. The next step is to determine what kind of evaluation you want the module to perform. You can select AND, OR, NAND or NOR via the Mode setup register.

3. Changes in the Result output register can be logged by selecting the LOG ON option using the EvLog Mode setup register.

Once you link an AND/OR module to its sources, they are evaluated and the Boolean result is written into the Result output register. Every time the Result changes from OFF to ON, a pulse is generated in the Trigger output register. Note that if *any* of the input registers becomes Not Available, the Result output register will be set to Not Available.

Example

The example below illustrates how you can link an AND/OR module to the Boolean output registers of two other modules.



Responses to Special Conditions

The following table summarizes how the AND/OR module behaves under different conditions.

Condition	Response of Output Register
If the Source input is *Not Available*	The Result output register becomes *Not Available*.
After the module is re-linked or its setup registers are changed.	The Result output register is *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	The Result output register is *Not Available*.

7700 ION Device Notes

The 7700 ION supports a total of 8 AND/OR modules, and all 8 are high-speed capable.

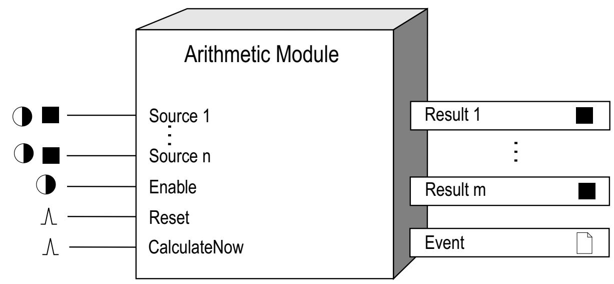
The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Mode	AND, OR, NAND or NOR	AND
EvLog Mode	LOG ON or LOG OFF	LOG OFF

ION Arithmetic Module

The Arithmetic module allows you to apply defined mathematical and logical functions to the inputs, and updates its output registers with the results of the calculations. A wide variety of defined functions are provided, and virtually any type of calculation can be performed.

Many calculations require previous values of a variable in addition to the current value in order to establish a rate of change. The Arithmetic module stores *x* previous values read at each Source input (the number of previous values, *x*, depends on the ION device you are using), and these values are easily referenced in Arithmetic module formulas.



Inputs

CAUTION

If you have linked the Arithmetic module's Source inputs using the ION Designer graphic user interface, unlinking any of them can change the results you obtain from your formulas.

When any existing Source input is unlinked, the Source inputs that come after it in numerical sequence are each shifted up by one to fill the space.

For example, if you have the first 5 inputs linked, then you unlink input 2, the inputs 3 through 5 are shifted up and become inputs 2 through 4. If you had previously referenced Source input 4 in any of your formulas, you would have to revise those formulas to reference Source input 3.

■ ◑ *Source 1 - n*

These are the inputs upon which the Arithmetic module's calculations can be performed. They can be numeric or Boolean registers from any other module's outputs. Linking these inputs is optional; any input you do not link will not have a value available for use in calculations. The number of Source inputs available depends on the ION device you are using (see Device Notes).

◑ *Enable*

This input enables or disables the Arithmetic module (by setting it to ON or OFF, respectively). Calculations on the formulas contained in the setup registers are not performed when the module is disabled. This input is optional; if you leave it unlinked, the module will be enabled by default.

Reset

This input resets the Arithmetic module. It can be linked to a pulse output from any other module's output. This input is optional; if you leave it unlinked it will never receive a pulse. All previous Source input values stored in memory become "Not Available" when a Reset occurs. Note that the Reset input overrides the Enable input: a Reset will clear previous values even when the module is disabled.

CalculateNow
The Arithmetic module performs the calculations contained in its setup registers when this input is pulsed. This input can be the pulse output of any other module. If CalculateNow is not linked, the formulas in the module's setup registers will be calculated at the default rate of the ION device you are using (usually 1 second — see Device Notes).

Output Registers

NOTE
Unlike other modules, the Arithmetic module's output registers do not depend directly on inputs. A Result output will be "Not Available" only if its corresponding setup register contains one of the following:

- a formula that references a Not Available Source input,
- a formula that results in a number that can't be displayed (such as a complex number), or
- no formula at all.

Result 1 - m
These output registers contain the results calculated by the formulas in their corresponding setup registers. The number of Result outputs depends on the ION device you are using (see Device Notes).

Event
Any events produced by the Arithmetic Module are recorded in the Event register. Possible events and their associated priority numbers are shown in the following table.

Event Priority Group	Priority	Description
Reset	5	A module reset has occurred.
Setup Change	10	Input links, setup registers or labels have changed.

The following information is included for each event written into the Event register:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

Formula
The Arithmetic module has one Formula setup register for each Result output register (the number of setup registers depends on the ION device you are using — see Device Notes). This register holds the formula you want the module to calculate. Formulas must conform to the syntax requirements and rules detailed on the following pages. In addition to the stated syntax requirements, formulas cannot contain double-quote characters ("), and must not end with a backslash character (\ ). (Backslashes elsewhere in the formula are permissible, as is a backslash at the end of the formula if it is followed by a space character.)

NOTE
The number of Setup registers, Source input registers and Result output registers depends on the ION device you are using. The number of Source inputs can be different than the number of Result outputs, but there will always be a setup register for each Result output.

The formula you enter in a setup register does not need to reference the corresponding Source input, or any input at all. As long as the formula uses correct syntax (as discussed later) the Result output corresponding to that setup register will be updated with the result of the calculation. Conversely, you can reference any Source input (or combination of Source inputs) in any setup register.

For example, consider the formula SUM(S2:S5) entered into setup register 1. The result of this calculation will be the sum of the Source inputs 2 through 5. This result will be written into the Result 1 output register, even though the calculation is not related to Source input 1.

Formula Rules

Certain rules must be followed when entering formulas into the Arithmetic module's setup registers. In most cases these rules are identical to those followed in conventional mathematics. The following paragraphs detail the rules used in the Arithmetic module, and define the terms used to describe references, functions and syntax errors.

NOTE

Discussions in this section refer to operators and operands. In the simplest form, a formula's operator is the function being performed, and its operand is the number or expression the function is being applied to. For example, in the formula *arcsin(S1)*, the operator is the function arcsin and the operand is S1, the reference to the value held in Source input 1. Formulas can have multiple operators, and many of the supported operators can have multiple operands.

The remainder of this section provides definitions and syntax requirements for the reference operators, functions and constants that can be used in the Arithmetic module.

Numbers, Expressions and Booleans

The sections that follow refer to *numbers*, *expressions* and *Booleans* when describing a function's usage. A *number* can be a constant, or a reference to a Source input or previous Source input value. In any case, *number* is defined as any real number.

An *Expression* is a mathematical "sentence", containing operators and numbers, that can be evaluated into a number. All of the Arithmetic module's supported functions accept expressions as well as numbers as valid operands.

Booleans are a special class of *number*, representing TRUE or FALSE. A Boolean value will result from any expression that can be evaluated to a non-zero number (TRUE), or to zero (FALSE). Arithmetic operators will also return TRUE or FALSE depending on whether their conditions are met; for example, S1=S2 will return TRUE if S1 is equal to S2, or FALSE if S1 and S2 are not equal.

Operator Associativity and Precedence

The following table shows the associativity and precedence of mathematical operators. Arithmetic module associativity and precedence conforms to that used in conventional mathematics.

Operator	Associativity	Precedence
+ or - (unary minus)	right to left	first
power or ^	left to right	second
* or /	left to right	third
+ or -	left to right	fourth
=, <, >, <=, >=, <>, !=, ~=	left to right	fifth

The operators in the above table execute with the associativity and precedence shown, provided there are no extra parentheses included in the formula. You can change the precedence of mathematical operators by placing the expressions that you want evaluated first inside a set of parentheses. Formulas that include multiple sets of parentheses are evaluated “from the inside out”; the expression contained in the innermost set of parentheses is evaluated first.

Syntax Errors in Formulas

After the formula is entered it must be sent to the ION device to be checked for syntax errors. It is recommended that a Send & Save operation is performed after each formula is written.

The following examples show formulas with syntax errors and their resulting error messages. The brackets containing the error will appear in the formula near where the error was detected.

1. This statement has a minus sign in the wrong place:

   sum(p1(1:10),p2(1:10),p3(-1:4))

   and results in the following error message:

   "sum(p1(1:10),p2(1:10) {Syntax error near here} ,p3(-1:4))"

NOTE

The examples on the right contain syntax errors that can only occur with certain ION devices.

2. This statement uses an unsupported previous level; namely 0:

   sum(p1(1:10),p2(1:10),p3(0:4))

   and results in the following error message:

   "sum(p1(1:10),p2(1:10),p3(0:4) {Previous level, 0, is not supported})"

3. This statement uses an unsupported previous level; namely 11. This happens to be larger than the level set for the ION device being used.

   sum(p1(1:10),p2(1:11),p3(1:4))

   and results in the following error message:

   "sum(p1(1:10),p2(1:11) {Previous level, 11, is not supported} ,p3(1:4))"

4. This statement's syntax is correct, but it needs too much internal storage. This is because the Arithmetic module expands all address ranges and previous ranges.

   sum(p1(1:10),p2(1:10),p3(1:5))

   and results in the following error message:

   "Expanded address ranges caused overflow in internal storage."

Reference Definitions

References allow you to call Source inputs, previous Source input values and ranges of values. Definitions and syntax requirements for the supported references and reference operators are provided in this section. The following table summarizes the available reference operators:

Reference	Description	Usage
S	Source input value	S*input#*
:	address range	S*input#1*:S*input#2*
P	previous Source input value	P*input#*(*previous#*) or P*input#*(*previous range*)
:	previous range	*previous#1*:*previous#2*

Referencing Source Input Values

Current values held in Source inputs Source 1 through Source *n* are referenced in formulas using the letter S and the number of the input. For example, Source 1 is referenced by the expression S1, and Source 8 is referenced with S8. The letter S can be uppercase or lowercase.

S (Source input)

Syntax

S*input#*

- *input#* is the Source input number.

Examples

S1 references Source input 1.

Referencing Previous Source Inputs Values

> **NOTE**
>
> By default, Source input values shift to previous values at the update rate of the ION device (usually once per second — see Device Notes). When a current Source input is shifted to previous input 1, all existing previous values shift one step back, and the last previous value is discarded.
>
> You can control when input values shift to previous values by linking the CalculateNow input.

A number of previous Source input values are stored in the ION device's memory and are available for use in Arithmetic module formulas (the number of previous values retained in memory depends on the ION device you are using — see Device Notes). Source input values are shifted to previous values in one of two ways, depending on whether the CalculateNow input is linked or unlinked. If CalculateNow is unlinked, input values shift one step back at the update rate of the ION device (see Device Notes). If CalculateNow is linked, input values shift one step back only when the CalculateNow input is pulsed.

Previous values are referenced using the form Px(y), where x represents the Source input number and y is the number of steps back from the current value. For example, P3(2) calls the second previous value from Source input 3.

P (previous)

Syntax

P*input#*(*previous#*)

- *input#* is the Source input number.
- *previous#* is the number of steps back from the current Source input value.

Examples

P1(1) calls the value from input 1, 1 step back from the current value

P5(6) calls the value from input 5, 6 steps back from the current value

SUM(P3(1:4)) will return the sum of previous values 1 through 4 from Source input 3 (see previous range function)

Reference Range Operators

Range operators can be used to simplify formulas when referencing Source inputs or Previous Source input values.

: (address range)

The Address Range operator provides a way to specify a sequential range of Source input references without having to type each one into the formula.

Syntax

Sinput#1:*Sinput#2*

- *Sinput#1* is the beginning of the sequential range of Source inputs.
- *Sinput#2* is the end of the sequential range of Source inputs.

Examples

SUM(S1:S5) returns the sum of the range S1, S2, S3, S4, S5

MAX(S1:S7) returns the maximum of the range from S1 to S7

: (previous range)

The Previous Range operator provides a way to specify a sequential range of previous Source input values inside the Previous function without having to type each value into the formula.

Syntax

previous#1:*previous#2*

- *previous#1* is the first in the sequential range of previous Source input values.
- *previous#2* is the last in the sequential range of previous Source input values.

Example

P1(1:4) references the Source input 1 previous values 1, 2, 3 and 4 steps back from the current value (see the Previous function)

Function Definitions

There are four types of functions that can be used in the Arithmetic module, classified by the number of operands they may contain. Syntax requirements for each function are detailed in this section.

Single-Operand Functions

Single-operand functions operate on a single *number*, *expression* or *Boolean* operand. The following table summarizes the available functions.

NOTE

Function operators can be entered using any combination of uppercase or lowercase letters.

Single-operand Function	Description	Usage
abs	absolute value	abs(*number*)
arccos	arccosine function	arccos(*number*)
arcsin	arcsine function	arcsin(*number*)
arctan	arctangent function	arctan(*number*)
cos	cosine function	cos(*number*)
ln	natural logarithm	ln(*number*)
log10	base 10 logarithm	log10(*number*)
not	Boolean NOT	not(*Boolean*)
sin	sine function	sin(*number*)
sqrt	square root	sqrt(*number*)
tan	tangent function	tan(*number*)
-	unary minus	-*number* or -(*expression*)

Note that *number* can be replaced by *expression* in the above table, except in the case of the unary minus function.

ABS

Returns the absolute value of a *number* or *expression*.

Syntax

ABS(*number*)

- *number* is the real number for which you want the absolute value.

Examples

ABS(-50) equals 50

ABS(50) equals 50

ARCCOS

Returns the arccosine of a *number* or *expression*. Arccosine is the inverse of cosine; the angle returned from the arccos function is the angle whose cosine is the original *number* entered into the function. The angle returned from the arccos function is given in radians, and will be in the range 0 <= *x* <= PI.

Syntax

ARCCOS(*number*)

- *number* is the cosine of the angle you want and must be in the range -1 <= *number* <= 1.

Examples

ARCCOS(-0.5) equals 2.094395 (2PI/3 radians)

ARCCOS(-0.5)*180/PI equals 120 (degrees)

ARCSIN

Returns the arcsine of a *number* or *expression*. Arcsine is the inverse of sine; the angle returned from the arcsine function is the angle whose sine is the original *number* entered into the function. The returned angle is given in radians in the range -PI/2 <= *x* <= PI/2.

Syntax

ARCSIN(*number*)

- *number* is the sine of the angle you want, and must be in the range -1 <= *number* <= 1.

Examples

ARCSIN(-0.5) equals -0.5236 (-PI/6 radians)

ARCSIN(-0.5)*180/PI equals -30 (degrees)

ARCTAN

Returns the arctangent of a *number* or *expression*. Arctangent is the inverse of tangent; the angle returned from the arctan function is the angle whose tangent is the original *number* entered into the function. The returned angle is given in radians in the range -PI/2 < *x* < PI/2.

Syntax

ARCTAN(*number*)

- *number* is the tangent of the angle you want.

Examples

ARCTAN(1) equals 0.785398 (PI/4 radians)

ARCTAN(1)*180/PI equals 45 (degrees)

COS

Returns the cosine of a *number* or *expression*.

Syntax

COS(*number*)

- *number* is the angle in radians for which you want the cosine.

Examples

COS(1.047) equals 0.500171

COS(60*PI/180) equals 0.5, the cosine of 60 degrees

LN

Returns the natural logarithm of a *number* or *expression*.

Syntax

LN(*number*)

- *number* is the positive real number for which you want the natural logarithm.

Examples

LN(86) equals 4.454347

LN(2.7182818) equals 1

LOG10

Returns the base 10 logarithm of a *number* or *expression*.

Syntax

LOG10(*number*)

- *number* is the positive real number for which you want the base 10 logarithm.

Examples

LOG10(86) equals 1.934498451

LOG10(10) equals 1

LOG10(10^5) equals 5

NOT

Returns the reverse value of a *Boolean*. If the *Boolean* is FALSE, NOT returns TRUE; if the *Boolean* is TRUE, NOT returns FALSE.

Syntax

NOT(*Boolean*)

- *Boolean* can be evaluated to TRUE (non-zero) or FALSE (0).

Examples

NOT(0) equals TRUE

NOT((1+1)=2) equals FALSE

NOTE

The expression SIN(PI) will return 1.22E-16, a number very closely approximating zero. The Arithmetic module interprets this number as non-zero, so it will return TRUE if used as a Boolean test.

SIN

Returns the sine of the *number* or *expression*.

Syntax

SIN(*number*)

- *number* is the angle in radians for which you want the sine.

Examples

SIN(PI) equals 1.22E-16, which is approximately zero (the sine of PI is zero)

SIN(PI/2) equals 1

SIN(30*PI/180) equals 0.5, the sine of 30 degrees

SQRT

Returns the square root of a *number* or *expression*.

Syntax

SQRT(*number*)

- ♦ *number* is the positive number for which you want the square root. If *number* is negative, the associated Result output register will be Not Available.

Examples

SQRT(16) equals 4

SQRT(-16) makes the associated Result output Not Available

TAN

Returns the tangent of a *number* or *expression*.

Syntax

TAN(*number*)

- ♦ *number* is the angle in radians for which you want the tangent.

Examples

TAN(0.785) equals 0.99920

TAN(45*PI/180) equals 1

- (unary minus)

Returns the arithmetic inverse of a *number* or *expression*.

Syntax

-number

-(expression)

- ♦ *number* is the positive real number for which you want the arithmetic inverse.
- ♦ *expressions* you want the inverse of must be enclosed in parentheses.

Examples

-56 equals “minus 56” (the arithmetic inverse of 56)

-(SIN(13.265)) equals the arithmetic inverse of SIN(13.265)

NOTE

Binary operators can be typed into the formula string with or without spaces between operators and operands. It is recommended that spaces are not used, as each space uses a small amount of memory in the ION device.

Binary or Two-Operand Functions

Binary functions operate on two *numbers*, *expressions* or *Booleans*. The following table summarizes the available functions.

Binary Function	Description	Usage
/	division	*number/number*
=	equals	*number=number*
>	greater than	*number>number*
>=	greater than or equal	*number>=number*
<	less than	*number<number*
<=	less than or equal	*number<=number*
-	minus	*number-number*
*	multiplication	*number*number*
<>, ~=, !=	does not equal	*number<>number* *number~=number* *number!=number*
+	addition	*number+number*
POWER, ^	exponent	POWER*(number, number)* *number^number*

Note that *number* can be replaced by *expression* in the above table.

= (equals)

The equals operator is used to test if one *number* or *expression* is equal to another.

Syntax

number1=number2

- The result will be TRUE if *number1* is equal to *number2*, and will be FALSE if *number1* does not equal *number2*.

/ (divide)

The divide operator is used to divide one *number* or *expression* by another.

Syntax

number1 / number2

- ♦ *number1* is the original value (dividend).
- ♦ *number2* is the value that *number1* is divided by (divisor).

Note

If *number2* is zero (0), the corresponding Result output will become Not Available.

> (greater than)

The greater than operator is used to test if one *number* or *expression* is greater than another.

Syntax

number1>number2

- ♦ The result will be TRUE if *number1* is greater (larger) than to *number2*, and will be FALSE if *number1* is less than or equal to *number2*.

>= (greater than or equal)

The greater than or equal operator is used to test if a *number* or *expression* is greater than or equal to another.

Syntax

number1>=number2

- ♦ The result will be TRUE if *number1* is greater (larger) than or equal to *number2*, and will be FALSE if *number1* is less than *number2*.

< (less than)

The less than operator is used to test if one *number* or *expression* is less than another.

Syntax

number1<number2

- ♦ The result will be TRUE if *number1* is less than *number2*, and will be FALSE if *number1* is greater than or equal to *number2*.

<= (less than or equal)

The less than or equal operator is used to test if one *number* or *expression* is less than or equal to some another *number* or *expression*.

Syntax

number1<=number2

- The result will be TRUE if *number1* is less than or equal to *number2*, and will be FALSE if *number1* is greater than *number2*.

- (minus)

The minus operator is used to subtract one *number* or *expression* from another.

Syntax

number1-number2

- *number2* is subtracted from *number1*.

*** (multiply)**

The multiplication operator is used to multiply one *number* or *expression* by another.

Syntax

*number1*number2*

- *number1* and *number2* are multiplied together.

<> (not equal)

The not equal operator is used to test if one *number* or *expression* is not equal to another.

Syntax

number1<>number2

number1~=number2

number1!=number2

- The result will be TRUE if *number1* does not equal *number2*, and will be FALSE if *number1* does equal *number2.*

+ (plus)

The addition operator is used to add one *number* or *expression* to another.

Syntax

number1+number2

- *number1* and *number2* are added together.

power

Raises a *number* or *expression* to the power of another *number* or *expression*.

Syntax

POWER(*number1*, *number2*)

number1^number2

- *number1* is the base number.
- *number2* is the exponent.

Examples

POWER(6,2) equals 36

6^2 equals 36

4^5/4 equals 5.656854

Tertiary or Three-Operand Functions

NOTE

The IF function is unique in that it can return a valid result when one of its operands is a reference to a Not Available Source input.

For example, in the expression *IF(S1, S2, S3)*, if S1 is TRUE, then S2 is returned. In this case, if S3 is Not Available, the function will still return S2 as a valid result. However, if S1 is FALSE, the function will attempt to return S3, and the result will be Not Available.

Tertiary functions operates on three operand expressions. The IF function is the only tertiary operator supported in the Arithmetic module.

Tertiary Function	Description	Usage
IF	if conditional	if(*Boolean*, *number*, *number*)

Note that *number* can be replaced by *expression* in the above table.

IF

Returns one *number* if the *Boolean* test evaluates TRUE (evaluates to a non-zero number), and another *number* if it evaluates FALSE (evaluates to 0).

Syntax

IF(*Boolean*, *number1*, *number2*)

- *Boolean* can be evaluated to TRUE (non-zero) or FALSE (0).
- *number1* is the value that is returned if *Boolean* is TRUE.
- *number2* is the value that is returned if *Boolean* is FALSE.

Example

IF(S1>S2, S3, S4) returns S3 if S1>S2, or returns S4 if S1<=S2

Multiple-Operand Functions

Multiple-operand functions operate on a list of operands. The following table summarizes the available functions.

Multiple-operand Function	Description	Usage
AND	Boolean AND	AND(*Boolean1, Boolean2…Boolean n*)
AVG	average	AVG(*number1, number2…number n*)
MAX	maximum	MAX(*number1, number2…number n)*
MIN	minimum	MIN(*number1, number2…number n)*
OR	Boolean OR	OR(*Boolean1, Boolean2…Boolean n*)
RMS	root mean square	RMS(*number1, number2…number n*)
SUM	summation	SUM(*number1, number2…number n*)
SUMSQ	square of the sum	SUMSQ(*number1, number2…number n*)

Note that *number* can be replaced by *expression* in the above table.

AND

Returns TRUE if all *Booleans* are TRUE; returns FALSE if one or more *Booleans* is FALSE.

Syntax

AND(*Boolean1,Boolean2, ...*)

- *Boolean1,Boolean2, ...* are 1 to *n* conditions you want to test that can be either TRUE (non-zero) or FALSE (0).

Examples

AND(1, 1) equals TRUE

AND(1, 0) equals FALSE

AND(2+2=4, 2+3=5) equals TRUE

If S1:S3 contains the values that evaluate to TRUE, FALSE, and TRUE, then:

AND(S1:S3) equals FALSE

AVG

Returns the average (arithmetic mean) of the *numbers* or *expressions*.

Syntax

AVG(*number1, number2, ...*)

- *number1, number2,...* are 1 to *n numbers* for which you want the average.

Examples

If S1:S5 contains the numbers 10, 7, 9, 27, and 2, then:

AVG(S1:S5) equals 11

AVG(S1:S5, 5) equals 10

MAX

Returns the maximum value in a list of *numbers* or *expressions*.

Syntax

MAX(*number1, number2, ...*)

- *number1, number2,...* are 1 to *n numbers* for which you want the maximum.

Examples

If S1:S5 contains the numbers 12, 7, 9, 27, and 2, then:

MAX(S1:S5) equals 27

MIN

Returns the minimum value in a list of *numbers* or *expressions*.

Syntax

MIN(*number1, number2, ...*)

- *number1, number2,…* are 1 to *n* numbers for which you want the minimum.

Examples

If S1:S5 contains the numbers 42, 7, 9, 27, and 2, then:

MIN(S1:S5) equals 2

MIN(S1:S5, 0) equals 0

OR

Returns TRUE if any *Boolean* is TRUE; returns FALSE if all *Booleans* are FALSE.

Syntax

OR(*Boolean1,Boolean2,…*)

- *Boolean1,Boolean2,…* are 1 to *n* conditions that can be either TRUE (non-zero) or FALSE (0).

Examples

OR(1) equals TRUE (non-zero)

OR(1+1=1,2+2=5) equals FALSE (0)

RMS

Returns the Root Mean Square of the *numbers* or *expression*s.

Syntax

RMS(*number1, number2, ...*)

- *number1, number2, ...* are 1 to *n numbers* for which you want the Root Mean Square.

Examples

RMS(2,3) equals 2.549510

SUM

Returns the sum of the *numbers* or *expressions*.

Syntax

SUM(*number1, number2, ...*)

- *number1, number2,...* are 1 to *n numbers* for which you want the sum.

Examples

SUM(3, 2) equals 5

SUM(S2:S5) equals the sum of Source inputs 2, 3, 4 and 5

SUMSQ

Returns the sum of the squares of the *numbers* or *expressions*.

Syntax

SUMSQ(*number1, number2, ...*)

- *number1, number2,...* are 1 to *n numbers* for which you want the sum of the squares.

Example

SUMSQ(3, 4) equals 25

Constants

Arithmetic module formulas can include the following constant:

Constant	Description
PI	The constant PI; the relationship of a circle's circumference to its diameter.

PI

The constant PI is equal to 3.14159265358979, accurate to 15 digits.

Syntax

PI

Example

4*PI equals 4 times PI, or 12.5664

Detailed Operation

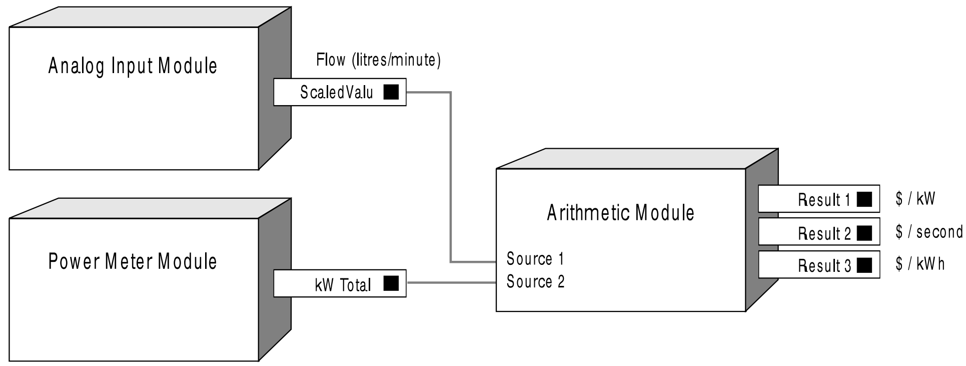
The Arithmetic module is capable of a wide variety of calculations. To illustrate a typical application, the following example shows how to use the Arithmetic module to calculate the cost of fuel per kilowatt ($/kW) and the cost of fuel per kilowatt-hour ($/kWh) for a simple mechanical generation system comprised of a diesel generator. The cost per second ($/second) consumed by the system is also included.

Before programming the module, create your formulas on paper and test them. Remember to check the units of the quantities used in the formula to ensure they are balanced correctly.

The first step is to identify the components of your formula; the constants and variables required to achieve the results. In this example, the $/kW and $/kWh values are based on the cost of fuel, the fuel flow rate, and the instantaneous kW. These values are as follows:

Formula Component	Source	Units
fuel cost	constant, currently 0.30	$/l
fuel flow rate	analog input attached to a flow sensor on the generator's fuel line	l/min
instantaneous kW	Power Meter module's *kW total* output	kW

Next, the modules must be linked to provide the fuel flow rate and the kW total. The resulting framework will look like this:



As the fuel cost is constant, it can be entered directly into the formula as a numeric value. The fuel flow rate will be read at Source input 1, so it will be referenced in formulas as S1. Note that S1 has units of l/min which must be converted to l/sec to balance with the units of the other quantities (dividing by 60 will convert 1/min to 1/sec). The instantaneous kW will be read at Source input 2, so it will be referenced as S2.

To generate the results, $/kW, $/kWh, and $/second being consumed by the system, setup registers must be programmed with the appropriate formula for each result we want. The formulas you need are as follows:

Setup Register	Formula
1	(S1/60) * .3 / S2
2	(S1/60) * .3
3	((S1/60) * .3) * 3600/S2

Remember that the module will place the result of the calculation in the Result output corresponding to the setup register (i.e. Result 1 will hold the result of the formula in setup register 1).

Responses to Special Conditions

The following table summarizes how the Arithmetic module behaves under different conditions.

Condition	Response of Output Register
If the Source inputs are *Not Available*	Any formulas that reference a *Not Available* Source input will return a *Not Available* value to the corresponding Result output. Note: the IF function can reference *Not Available* inputs and still provide a valid Result output. Refer to the IF function description for details.
If the Enable input is OFF	The Result output registers are *Not Available*.
After the module is re-linked or its setup registers are changed	The Result output registers are *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	The Result output registers are *Not Available*.

7700 ION Device Notes

The 7700 ION supports a total of 2 Arithmetic modules. Both support 8 Source inputs, 8 Setup registers and 8 Results outputs. Setup registers are empty by default.

Formula Size

Arithmetic modules in the 7700 can contain formulas up to 50 characters long, including spaces.

Previous Value Buffers

The previous value buffers in the 7700 ION hold a maximum of 10 previous values for each Source input.

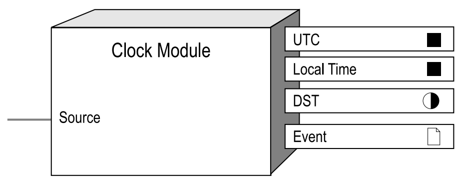
Default Update Rate

The default update rate of the 7700 ION is 1 second. If the CalculateNow input is not linked, the formulas contained in the module's Setup registers will be calculated every 1 second.

ION Clock Module

The Clock module provides the corrected local time required by the ION Scheduler module. The module obtains the Universal Time from the ION device and converts it to local time, taking time zones and Daylight Savings into account.

The Clock module uses Universal Time, a measurement system that reports the date and time as the number of seconds that have elapsed since January 1, 1970, at 12:00 A.M.. A utility is provided to convert between Universal Time and standard calendar dates and times (DD-MM-YY hh:mm:ss). Universal Time is required when entering time values into the module's Daylight Savings setup registers.



Inputs

Source
The Clock module's input receives the Coordinated Universal Time (UTC) from the ION device. This input is fixed at the factory and cannot be linked to other output registers.

Output Registers

All Clock modules have the following output registers:

■ *UnivTime*
This register contains the uncorrected UTC that is read from the ION device. The UTC is reported as the number of seconds elapsed since 12:00 A.M. January 1, 1970.

■ *LocalTime*
This register contains the local time, corrected to reflect the values input in the TZ offset and DST offset setup registers. The Local Time is reported as the number of seconds since 12:00 A.M. January 1, 1970.

NOTE
The time2sec conversion utility can also be used to convert Universal Time into standard date and time format. Type *time2sec* (enter ↵) at the command prompt for usage information.

◑ *DSTFlag*
This Boolean register turns ON when Daylight Savings is in effect, and changes to OFF when Daylight Savings is not in effect.

NOTE

The Clock module will issue a warning immediately after a DST period expires, reminding you to program the next DST Start or End time. These warnings, which are sent to the Event register, repeat every 24 days until the new DST Start or End is programmed. If DST is disabled (the DST Offset is set to zero), no warnings are issued.

Event

All events produced by the Clock module are recorded in the Event register. Possible events and their associated priority numbers are shown in the following table.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
Information	25	DST period Start or End has occurred.
Warning	30	DST Start and End times require reprogramming.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The Clock module has setup registers that allow you to input time zone and Daylight Savings Time information. This information allows the Clock module to calculate the corrected local time.

TZ Offset

The TZ offset setup register is used to specify the time zone applicable to the area you are in. TZ offset is obtained by adding or subtracting from Greenwich Mean Time (GMT).

To obtain the TZ offset, refer to your computer system's Control Panel. Inside the Control Panel is the Date/Time applet that reports the settings currently in effect on your workstation. Double-click on the Date/Time icon, and you will see a display similar to the following:

Timezone information is reported with respect to the GMT; the above graphic shows that (GMT -08.00) represents Pacific Time. To obtain the required value for TZ Offset, take the GMT offset value from the Date/Time applet and multiply by 3600. The result is the TZ Offset, in seconds, for your location. For example, if you are in the Pacific Time zone, your TZ Offset is (-8.0 x 3600) -28, 800.

- *DST Start*
  The DST Start setup register is used to specify the date and time when Daylight Savings Time begins. DST End must be entered in Universal Time.

  Typically, the Daylight Savings Time Start value will be available to you as a date and time. To convert date and time into Universal Time, the *time2sec* utility included with PEGASYS can be used.

  Time2sec is a command line program that is accessed from the MS-DOS Command Prompt in Windows NT or Windows 95. To run time2sec, do the following:

NOTE

To change directories in the MS-DOS Command Prompt window, use the DOS 'CD' command. Refer to your DOS manual for more information.

1. Activate the Command Prompt (located in the Main program group in Windows NT 3.5x, or on the Programs submenu of the Start menu in Windows 95 and NT 4.0).

2. Switch to your Pegasys directory, and type time2sec (enter ↵). An information screen will appear describing the usage of the utility.

3. Type time2sec followed by the date and time in DD-MM-YY hh:mm:ss format:

   time2sec 03-05-96 02:00:00 (enter ↵)

   Note that leading zeros must always be used when any date or time value is less than 10, and time values must be entered using the 24 hour clock (i.e. 12:00:00 A.M. is entered as 00:00:00).

After running the time2sec utility, the Universal Time is returned on the screen. Both Windows NT and Windows 95 allow you to select, mark and copy text in the Command Prompt window, so you can copy the Universal Time value returned by time2sec, and paste it into the Clock module's setup registers as required.

- *DST End*
  The DST End setup register is used to specify the date and time when Daylight Savings Time ends. DST End must be entered in Universal Time.

  Typically, the Daylight Savings Time End value will be available to you as a date and time. To convert date and time into Universal Time, the *time2sec* application included with PEGASYS can be used. Refer to the DST Start setup register discussion above for details on using time2sec.

- *DST Offset*
  The DST Offset setup register holds the Daylight Savings Time offset applicable to your location. The Daylight Savings Time offset is the amount of time that the clock is moved forward when Daylight Savings Time begins. For example, the DST offset in North America is 3600s (1 hour). DST Offset must be entered in seconds.

  If the DST Offset is set to zero (0), the DST feature is disabled, and no warning messages are sent to the Event register when the DST period expires.

Detailed Operation

The Clock module automatically receives the Coordinated Universal Time (UTC) from the ION device, and converts it to Local Time, based on the values input into the TZ Offset and DST Offset setup registers, and whether DST is enabled or not. The corrected local time in the LocalTime output register is automatically read by the Scheduler module (the modules are linked by default, but they can be unlinked).

The Clock module provides both the UTC and the local time as linkable numeric outputs. Both values are in Universal Time format.

Responses to Special Conditions

The following table summarizes how the Clock module behaves under different conditions.

Condition	Response of Output Register
After the module is re-linked or its setup registers are changed	All output registers are *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	All output registers are *Not Available*.

7700 ION Device Notes

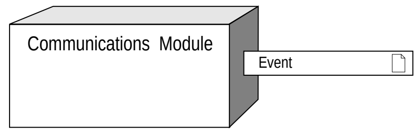
The 7700 ION supports a single Clock module.

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
TZ Offset	-43,200 to 43,200	0
DST Start	0 to 4.3×10^9	0
DST End	86400 to 4.3×10^9	0
DST Offset	-10,800 to 10,800	0

ION Communications Module

The Communications module allows you to set up the communications interface of the device. It defines all the settings of the communications card, allowing you to integrate the device into a large energy-monitoring system. It also establishes communication with SCADA systems, such as Power Measurement's ION-compliant PEGASYS software.



Inputs

The Communications module has no programmable inputs.

Output Registers

All Communications modules have the following output register:

Event
Any events produced by the Communications module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
Information	25	Time has changed on the meter (time synch received).

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The setup registers of the Communications module should all be set to reflect the communication configuration you are using:

- *Comm Mode*
  This register specifies what communication standard the device is using.

- *Baud Rate*
  This register specifies the baud rate at which the device is communicating. It should be set to correspond with the baud rate of the computer.

NOTE

When using a modem between the host computer and a remote device, do not set the Baud Rate outside the working range of the modem. Doing so will cause that device to cease communicating. To re-establish communication with that meter, you must reset the Baud Rate of the remote device *from the MGT for a 7700 ION, or from the front panel for a 7300 ION* to a value within the working range of the modem.

- *HshakeMode*
  This register specifies the handshake mode the device is using when the Comm Mode is RS232. Selecting RTS/CTS instructs the device to wait for a clear-to-send (CTS) signal to be asserted before sending data to the computer. Selecting RTS WITH DELAY instructs the device to wait for a specified amount of time after asserting the RTS signal before sending data to the computer.

- *RTS Level*
  This register indicates the active logic level asserted by the RTS line when the Comm Mode register is set to RS232. The choices are NORMAL or INVERTED.

- *CTS Level*
  This register indicates the active logic level asserted by the CTS line when the Comm Mode register is set to RS232 and Hshake Mode is RTS/CTS. The choices are NORMAL or INVERTED.

- *RTS Delay*
  This register specifies the transmission delay in seconds after the RTS has been asserted when Hshake Mode is RTS WITH DELAY.

- *Unit ID*
  This register specifies the communications identification (ID) for the device. Every device should be assigned a unique Unit ID.

- *Protocol*
  This register allows you to select the communications protocol for the device. Options currently supported are ION and Modbus.

7700 ION Device Notes

The 7700 ION supports three Communications modules. Communications module 1 includes all of the setup registers detailed above. Com-munications modules 2 and 3 contain a subset of these registers, as shown below.

Communications module 1 is used for all communications between 7700 ION's main communications port and the local or remote Pegasys workstation. Communications modules 2 and 3 are used for the Com 2 and Com 3 ports on the optional 7700 ION Xpress Card.

Communications Module 1

The supported ranges or options and the factory default settings for the setup registers in Communication module 1 are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Comm Mode	RS232 or RS485	RS485
Baud Rate	300, 1200, 2400, 4800, 9600, 19200	9600
HshakeMode	RTS/CTS or RTS WITH DELAY	RTS WITH DELAY
RTS Level	NORMAL or INVERTED	NORMAL
CTS Level	NORMAL or INVERTED	NORMAL
RTS Delay	0 to 1 second	0.01 seconds
Unit ID	1 to 9999	*see below*
Protocol	ION or Modbus	ION

The serial number for a 7700 ION has the following form. The default Unit ID of the device is derived from the digits indicated:

P M - 9 6 0 [8] A [0] [3] [5] - 0 1 *(The unit ID here is 8035)*

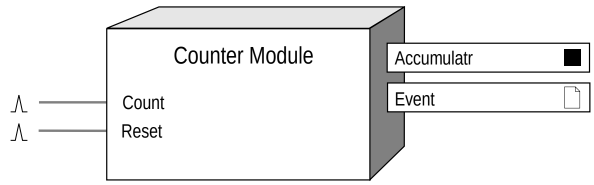
Communications Modules 2 and 3

Communication modules 2 and 3 contain the following four setup registers. The supported ranges or options and the factory default settings for these registers are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Baud Rate	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	9600
RTS Delay	0 to 1 second	0.01 seconds
Unit ID	1 to 9999	101 (Com 2), 102 (Com3)
Protocol	ION or Modbus	ION

ION Counter Module

The Counter module provides a facility to count how many times a certain event occurs. It increases or decreases its output by a specified amount every time it is triggered.



Inputs

All Counter modules have the following inputs:

Count
When this input receives a pulse, it either increases or decreases the number in the Accumulatr output register by an amount defined by the Multiplier setup register. Linking this input is mandatory.

Reset
When this input receives a pulse, it resets the Counter module, clearing the Accumulatr output register to 0. Linking this input is optional; the module will still operate if you leave this input unlinked.

When the module receives simultaneous reset and count pulses, the module resets before counting.

Output Registers

All Counter modules have the following output registers:

■ *Accumulatr*
This numeric variable register contains the accumulated count.

Event
Any events produced by the Counter module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Reset	5	A module reset has occurred.
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

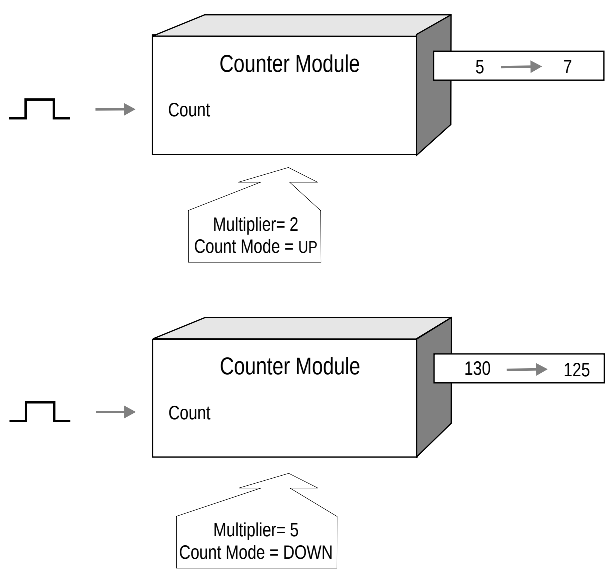
The setup register of the Counter module control the magnitude and direction of the count. All Counter modules have the following setup registers:

Multiplier
This register specifies the amount to increase (or decrease) the output by for every incoming trigger.

Count Mode
This register specifies if you want to increment or decrement the value in the output register. Select UP to increase the value and DOWN to decrease it.

Detailed Operation

The figure below illustrates the operation of a Counter module. Both examples indicate how the Multiplier and Count Mode setup registers affect what value is recorded in the Accumulatr output register.



When a pulse is received on the Trigger input, the Counter module updates the Accumulatr output register by the amount defined in the setup registers. Note that if the values of the inputs become Not Available, the Accumulatr output register is reset to 0.

Responses to Special Conditions

The following table summarizes how the Counter module behaves under different conditions.

Condition	Response of Output Register
After the module is re-linked or its setup registers are changed	The Accumulatr output register value is zero.
When the device is started or powered-up (either the first time, or after a shut-down)	The Accumulatr output register retains the value it held at shut-down.

7700 ION Device Notes

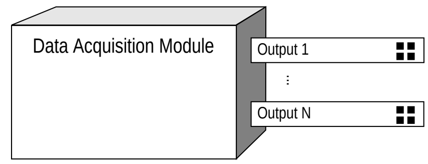
The 7700 ION has a total of 10 Counter modules. These modules are not high-speed capable.

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Multiplier	-1×10^9 to 1×10^9	1
Count Mode	UP or DOWN	UP

ION Data Acquisition Module

The Data Acquisition module performs analog to digital conversions on input signals. It converts the waveforms that are being sampled by the device into numeric array format.



Inputs

The Data Acquisition module has no programmable inputs.

Output Registers

All Data Acquisition modules have an output register for every input they are sampling. Each output register contains sampled points of a waveform in numeric array format.

Note that no event messages are created by the Data Acquisition module.

Setup Registers

The Data Acquisition module has no setup registers.

Response to Special Conditions

The following table summarizes how the Data Acquisition module behaves under different conditions.

Condition	Response of Output Register
When the device is started or powered-up (either the first time, or after a shut-down)	All output registers are *Not Available*.

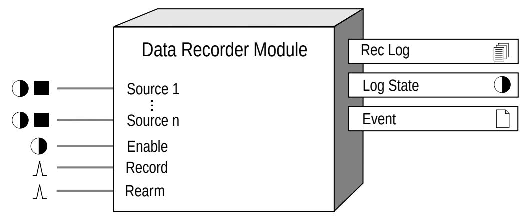
7700 ION Device Notes

The 7700 ION has a single Data Acquisition module. This module is factory-set as high-speed.

ION Data Recorder Module

Data Recorder modules are flexible tools that allow you to record and store different kinds of data. They can be configured to start recording under a specified circumstance. Possible applications for Data Recorder modules include fault analysis, historical trending, and creating coincidental Min/Max logs

The Data Recorder module records the values of its inputs each time its trigger input is pulsed and stores them in a log register. The log register contains a timestamped record of the values of the input registers at each trigger point.



Inputs

All Data Recorder modules have the following inputs:

NOTE
You only need to link the first Source input for the module to operate; linking the remaining Source inputs is optional.

Source
These are the inputs whose values are recorded. Each time the Record input is pulsed, the values of the Source inputs are stored in the Data Log output register. Refer to the Module Summary table in Chapter 3 for the number of Source inputs supported. Source inputs can be numeric variables or Boolean variables from the output registers of other modules.

Enable
This input enables or disables the Data Recorder module (by setting it to ON or OFF respectively). If you disable a Data Recorder module, it disregards pulses to the Record input. Linking this input is optional; if you leave it unlinked, the module will still operate and the Enable input will default to ON.

Record
When this register is pulsed, the source inputs are copied to the Data Log output register if the Enable input is ON and the Data Log register is not full in STOP-WHEN-FULL mode. Linking this input is mandatory.

Rearm
When this register is pulsed and the RecordMode setup register has been set to STOP-WHEN-FULL, the Data Recorder module will reset to allow full capacity. If the RecordMode setup register has been set to CIRCULAR, pulses on the Rearm input are ignored. Linking this input is mandatory if the module is used in STOP-WHEN-FULL RecordMode; if it is not linked when the module is in STOP-WHEN-FULL RecordMode, the Log Server cannot rearm the module, and no records will be uploaded after the initial retrieval. Rearm can be left unlinked only if CIRCULAR mode is used exclusively.

Output Registers

All Data Recorder modules have the following output registers:

Data Log
This register contains a log of the values of the inputs recorded at each trigger point. It's capacity is determined by the setup registers.

Log State
This register indicates when the Data Log register is full. If the RecordMode setup register is set to STOP-WHEN-FULL and the Data Log register has reached its depth, this register is ON (it's default ON label is *Full*). When the RecordMode setup register is set to CIRCULAR, or when the RecordMode is set to STOP-WHEN-FULL but Data Log register has not yet reached its depth, the Log State register is OFF (it's default OFF label is *Not Full*).

Event
Any events produced by the Data Recorder module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

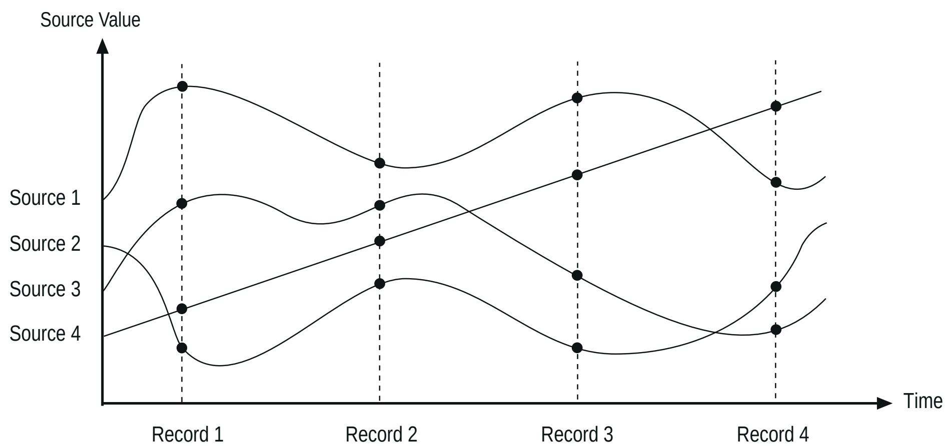
The setup registers of the Data Recorder module determine how much information the module can store. All Data Recorder modules have the following setup registers:

Depth
This numeric bounded register determines the maximum number of entries in the output log. Setting to zero disables data recording.

- *RecordMode*
  This register determines the recording mode, defining what happens when the Data Log output register is full. If you select CIRCULAR, the newest values get recorded and the oldest are dropped (FIFO). If you select STOP-WHEN-FULL, the Data Recorder module stops writing new values into the Data Log output register when it reaches its depth.

Detailed Operation

The figure below shows an example of a Data Recorder module recording the values of 4 Source inputs. Each time the Record input receives a pulse, the values of the Source inputs (represented by the black dots) are copied into the Data Log output register along with a timestamp indicating when the Record input was pulsed.



Linking Source Inputs

You do not need to link all the source inputs on the Data Recorder module; however, if you choose to use only a few you must link them consecutively, starting with the first register. When the Data Recorder module receives a pulse on its Record input, it records the value of each source input until it comes to an unlinked input; after that it ignores the rest of the source inputs. For example, if you skip the fourth input and link the fifth and sixth, they will not be recorded in the Data Log output register.

When choosing the sources for this module, be sure that they all have the same update rate. If you mix high-speed and high-accuracy inputs, the Data Recorder module will give unexpected results.

WARNING

If you re-link any of the inputs or make any changes to the setup registers, the contents of the Data Log output register are cleared. If you wish to save the information, ensure the data has first been uploaded before re-linking inputs or changing setup registers.

Using the Module

The following steps outline how to use a Data Recorder module. It is not necessary to do these steps in order; for example, you could set the setup registers first and not actually link the recorder to another module until later.

1. The first step in using a Data Recorder module is to determine what values you want to record. These will become your source inputs. You can link these values (which are the outputs from other modules) immediately or you can wait until later.

2. The next step is to specify when, or under what condition you want these values recorded. You must select another module with an output register that generates a pulse. This pulse defines when values are recorded. For example, if you link the pulse output of the Periodic Timer module to the Record input, your Source inputs will be recorded at regular defined intervals (in effect producing an interval snapshot log).

3. If you wish, you can link the Enable input to another module that will control when the module is operational. For example, if you link to an External Control module, you can manually enable or disable the Data Recorder module. If you leave the Enable unlinked, the module is enabled by default.

4. Next you must determine how much data you want to store. This will be limited by how many source inputs you are recording, as well as how many Data Recorder modules (and other modules requiring memory to store data) you are using. You can set the Depth setup register to the number of entries you wish to store. Note that you will receive an error message if the device has insufficient memory for the Depth you requested. In this case, you would need to select a smaller depth, or free up memory used by other modules.

5. You also need to determine what you want to happen to new data when the Data Log output register is full. You can set the RecordMode setup register to CIRCULAR to overwrite old entries with new ones. If you want to ignore new entries, set RecordMode to STOP-WHEN-FULL.

6. If you want to clear the Data Log register when it is full (in STOP-WHEN-FULL mode), you can do so via the Rearm input. Link the Rearm input to the output of an External Pulse module. When the Data Log register becomes full, the log server will cause the External Pulse module to trigger the Rearm and clear the Data Log.

Responses to Special Conditions

The following table summarizes how the Data Recorder module behaves under different conditions.

Condition	Response of Output Register
If the inputs are *Not Available*	All output registers hold the last values obtained when inputs were available.
If the Enable input is OFF	The Data Log register retains the data that was logged before the Enable input became FALSE. The Log State register is unaffected.
After the module is re-linked or its setup registers are changed	All logged data in the Data Log register is deleted.
When the device is started or powered-up (either the first time, or after a shut-down)	The Data Log register retains the data it held at shut-down.

7700 ION Device Notes

The 7700 ION has a total of 20 Data Recorder modules, and all 20 are high-speed capable.

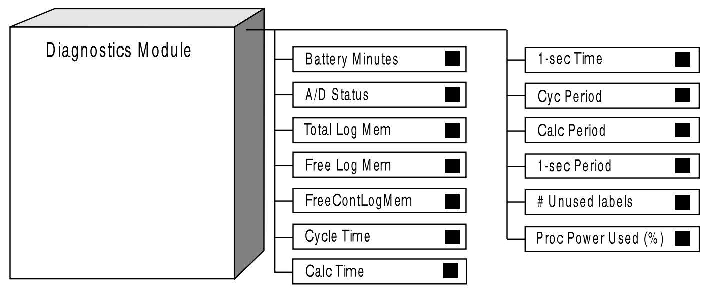
The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Depth	0 to 4×10^9	0
RecordMode	CIRCULAR or STOP-WHEN-FULL	CIRCULAR

ION Diagnostics Module

The Diagnostics module provides real-time information about the status of the 7700 ION. The module keeps track of various operating parameters and updates its output registers with the current values read from the device.

A few of the Diagnostics module's output registers provide information that can assist you with the application and maintenance of your 7700 ION. Most of the module's outputs, however, contain high-level diagnostic information that is only useful when you are troubleshooting the device's operation with a Power Measurement Customer Service Engineer.



Inputs

The Diagnostics module has no programmable inputs.

Output Registers

Diagnostics modules have the following output registers:

- *Battery Minutes*
  This register contains an estimate of the time remaining in the service life of the device's backup battery.
- *A/D Status*
  This register contains diagnostic information for use by Power Measurement Customer Support.
- *Total Log Mem*
  This register indicates the total amount of memory, in kilobytes (KB), that is available in the device for Event, Data Recorder and Waveform Recorder logs.
- *Free Log Mem*
  This register indicates what amount of the Total Log Mem, in kilobytes (KB), is currently unused and available for new logging operations.

- *Num Unused labels*
  This register indicates how many unused (available) labels there are in the device. The 7700 ION allows a maximum of 200 custom ION labels.

- *Proc power used (%)*
  This register indicates what percentage of the device's processor power is being used by functioning ION modules.

  The following output registers contain diagnostic information for use by Power Measurement Customer Service:

  - *Cycle Time*
  - *Calc Time*
  - *1-sec Time*
  - *Cyc Period*
  - *Calc Period*
  - *1-sec Period*
  - *FreeContLogMem*

- *Event*
  Any events produced by the Diagnostics module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description/Possible Causes
Setup Change	10	Input links, setup registers or labels have changed.
Warning	30	A link to a destroyed register was detected at start-up.
Failure	255	Internal data structure corruption detected at start-up; serial EEPROM corruption detected; Xpress Card failure detected; DSP problem detected; Watchdog Timer reset has occurred.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

Diagnostics modules have no setup registers.

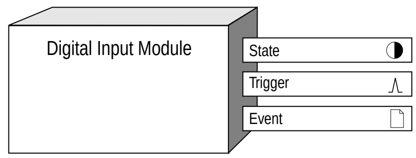
Responses to Special Conditions

The following table summarizes how the Diagnostics module behaves under different conditions.

Condition	Response of Output Register
When the device is started or powered-up (either the first time, or after a shut-down)	Output registers are updated with the current values read from the 7700 ION.

ION Digital Input Module

The Digital Input module takes a signal from one of the device's digital input ports, debounces it, triggers for each valid transition and makes the state available as an output. The State output register indicates the current state of the digital input.



Inputs

The Digital Input module has no programmable inputs.

Output Registers

All Digital Input modules have the following output registers:

State
This Boolean register contains the current debounced state of the input.

Trigger
This register generates a pulse each time the signal changes state (KYZ mode) or each time the hardware changes to the asserted state (Pulse mode) for a period longer than that specified in the Debounce setup register.

Event
All events produced by the Digital Input module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
I/O State Change	20	Input transaction logged. *
Failure	255	Frequency of digital input device too high; input device shut down.

* These events are only recorded if the EvLog Mode setup register is set to LOG ON.

For each event, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.

- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The setup registers define how the Digital Input module interprets the external signal. All Digital Input modules have the following setup registers:

Input Mode
This register indicates the type of external signal. Specifying KYZ indicates a transition pulse; specifying PULSE indicates a complete pulse.

EvLog Mode
This register specifies if changes in the State output register are recorded as events in the Event output register. If you select LOG ON, these events are logged. If you select LOG OFF, these events are not included in the Event output register. (Note changing setup registers are still logged in the Event register.)

NOTE
Specifying a Debounce time of less than 1 second will cause the Digital Input module, and all ION modules linked to it, to update at 1 cycle intervals. Specifying a Debounce time of 1 second or more will change the update rate to once per second.

Polarity
This register specifies whether the signal from hardware is inverted (INVERTING) or not (NON-INVERTING).

Debounce
This numeric bounded register allows you to specify for mechanical contact bounce by defining (in seconds) how long the external signal must remain in a certain state to be considered a valid state change.

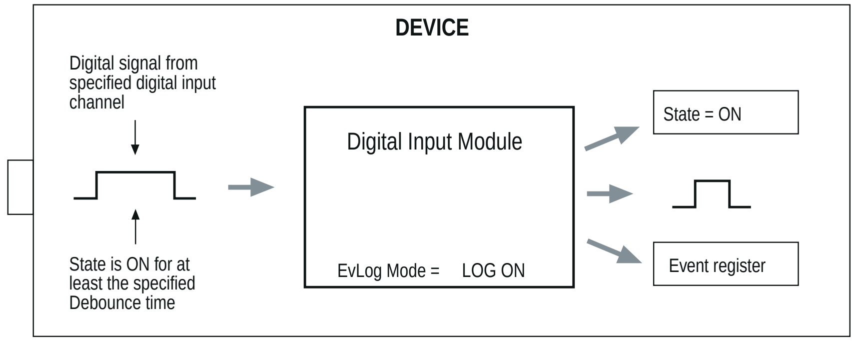
Port
This register defines which hardware port is providing the signal. Refer to the hardware options table in Chapter 3 for a list of available ports.

Detailed Operation

The following examples illustrate the operation of the Digital Input module:

Pulse Mode

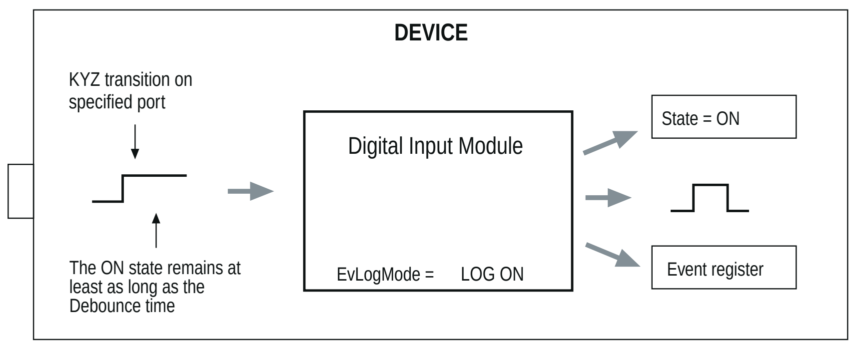
In this example, the digital input port is monitored for an ON state (Input Mode= PULSE, Polarity=NON-INVERTING). Once this state has existed for longer than the debounce time, a pulse is generated on the Trigger output register, the State output register changes to ON, and an event is recorded in the Event output register.



When the state changes to OFF, the State output register changes to OFF; however, no pulse is generated on the Trigger output register

KYZ Mode

In this example, the digital input port is monitored for a transition from ON to OFF (InputMode= KYZ). Once the ON state has existed for longer than the debounce time, a pulse is generated on the Trigger output register, the State output register changes to ON, and an event is recorded in the Event output register.



If the state of the digital signal changes to OFF (and remains off for at least the Debounce time), the State output register changes to OFF and another pulse is generated on the Trigger output.

Specifying a Debounce Time

The value you should specify for the Debounce setup register depends on what kind of signal and the input devices you are monitoring. For solid state dry contacts, 0 to 5 ms is typical. For mechanical dry contacts, 1 to 80 ms is typical. Note that some input devices may already have a built-in debounce time (referred to also as a *Turn On* or *Turn Off* time). Refer to the technical specifications in Appendix A for more detailed information.

Responses to Special Conditions

The following table summarizes how the Digital input module behaves under different conditions.

Condition	Response of Output Register
When the device is started or powered-up (either the first time, or after a shut-down)	The State output matches the state of the hardware port.

7700 ION Device Notes

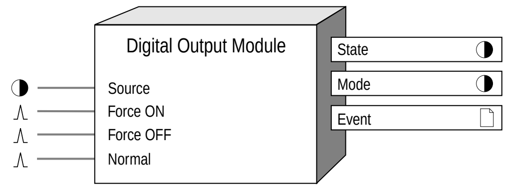
The 7700 ION has a total of 38 Digital Input modules, and all 38 are high-speed capable. Of these, 8 are for onboard digital inputs, and up to 30 are provided for external digital inputs (i.e. expansion boards).

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Input Mode	PULSE or KYZ	PULSE
EvLog Mode	LOG ON or LOG OFF	LOG OFF
Polarity	INVERTING or NON-INVERTING	INVERTING
Debounce	0 to 65.525 seconds	0
Port	The Port option is variable, and depends on the options ordered with the 7700 ION. There is no default port; the available ports will be presented when you enter this setup register.	

ION Digital Output Module

The Digital Output module acts as an intermediary between another module in the device and a hardware port. It takes a Boolean input and sends it out a hardware channel as a constant level or a pulse. This provides access to external relays and control capabilities.



Inputs

All Digital Output modules have the following inputs:

◑ *Source*
This is the value that the module takes and sends to a hardware port. Linking this input is optional; if you leave it unlinked, the hardware port will be controlled by the Force ON and Force OFF inputs.

⅄ *Force ON*
When pulsed, this input forces the State output register ON and sends a pulse to a hardware port (the pulse duration and port are specified in the setup registers). If the PulseWidth setup register is 0, a continuous output is generated rather than a pulse. This input is optional; if you leave it unlinked, it will by default never receive a pulse.

⅄ *Force OFF*
When pulsed, this input forces the State output register OFF. The Force OFF register is ignored if the PulseWidth setup register is set to a value other than 0. This input is optional; if you leave it unlinked, it will by default never receive a pulse.

⅄ *Normal*
When this input is pulsed, it returns control of the module to the Source input if the module has been forced ON or OFF. Note that the Normal register is ignored if the PulseWidth setup register is set to a value other than 0. This input is optional; if you leave it unlinked, it will by default never receive a pulse.

Output Registers

All Digital Output modules have the following output registers:

◑ *State*
This register reflects the current state of the Source input. The State register is ON when the Source input is ON, or if the Force ON input has been pulsed; conversely, it is OFF when the Source input is OFF, or if the Force OFF input has been pulsed. If the PulseWidth setup register is set to a value other than 0, the State register will remain ON until the pulse is finished, then it changes to OFF. Refer to the tables in the *Detailed Operation* section for information about how the State output register relates to the status of the associated relay.

◑ *Mode*
This Boolean register indicates which input was responsible for the value in the State output register. If the Force ON or Force OFF inputs were responsible for the value in the State output, the Mode register is ON. If the Source input caused the value, the Mode register is OFF.

Event
All events produced by a Digital Output module are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
I/O State Change *	20	Output forced ON; forced OFF or forced NORMAL; output transaction has occurred.

* These events are only recorded if the EvLog Mode setup register is set to LOG ON.

For each event, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The setup registers of the Digital Output module define what kind of output the module produces and on what hardware port. All Digital Output modules have the following setup registers:

- *EvLog Mode*
  This register determines whether events associated with changes to the State output register are logged in the Event output register. If you select LOG ON, these events are logged; if you select LOG OFF, these events are not included in the Event register. Note that the events associated with linking the module and changing setup registers are still logged.

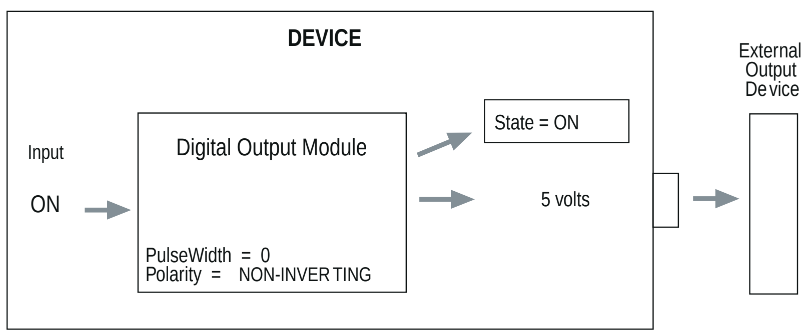
- *Polarity*
  This register controls whether the module inverts the input before sending it to the hardware channel (INVERTING) or not (NON-INVERTING).

- *PulseWidth*
  This numeric bounded register specifies the width of the output pulse in seconds. If this register is set to 0, the output is continuous.

- *Port*
  This register determines to which hardware port the pulse (or continuous) output is sent. Refer to the hardware options table in Chapter 3 for a list of available ports.

Detailed Operation

This figure 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 will contain whatever is appropriate.



Responses to Special Conditions

The following table summarizes how the Digital Output module behaves under different conditions.

Condition	Response of Output Register
If the Source input is *Not Available*	The Output register retains the state it held when the Source input was available. The module still responds to FORCE ON and FORCE OFF pulses. Note: If the Port Setup register is set to NotUsed, Output registers will be *Not Available*.
When the device is started or powered-up	The Output registers are OFF (0). All force

(either the first time, or after a shut-down)	conditions (i.e. FORCE ON or FORCE OFF) are discarded. Note: If the Port Setup register is set to NotUsed, Output registers will be Not Available.

7700 ION Device Notes

The 7700 ION supports a total of 30 Digital Output modules, for use with external digital outputs (i.e. expansion boards). All 30 modules are high-speed capable.

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
EvLog Mode	LOG ON or LOG OFF	LOG OFF
Polarity	INVERTING or NON-INVERTING	INVERTING
PulseWidth	0 to 2 x 10^6 seconds	0
Port	The Port option is variable, and depends on the options ordered with the 7700 ION. There is no default port; the available ports will be presented when you enter this setup register.	

Configuring the Polarity and State On/Off Labels

A primary function of the Digital Output module is to control relay operation via a physical output device. When specifying the Polarity setup register, you must consider the characteristics of your output device (see the specifications given for the external I/O devices in Appendix A).

In addition, if you have defined different ON or OFF labels for the State output register, you should consider the characteristics of your output device and the Polarity setting. If you want the label to reflect the state of a relay, you may need to reverse the labels.

Refer to the following tables for details about how the Polarity affects relays in different circumstances and the results in the State output register.

Using Digital Output Devices that have Asserted Low Inputs

The following table lists how all the different combinations of relay types, inputs to the Digital Output module, and the Polarity settings affect the state of a relay and the result in the State output register when using an asserted *low* output device.

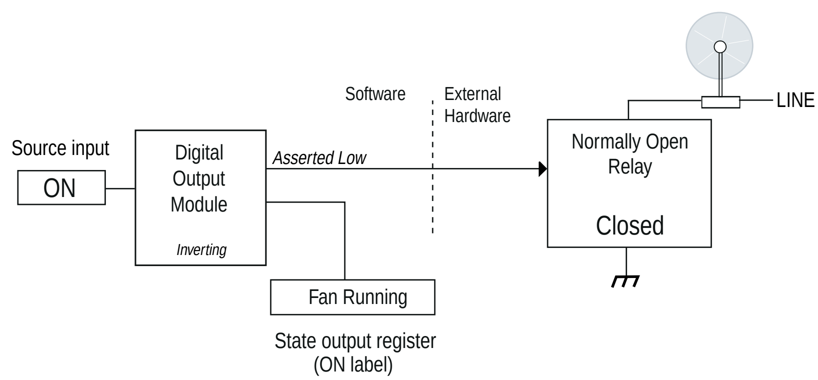
NOTE

Refer to Chapter 2 and to Appendix A for additional information regarding Power Measurement-supported I/O devices.

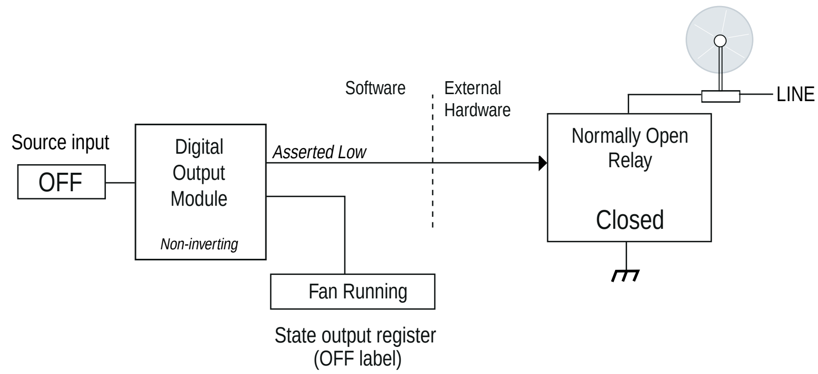
Relay Type	Input to ION Digital Output Module	Polarity	Relay State	State Output*
Normally Open	ON	Inverting	Closed	ON
Normally Open	OFF	Inverting	Open	OFF
Normally Open	ON	Non-Inverting	Open	ON
Normally Open	OFF	Non-Inverting	Closed	OFF
Normally Closed	ON	Inverting	Open	ON
Normally Closed	OFF	Inverting	Closed	OFF
Normally Closed	ON	Non-Inverting	Closed	ON
Normally Closed	OFF	Non-Inverting	Open	OFF

* The ON/OFF State Output labels are user-configurable.

This figure illustrates using an output device with a normally open relay with asserted low inputs. The Polarity in this example has been set to INVERTING. The ON label of the State output has been assigned according to the resulting state of the fan rather than the state of the output.



In this figure, the Polarity has been changed to NON-INVERTING. In this situation, the State output is now OFF but the resulting state of the relay is the same. The OFF label has been assigned the appropriate name.



Using Digital Output Devices that have Asserted High Inputs

The following table lists how different combinations affect the state of a relay and the result in the State output register when using an asserted *high* output device.

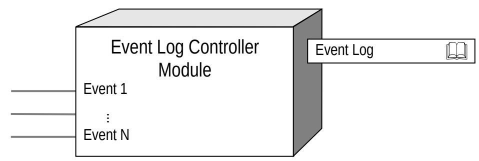
Relay Type	Input to Digital Output Module	Polarity	Relay State	State Output
Normally Open	ON	Inverting	Open	ON
Normally Open	OFF	Inverting	Closed	OFF
Normally Open	ON	Non-Inverting	Closed	ON
Normally Open	OFF	Non-Inverting	Open	OFF
Normally Closed	ON	Inverting	Closed	ON
Normally Closed	OFF	Inverting	Open	OFF
Normally Closed	ON	Non-Inverting	Open	ON
Normally Closed	OFF	Non-Inverting	Closed	OFF

ION Event Log Controller Module

The Event Log Controller module provides a history of all the events that have occurred on the device. Possible applications for the Event Log Controller module include a complete sequence-of-events record for:

breaker and transfer switch operations
alarm conditions
equipment starts and stops.

The Event Log Controller module monitors the Event output registers of other modules for new event records. Any new events are stored in the Event Log output register in internal non-volatile memory.



Inputs

The Event Log Controller module has as its inputs the Event output registers from the other modules in the device. These inputs are fixed at the factory; you cannot link them to other output registers.

Output Registers

Event Log
All Event Log Controller modules have one output register called the Event Log register. This register stores the device's event information. The Event Log register is circular; once the log is full, adding additional event records will result in the loss of the *oldest* event records.

The Event Log offers protection from losing important events. Events with an Event Priority higher than that set in the Protection Priority setup register are summarized and saved rather than overwritten.

The information in the Event Log register is accessible via communications.

Setup Registers

All Event Log Controller modules have the following setup registers:

NOTE

When the Depth register is re-programmed, all events stored in the Event Log register will be lost.

- *Depth*
  This register defines the number of events which can be stored in the Event Log output register. The higher you set this number, the more events the Event Log can store at once and the more memory it requires. Setting Depth to zero (0) disables all event logging, regardless of Protection register settings. Note that if the Depth register is set to 0, all event logging will be disabled.

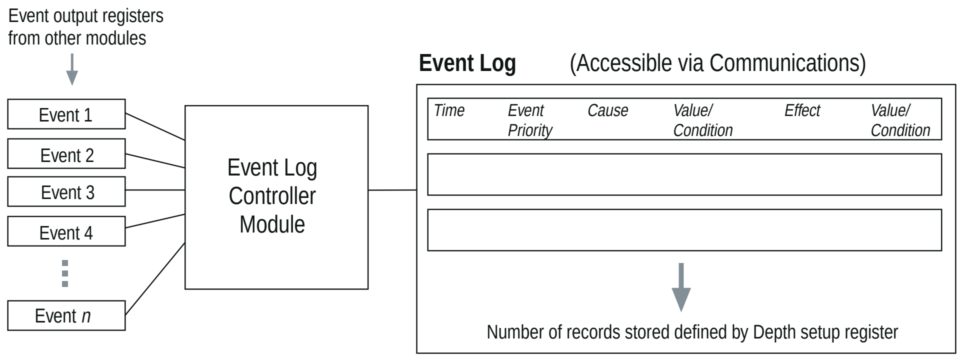
- *Protection*
  If you are polling the Event Log infrequently (e.g. via modem), the log may fill and start to overwrite the oldest records before you have had a chance to see them. The Protection register allows you to specify a priority level that protects important events from being lost if the log rolls over. When an event is logged with an event priority greater or equal to the value in the Protection register, that event will be stored in an abbreviated form and not lost. Note that events with priority values less than or equal to the Cutoff value are not logged.

  Another function of the Protection register is to define what events are displayed immediately in the Event Log. If you have specified a large Event Log Depth, a high priority event could be far down in the log and take time to access. Events with Event Priorities above the Protection priority are displayed immediately in an abbreviated form for swift attention. Detailed information is filled in as it is available.

- *Cutoff*
  This register allows you to specify which events you want to log, based on event priority. Events with priority values less than or equal to the Cutoff you specify will not be logged. Cutoff supersedes Protection; any events with priority values equal or below the Cutoff value will not be logged, regardless of the value entered into the Protection register.

Detailed Operation

This figure illustrates the operation of the Event Log Controller module.



Changing one of the Event Log Controller module's setup registers constitutes an event (with a pre-defined priority of 10). The Event Log Controller writes these events directly into the Event Log; it does not require an Event output register.

Response to Special Conditions

The following table summarizes how the Event Log Controller behaves under different conditions.

Condition	Response of Output Register t
After the module is re-linked or its setup registers are changed	All logged data in the Event Log register is deleted.
When the device is started or powered-up (either the first time, or after a shut-down)	The Event Log register retains the data it held at shut-down.

7700 ION Device Notes

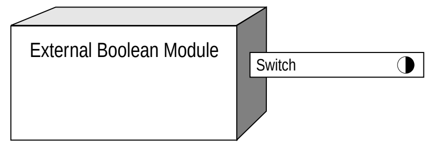
The 7700 ION has a single Event Log Controller module.

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Depth	0 to 20 000	500
Protection	The Protection register is factory-set to 128.	
Cutoff	0 to 255	0

ION External Boolean Module

The External Boolean module provides a single Boolean register that you can define as either ON or OFF. For example, if you want to disable a module under certain circumstances, you can link its Enable input to an External Boolean module that you can switch to OFF.



Inputs

External Boolean modules have no inputs; they are controlled via communications.

Output Registers

External Boolean modules have the following output register:

◑ *Switch*
All External Boolean modules have a single switch register which can be manually switched ON or OFF via communications.

Setup Registers

External Boolean modules have no setup registers.

Responses to Special Conditions

The following table summarizes how the External Boolean module behaves under certain conditions.

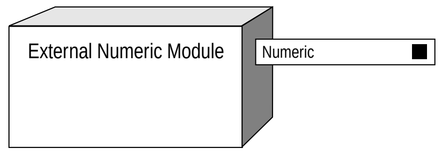
Condition	Response of Output Register
When the device is started or powered-up (either the first time, or after a shut-down)	The Switches output register retains the value it held at shut-down.

7700 ION Device Notes

The 7700 ION supports a total of 32 External Boolean modules.

ION External Numeric Module

This module provides a numeric register that you can set to a certain value. This can be useful for testing frameworks that have an initial numeric input. For example, if you have created a framework that performs a function based on the value of *I avg* from the Power Meter module, you can test it with known values before actually linking it to the *I avg* register. In addition, if your device has Analog Output modules, you can use an External Numeric module to specify the current or voltage you wish to deliver to some external equipment.



Inputs

External Numeric modules have no inputs; they are controlled via communications.

Output Registers

External Numeric modules have the following output register:

- *Numeric*
  External Numeric modules have a single numeric register which can be manually controlled via communications.

Setup Registers

External Numeric modules have no setup registers.

Responses to Special Conditions

The following table summarizes how the External Numeric module behaves under certain conditions.

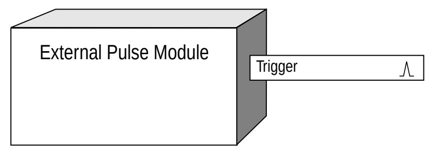
Condition	Response of Output Register
When the device is started or powered-up (either the first time, or after a shut-down)	The Numeric output register retains the value it held at shut-down.

7700 ION Device Notes

The 7700 ION supports a total of 8 External Numeric modules.

ION External Pulse Module

This module provide a pulse register that can be configured to pulse on demand. This allows you to manually trigger any module in the device that accepts a pulse input. For example, you can reset counters or timers, or pulse external equipment (if your device has Pulser modules).



Inputs

External Pulse modules have no inputs; they are controlled via communications.

Output Registers

External Pulse modules have the following output register:

Trigger
External Pulse modules have a single trigger register which is manually controlled via communications.

Setup Registers

External Pulse modules have no setup registers.

Responses to Special Conditions

The following table summarizes how the External Pulse module behaves under different conditions.

Condition	Response of Output Register
When the module is started or powered-up (either the first time or after a shut-down)	Trigger output registers do not “contain” a pulse at start-up.

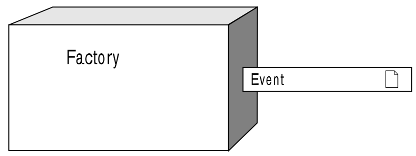
7700 ION Device Notes

The 7700 ION supports a total of 128 External Pulse modules.

ION Factory Module

The Factory module allows you to view your ION device's type, revision number, serial number, and installed options. Registers are also provided for you to input your name, address or any other particulars you wish to store onboard the device.

Most of the Factory module's registers contain calibration constants used at the factory. These registers can be viewed, but they cannot be changed.



Inputs

The Factory module has no programmable inputs.

Output Registers

The Factory module has the following output register:

Event Register
All events produced by the Factory module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

Most of the setup registers in the Factory module are read-only, which means that you can only view them, not edit them.

T *Device Type*
This String register shows the type of ION device that is in operation.

T *Compliance*
This register indicates if the attached device is ION compliant or not.

T *Options*
This register lists the options that are included with the attached ION device.

T *Revision*
This register stores the revision number of the ION device.

T *Serial Number*
This register holds the serial number of the ION device.

T *Owner*
This user-configurable string register is available for storing the name of the device's owner.

T *Tag1*
This user-configurable string register is available for storing additional information, such as the name or address of the owner's organization.

T *Tag2*
This user-configurable string register is available for storing additional information, such as the name or address of the owner's organization.

NomFreq
This register contains the expected frequency of operation for the device.

Each of the following output registers contain a calibration constant for use at the factory:

- *Vnominal*
- *Inominal*
- *I4nominal*
- *I20nominal*
- *V1cal*
- *V2cal*
- *V3cal*
- *I1cal*
- *I2cal*
- *I3cal*
- *I4cal*
- *I1x20cal*
- *I2x20cal*
- *I3x20cal*
- *CT1aSmooth*
- *CT1bSmooth*
- *CT1cSmooth*
- *CT2aSmooth*
- *CT2bSmooth*
- *CT2cSmooth*
- *CT3aSmooth*
- *CT3bSmooth*
- *CT3cSmooth*
- *I1off*
- *I2off*
- *I3off*
- *I4off*
- *V_force*
- *I_force*
- *I4_force*
- *VX_force*
- *Vx1cal*
- *Vx2cal*
- *Vx3cal*
- *Vx4cal*
- *Vx1dc*
- *Vx2dc*
- *Vx4dc*

Responses to Special Conditions

The following table summarizes how the Factory module behaves under different conditions.

Condition	Response of Output Register
When the device is started or powered-up (either the first time, or after a shutdown)	All output registers retain the values they held when the device was shut-down.

ION FFT Module

The FFT module performs Fast Fourier Transforms on waveforms sampled by the Data Acquisition module. This prepares the waveforms for input into the Harmonics Analyzer module.

Inputs

The inputs of the FFT module are not programmable. The are pre-linked at the factory to the output registers of the Data Acquisition module .

Output Registers

All outputs of the FFT module are pre-linked at the factory to the inputs of the Harmonics Analyzer module. They cannot be linked to any other module.

Setup Registers

The FFT module has no setup registers.

Responses to Special Conditions

The following table summarizes how the FFT module behaves under different conditions.

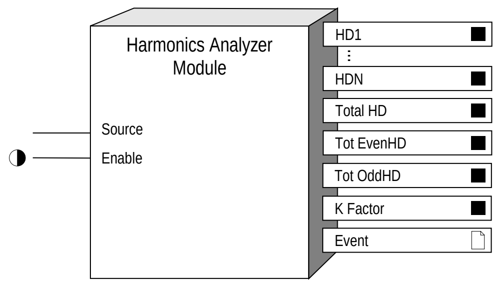
Condition	Response of Output Register
If the inputs are *Not Available*	The output registers are *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	The output registers are *Not Available*.

ION Harmonics Analyzer Module

The Harmonics Analyzer module provides detailed harmonics calculations for a voltage or current input on the device. This information is valuable for power quality analysis, selecting properly-rated transformers, and fault detection.

It can calculate the following harmonic distortion values as a percentage of the fundamental:

- % harmonic distortion
- total harmonic distortion
- total odd harmonic distortion
- total even harmonic distortion
- K-Factor (for current inputs)



Inputs

◑ All Harmonics Analyzer modules have one programmable input called the *Enable* input. When this register is set to ON, the module is enabled; when it is set to OFF, the module is disabled and it ceases to calculate harmonics and update its output registers. This input is optional; if you leave it unlinked, the module will be enabled by default.

The *Source* input of Harmonics Analyzer modules is fixed. It receives data either from the voltage, current or analog inputs.

Output Registers

All Harmonics Analyzer modules have the following output registers:

NOTE
The number of individual harmonics supported depends on the implementation; refer to the Module Summary table in Chapter 3 for details.

■ *HD1...HDn*
These registers contain the harmonic distortion of the input as a percentage of the fundamental for each individual harmonic.

■ *Total HD*
This register contains the total harmonic distortion of the input. An FFT is performed on the sample waveform to determine the harmonic components of the signals. They are then used in the following formula:

$$\text{Total HD} = \frac{1}{f_1}\sqrt{\sum_{n=2}^{k}(f_n)^2} \times 100\%$$

where
k = the highest harmonic order number
n = the harmonic order number
f_1 = the magnitude of the fundamental
f_n = the magnitude of the n^{th} harmonic

- *Tot EvenHD*
  This register contains the total even harmonic distortion of the input.

- *Tot OddHD*
  This register contains the total odd harmonic distortion of the input.

- *K Factor*
  This register contains the K-Factor of the input signal. It is available only for current inputs. An FFT is performed on the sample current waveform to determine the harmonic components of the signals. They are then used in the following formula

$$\text{K Factor} = \frac{\sum_{n=1}^{k} (f_n n)^2}{\sum_{n=1}^{k} (f_n)^2}$$

where k = the highest harmonic order number
n = the harmonic order number
f_n = the magnitude of the n^{th} harmonic

Event
Any events produced by the Harmonics Analyzer module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

Harmonics Analyzer modules have no setup registers.

Responses to Special Conditions

The following table summarizes how the Harmonics Analyzer module behaves under different conditions.

Condition	Response of Output Register
If the Source input is *Not Available*	All output registers are *Not Available*.
If the Enable input is OFF	All output registers are *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	All output registers are *Not Available.*

7700 ION Device Notes

The 7700 ION supports a total of 7 Harmonics Analyzer modules. None of the modules are high-speed capable.

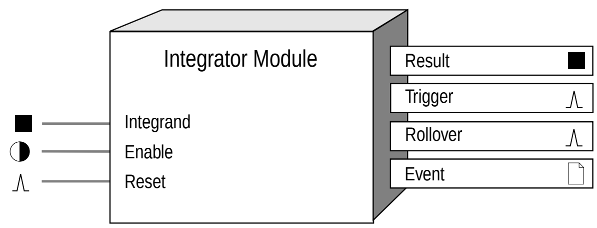
ION Integrator Module

The Integrator module integrates a specified source value, or Integrand, over time. The module reads the value of the Integrand at the update rate of the ION device, divides it by a specified amount (typically representing time) and adds the result to its output value. It uses the following equation:

$$R_n = \frac{\text{Integrand}}{\text{Divisor}} + R_{n-1}$$

The most common application of the Integrator module is to calculate energy values, such as:

Real energy, or kW hours (kWh)
Reactive energy, or kVAR hours (kVARh)
Apparent energy, or kVA hours (kVAh)



Inputs

All Integrator modules have the following inputs:

■ *Integrand*
This input is the value which is integrated. It must be a numeric register from any other module's outputs. Linking this input is mandatory.

◑ *Enable*
This input enables or disables the Integrator module (by setting it to ON or OFF respectively). When the module is disabled, it stops updating the Result output register. This input is optional; if you leave it unlinked, the module will be enabled by default.

NOTE
The *Reset* input overrides the *Enable* input; the module can be reset even when it is disabled.

⎍ *Reset*
This input resets the Integrator module, resetting the Result output register to 0. This input is optional; if you leave it unlinked, it will by default never receive a pulse.

Output Registers

All Integrator modules have the following output registers:

■ *Result*
This numeric register contains the result of the integration. The Result will rollover (reset to zero) if the value in the Rollvalue Setup register is reached.

Trigger
This register generates a pulse every time the Result output increases or decreases by the value specified in the Valu/Pulse setup register. If the Result increases by double the Valu/Pulse register, two pulses are generated, etc..

Rollover
This register generates a pulse every time the Result output reaches the value specified in the RollValue setup register.

Event
Any events produced by the Integrator module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Reset	5	A module reset has occurred.
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The setup registers of the Integrator module define the particulars of the integration. All Integrator modules have the following setup registers:

Divisor
This numeric bounded register specifies the value by which the Integrand is divided before it is added to the Result. For example, to calculate KWh, the Divisor register would be set to 3600.

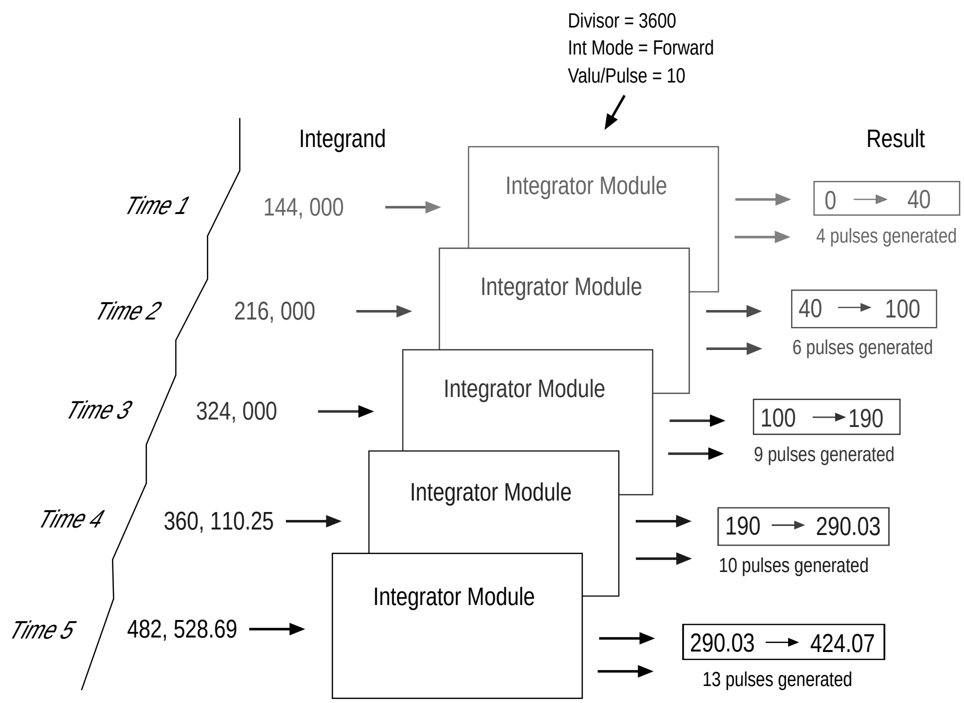
Int Mode
This register specifies the type of integration to be performed. If you select FORWARD, only positive Integrands are added to the Result output. If you select REVERSE, only negative Integrands are added to the output. If you select ABSOLUTE, the absolute value of the Integrand is added to the output. If you select NET, all Integrands are added to the output.

- *Valu/Pulse*
  This numeric bounded register defines the value the Result must increase (or decrease) by for a pulse to be generated on the Trigger output. Setting this register to zero disables the feature (no pulses will be output from the Trigger register).

- *RollValue*
  When the Result output register reaches the value specified by the RollValue setup register, the Result output register will rollover (be reset to 0). Setting this register to zero disables the Rollover feature (no rollovers will occur).

Detailed Operation

The figure below illustrates the operation of the Integrator module. The Integrand can be any numeric value, but typically it would be a power measurement from the Power Meter module (e.g. kW, kVAR, kVA). Integrating these measurements provides accumulating energy values, for each phase or the average of all phases.



If the value in the Result output register increases by an uneven multiple of the Valu/Pulse, the remainder is carried over to the next update time. For example, in the above illustration, if at Time 6 the Result increases by 17, 1 pulse is generated and the value 7 is carried over to contribute to pulses at Time 7.

Integration Interval

The value in the Divisor setup register specifies the boundary of the integration interval and is given in seconds. This controls the unit of time in the Result. For example, to obtain kWh readings, set the Divisor to 3600.

Integration Modes

When used for calculating energy values, the options available for the Int Mode setup register specify four measurement modes which indicate bi-directional power flow:

FORWARD	use for imported energy, or energy in the positive or forward direction (i.e. energy consumed).
REVERSE	use for exported energy, or energy in the negative or reverse direction (i.e. energy generated or fed back to the utility).
ABSOLUTE	use to obtain the sum of (the absolute values of) the energy imported and exported. In other words, the Result increments whether energy is being imported or exported.
NET	use to obtain the difference between energy imported and exported. A net export of energy is displayed as a negative number. Note that the Trigger output functions the same with NET Int mode as it does when the ABSOLUTE Int mode is used.

Responses to Special Conditions

The following table summarizes how the Integrator module behaves under different conditions.

Condition	Response of Output Register
If the Input is *Not Available*	Integrating stops and the Result output holds the current value.
If the Enable input is OFF	Integrating stops and the Result output holds the current value.
After the module is re-linked or its setup registers are changed	The Result output goes to zero.
When the device is started or powered-up (either the first time, or after a shut-down)	The Output registers retain the values they held at shut-down.

7700 ION Device Notes

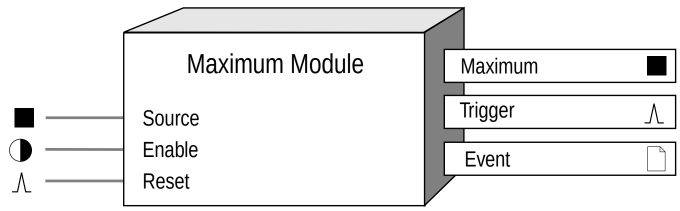
The 7700 ION supports a total of 16 Integrator modules. Integrator modules are not high-speed capable.

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Divisor	0 to 1 000 000 seconds	3600
IntMode	FORWARD, REVERSE, ABSOLUTE or NET	NET
Valu/Pulse	0 to 1×10^9	0
Rollvalue	0 to 1×10^9	0

ION Maximum Module

The Maximum module records the maximum value reached by a single numeric variable. It can be reset and enabled or disabled.



Inputs

All Maximum modules have three inputs:

Source
This input is monitored for a maximum value. It must be a numeric variable register from any other module's outputs. Linking this input is mandatory. The Maximum module ignores any source that is Not Available.

Enable
This input enables or disables the Maximum module (by setting it to ON or OFF respectively). When a Maximum module is disabled, it disregards any new maximum values at the Source input. This input is optional; if you leave it unlinked, the module is enabled by default.

Reset
This input resets the Maximum module, setting the Maximum output register to Not Available. The module can be reset even if it is disabled. This input must be a pulse register from any other module's outputs. This input is optional; if you leave it unlinked, it will by default never receive a pulse.

Output Registers

All Maximum modules have the following output registers:

Maximum
This numeric variable register contains the maximum value attained by the Source input since the last reset.

Trigger
Each time a new maximum value occurs, the Trigger output register generates a pulse.

Event
Any events produced by the Maximum module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Reset	5	A module reset has occurred.
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the event register, the following information is included:

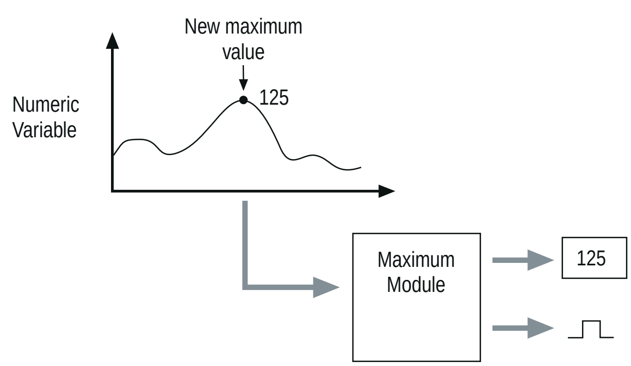
- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

Maximum modules have no setup registers.

Detailed Operation

The figure below illustrates the operation of a Maximum module. As long as the Enable input is ON, it monitors a numeric variable and every time the variable reaches a new maximum, the Maximum module stores that value and generates a pulse.



Responses to Special Conditions

The following table summarizes how the Maximum module behaves under different conditions.

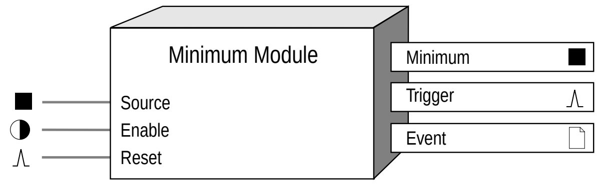
Condition	Response of Output Register
If the Source input is *Not Available*	The Maximum output retains the value it held when the Source input was available.
If the Enable input is OFF	The Maximum output retains the value it held when the Source input was available.
After the module is re-linked or its setup registers are changed	The Maximum register is *Not Available*.
When the module is started or powered-up (either the first time, or after a shut-down)	The Maximum output register retains the value it held at shut-down.

7700 ION Device Notes

The 7700 ION supports a total of 32 Maximum modules. All 32 are high-speed capable.

ION Minimum Module

The Minimum module records the minimum value reached by a single Numeric Variable. The minimum can be reset and enabled or disabled .



Inputs

All Minimum modules have the following three inputs:

■ *Source*
This input is monitored for a minimum value. It must be a numeric variable register from any other module's outputs. Linking this input is mandatory. The Minimum module ignores any source that is Not Available.

◑ *Enable*
This input enables or disables the Minimum module (by setting it to ON or OFF respectively). When a Minimum module is disabled, it disregards any new minimum values in the Source input. This input is optional; if you leave it unlinked, the module is enabled by default.

Reset
This input resets the Minimum module, setting the Minimum output register to Not Available. The module can be reset even if it is disabled. This input must be a pulse register from any other module's outputs. This input is optional; if you leave it unlinked, it will by default never receive a pulse.

Output Registers

All Minimum modules have the following output registers:

■ *Minimum*
This numeric variable register contains the minimum value attained by the Source input since the last reset.

Trigger
Each time a new minimum value occurs, the Trigger output register generates a pulse.

Event
Any events produced by the Minimum module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Reset	5	A module reset has occurred.
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the event register, the following information is included:

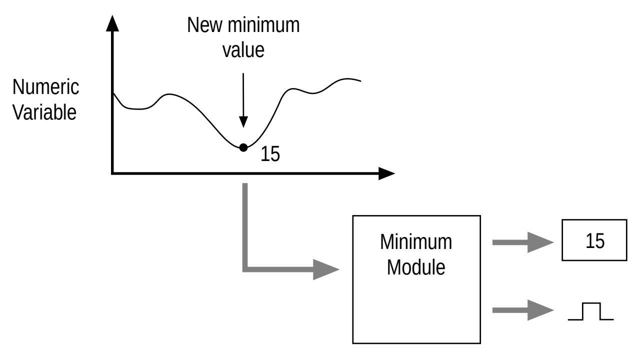
- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

Minimum modules have no setup registers.

Detailed Operation

The figure below illustrates the operation of a Minimum module. As long as the Enable input is ON, it monitors a numeric variable and every time the variable reaches a new minimum, the Minimum module stores that value and generates a pulse.



Responses to Special Conditions

The following table summarizes how the Minimum module behaves under different conditions.

Condition	Response of Output Register
If the Source input is *Not Available*	The Minimum output register retains the value it held when the Source input was available.
If the Enable input is OFF	The Minimum output register retains the value it held when the Source input was available.
After the module is re-linked or its setup registers are changed	The Minimum output register is *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	The Minimum output register retains the value it held at shut-down.

7700 ION Device Notes

The 7700 ION supports a total of 32 Minimum modules. All 32 are high-speed capable.

ION Modbus Slave Module

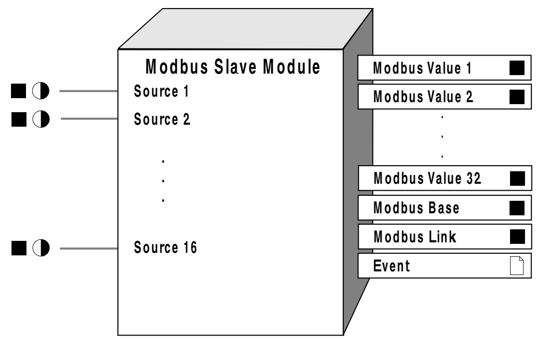
NOTE

For a complete reference to Modbus register numbers for ION module setup registers, ION External Control module output registers and ION Modbus module registers, refer to the POWER MEASUREMENT document:

ION / MODBUS REGISTER MAP

The Modbus standard describes a popular communications methodology that allows devices made by different manufacturers to communicate with each other. The Modbus Slave module allows an ION device to be integrated into a Modbus network. Data measured or calculated by ION devices can be made available to other devices on the Modbus network and further manipulated or analyzed.

The Modbus Slave module makes the values in ION registers available to a Modbus master device. Each module can be set to map up to 16 values to a specified base address in the Modbus holding register address range (40001 to 41800), and can present the data using 16-bit or 32-bit integer or Modbus formats, as well as packed Boolean.



Inputs

Modbus Slave modules have the following inputs:

■◑ *Source*

The Modbus Slave module takes the numeric or Boolean value on each input and makes it available to READ requests from the Modbus master. You may link any or all source inputs to the output registers of other ION modules.

Output Registers

Modbus Slave modules have the following output registers:

■ *Modbus Value #n*

There are 32 Modbus Value output registers, each of which contains one 16-bit integer value. These ION registers can be used to confirm the information presented to the Modbus Master. The validity of data in these registers depends on the availability of the corresponding input and the current value of the setup registers. The values can be signed or unsigned values, and may need to be interpreted in pairs to obtain 32-bit values.

- *Modbus Base*
  This register indicates the address of the first value available to the Modbus master, which is stored in the Modbus Value #1 output register.

- *Modbus Link*
  This register contains the next available Modbus holding register address, i.e. the first address following the last valid output register of this module. Refer to this register if you want to create a contiguous address range; enter the value in this register in the Base Addr setup register of another Modbus Slave module.

- *Event*
  All events produced by the Modbus Slave Module are recorded in the Event register. Possible events and their associated priority numbers are shown in the following table.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

Format
This register defines what format of data the module provides. The choices are:

Unsigned 16	Integer in the range 0 to 65535
Signed 16	Integer in the range -32767 to 32767
Unsigned 32	Integer in the range 0 to 2,147,483,647
Signed 32	Integer in the range -2,147,483,647 to 2,147,483,647
U32-MFP	Integer in the range 0 to 655,350,000
S32-MFP	Integer in the range -327,670,000 to 327,670,000
Packed Boolean	Integer in the range 0 to FFFF representing Boolean inputs.

For any 32-bit format, the 32-bit equivalent to the input uses two consecutive output registers (low address register contains high order word). For the Packed Boolean format, only the first output register contains a valid response.

U32-MFP and S32-MFP refer to Modbus Floating Point formats. The first 16-bit word in each case specifies the number (0 to 65,535 or -32,767 to 32,767); the second 16-bit word specifies the multiplier (1 to 10,000).

- *Base Addr*
  This register specifies the lowest address that the Modbus master can use to READ the data stored in the Modbus Value #1 output register. Each subsequent output register is addressable by the appropriate offset from this base address. The range for this register is 400001 to 41800.

- *Scaling*
  This register specifies whether or not the output values will be scaled. If Scaling is set to YES, then the values in the *In Zero*, *Out Zero*, *In Full* and *Out Full* registers are used to scale the output values; if it is set to NO, no scaling is performed, and the values in the *In Zero*, *Out Zero*, *In Full* and *Out Full* registers are ignored.

- *In Zero, In Full*
  These registers specify the input range for all values to which the module is linked. Any value less than the In Zero setting will be treated as an In Zero value, and any values exceeding the In Full value will be treated as an In Full value.

- *Out Zero, Out Full*
  These registers specify the output range for all values available from this module. The output values are linearly interpolated from the input range.

Detailed Operation

Boolean Inputs & Packed Boolean Format

If the Format setup register is set to Packed Boolean and the source inputs are connected to Boolean inputs, the Modbus Value 1 register contains a 16-bit map for the Boolean inputs. The most significant bit (MSB) corresponds to the value linked to the Source 1 input, and the least significant bit corresponds to the value linked to the Source 16 input. All other output registers are Not Available. The scaling registers have no effect if Packed Boolean format is selected.

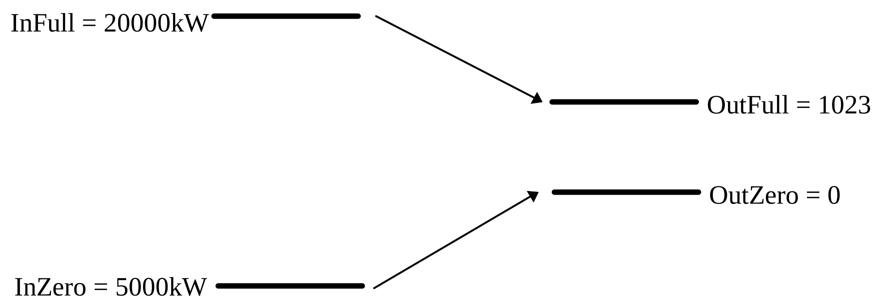
If the Format setup register is set to Packed Boolean and some of the source inputs are connected to numeric inputs, each non-zero numeric value is treated as a Boolean “1” and a zero numeric value is treated as a Boolean “0”.

If the Format setup register is set to *anything other than* Packed Boolean and some of the source inputs are connected to Boolean inputs, each Boolean “1” is placed in the corresponding output register as a numeric “1”and each Boolean “0” as a numeric “0” (each output uses 16 or 32 bits, depending on the Format setup register). The scaling registers have no effect on source inputs linked to Boolean values.

Scaling

Four setup registers (In Zero, In Full, Out Zero and Out Full) may be used to scale a range of numeric input values to a specified output range.

The following diagram shows how the scaling operation works. For example, suppose the Modbus Master needs 10-bit data for all inputs, and the kW reading is required. The Modbus Slave module Format register is set to use Unsigned 16-bit; the input range is specified as 5000kW to 20000 kW, and the output range is set from 0 to 1023 to give maximum resolution over this range.



Any values for the kW register below 5000kW will be exported to the MODBUS Master as a value of 0; any reading in excess of 20,000kW will be exported as a reading of 1023. The Modbus Master typically can apply the appropriate scaling and offset values necessary to interpret these values.

Note that if the Modbus Master reads data from any register that does not contain valid data (i.e. if any of the module inputs are not available), the data will be indicated by the hexadecimal value 0xFFFF; this should not be mistaken for a valid reading. Ensure that the Modbus Master can recognize this "invalid" response. In the case of Packed Boolean format, each unconnected or unavailable input is represented by a "0" in the output register.

Modbus Address Ranges

Many operating parameters of ION devices can be configured via Modbus WRITE commands. Setup registers are mapped to a fixed address range. You cannot use addresses in this range for access to Modbus Slave module output registers. The fixed address range used for access to ION setup registers includes all addresses between 42000 and 49999.

You may map the Modbus Slave module output registers (available for Modbus READ requests) to any range below 42000.

If you are using extended Modbus addressing, the setup registers are mapped to the address range 402000 and 409999; you can map the output registers to any range between 409999 and 465535.

Responses to Special Conditions

The following table summarizes how the Modbus Slave module behaves under different conditions.

Condition	Response of Output Register
If the Source input is *Not Available*	The Modbus Value registers are set to zero.(0)
After the module is re-linked or its setup registers are changed.	The Modbus Value registers are *Not Available.* The ModBase register is equal to the Base Addr setup register value. The ModLink register equals Modbase plus N.
When the device is started or powered-up (either the first time, or after a shut-down)	The Modbus Value registers are *Not Available*. The ModBase register is equal to the Base Addr setup register value. The ModLink register equals Modbase plus N.

7700 ION Device Notes

The 7700 ION supports a total of 4 Modbus Slave modules. All 4 are high-speed capable.

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Format	Unsigned 16; Signed 16; Unsigned 32; Signed 32; U32-MFP; S32-MFP; Packed Boolean	Modbus Slave #1: Unsigned 16 Modbus Slave #2 & #3: Signed 32 Modbus Slave #4: S32-MFP
Base Addr	400001 to 41800	Modbus Slave #1: 40011 Modbus Slave #2: 40027 Modbus Slave #3: 40059 Modbus Slave #4: 40089
Scaling	YES or NO	Modbus Slave #1, #2 and #3: YES Modbus Slave #4: NO
In Zero, In Full	-9×10^{37} to 9×10^{37} *	Modbus Slave #1: 0, 6553 Modbus Slave #2: -214748364, 214748364 Modbus Slave #3: -214748364, 214748364 Modbus Slave #4: NO Scaling
Out Zero, Out Full	-2147483647 to 2147483647 *	Modbus Slave #1: 0, 65530 Modbus Slave #2: -2147483640, 2147483640 Modbus Slave #3: -2147483640, 2147483640 Modbus Slave #4: NO Scaling

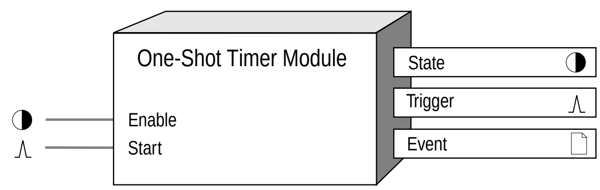
* Supported Range depends on Format used; maximum ranges shown.

ION One-Shot Timer Module

The One-Shot Timer module provides a time-delay function that can be used to postpone the operation of another module for a defined time period. Possible applications include:

implementing a delay before recording a waveform
delaying relay operation

The One-Shot Timer module turns a Boolean register ON for a specified time period whenever its Start input is pulsed. At the end of this time period, an output pulse is generated. A One-Shot Timer can be disabled.



Inputs

All One-Shot Timer modules have the following inputs:

NOTE

If the Enable input becomes Not Available, the One-Shot Timer does not operate.

Enable
This input enables or disables the One-Shot Timer module (by setting it to ON or OFF respectively). When the timer is running (i.e. if a pulse was received on the Start input but the time specified in the Duration setup register has not elapsed), disabling the Module has no immediate effect. However, subsequent pulses on the Start input will be ignored. This input is optional; if you leave it unlinked, the module will be enabled by default.

Start
This input triggers the time countdown to start. While the timer is running (i.e. when the State output register is ON) all input triggers are ignored; in other words, Start pulses cannot pre-empt the timer operation. Linking this input is mandatory.

Output Registers

All One-Shot Timer modules have the following output registers:

State
This Boolean register changes to ON when a pulse is received on the Start input and remains on for the time specified in the Duration setup register. Once the Duration has elapsed, the State output changes to OFF.

Trigger
Each time a pulse is received on the Start input and the time specified in the Duration setup register elapses, the One-Shot Timer module writes a pulse into the Trigger register.

Event

All events produced by a One-Shot Timer module are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

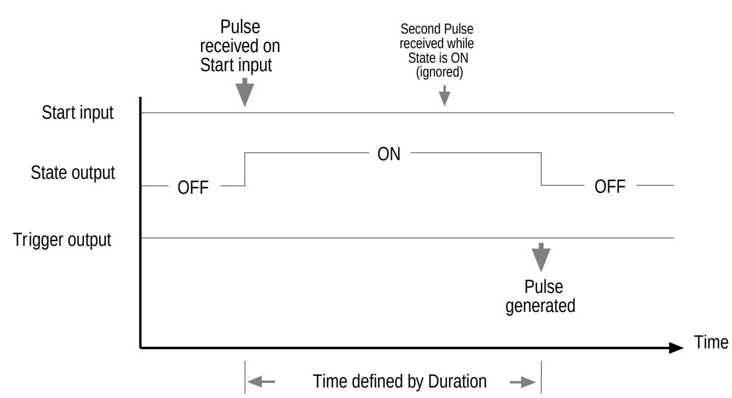
Setup Registers

Duration

All One-Shot Timer modules have one numeric bounded setup register called Duration. It specifies the time that must elapse after a pulse is received on the Start input before a pulse is generated on the Trigger output register. This time is specified in seconds.

Detailed Operation

The figure below illustrates the operation of an enabled One-Shot Timer module. When the pulse is received on the Start input, the State output register changes to ON for the time defined by the Duration. Once the Duration has elapsed, a pulse is generated on the Trigger output and the State output changes back to OFF. Note that the second pulse is ignored while the State output is ON.



Responses to Special Conditions

The following table summarizes how the One-Shot Timer module behaves under different conditions.

Condition	Response of Output Register
If the Enable input is OFF	If a Trigger pulse is in progress, the State output register remains ON for the duration of the pulse. If no pulse is in progress, State is OFF.
After the module is re-linked or its setup registers are changed	The State output register is OFF. Any Trigger pulse in progress is discarded.
When the device is started or powered-up (either the first time, or after a shut-down)	The State output register is OFF. Any Trigger pulse in progress is discarded.

7700 ION Device Notes

The 7700 ION supports a total of 12 One-shot Timer modules. All 12 are high-speed capable.

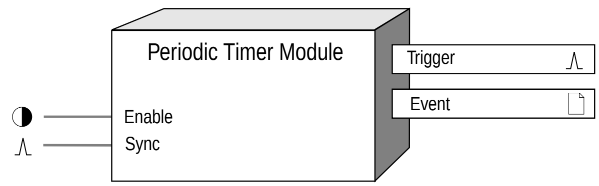
The supported ranges or options and the factory default settings for the setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Duration	0.010 to 2×10^{6} seconds	1

ION Periodic Timer Module

The Periodic Timer module provides a running timer that generates a pulse at programmable intervals. This pulse can be synchronized to the hour of the device's internal clock or to an external pulse received on the Sync input.

When used together with other modules, the Periodic Timer allows you to make events happen on a regular basis. For example, when used with a Recorder module, the Period Timer can be used to implement a snaphsot log.



Inputs

All Periodic Timer modules have the following inputs:

◑ *Enable*
This input enables or disables the Periodic Timer module (by setting it to ON or OFF respectively). When the module is disabled, no pulses are generated on the Trigger output register. Linking this input is optional; the module is enabled by default.

⋀ *Sync*
This input defines the starting point at which the Periodic Timer module begins timing. When a pulse is received on this input, the Periodic Timer starts timing from this new starting point. This input is optional; if you leave it unlinked, it will by default never receive a pulse.

Output Registers

All Periodic Timer modules have the following output registers:

⋀ *Trigger*
When the module is enabled, this pulse register generates a pulse every time the period specified by the Period setup register expires. If the Sync input is linked and you have set the Sync Mode setup register to TRIG ON SYNC, the Trigger output will generate a pulse every time the Sync input is pulsed, in addition to pulsing each time the period expires.

Event
All events produced by a Periodic Timer module are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Reset	5	A module resynch has occurred.
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The setup registers of the Period Timer module determine at what point output pulses are generated. All Periodic Timer modules have the following setup registers:

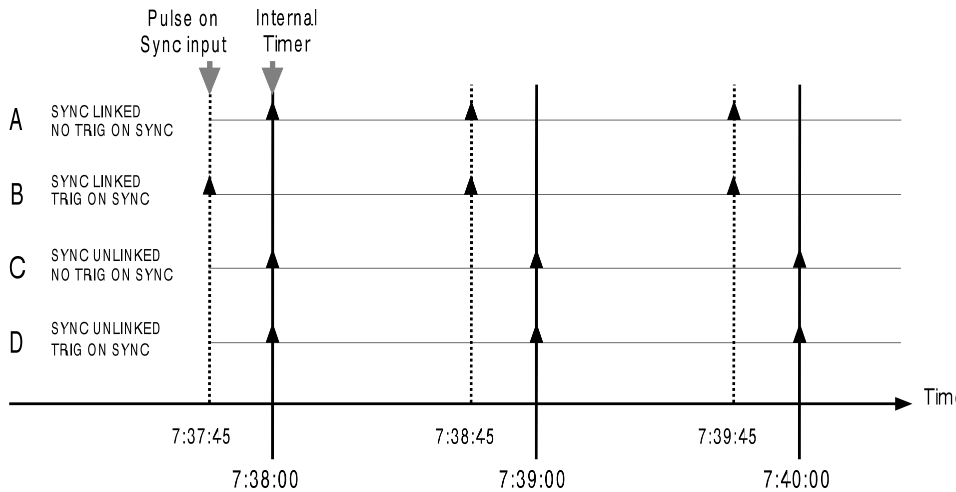
Period
This numeric bounded register specifies the number of seconds between pulses on the Trigger output register.

Sync Mode
This register determines whether the Trigger output generates a pulse when the Sync input is pulsed (TRIG ON SYNC) or if it waits for the first period to expire (NO TRIG ON SYNC).

Detailed Operation

The figure on the following page illustrates the operation of the Periodic Timer module with the Sync input linked or unlinked. The dots indicate when a pulse is generated on the Trigger output.

In all four cases, the Period is set to 60 s (1 minute).



Note how the timing of the Trigger pulse is affected by linking or unlinking the Sync input. The Sync input controls whether the Trigger pulses occur on regular time boundaries (e.g. 7:38:00, 7:39:00, 7:40:00) or in-between (e.g. 7:37:45, 7:38:45, 7:39:45). Sync Mode controls whether a pulse is immediately generated when an Sync pulse is received (e.g. at 7:37:45) or if it is delayed.

Responses to Special Conditions

The following table summarizes how the Periodic Timer module behaves under different conditions.

Condition	Response of Output Register
If the Enable input is OFF	No pulses will be generated at the output register.
When the module is re-linked or its setup registers a re changed	The Trigger output register does not "contain" a pulse on start-up. Pulses are generated only in response to the conditions described above. Note: If the *Sync* input is linked, the module will start its period from the time of start-up.

7700 ION Device Notes

The 7700 ION supports a total of 20 Periodic Timer modules. All 20 are high-speed capable.

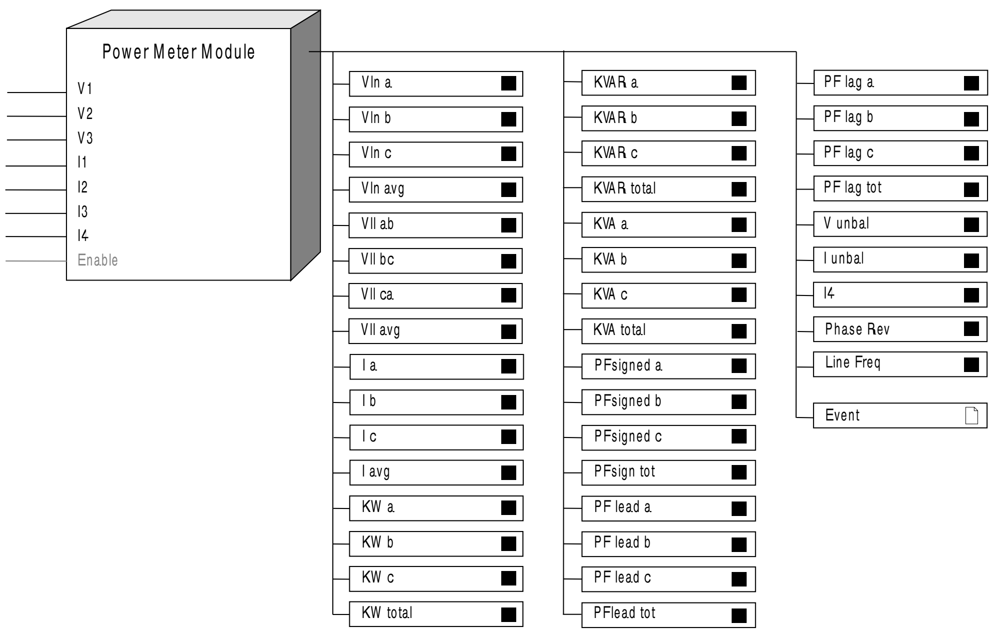
The supported ranges or options and the factory default setting for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Period	0.010 to 2 x 10^6 seconds	900
Sync Mode	NO TRIG ON SYNC or TRIGGER ON SYNC	NO TRIG ON SYNC

ION Power Meter Module

The Power Meter module performs calculations on sample waveforms of a 3-phase or single phase power system. It is automatically linked to the Data Acquisition module, and together these modules serve as the link between all other ION modules and the physical world. The Power Meter module's outputs are all the measured and calculated results from the device's voltage and current inputs.

The Meter Units Power Meter is a special type of Power Meter module that performs the same function as a regular Power Meter but it reports secondary values instead of primary values. When the device is connected to the power system, current transformers (CTs) are always required and potential transformers (PTs) may be required to transform the current and voltage to a level compatible with the device's input ratings. The Meter Units Power Meter module displays readings based on the voltage and current *after* they have been transformed to fall within the input ranges of the device. (The regular Power Meter uses scaling factors to display readings that reflect the actual levels of the power system.)



Inputs

The Power Meter module has a group of pre-defined inputs that receive their values from the Data Acquisition module:

- *V1-V3 and I1-I4*
  These inputs are sampled waveforms originating from a 3-phase or single-phase power system. Their links are pre-defined.

- *Enable*
  The enable input is not currently supported. The module is enabled by default.

Output Registers

The output registers of the Power Meter module contain all the current and voltage-based values that are measured or calculated by the meter. All Power Meter modules have the following output registers:

NOTE

For all voltage readings, the regular Power Meter reports primary values and the Meter Units Power Meter (MU Power Meter) reports secondary values.

- *Vln a*
  This numeric register contains the RMS voltage on phase A. Note that if Volts Mode is DELTA, this register will be set to Not Available.

- *Vln b*
  This numeric register contains the RMS voltage on phase B. Note that if Volts Mode is DELTA, this register will be set to Not Available.

- *Vln c*
  This numeric register contains the RMS voltage on phase C. Note that if Volts Mode is DELTA or SINGLE, this register will be set to Not Available.

- *Vln avg*
  This numeric register contains the average of Vln a, Vln b and Vln c. Note that if Volts Mode is SINGLE, this register will be set to the average of Vln a and Vln b only. If Volts Mode is DELTA, this register will be set to Not Available.

- *Vll ab*
  This numeric register contains the RMS voltage from phases B to A.

- *Vll bc*
  This numeric register contains the RMS voltage from phases C to B. Note that if Volts Mode is SINGLE, this register will be set to Not Available.

- *Vll ca*
  This numeric register contains the RMS voltage from phase A to C. Note that if Volts Mode is SINGLE, this register will be set to Not Available.

- *Vll avg*
  This numeric register contains the average of Vll ab, Vll bc and Vll ca. Note that if Volts Mode is SINGLE, this register will be set to Not Available.

NOTE

For all current readings, the regular Power Meter reports primary values and the Meter Units Power Meter (MU Power Meter) reports secondary values.

- *I a*
  This numeric register contains the RMS current of phase A.

- *I b*
  This numeric register contains the RMS current of phase B.

- *I c*
  This numeric register contains the RMS current of phase C. Note that if Volts Mode is SINGLE, this register will be set to Not Available.

- *I avg*
  This numeric register contains the average of I a, I b and I c. Note that if Volts Mode is SINGLE, this register will be set to the average of I a and I b only.

NOTE

For all kilowatt readings, the regular Power Meter reports primary values and the Meter Units Power Meter (MU Power Meter) reports secondary values.

- *KW a*
  This numeric register contains the real power for phase A. Note that a negative value indicates reverse (exported) KW. If Volts Mode is DELTA, this register will be Not Available.

- *KW b*
  This numeric register contains the real power for phase B. Note that a negative value indicates reverse (exported) KW. If Volts Mode is DELTA, this register will be Not Available.

- *KW c*
  This numeric register contains the real power for phase C. Note that a negative value indicates reverse (exported) KW. If Volts Mode is DELTA or SINGLE, this register will be Not Available.

- *KW total*
  In Wye mode, this numeric register contains the sum of KW a, KW b, and KW c. Note that a negative value indicates reverse (exported) KW. If Volts Mode is SINGLE, this register will contain the sum of KW a and KW b.

NOTE

For all KVAR readings, the regular Power Meter reports primary values and the Meter Units Power Meter (MU Power Meter) reports secondary values.

- *KVAR a*
  This numeric register contains the reactive power for phase A. Note that a negative value indicates reverse (exported) KVAR. If Volts Mode is DELTA, this register will be Not Available.

- *KVAR b*
  This numeric register contains the reactive power for phase B. Note that a negative value indicates reverse (exported) KVAR. If Volts Mode is DELTA, this register will be Not Available.

- *KVAR c*
  This numeric register contains the reactive power for phase C. Note that a negative value indicates reverse (exported) KVAR. If Volts Mode is DELTA or SINGLE, this register will be Not Available.

- *KVAR total*
  In Wye mode, this numeric register contains the sum of KVAR a, KVAR b, and KVAR c. Note that a negative value indicates reverse (exported) KVAR. If Volts Mode is SINGLE, this register will contain the sum of KVAR a and KVAR b.

NOTE

For all KVA readings, the regular Power Meter reports primary values and the Meter Units Power Meter (MU Power Meter) reports secondary values.

- *KVA a*
  This numeric register contains the RMS value of apparent power for phase A. Note that if Volts Mode is DELTA, this register will be Not Available.

- *KVA b*
  This numeric register contains the RMS value of apparent power for phase B. Note that if Volts Mode is DELTA, this register will be Not Available.

- *KVA c*
  This numeric register contains the RMS value of apparent power for phase C. Note that if Volts Mode is DELTA or SINGLE, this register will be Not Available.

- *KVA total*
  In Wye mode, this numeric register contains the vector sum of KW total and KVAR total:

$$\sqrt{KW_{total}{}^{2} + KVAR_{total}{}^{2}}$$

NOTE

For all the following Power Factor (PF) registers, refer to the section *Power Factor, Power and Energy Interpretation* for more information regarding the interpretation of Power Factor.

- *PFsigned a*
  This numeric register contains the power factor on phase A. The value can range from 0 to 100 and -100 to -0. If the value is negative, the power factor is lagging; if the value is positive, the power factor is leading. Note that if Volts Mode is DELTA, this register will be Not Available.

- *PFsigned b*
  This numeric register contains the power factor on phase B. The value can range from 0 to 100 and -100 to -0. If the value is negative, the power factor is lagging; if the value is positive, the power factor is leading. Note that if Volts Mode is DELTA, this register will be Not Available.

- *PFsigned c*
  This numeric register contains the power factor on phase C. The value can range from 0 to 100 and -100 to -0. If the value is negative, the power factor is lagging; if the value is positive, the power factor is leading. Note that if Volts Mode is DELTA or SINGLE, this register will be Not Available.

- *PFsign tot*
  In Wye mode, this numeric register contains the total power factor on phases A, B, and C. The value can range from 0 to 100 and -100 to -0. Note that if Volts Mode is SINGLE, this register will contain the total power factor on phases A and B.

- *PFlead a*
  This numeric register contains the leading power factor on phase A. The value can range from 0 to 100. Note that if Volts Mode is DELTA or the power factor is lagging, this register will be Not Available.

- *PFlead b*
  This numeric register contains the leading power factor on phase B. The value can range from 0 to 100. Note that if Volts Mode is DELTA or the power factor is lagging, this register will be Not Available.

- *PFlead c*
  This numeric register contains the leading power factor on phase C. The value can range from 0 to 100. Note that if Volts Mode is DELTA or SINGLE, or the power factor is lagging, this register will be Not Available.

- *PFlead tot*
  In Wye mode, this numeric register contains the total leading power factor on phases A, B, and C. The value can range from 0 to 100. Note that if Volts Mode is SINGLE, this register will contain the total leading power factor on phases A and B. If the total power factor is lagging, this register will be Not Available.

- *PFlag a*
  This numeric register contains the lagging power factor on phase A. The value can range from 0 to 100. Note that if Volts Mode is DELTA or the power factor is leading, this register will be Not Available.

- *PFlag b*
  This numeric register contains the lagging power factor on phase B. The value can range from 0 to 100. Note that if Volts Mode is DELTA or the power factor is leading, this register will be Not Available.

- *PFlag c*
  This numeric register contains the lagging power factor on phase C. The value can range from 0 to 100. Note that if Volts Mode is DELTA or SINGLE, or the power factor is leading, this register will be Not Available.

- *PFlag tot*
  In Wye mode, this numeric register contains the total lagging power factor on phases A, B, and C. The value can range from 0 to 100. Note that if Volts Mode is SINGLE, this register will contain the total lagging power factor on phases A and B. If the total power factor is leading, this register will be Not Available.

- *V unbal*
  This numeric register contains the percentage deviation from Vln avg for the voltage phase having the greatest unbalance. It is calculated as follows:

Wye mode

$$\frac{\text{Largest Deviation from Vln avg}}{\text{Vln avg}} \times 100\%$$

Delta mode

$$\frac{\text{Largest Deviation from Vll avg}}{\text{Vll avg}} \times 100\%$$

- *I unbal*
  This numeric register contains the percentage deviation from I avg for the current phase having the greatest unbalance.

$$\frac{\text{Largest Deviation from I avg}}{\text{I avg}} \times 100\%$$

- *I4*
  This numeric register contains the RMS current - calculated using the I4 input.

◑ *Phase Rev*
This Boolean register indicates if there is a Phase reversal. When the voltage phases do not rotate in the sequence specified by the PhaseOrder setup, this register is ON. Note that if Volts Mode is SINGLE, this register is Not Available.

■ *Line Freq*
This numeric register contains the Fundamental frequency of phase A voltage.

Event
All events produced by a Power Meter module are written into this register. Events in the Power Meter module are any changes to the setup registers, input links or labels. These events all have a pre-defined priority of 10.

Setup Registers

The setup registers for the Power Meter module define the characteristics of the power system being monitored and influence the calculations that are performed. All Power Meter modules have the following setup registers:

Volts Mode
This register reflects the power system configuration and determines the mode of calculation. The choices are: 4W-WYE, 3W-WYE, DELTA, SINGLE and DEMO. The device offers a demonstration mode which generates dynamic artificial readings for all real-time measurement output registers. Refer to Chapter 2, *Installation* for details about which configuration is appropriate under different circumstances as well as detailed wiring diagrams.

NOTE
The PT and CT scaling factors are ignored for the Meter Units Power Meter (MU Power Meter).

▣ *PT Prim*
If potential transformers (PTs) are used on V1 - V3 inputs, this register should be set to the primary winding rating for the PTs. If direct connection is used, this register should be set to the full scale ratings of the V1 - V3 inputs.

▣ *PT Sec*
If potential transformers (PTs) are used on V1 - V3 inputs, this register determines the secondary winding rating for the PTs. If direct connection is used, this register sets the full scale ratings of the V1 - V3 inputs.

▣ *CT Prim*
This register should be set to the Current Transformer (CT) primary winding rating for inputs I1 - I3.

▣ *CT Sec*
This register should be set to the Current Transformer (CT) secondary winding rating for inputs I1 - I3.

▣ *I4 CT Prim*
This register should be set to the Current Transformer (CT) primary winding rating for input I4.

▣ *I4 CT Sec*
This register should be set to the Current Transformer (CT) secondary winding rating for input I4.

- *V1Polarity*
  This register should be set to the polarity of the V1 Potential Transformer (PT). The choices are NORMAL and INVERTED.

- *V2Polarity*
  This register should be set to the polarity of the V2 Potential Transformer (PT). The choices are NORMAL and INVERTED.

- *V3Polarity*
  This register should be set to the polarity of the V3 Potential Transformer (PT). The choices are NORMAL and INVERTED.

- *I1Polarity*
  This register should be set to the polarity of the I1 Current Transformer (CT). The choices are NORMAL and INVERTED.

- *I2Polarity*
  This register should be set to the polarity of the I2 Current Transformer (CT). The choices are NORMAL and INVERTED.

- *I3Polarity*
  This register should be set to the polarity of the I3 Current Transformer (CT). The choices are NORMAL and INVERTED.

- *I4Polarity*
  This register should be set to the polarity of the I4 Current Transformer (CT). The choices are NORMAL and INVERTED.

- *PhaseOrder*
  This register defines the expected rotation of voltage phases. The choices are ABC and ACB.

NOTE

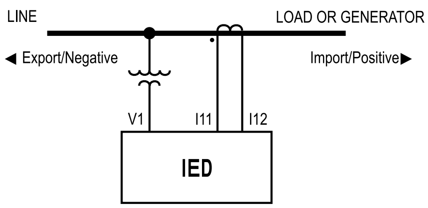
It is important that Nom Freq is set correctly, as the accuracy of the KW, KVAR, and power factor measurements can be seriously affected.

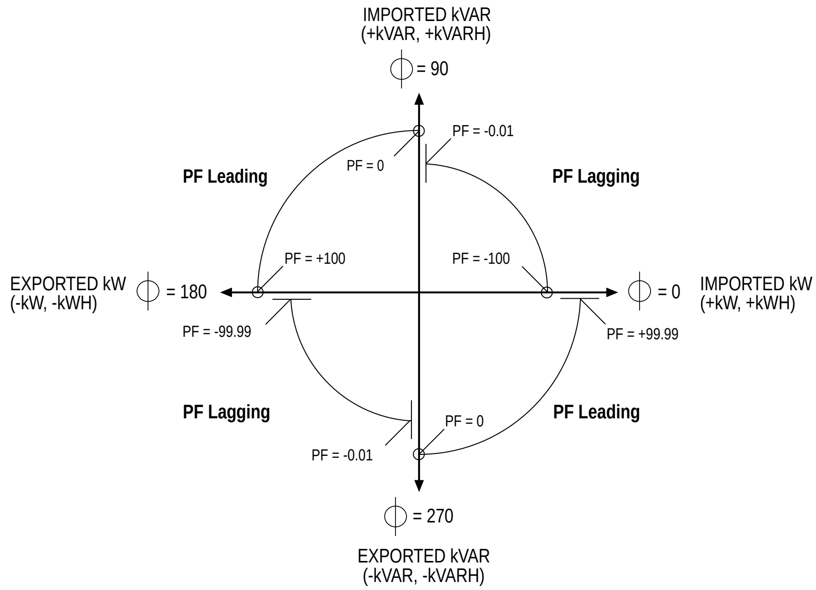
- *Nom Freq*
  This register defines the expected *fundamental* frequency of the input waveforms.

- *Phase Lbls*
  This register determines the phase label formats given to the output registers. The choices are ABC, RST, XYZ, and RYB, 123.

Power Factor, Power and Energy Interpretation

Values for power factor, and import/export indication for energy are interpreted according to the figures below:





Responses to Special Conditions

The following table summarizes how the Power Meter module behaves under different conditions.

Condition	Response of Output Register
If any Source inputs are *Not Available*	All output registers are *Not Available*.
If the Enable input is OFF	All output registers are *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	All output registers are *Not Available*.

7700 ION Device Notes

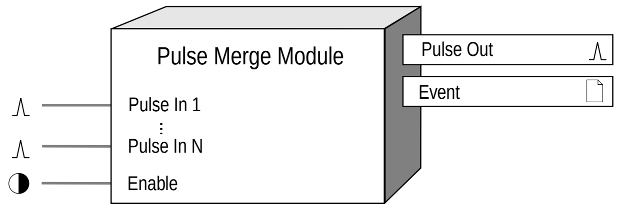
The 7700 ION supports 3 Power Meter modules. Of these, 1 is high-speed capable.

The supported ranges or options and the factory default settings for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Volts Mode	4W-WYE, 3W-WYE, DELTA, SINGLE or DEMO	4W-WYE
PT Prim	1 to 999999	1200
PT Sec	1 to 999999	120
CT Prim	1 to 999999	5000
CT Sec	1 to 999999	5
I4 CT Prim	1 to 999999	5000
I4 CT Sec	1 to 999999	5
V1Polarity	NORMAL or INVERTED	NORMAL
V2Polarity	NORMAL or INVERTED	NORMAL
V3Polarity	NORMAL or INVERTED	NORMAL
I1Polarity	NORMAL or INVERTED	NORMAL
I2Polarity	NORMAL or INVERTED	NORMAL
I3Polarity	NORMAL or INVERTED	NORMAL
I4Polarity	NORMAL or INVERTED	NORMAL
PhaseOrder	ABC or ACB	ABC
Nom Freq	Nom Freq is factory set according to the selected ordering option.	
Phase Lbls	ABC, RST, XYZ, RYB or 123	ABC

ION Pulse Merge Module

The Pulse Merge module takes input pulses from multiple sources and outputs them into a single pulse output register. This module is useful for triggering an ION module from several different pulse sources. For example, if you want to pulse an ION module when any one of a group of ION modules pulses, you can route the outputs of each module in the group to a Pulse Merge module, and then use the Pulse Merge module to pulse the module you want to control.



Inputs

All Pulse Merge modules have the following inputs:

Pulse In 1,2,3,...N
These inputs are monitored for pulses and any pulses received on these inputs are subsequently sent to the Pulse Out output register (see the Module Summary table at the beginning of Chapter 5 for the number of Pulse In inputs supported). At least one of these inputs must be linked for the module to operate.

Enable
This input enables or disables the Pulse Merge module by setting it ON or OFF respectively. If you disable a Pulse Merge module, pulses on the Pulse In inputs are ignored. Linking this input is optional; if you leave it unlinked, the module will be enabled by default.

Output Registers

All Pulse Merge modules have the following output registers:

Pulse Out
This register outputs a pulse anytime a pulse is received at any of the Pulse In inputs.

Event
All events produced by a Pulse Merge module are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
Input Register Change	15	Pulse received on Source input. *

* These events are only recorded if the EvLog Mode setup register is set to LOG ON.

For each event, the following is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

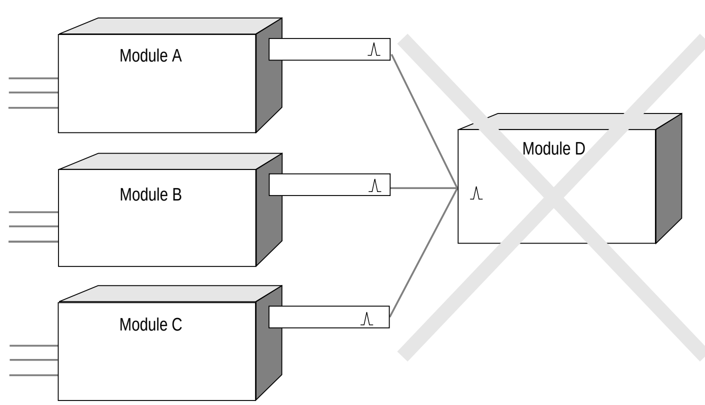
Setup Registers

EvLog Mode
All Pulse Merge modules have one setup register called EvLogMode. It determines whether pulses received on the inputs are logged as events in the Event output register. If this register is set to LOG ON, each time a pulse is received on a Source input when the module is enabled, an event is logged indicating which input was pulsed. If EvLog Mode is set to LOG OFF, these events are not logged. Note that in either case, linking the module inputs and changing setup registers are still logged as events in the Event output register.

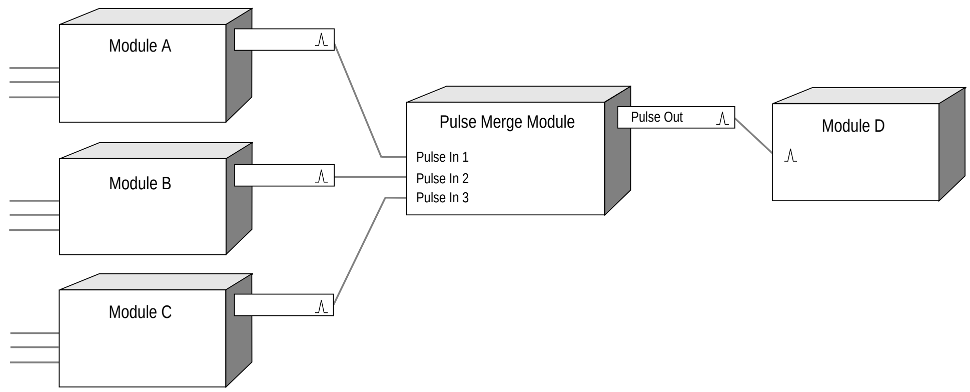
Detailed Module Operation

The primary function of the Pulse Merge module is to act like an OR gate for pulse outputs. In a situation where you want to pulse the inputs of a module if any one of a group of modules pulses, you must use the Pulse Merge module because you cannot link multiple outputs registers into a single input.

For example, suppose you want to trigger module D any time module A, B *or* C pulses. Although you may be tempted to link the modules as shown in the picture below, this kind of linkage is not supported. An input can only be linked to one output at a time.

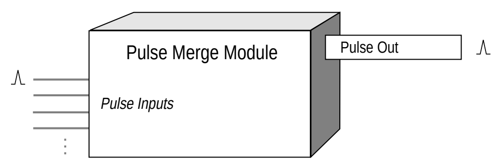


To achieve the desired result, you must route the outputs of modules A, B and C through a Pulse Merge module and then link its Pulse Out register to module D. In this case any time module A, B or C outputs a pulse, the Pulse Merge module will pulse module D.

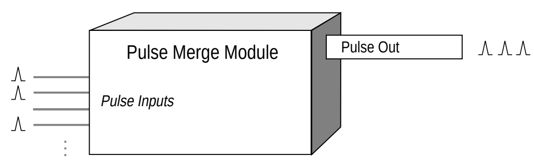


The figures below show the module operation under various input conditions.

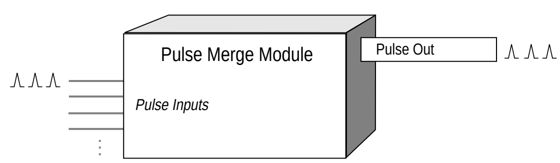
Here, one pulse on a single input results in a single pulse out:



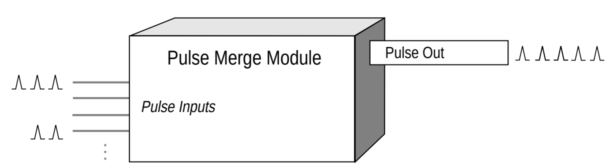
In this case, a single pulse on three separate inputs results in three pulses out:



In this case, three pulses on a single input results in three pulses out:



Finally, three pulses on one input and two pulses on a different input results in a total of five pulses out:



Responses to Special Conditions

The following table summarizes how the Pulse Merge module behaves under different conditions.

Condition	Response of Output Register
When the module is first created	The Pulse Out output will not pulse until the inputs are evaluated.
If the Enable input is OFF	The Pulse Out output will not pulse.
After the module is re-linked or its setup registers are changed	The Pulse Out output will not pulse until the inputs are evaluated.

7700 ION Device Notes

The 7700 ION supports a total of 8 Pulse Merge modules, and all 8 are high-speed capable.

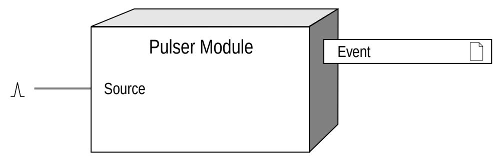
The supported ranges or options and the factory default setting for the setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
EvLog Mode	LOG ON or LOG OFF	LOG OFF

ION Pulser Module

The Pulser module serves as a intermediary between other module's 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. You must specify whether the output is a transition or complete pulse, and you must indicate if it will pulse high or low. You must also select on which hardware port the pulses will appear.

For each pulse received at the source input, a single pulse is sent to the specified hardware output channel.



Inputs

Source
All Pulser modules have one input called the Source. This input can be the pulse output register from any other module. It is monitored for a pulse and when one is present, it sends a pulse to the specified hardware output channel. Linking this input is mandatory.

Output Registers

The primary effect of the Pulser module is not to send a value to an output register but to send a pulse to the actual hardware. This makes it slightly different from most of the other modules. Pulser modules do however generate events and thus, they have an Event register:

NOTE
You do not need to use a ION Digital Output module to control the hardware device; the Pulser module can control the hardware device itself.

Event
Any events produced by the Pulser module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.

- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

All Pulser modules have the following setup registers:

▣ *PulseWidth*
This numeric bounded register specifies the minimum pulse width the module may send out the hardware channel. PulseWidth is specified in seconds.

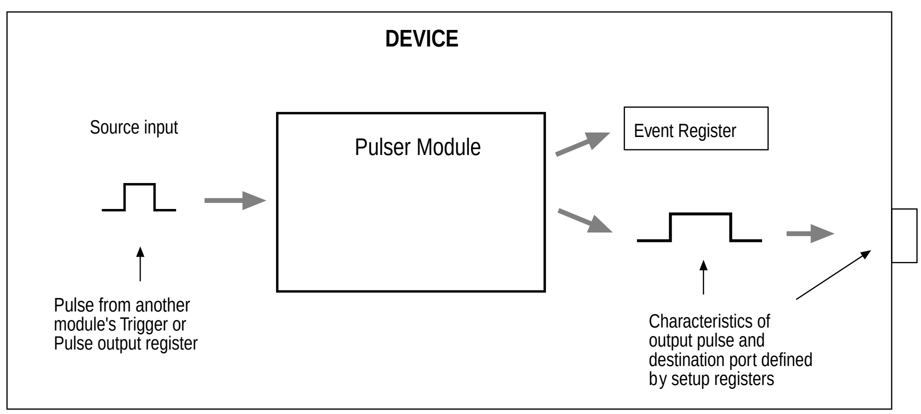
☰ *OutputMode*
This register specifies whether the output is a complete pulse (PULSE) or a transition pulse (KYZ).

☰ *Polarity*
If you have selected a complete pulse as the OutputMode, this register defines the output polarity of the pulses. It has no effect if you selected transition mode.

☰ *Port*
This register specifies which hardware port the output appears on. Refer to the hardware options table in Chapter 3 for a list of available ports.

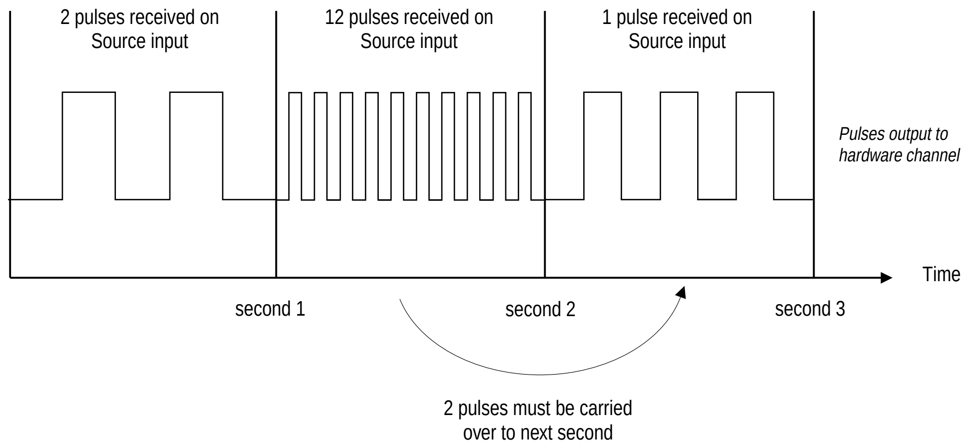
Detailed Operation

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 a like number of pulses to the specified hardware output channel. Because the Pulse Width 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.

In the figure below, the Pulse Width is set to 0.100 seconds and the Output Mode is set to PULSE. This means that a maximum of 10 pulses can be output to the hardware channel in one second.



Note that in the first second, the two output pulses are spread evenly across the second rather compressed into the first or last portion of the second.

Responses to Special Conditions

The following table summarizes how the Pulser module behaves under different conditions.

Condition	Response of Output Register
After the module is re-linked or its setup registers are changed	Any pulses in progress are discarded.
When the device is started or powered-up (either the first time, or after a shut-down)	No pulses are sent to the hardware port, and all pending pulses are discarded.

7700 ION Device Notes

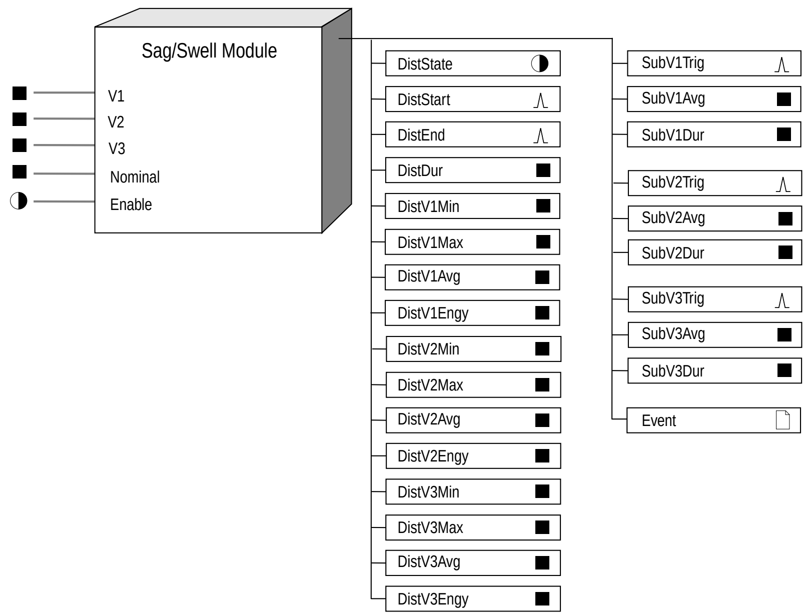
The 7700 ION supports a total of 10 Pulser modules. Pulser modules are not high-speed capable.

The supported ranges or options and the factory default setting for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
PulseWidth	0 to 2 x 10^6 seconds	1
OutputMode	PULSE or KYZ	PULSE
Polarity	INVERTING or NON-INVERTING	INVERTING
Port	The Port option is variable, and depends on the options ordered with the 7700 ION. There is no default port; the available ports will be presented when you enter this setup register.	

ION Sag/Swell Module

The Sag/Swell module monitors voltage inputs for disturbances, which are defined as one or more of the inputs straying above a high limit (swells) or below a low limit (sags or interruptions). When it detects a disturbance, the Sag/Swell module provides information about the entire disturbance; in addition, it breaks up the disturbance into discrete components, or *sub-disturbances*, to provide for a more detailed analysis. It determines the RMS magnitude and the duration of each sub-disturbance so that they may be plotted on a CBEMA curve using PEGASYS.



The primary application for the Sag/Swell module is voltage quality monitoring and analysis. For both utilities and their customers, poor voltage quality can have expensive results. Electrical equipment is designed to operate within certain voltage limits; if there is a disturbance in voltage, equipment can fail or sustain permanent damage. Computer equipment is especially sensitive to disturbances in voltage. Utilities must often be able to prove to their customers that they are delivering high quality, reliable voltage. Likewise, customers must be able to assess voltage quality to ensure it meets the requirements of their equipment. The Sag/Swell module provides data for a detailed historical analysis of voltage quality. It also provides pulse outputs that can be used to control external equipment for a more proactive approach to managing voltage quality problems.

Inputs

All Sag/Swell modules have the following inputs:

NOTE

You must link at least one of V1, V2 or V3 for the Sag/Swell module to operate.

The Sag/Swell module is intended for use with the voltage output registers of the high-speed Power Meter module. You can link V1, V2 or V3 to other numeric output registers if you wish; however, the energy-related output registers will all be meaningless.

In addition, if the values appearing at the V1, V2, or V3 inputs are negative, the Sag/Swell module will provide meaningless results.

V1-V3

These inputs should be linked to voltage output registers from the Power Meter module (typically the high-speed Power Meter). The Sag/Swell module updates at the rate of the slowest input. The setting of the Power Meter module's Volts Mode setup register determines to what register you should link V1, V2 and V3. The following table summarizes how you should link these inputs:

Volts Mode	V1	V2	V3
4W-Wye	Vln a	Vln b	Vln c
3W-Wye	Vln a	Vln b[1]	Vln c
Delta	Vll ab	Vll bc	Vll ca
Single	Vln a	Vln b	*do not link*

Nominal

This optional input specifies what the nominal voltage of the power system is. Typically, the Nom Volts setup register is used to specify the nominal voltage; however, if your nominal voltage fluctuates and you want the Sag/Swell module to adjust accordingly, you must link this input to a register that correctly reports the nominal voltage[2]. The Nominal input is read once per second. If this input is linked, the setting in the Nominal setup register is ignored.

Enable

This input enables or disables the module (by setting it ON or OFF respectively). Linking this input is optional; if you leave it unlinked the module will be enabled by default.

Output Registers

The following output registers provide data about a disturbance as a whole and about all the sub-disturbances that comprised it. The data provided by these registers is historical rather than real-time; the disturbance values are not calculated until the end of the disturbance, and the sub-disturbance values are not calculated until the end of the sub-disturbance. The pulse registers are provided to trigger Data Recorder modules so the values can be logged and later analyzed.

[1] In a 3W-Wye system, Vln b is derived from the Vln a and Vln c measurements, assuming balanced voltages. Since voltages will typically be unbalanced during a disturbance, the value of Vln b may not be accurate.

[2] If this input drops to 0 or below, the value of the Nom Volts setup register is used instead.

◑ *DistState*
This Boolean register is ON when the RMS value of one or more of the inputs strays outside the limits defined by the Swell Lim and Sag Lim setup registers. This situation is referred to as a *disturbance*. DistState is OFF when all inputs fall within the limits.

⋏ *DistStart*
This pulse register outputs a pulse when a disturbance is detected.

⋏ *DistEnd*
This pulse register outputs a pulse when the RMS value of all inputs have returned to within the limits defined by the Swell Lim and Sag Lim setup registers.

■ *DistDur*
This register contains the duration of the last disturbance in seconds.

NOTE

V1, 2, and 3 correspond to different phases depending on how the Volts Mode setup register of the Power Meter module is set:

V1:

4W-Wye.................................. Vln a
3W- Wye................................. Vln a
Delta....................................... Vll ab
Single .... Vln a

V2:

4W-Wye.................................. Vln b
3W- Wye................................. Vln b*
Delta....................................... Vll bc
Single .... Vln b

V3:

4W-Wye.................................. Vln c
3W- Wye................................. Vln c
Delta....................................... Vll ca
Single .... NA

* This value will be inaccurate if the voltages are unbalanced.

■ *DistV1Min, DistV2Min, DistV3Min*
These registers contain the minimum RMS magnitude reached during the last disturbance on V1, V2 and V3 respectively. They are expressed as a percentage of the nominal voltage. For example, if V1 sags from 120 V nominal down as far as 90 V, the DistV1Min register will contain 75.

■ *DistV1Max, DistV2Max, DistV3Max*
These registers contain the maximum RMS magnitude reached during the last disturbance on V1, V2, and V3 respectively. They are expressed as a percentage of the nominal voltage. For example, if V2 swells from 120 V nominal up as far as 150 V, the DistV2Max register will contain 125.

■ *DistV1Avg, DistV2Avg, DistV3Avg*
These registers contain the average RMS magnitude during the last disturbance on V1, V2 and V3 respectively. They are expressed as a percentage of the nominal voltage. For example, on a 120 V nominal system, if the average V3 voltage throughout a disturbance is 30 V, the DistV3Avg register will contain 25.

■ *DistV1Engy, DistV2Engy, DistV3Engy*
These registers contain the energy delta during the last disturbance on V1, V2, and V3 respectively. They indicate how much extra energy was present during the disturbance, or how much was lacking. These registers are expressed as a percentage of Nominal voltage energy and are calculated according to the following formula (where V_x is either V1, V2, or V3):

$$\frac{\int V_x^2 t}{\int V_{nominal}^2 t} \times 100$$

NOTE

Refer to the description of the ChangeCrit setup register for details about how a sub-disturbance is defined.

SubV1Trig, SubV2Trig, SubV3Trig
These pulse registers output a pulse at the boundary between sub-disturbances on V1, V2, and V3 respectively. This includes the beginning of the disturbance (which is also the beginning of the first sub-disturbance), the beginning of any new sub-disturbances, and the return to normal voltage.

For example, there is a pulse on SubV1Trig whenV1 falls outside the Swell and Sag Limits specified in the setup registers, when a new sub-disturbance occurs on V1, and whenV1 returns to within the Swell and Sag Limits. See the section Disturbance Sub-Divisions for a detailed description of when these outputs pulse during a complex disturbance.

SubV1Avg, SubV2Avg, SubV3Avg
These registers contain the average RMS magnitude during the previous sub-disturbance onV1, V2 and V3 respectively. These values can be used to plot the sub-disturbance on a Magnitude vs. Duration curve (such as CBEMA).

SubV1Dur, SubV2Dur, SubV3Dur
These registers contain the duration (in seconds) of the previous sub-disturbance on V1, V2 and V3 respectively. These values can be used to plot the sub-disturbance on a Magnitude vs. Duration curve (such as CBEMA).

Event
All events produced by a Sag/Swell module are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
Information	25	*Not Available* input caused output to go *Not Available.*
Setpoint	*	Disturbance started; Disturbance ended; setup changed while a Disturbance was present; module disabled while a Disturbance was present.

* The priority of these events is determined by the value in the EvPriority setup register.

Note that no events are generated by start or end of a sub-disturbance. For each event written into the event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

These registers define what is interpreted as a disturbance and a sub-disturbance. All Sag/Swell modules have the following setup registers:

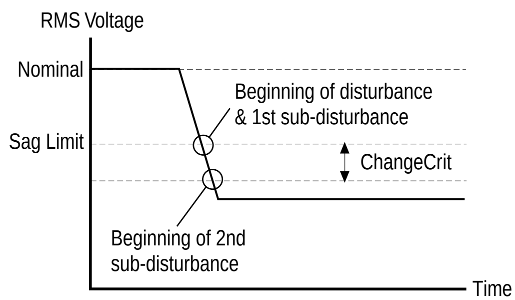
> **NOTE**
> The Swell Lim must be over 100 and the Sag Lim must be between 1 and 100 for the module to operate.

- *Swell Lim*
  This register specifies what limit any of the inputs must exceed for the DistState output register to change to ON. It is specified as a percentage of the nominal voltage. (The ANSI C84.1 1989 standard recommends a limit of 106% for Range B voltage levels.)

- *Sag Lim*
  This register specifies what limit any of the inputs must fall below for the DistState output register to change to ON. It is specified as a percentage of the nominal voltage. (The ANSI C84.1 1989 standard recommends for Range B voltage levels a limit of 88% for load voltages and 92% for the service entrance.)

> **NOTE**
> Changes in voltage are only considered sub-disturbances while a disturbance is in progress. For example, if the Sag Lim is 95% and the ChangeCrit is 2%, a voltage drop to 97% of nominal is *not* considered a sub-disturbance; the drop exceeded the ChangeCrit but the voltage did not fall below the Sag Lim and hence there was no disturbance.

- *ChangeCrit*
  This register provides the means to sub-divide a disturbance into discreet sub-disturbances. It specifies by how much an input must change during a disturbance to be considered a new sub-disturbance. The percentage you define is with respect to the nominal voltage, not the voltage at the time of the change. For example, if your nominal voltage is 120V and your ChangeCrit is 10%, any voltage drop of 12V or more during a disturbance will mark a new sub-disturbance.



- *Nom Volts*
  This register specifies the nominal voltage of the power system you are monitoring. If this value is constant for your system, you should specify it here and leave the Nominal input unlinked.

- *EvPriority*
  This register allows you to assign a priority level to the following events produced by the Sag/Swell module:

  - The DistState output register changes to ON.
  - The DistState output register changes to OFF.
  - Setup changes made while a Disturbance is present.
  - Module disabled while a Disturbance is present.

  The priority level you specify will apply to all of the above events.

> **NOTE**
> If EvPriority is set to zero (0), the following events will not be logged:
> - Sag/Swell Disturbance Start.
> - Sag/Swell Disturbance End.

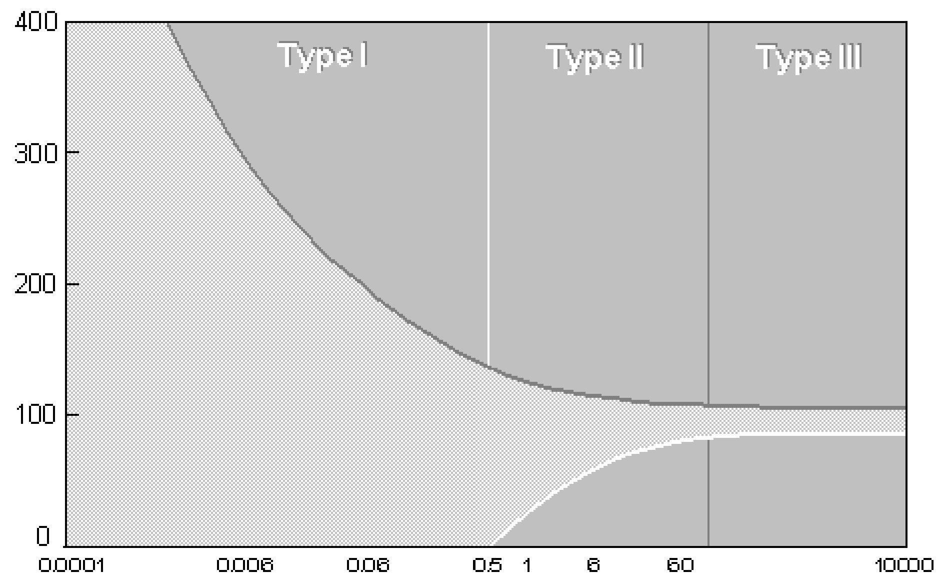
Detailed Operation

A major concern about disturbances in power quality is the adverse effect sags and swells can have on electrical equipment. These effects can range from a momentary disruption in operation to permanent damage, all of which can be expensive.

The severity of a sag or a swell in voltage is determined by a combination of how large it was and how long it lasted. A piece of equipment may be able to tolerate a large, but short duration disturbance in voltage. Likewise, it may be able to tolerate a disturbance that is small but longer in duration.

Power Tolerance Curves

The CBEMA[3] curve is a power tolerance curve that describes what types of disturbances electrical equipment can typically ride through, and what types can cause equipment failure or damage. It plots the magnitude of the disturbance (in percentage) on the Y-axis and the duration of the disturbance on the X-axis. Disturbances that fall within the envelope defined by the upper and lower curve are typically not harmful to electrical equipment; disturbances that fall outside the envelope may disrupt or damage the equipment.



CBEMA is not the only power tolerance curve available. ANSI Standard C84.1 also defines a curve that places an upper and lower bound on voltage excursions of different durations. Both of these curves are available in the data log plotters in the PEGASYS Vista software. If you plot the magnitude and duration of the sub-disturbances detected by the Sag/Swell module, you can overlay either of these curves, or a custom power tolerance curve to see if equipment might be affected by the sub-disturbance. See the PEGASYS Vista User's Guide for details about creating a custom power tolerance curve.

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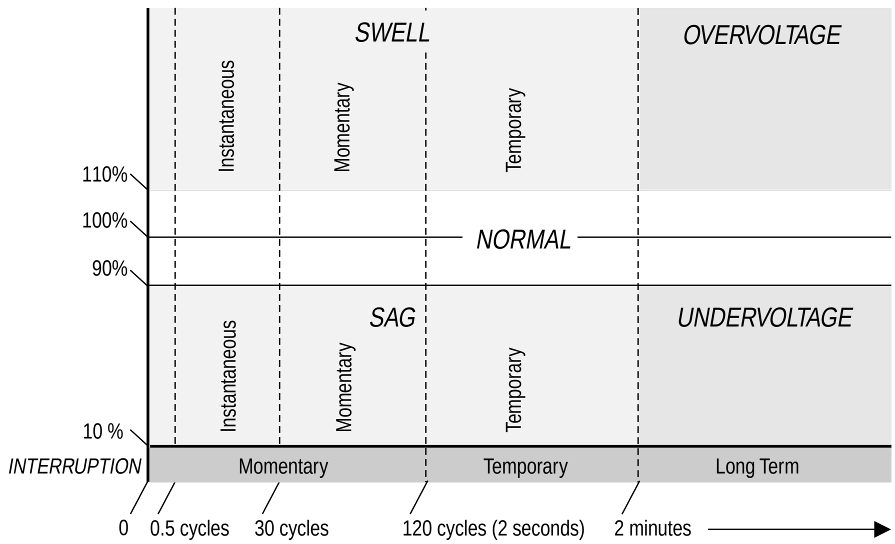
[3] Computer Business Equipment Manufacturers Association

Disturbance Categories as Defined by IEEE

The IEEE 1159 standard categorizes a wide range of electrical disturbances according to their typical duration and magnitude. The categories that are addressed by the Sag/Swell module include short-duration variations, long-duration variations and interruptions in RMS voltage. The figure below summarizes these categories:



Sags and swells are described as short-duration variations; under and overvoltages are described as long-duration variations. When the voltage drops below 10% of the nominal voltage, it is called an interruption.

As a disturbance progresses, it will likely move through several of these categories. It isn't until the voltage has returned to the normal parameters that the disturbance can be categorized. Even then, a single disturbance often cannot be categorized because there were many. To address this, the ChangeCrit setup register allows you to break the disturbance into sub-disturbances.

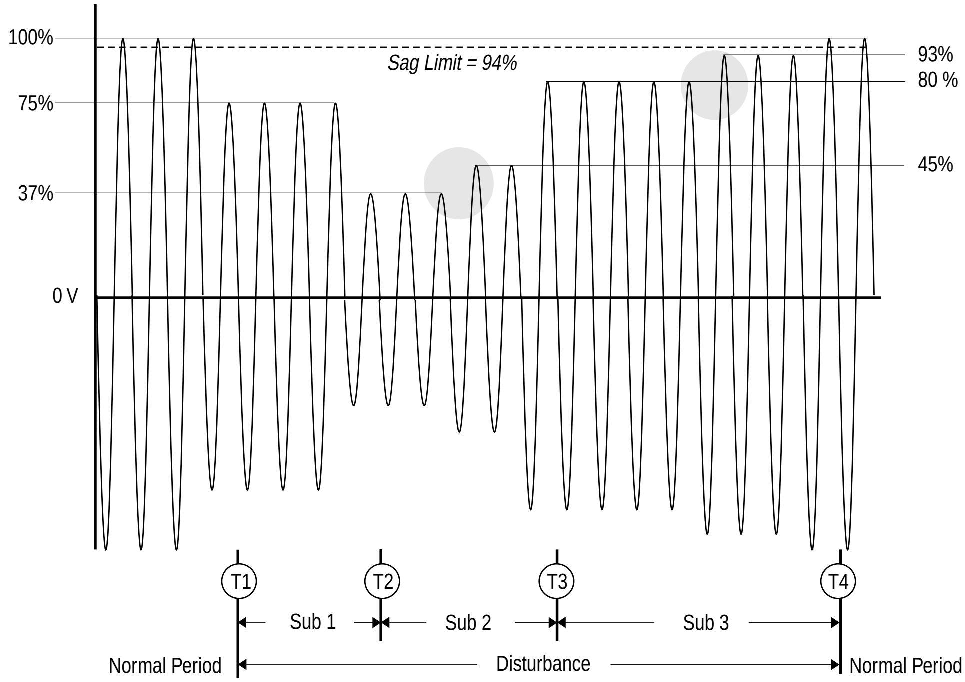
Disturbance Sub-Divisions

Within a complex disturbance, the voltage may fluctuate before returning to within the limits defined by the Swell Lim and the Sag Lim setup registers. Disturbances such as these cannot be plotted on a Magnitude vs. Duration graph since there can be many different magnitudes throughout the disturbance, each one sustained for a different duration. To address this, the Sag/Swell module breaks the disturbance up into sub-disturbances so that each part of the disturbance can be recognized and analyzed independently. During a disturbance, if the voltage on an input changes by more than the amount specified in the ChangeCrit register, the corresponding SubTrig output register will pulse, marking the beginning of a new sub-disturbance.

The diagram below shows a sag disturbance on the V1 input. In this example, the nominal voltage is **120V** and the ChangeCrit setup register is set to **10%.** The Sag Lim is set to **94%**.

NOTE

The highlighted areas indicate changes in the input that were less than the ChangeCrit setup register. In these cases, there was no new sub-disturbance.



NOTE

The Sag/Swell module uses RMS values. Thus, in each case, it takes a full cycle for a disturbance or a sub-disturbance to be detected.

(T1) This is the beginning of the disturbance as well as the beginning of the first sub-disturbance. At this point, the output registers are:

- DistState = ON
- DisStart pulses
- SubV1Trig pulses
- SubV1Avg = n/a (it was the period of normal operation)
- SubV1Dur = n/a (it was the period of normal operation)

(T2) This is the beginning of the second sub-disturbance because the voltage has changed by more than 10% of nominal. At this point, output registers are:

- DistState = ON
- SubV1Trig pulses
- SubV1Avg = average magnitude of sub-disturbance 1
- SubV1Dur = duration of sub-disturbance 1.

(T3) This is the beginning of the third sub-disturbance because the voltage has changed by more than 10% of nominal. At this point, output registers are:

- DistState = ON
- SubV1Trig pulses
- SubV1Avg = average magnitude of sub-disturbance 2
- SubV1Dur = duration of sub-disturbance 2.

(T4) This is the return to normal operating parameters (within the Swell and Sag Limits). At this point, output registers are:

- DistState = OFF
- DistEnd pulses
- SubV1Trig pulses
- SubV1Avg = average magnitude of Sub-disturbance 3
- SubV1Dur = duration of Sub-disturbance 3

Responses to Special Conditions

The following table summarizes how the Sag/Swell module behaves under different conditions.

Condition	Response of Output Registers
When the module is first created	All numeric and Boolean output registers are *Not Available*.
If V1, V2, or V3 is not linked	All numeric and Boolean output registers related to that input are *Not Available*.
If V1, V2, or V3 is Not Available	All numeric and Boolean output registers are *Not Available*.
If the Enable input is OFF	All numeric and Boolean output registers are *Not Available*.
After the module is re-linked or its setup registers are changed	All numeric and Boolean output registers are *Not Available.*
When the device is powered up (either the first time, or after a shutdown)	All numeric and Boolean output registers are *Not Available* until the inputs are evaluated.

7700 ION Device Notes

The 7700 ION supports a single high-speed Sag/Swell module.

The supported ranges or options and the factory default settings for each setup register are described in the table below.

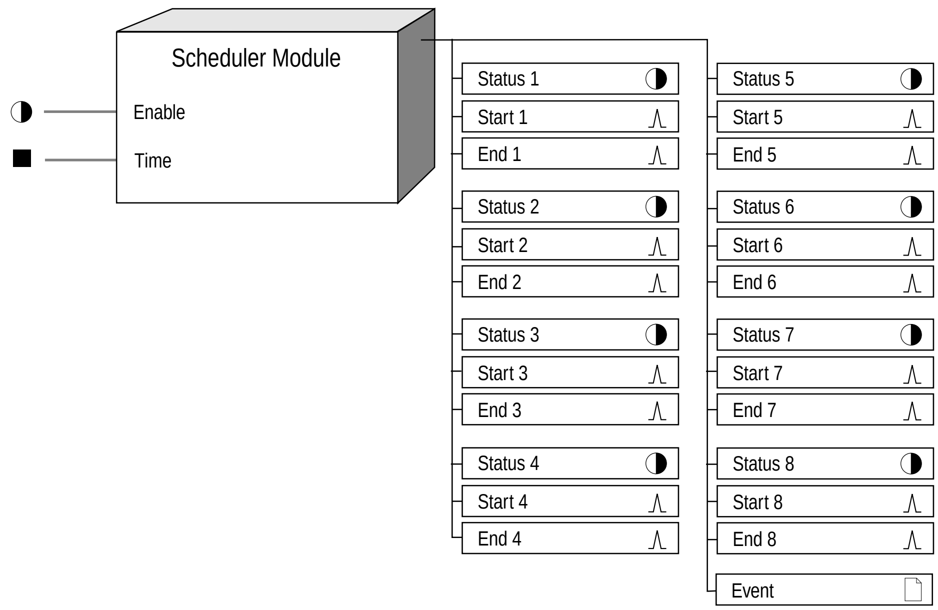
Setup Register	Supported Range or Options	Default Setting
Swell Limit	100 to 1000	106
Sag Limit	0 to 100	88
ChangeCrit	0 to 100	10
NomVoltage	1 to $1x10^6$	1200
EvPriority	0 to 255	127

ION Scheduler Module

The Scheduler module provides the ability to create up to eight periodic or aperiodic schedules for up to two years (24 months). You can use the Scheduler for:

Time Of Use	Logging
Demand Control	Periodic Resetting
Load Scheduling	Alarm Gating

On a 7700 ION, the Scheduler works in conjunction with the Clock module to automatically account for time zone variations and daylight savings times. On a VIP, the Scheduler module obtains the correct time from the computer on which the VIP is running.



Inputs

◑ *Enable*

This input enables or disable the Scheduler Module (by setting it to ON or OFF respectively). Any time this register changes from ON to OFF, all eight Status output registers are set to *Not Available*. It must be a Boolean register from any other module's output. This input is optional; if you leave it unlinked, the module will be enabled by default.

NOTE

Linking the Time input to an output register other than the LocalTime output register of the Clock module will cause undefined behavior in the Scheduler module.

■ *Time*

On a 7700 ION, this input is by default linked to the LocalTime output register of the Clock module. This will provide the Scheduler with the correct local time (accounting for time zones and daylight savings time). If you unlinked this input on a 7700 ION, the Scheduler will not function.

On a VIP, the Scheduler module gets the correct time from the computer on which the VIP is running. Linking this input is optional on the VIP. If you want the Scheduler on the VIP to use the same time as a 7700 ION, you can link the LocalTime output register of that 7700 ION's Clock module to the Time input of the Scheduler on the VIP.

Output Registers

The Scheduler module allows you to program up to eight groups of output registers. Each output group has a Status, a Start and an End output register. (Collectively, these three register are referred to as an *output*.)

Status 1 to *Status 8*
These Boolean registers indicate when an interval is in progress. This register will be ON for the duration of the interval.

NOTE
See the Setup Registers section for details about profiles, intervals and pulses.

Start 1 to *Start 8*
Each time an interval starts, the Start output register generates a pulse. These output registers also generate a pulse for each pulse activity.

End1 to *End8*
Each time an interval ends, the End output register generates a pulse. These output registers also generate a pulse for each pulse activity.

Event
Any events produced by the Scheduler module will be recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
Warning	30	Calendar expiry pending in 30 days; Calendar expired.

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event
- Any values or conditions associated with the effect.

Setup Registers

Calendar
Because of its sophisticated timing facilities, setting up the Scheduler module is more involved than setting up many of the other ION modules. The process of

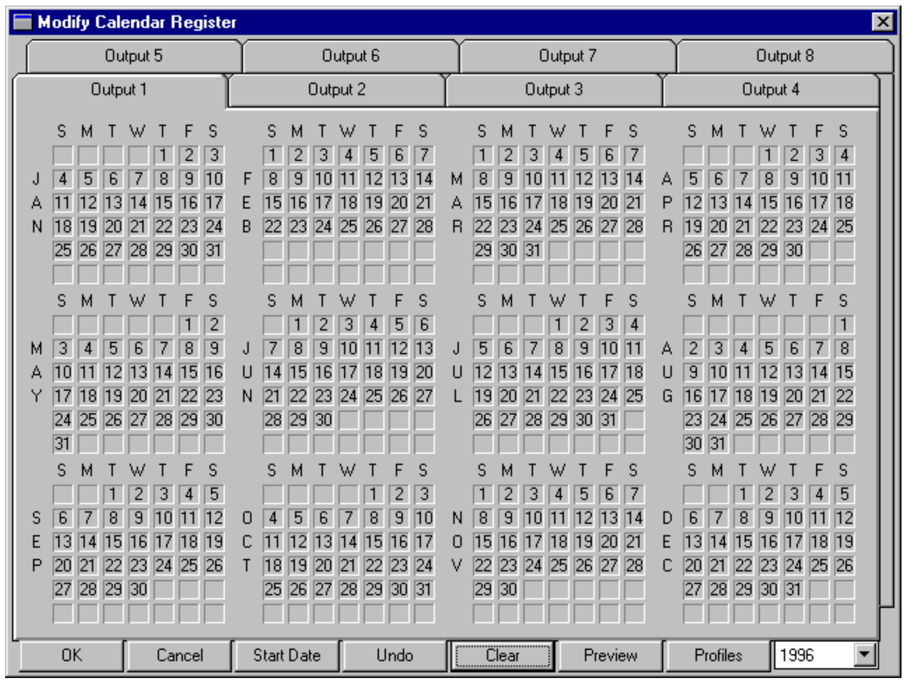
adding a Scheduler module to a node diagram in the PEGASYS ION Designer is the same as for other modules, and selecting Setup registers is also the same. Once you have selected the Calendar setup register however, a more advanced configuration utility will appear.

Main Scheduler Screen

NOTE

Each output includes a Status, Start and End output register.

The first screen to appear is the Scheduler screen with a tab for each of the 8 outputs. Under each tab is a calendar that displays the schedule for that output. When you first configure the Scheduler module, there are no schedules defined and the calendars are all blank. For each of the 8 outputs, you can define a schedule that defines the behavior of its Status, Start and End output registers for a period of two years.



To define a schedule you must:

NOTE

Once you have specified a start date, you can perform the other steps in any order.

- Select a start date from when your 2 year calendar begins.
- Select which days in the calendar you want to use different daily profiles.
- Configure each daily profile, specifying when the outputs should be ON or OFF and when pulses should occur.
- Repeat for each output, or copy one output's calendar over other outputs. (Profiles must be defined separately for each output.)
- Preview the schedules for each output

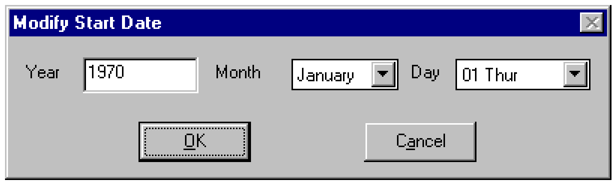
> **NOTE**
> The Scheduler modules will generate Events in the device's event log when the programmed schedule is within 30 days of expiration.

Selecting a Start Date for the Schedule

By default, a Scheduler module running on a 7700 ION has a start date of January 1, 1970. On a VIP, the default start date will depend on when the Scheduler module was created. In either case, you will need to change this date to the day you want your schedule to start. You will also need to change this date every two years when you reprogram the Scheduler module.

To change the start date:

1. Press the Start Date button at the bottom of the window. The following dialog box will appear:



2. Type in the year, and select the month and day on which you wish the schedule to start.

3. Press the OK button.

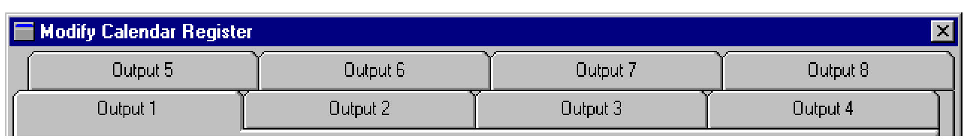
> **NOTE**
> Changing the start date is an irreversible operation. If you had activities scheduled on days that are not part of the new calendar, you will lose them.

The calendar in the main window will be updated; all days from the start date to 24 months after the start date will be active. Days prior to, and more than 24 months after the start date will be grayed out to indicate they are not included in the schedule.

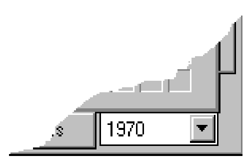
Assigning Profiles to Days in the Calendar

The first step in programming a schedule is to select an output and apply profiles to the days in the calendar. This allows you to make an output behave a particular way on a certain type of day. For example, Output 1 (Status 1, Start 1 and End 1) may control a module that you want to do one thing during the week, and something different on a weekend.

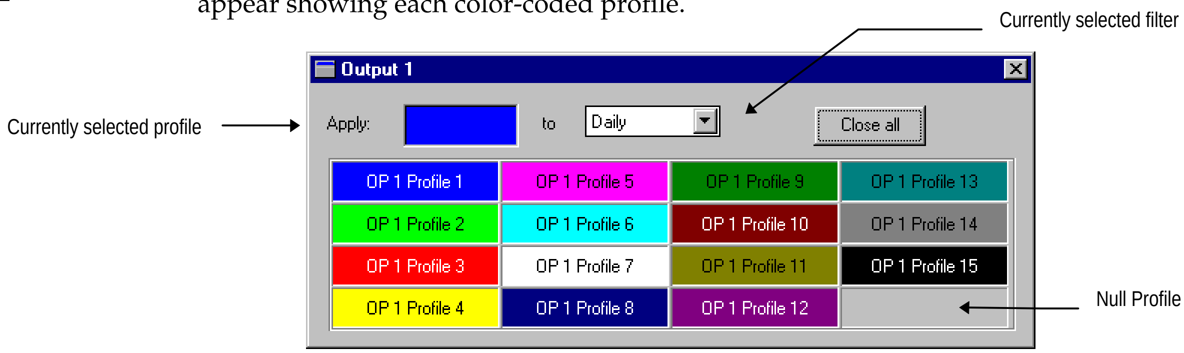
To select an output, click on its tab at the top of the Scheduler screen:



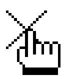
Double-check the year box at the bottom of the window to ensure you are working in the correct year (there may be up to 3 years depending on your start date).



To access the profiles for that output, click on the Profiles button. A palette will appear showing each color-coded profile.



When applying profiles to the calendar, you can do it to a range of days and use filters to speed up the task of programming. The filters allow you to apply the selected profile only to days matching the selected criterion (for example, all weekdays, or all weekends). The default is Daily which will apply the profile to all days in the selected range.



When you point to a day in the calendar the cursor changes to a hand with a cross-hair.

To apply a profile:

1. Click on the profile you want in the palette. (Its color appears at the top.)
2. If you want to select a single day in the calendar, double-click on it.
3. If you want to apply a profile across a range of days in the calendar, click on the first day of the range to which you want to apply the profile, then click on the final day of the range. If the final day is in a different year, use the year drop-box at the bottom of the screen to switch to another year. (You can also start with the final day and then click on the first day of the range.)
4. The selected days in the calendar will change to the color of the selected profile (in accordance with the selected filter). If any of the days were already assigned a profile, you will be prompted to overwrite the existing profiles.

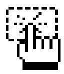
NOTE

To remove a profile from one or more days in the calendar, use the same procedure but select the null profile (i.e. the light gray box in the lower-right corner of the palette to paint over the existing profile.

Repeat these steps until every day in the calendar for the selected output is "painted" with the appropriate color (i.e. each day is assigned the appropriate profile). Be sure to program the full 24 months. When you have set up the calendar for one output, you need to do the same for the other outputs that you plan to use. You can repeat the steps described above, or as a shortcut, you can copy the calendar from one output over top another.

If you make a mistake applying profiles to the calendar, you can press the Undo button at the bottom of the window; this will undo only the most recent change.

Copying Calendars from One Output to Another



When copying a calendar, the cursor will change to a hand with a box.

To copy an output's calendar over to another output, hold down the Shift key and click on the tab of the output you wish to copy, then drag the cursor to the tab of the output you wish to overwrite. The complete calendar (all 24 months) of the first output will be copied to the second output. Note that only the calendar is copied; since each output has its own profiles, you will need to define profiles separately for each output.

Defining a Daily Profile

A daily profile is a simply a 24 period that consists of activities, which can include intervals, pulses or both.

NOTE

The Scheduler module support a total maximum of 900 activities or pulses. This includes all profiles for all outputs.

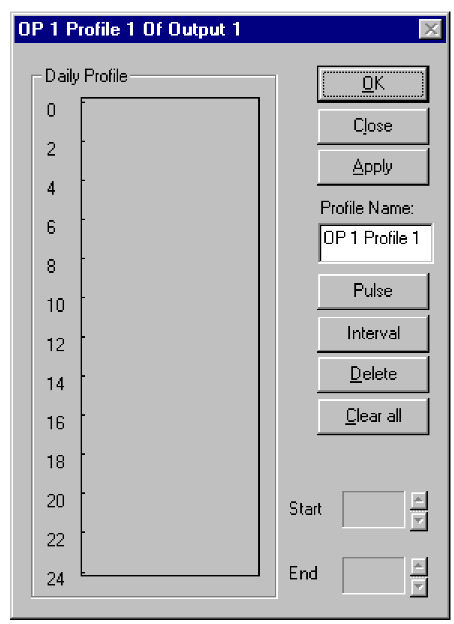
- An *interval* is characterized by a pulse on the Start output register, the Status register going ON for some period of time, then the End register pulsing and the Status register going back to OFF.
- A *pulse* is just the Start and End output registers pulsing simultaneously with no change in the Status output register.

Each output has 15 daily profiles.

To define a daily profile, either right-click on the profile in the Profiles palette, or right-click on a day in the calendar colored with the profile you wish to define. The following dialog box, referred to as a profile editor, appears:

The title bar indicates which profile you are editing and for which output.

The numbers along the left side of the box represent a twenty-four hour clock.



Before creating activities, you may want to assign a descriptive name to the profile to make it easier to remember where you plan to use it. For example, you may want to name it "Weekend". Creating custom labels for these profiles does use up labels on the device however. If the device is a 7700 ION, there are a limited number of custom labels available.

To create a name for the profile, type a name into the Profile Name box. It must be 15 characters or less. The name will appear in the Profile palette.

To add an interval to the daily profile:

1. Press and hold down the Interval button and drag the interval cursor into the Daily Profile box (but not on top of an existing interval or pulse). A colored bar will appear.

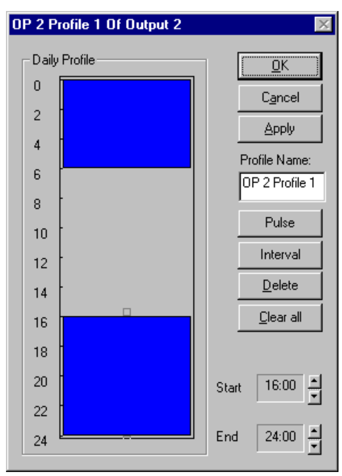
> **NOTE**
> You cannot have more than one activity at the same time. If you want to schedule multiple events at the same time, you must use separate outputs.

2. Click on the colored bar and drag it until the top of the box is positioned where you want the interval to begin (i.e. the Start time). Dragging allows you to move in steps of 5 minutes. If you want to position the bar more precisely, use the Start box which provides 1 minute resolution.

3. To adjust the End time of the interval, click on the bottom sizing handle and drag it down to the point where you want the interval to end. Again, dragging gives you 5 minutes resolution. Use the End box to enter a more precise End time.

Repeat steps 1-3 for each interval you want to add. Note that you cannot overlap intervals within a 24-hour period; they must be separated by at least 1 minute. If you try to start an interval while another one is in progress or if you try to drag one over a pulse, you will be warned that there is a conflict.

There is one exception to the aforementioned rule: you can create one interval that begins at 0:00 and another that ends at 24:00. If the profile is applied to two consecutive days, the two intervals are treated as a single interval that spans two days. For example, if you create an profile that looks like this, then apply it to a Monday, Tuesday, Wednesday & Thursday (and Friday has a NULL profile), the pulse outputs will behave as follows:



Monday @ midnight	Start pulses
Monday @ 6 a.m.	End pulses
Monday @ 4 p.m.	Start pulses
Tuesday @ 6 a.m.	End pulses
Tuesday @ 4 p.m.	Start pulses
Wednesday @ 6 a.m.	End pulses
Wednesday @ 4 p.m.	Start pulses
Thursday @ 6 a.m.	End pulses
Thursday @ 4 p.m.	Start pulses
Thursday @ midnight	End pulses

If you create a single interval starting at 0:00 and ending at 24:00, then apply it to a contiguous range of days, there will be a Start pulse at midnight of the first day and an End pulse at midnight of the last day, but no pulses in-between.

Note that the intervals that span across day boundaries do not have to be in the same profile. If Monday is assigned Profile 1, which has an interval from 18:00 to 24:00 and Tuesday is assigned Profile 2, which has an interval from 0:00 to

8:00, there will be a Start pulse on Monday at 6 p.m., the Status output will go ON until Tuesday at 8 a.m., at which point the End output will pulse and the Status output will go OFF.

To add a pulse to the daily profile:

1. Press and hold down the Pulse button and drag the pulse cursor anywhere into the Daily Profile box except on an existing interval or pulse. A line will appear.

2. Click on the line and drag it to where you want the pulse to occur. Dragging allows you to move in steps of 5 minutes. If you want to position the pulse more precisely, use the Start box which provides 1 minute resolution.

3. Repeat steps 1-2 for each pulse you want to add.

To delete an activity:

1. Click on the interval or pulse you wish to delete and press the Delete button. The selected activity will disappear from the Daily Profile box.

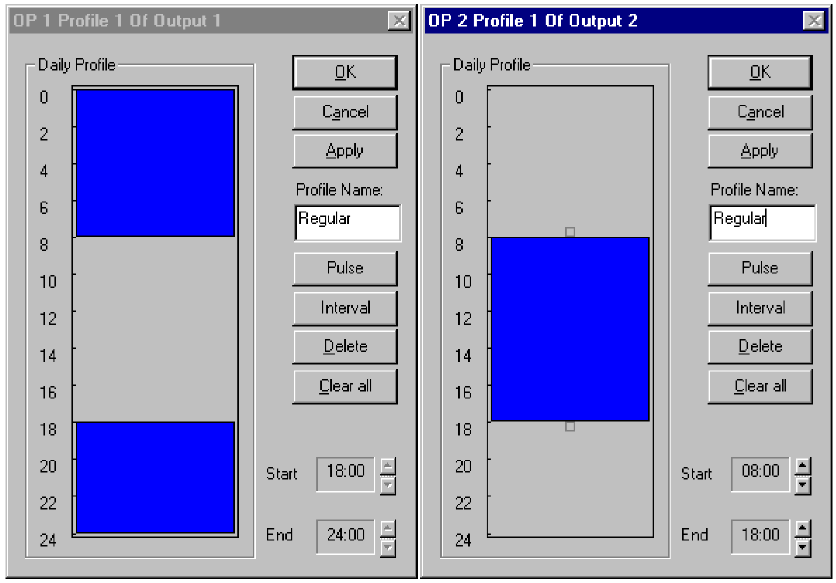
2. If you want to deleted all the activities from an profile, click the Clear All button.

Once you have created all the activities you want to comprise the profile and given the profile a descriptive name, press the OK button to save your changes and close the profile editor. If you press Cancel, your changes will be lost and the profile editor will close.

NOTE

If you have multiple profile editors open at the same time, you can close them all by pressing the Close All button in the Profiles palette.

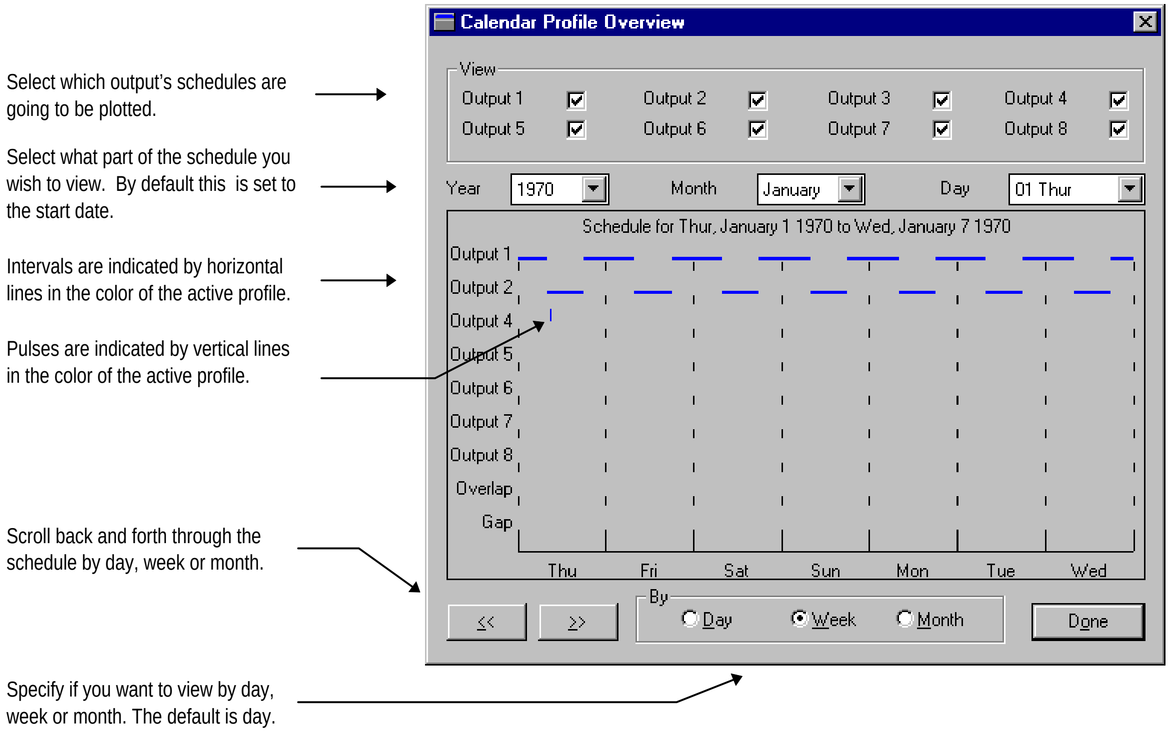
You can also press the Apply button if you want to save your changes but keep the profile editor open. This may be useful when you want to make adjustments to multiple profiles at the same time. For example, if you want to run motor A from 8:00 a.m. to 6:00 p.m. (i.e. during the day) and run motor B from 6:00p.m. to 8:00 a.m. (i.e. at night) you would need to use 2 different outputs: one to control motor A and one to control motor B. You would then need to define profiles for both these outputs. If may be helpful to see both profiles at the same time to ensure there is no gap between when motor A turned OFF and motor B turned ON.



Previewing Schedules

If you are programming a complicated schedule, it may be difficult to keep track of all your outputs. Once you have created schedules for all the outputs you plan to use, you can preview these schedules in a chart format so you see when outputs are going ON and OFF and ensure there are no gaps or overlapping periods. This allows you to verify that the schedule you created is correct.

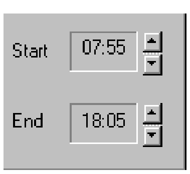
For example, in the case described earlier, motor B is supposed to turn ON at the same time that motor A is turning OFF. If you want to ensure that there is no gap between these two events, and to see how they fit in with the rest of the outputs, you can preview the schedule by pressing the Preview button. A dialog box like the following will appear (in its default state it will show the outputs by day rather than by week):



You can have the preview box open at the same time as one or more profile editors and it will update automatically to reflect changes in the profiles. This allows you to make adjustments to your profiles and dynamically preview them. The check boxes at the top allow you to select which outputs you want to view so you can display any combination.

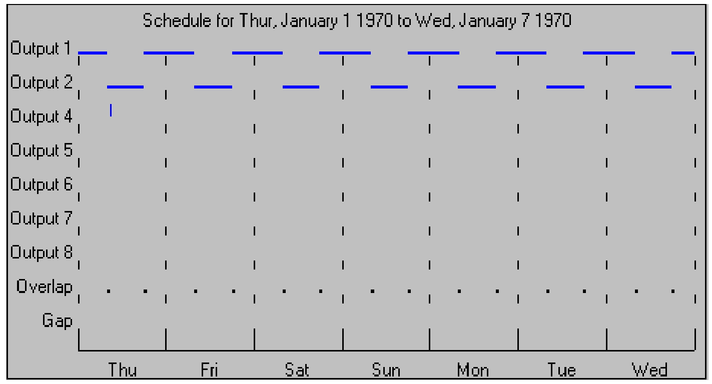
Overlap and Gap

The Overlap and Gap rows in the chart allow you to compare two or more outputs and display when they are all ON at the same time and when they are all OFF at the same time.



In the motors example described earlier, if you decide that you want a 5 minute overlap between when the motors A and B turn ON and OFF to ensure that at least on of them is running all the time, you can edit the profile for output 2 to go ON at 7:55 a.m. and OFF at 6:05 p.m.. If you press the Apply button in the profile editor, the profile editor will remain open and the preview box will update as follows:

The Overlap row indicates where more than one output is on at the same time.



You can see in the chart that each time output 1 goes OFF and output 2 goes ON, there is a line in the Overlap row to confirm that these outputs are indeed timed as you specified.

The Gap row is useful for showing if there are periods of time in your calendar during which no activities are scheduled. If you see a gap where you don't expect one, you can go back to the output and either edit the profile in effect at that time, or assign a new profile to that day.

You can preview a full day, week or month depending on which radio button you select. This allows you to see details or to get a broader view of your schedule.

Detailed Operation

The Scheduler module itself has no awareness of the passage of time. It simply gets the correct time (either from the Clock module or the computer's system clock) every minute and determines from the programmed schedule what each output register should do. In the case of intervals, the Scheduler determines the values of its outputs as follows:

If Status was OFF in the previous minute and an interval is scheduled	Start pulses and Status is turned ON.
If Status was ON in the previous minute and an interval is scheduled	Status remains ON.
If Status was OFF in the previous minute and no interval is scheduled	Status remains OFF.
If Status was ON in the previous minute and no interval is scheduled	End pulses and Status is turned OFF

In the case of pulses, the Scheduler checks the time and if a pulse is scheduled for that minute, it will pulse both Start and End.

Accounting for Daylight-Savings Time

If the device's Clock module (or the computer) is programmed to adjust for Daylight Savings Time, it is possible that scheduled activities may be not happen as expected.

In the Case of Pulses

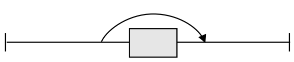
Pulses are more susceptible to Daylight Savings Time changes simply because of their short duration.

- If there are pulses scheduled to occur during the time that is lost when the clocks are moved ahead, the pulses will be missed. (For example, if a pulse is scheduled for 12:05, and the clocks are moved ahead an hour at 12:00, the pulse will not happen because the clock jumps directly from 12:00 to 1:00.)
- If there are pulses scheduled to occur during the time that is gained when the clocks are moved backed, the pulses will occur twice. (For example, if a pulse is scheduled for 11:30, and the clocks are moved back an hour at 12:00, the pulse will happen once at 11:30 and then again an hour later.)

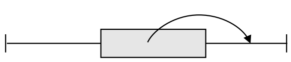
In the Case of Intervals

Different outcomes are possible in the case of intervals, depending on whether the time change jumps into, out of, or completely over an interval. Generally, when the clocks are moved forward, it is possible that intervals could be cut short or missed. When the clocks are moved back, it is possible that intervals will be repeated (either in part or in whole).

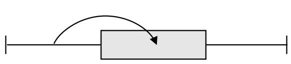
When the Clock is Moved Forward



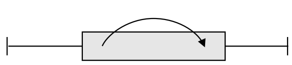
If there are intervals scheduled to both start and end during the time that is lost when the clocks are moved ahead, they will be missed (just like a pulse described above). For example, if a 10-minute interval is scheduled for 12:05, and the clocks are moved ahead an hour at 12:00, the interval will not happen because the clock jumps directly from 12:00 to 13:00.



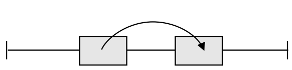
If an interval is in progress and the clock is moved ahead to a time outside the interval, the duration of the interval will be cut short (i.e. you will lose the second part of the interval). For example, if a 1-hour interval starts at 11:30 but at 12:00 the clocks are moved ahead 1 hour, Status will go OFF and End will pulse after only a half an hour.



If there is no interval in progress but the clock is moved ahead to a time inside an interval, the duration of the interval will be shorter than expected (i.e. you will lose the beginning part of the interval). For example, if a 1-hour interval starts at 10:30 but at 12:00 the clocks are moved ahead 1 hour, Status will go OFF and End will pulse after only a half an hour.

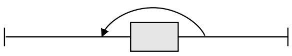


If an interval is in progress and the clock is moved ahead to a time inside the interval, the duration of the interval will be cut short (i.e. you will lose the second part of the interval). For example, if a 1-hour interval starts at 11:30 but at 12:00 the clocks are moved ahead 1 hour, Status will go OFF and End will pulse after only a half an hour.

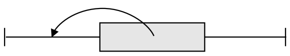


If an interval is in progress and the clock is moved ahead to a time inside another interval, the duration of both intervals will be cut short (i.e. you will lose the end of the first interval and the beginning of the second interval).

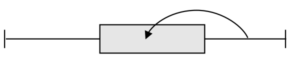
When the Clock is Moved Back



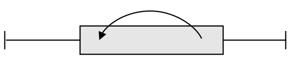
If there are intervals scheduled to both start and end during the time that is gained when the clocks are moved back, they will be repeated. For example, if a 15-minute interval is scheduled for 11:30, and the clocks are moved back an hour at 12:00, the interval will happen twice that day because 11:30 happens twice.



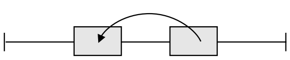
If an interval is in progress and the clock is moved back to a time outside the interval, the duration of the interval will be cut short (i.e. you will lose the second part of the interval) but then the complete interval will be repeated. For example, if a 1-hour interval starts at 11:30 but at 12:00 the clocks are moved back 1 hour, Status will go OFF and End will pulse after a half an hour, and then half an hour later, the complete interval will occur.



If an interval has just completed, and then the clock is moved back to a time inside that interval, the second portion of the interval will be repeated. For example, if a 1-hour interval starts at 10:30 and ends at 11:30, but at 12:00 the clocks are moved back 1 hour, Start will pulse and Status will go ON again for another half an hour.



If an interval is in progress and the clock is moved back to a time inside the same interval, the middle part of the interval will be repeated. The Start and End pulses will occur at the correct times but Status will remain ON for longer. For example, if a 3-hour interval starts at 10:00 but at 12:00 the clocks are moved back 1 hour, Status will stay on for 4 hours (instead of 3). Start will still pulse at 10:00 and End will still pulse at 1:00.



If an interval is in progress and the clock is moved ahead to a time inside another interval:

- ♦ the first interval starts and ends normally, then the second interval starts;
- ♦ the clocks are moved back and the last part of the first interval is repeated, as is the first part of the second interval;
- ♦ the second part of the second interval continues normally.

Responses to Special Conditions

The following table summarizes how the Scheduler module behaves under different conditions.

Condition	Response of Output Registers
If the Time input is linked but *Not Available*	All Status output registers contain Not Available
If the Enable input is OFF	All Status output registers contain Not Available and no pulses occur.
Immediately after the module is re-linked or its setup registers are changed	

7700 ION Device Notes

The 7700 ION supports a single Scheduler module. Scheduler modules are not high-speed capable.

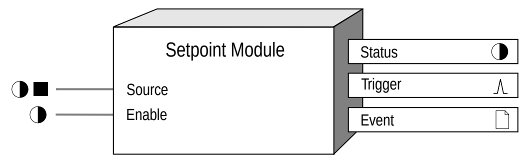
ION Setpoint Module

Setpoints provide extensive control, secondary protection and analysis capabilities by allowing you to initiate an action in response to a specific condition.

Some possible applications for the Setpoint module include:

demand control	activating alarms
power quality monitoring	gated logging functions
fault detection	

A Setpoint module monitors a single numeric or Boolean input for a specific condition. When the condition is met the Status output register changes to ON, and a trigger pulse is generated.



Inputs

Setpoint modules have two inputs:

■ ◑ *Source*
This input is monitored for a specified condition, or *setpoint condition*. It can be either a numeric register or Boolean register from any other module's outputs. Linking this input is mandatory.

◑ *Enable*
This input enables or disables the Setpoint module (by setting it to ON or OFF respectively). Disabling the module forces the Status output register OFF, overriding the Setpoint condition. This input is optional; it you leave it unlinked, the module will be enabled by default.

Output Registers

All Setpoint modules have the following output registers:

◑ *Status*
During normal operation, this Boolean register contains ON when the Setpoint condition is met and OFF when the Setpoint condition is not met. If the Enable input is OFF, the Status output register will change to OFF. Also, if the Source input or any of the setup registers are changed while the Status register is ON, it will automatically change to OFF.

⋀ *Trigger*
When the Setpoint condition is met, the Trigger output register generates a *pulse*.

Event
Any events produced by the Setpoint module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.
Information	25	Extreme value was recorded while Setpoint was ON; *Not Available* input caused output to go *Not Available.*
Setpoint	*	Setpoint condition started; Setpoint condition ended; setup changes made while Setpoint was ON; module disabled while Setpoint was ON.

* The priority of these events is determined by the value in the EvPriority setup register.

NOTE
If any changes are made to the Setpoint module while the Status output register is ON, the Status output register will be forced OFF and the module will be reevaluated for the setpoint condition.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The setup registers of the Setpoint module define the conditions of Setpoint activity. All Setpoint modules have the following setup registers:

Eval Mode
This register specifies the criterion by which the Source input is evaluated. It contains either the value LESSTHAN or GREATERTHAN.

NOTE
Do not set the Low Limit higher than the High Limit or the setpoint will oscillate.

High Limit
When the Eval Mode is GREATERTHAN, this register specifies what limit the Source input must exceed for the Status output register to change to ON. When the Eval Mode is LESSTHAN, it specifies what limit the Source input must exceed for the Status output register to change to OFF. If the Source input is Boolean, the value entered into this register is disregarded, and the High Limit is automatically set to 0.

Low Limit
When the Eval Mode is LESSTHAN, this register specifies what limit the Source input must fall below for the Status output register to change to ON. When the Eval Mode is GREATERTHAN, it specifies what limit the Source input must fall below for the Status output register to change to OFF. If the Source input is Boolean, the value entered into this register is disregarded, and the Low Limit is automatically set to 1.

- *SusUntlON*
  When the Eval Mode is GREATERTHAN, this register defines the amount of time in seconds the Source input must exceed the High Limit for the Status output register to change to ON. When the Eval Mode is LESSTHAN , this register defines the amount of time the Source input must fall below the Low Limit for the Status output register to change to ON.

- *SusUntlOFF*
  When the Eval Mode is GREATERTHAN, this register defines the amount of time in seconds the Source input must fall below the Low Limit for the Status output register to change to OFF. When the Eval Mode is LESSTHAN , this register defines the amount of time the Source input must exceed the High Limit for the Status output register to change to OFF.

- *Input Mode*
  This register specifies how the value of the Source input is interpreted. When Input Mode is ABSOLUTE, the absolute value of the Source input is used in Setpoint calculations, and the high and low limits, if negative, are converted to their absolute values. When Input Mode is SIGNED, the Source input is taken to be a signed value.

- *EvPriority*
  This register allows you to assign a priority level to the following events produced by the Setpoint module:

  - The Status output register changes to ON because the setpoint condition is met.
  - The Status output register changes to OFF because the setpoint condition is no longer met.
  - The Setpoint module is re-linked, reset or disabled while the Status output register is ON.
  - Setup registers are changed while the Status output register is ON.

  The priority level you specify applies to all of the above events.

NOTE

If the EvPriority is set to zero (0), the following events will not be logged:

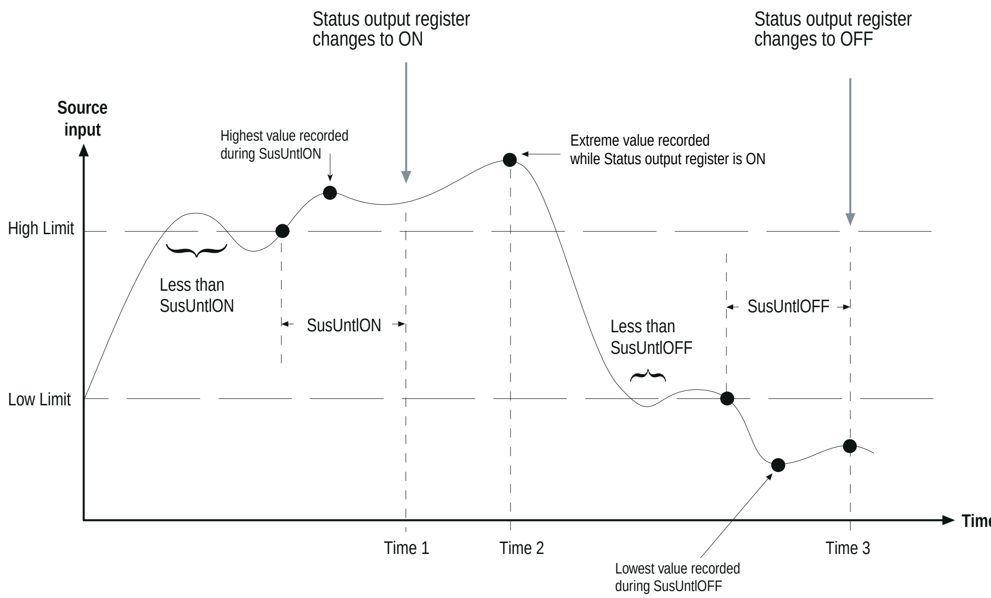
- Setpoint ON.
- Setpoint OFF.
- Setpoint extreme.

Detailed Operation

The diagrams that follow illustrate the operation of a Setpoint module with different setup register configurations. The first two examples involve Source inputs that are numeric variables; the third example shows the operation of a Setpoint with a Boolean Source input.

Eval Mode = GREATERTHAN

The figure below shows how the SusUntlON and SusUntlOFF setup registers affect Setpoint operation when Eval Mode is GREATERTHAN. It also shows the events and the values that are recorded during the operation of a Setpoint.



NOTE

If you are monitoring the absolute value of a numeric Source, do not set the Low Limit to 0 (since the Source value will never be negative).

This Status output register of this Setpoint module changes to ON when input exceeds and remains over the value of the High Limit for a time longer than SusUntlON. This Status output register changes to OFF when the Source input falls below the value of the Low Limit for a time longer than SusUntlOFF. The differential between the high and low limits effectively produces a programmable level of operational *hysterisis* (or *deadband*) ..

The Time 1, Time 2 and Time 3 points indicate the events produced by the Setpoint module:

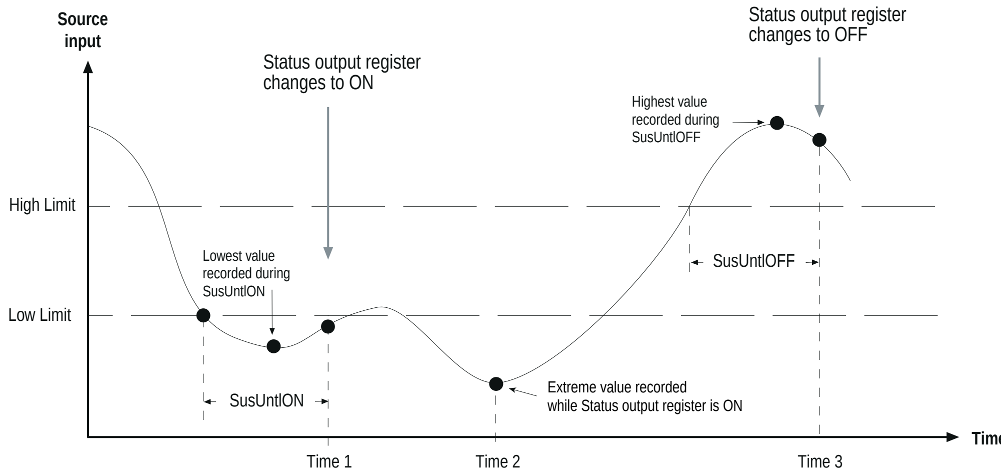
1. The first event records the Status output register changing to ON and the extreme value attained during the SusUntlON period.

2. The second event records the extreme value attained by the Source input while the Status output register was ON.

3. The third event records the Status output register changing to OFF and the extreme low value attained by the Source input during the SusUntlOFF period.

Eval Mode = LESSTHAN

This figure shows how Setpoints operate when Eval Mode is LESSTHAN. It also shows the different events and the values that are recorded during the operation of a Setpoint.



NOTE

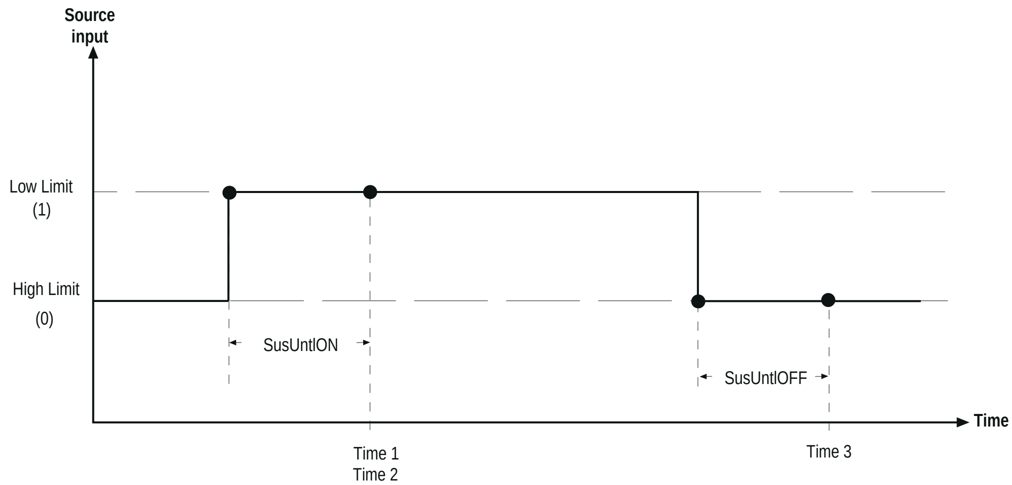
If you are monitoring the absolute value of a numeric Source, do not set the Low Limit to 0 (since the Source value will never be negative).

This example differs from the first only in that the meanings of High Limit and Low Limit are reversed. The Status output register changes to ON when the Source input falls below the value of the Low Limit for a time longer than SusUntlON. The Status output register changes to OFF when the Source input exceeds and remains over the value of the High Limit parameter for a time longer than SusUntlOFF. Similar to the first example, the differential between the high and low limits produces an area of hysterisis, or *deadband*.

The Time 1, Time 2 and Time 3 points indicate the events produced by the Setpoint module. The same events are recorded as in the first figure.

Source Input is Boolean

The following figure shows the operation of a Setpoint module with a Boolean input operating in GREATERTHAN mode. Note that if you have a Boolean Source, the High Limit and Low Limit registers are automatically set to 0 and 1, respectively. This is the case for both GREATERTHAN and LESSTHAN mode.



In this example, there is an event when the Status output register changes to ON, and when it changes to OFF. There is also an event that reports the extreme value while the Status output register was ON; in the case of a Boolean Source, that value is simply ON.

Changing the Eval Mode setup register will invert the Setpoint action when the Source input is Boolean. The following table summarizes the effects of changing Eval Mode:

Source Input	Eval Mode	Status Output register
ON	GREATERTHAN	ON
OFF	GREATERTHAN	OFF
ON	LESSTHAN	OFF
OFF	LESSTHAN	ON

Disabling a Setpoint

You may want to enable or disable a Setpoint module under different conditions. For example, you may have a Setpoint set up to shed loads and you only want it enabled during times when a penalty tariff is in effect. When the Enable register is OFF, the Setpoint will not evaluate the Source input and the Status is forced OFF.

Using the Module

The following steps outline how to use a Setpoint module. It is not necessary to do these steps in order; for example, you could set all the setup registers first and not actually link the Setpoint to another module until later.

1. The first step in using a Setpoint module is to determine what value you wish to monitor. This becomes your Source input. You can link this value (which is the output from some other module) to your Setpoint immediately or you can wait until later.

2. You may also link the Enable input if you want to be able to enable or disable the Setpoint module. If you always want it enabled, you can leave this input unlinked as the module is by default enabled

3. You must specify if you want to monitor the absolute value of the Source or the signed value. This is determined by the INPUT MODE setup register.

4. The next step is to define the behavior of the Setpoint:
   - ♦ Your Status output register can change to ON if your Source value falls *below* a certain level. In this case you would set the Eval Mode to LESSTHAN.
   - ♦ It can change to ON if the Source value rises *above* a certain level. In this case you would set the Eval Mode to GREATERTHAN.
5. After selecting your evaluation mode, you need to specify a high and low limit to define when the Setpoint activates or deactivates:
   - ♦ For GREATERTHAN, the Status output register changes to ON when the Source exceeds the High Limit and inactive when the Source falls below the Low Limit.
   - ♦ For LESSTHAN, the Status output register changes to ON when the Source falls below the Low Limit and goes inactive when the Source exceeds the High Limit.
6. The Setpoint module allows you to introduce time delays before the Setpoint activates or deactivates. You can specify that the condition you are monitoring must persist for a specified amount of time before the Setpoint will activate. You can also require a time delay before deactivating the Setpoint. By using these delays, you can protect the Setpoint from temporary spikes in the Source value. The times are entered in seconds.

   For example, you may want a Setpoint to activate if your current goes above 800 Amps, but only if it remains that high for more than five seconds. Likewise, you may want the Setpoint to deactivate when the current drops, but only if it has stayed below 750 Amps for at least ten seconds. In this case you would set SusUntlON to 5 and SusUntlOFF to 10.

7. You can also attach a priority level that applies to most of the events produced by a Setpoint module (see the *Setup Registers* section). These priority levels are logged along with the events and any associated values.

Responses to Special Conditions

The following table summarizes how the Setpoint module behaves under different conditions.

Condition	Response of Output Register
If the input is *Not Available*	The Status output register is *Not Available*.
If the Enable input is OFF	The Status output register is *Not Available*.
After the module is re-linked or its setup registers are changed	The Status output register is *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	The Status output register is *Not Available*.

7700 ION Device Notes

The 7700 ION supports a total of 24 Setpoint modules. All Setpoint modules are high-speed capable.

The supported ranges or options and the factory default setting for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
High Limit	-1×10^9 to 1×10^9	0
Low Limit	-1×10^9 to 1×10^9	0
SusUntlON	0 to 3600 seconds	0
SusUntlOFF	0 to 3600 seconds	0
Input Mode	SIGNED or ABSOLUTE	SIGNED
Eval Mode	GREATERTHAN or LESSTHAN	GREATERTHAN
EvPriority	0 to 255	128

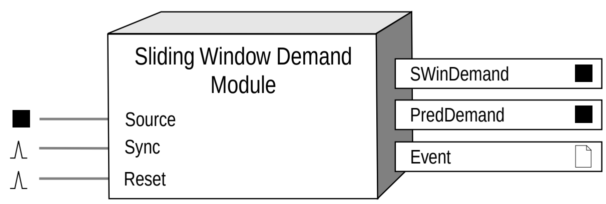
ION Sliding Window Demand Module

Power utilities generally bill commercial customers based on their energy consumption (in kWh) and their peak usage levels, called *peak demand* (in kW). Demand is a measure of average power consumption over a fixed time interval, typically 30 minutes. Peak (or maximum) demand is the highest demand level recorded over the billing period. *Sliding window demand* is one method of measuring demand.

To compute sliding window demand values, the Sliding Window Demand module uses the *sliding window averaging* (or *rolling interval*) technique which divides the demand interval into sub-intervals. The demand is measured electronically based on the average load level over the most recent set of sub-intervals. This method offers better response time than fixed interval methods.

The Sliding Window Demand module calculates sliding window and predicted demand over a specified number of sub-intervals of a specific length. The module can be either internally or externally synchronized. For external synchronization, you would typically use the output from a Digital Input module as a Sync pulse.

The module performs predicted sliding window demand by automatically predicting the value that each sliding window demand parameter will attain when updated at the start of the next interval.



Inputs

All Sliding Window Demand modules have the following inputs:

■ *Source*
This is the value for which sliding window demand and predicted sliding window demand are calculated. It must be a numeric register from any other module's outputs. Linking this input is mandatory.

⋀ *Sync*
This input receives a pulse which can be used for external synchronization of the module. The Sync input must be a pulse register from any other module's output. This input is optional; if you leave it unlinked, the input by default will never receive a pulse.

Reset
This input resets the SWinDemand and PredDemand output registers to 0. Note that the SwinDemand output will be Not Available until the number of sub-intervals indicated by the #SubIntvls setup register have expired. The PredDemand output will be Not Available until one sub-interval before that. This input is optional; if you leave it unlinked, the input by default will never receive a pulse.

Output Registers

All Sliding Window Demand modules have the following output registers:

■ *SWinDemand*
This numeric register contains the accumulated sliding window demand. Note that if the module is re-linked, the Reset input is pulsed, or a setup register is changed, this value will be Not Available until the number of sub-intervals specified in the #SunIntvls setup register have expired.

■ *PredDemand*
This numeric register contains the accumulated predicted demand. When the module is linked, the Reset input is pulsed or a setup register is changed, this register is Not Available until one less than the number of sub-intervals specified in the #SunIntvls setup register have expired. If the Sync input is not linked, unless the module was linked or Reset on a regular time boundary, the PredDemand value will be inaccurate until the SWD output becomes valid.

Event
All events produced by a Sliding Window Demand module are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Reset	5	A module reset has occurred.
Setup Change	10	Input links, setup registers or labels have changed.
Information	25	*Not Available* input caused output to go *Not Available.*

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

All Sliding Window Demand modules have the following setup registers:

- *Sub Intvl*
  This numeric bounded register specifies the number of seconds in the sliding window demand sub-interval. If the Sync input is linked, the Sub Intvl register is ignored for the sliding window demand calculation. It is however still used for the predicted sliding window demand calculation.

  If the frequency of the pulses on the Sync input is higher than the Sub Intvl setup register indicates, the PredDemand output may not be accurate (since it will not have enough time to reach its steady state value between sub-intervals). If the frequency is lower, PredDemand will act as though the Pred Resp is set to a faster value (i.e. the steady state will be reached before the end of the sub-interval).

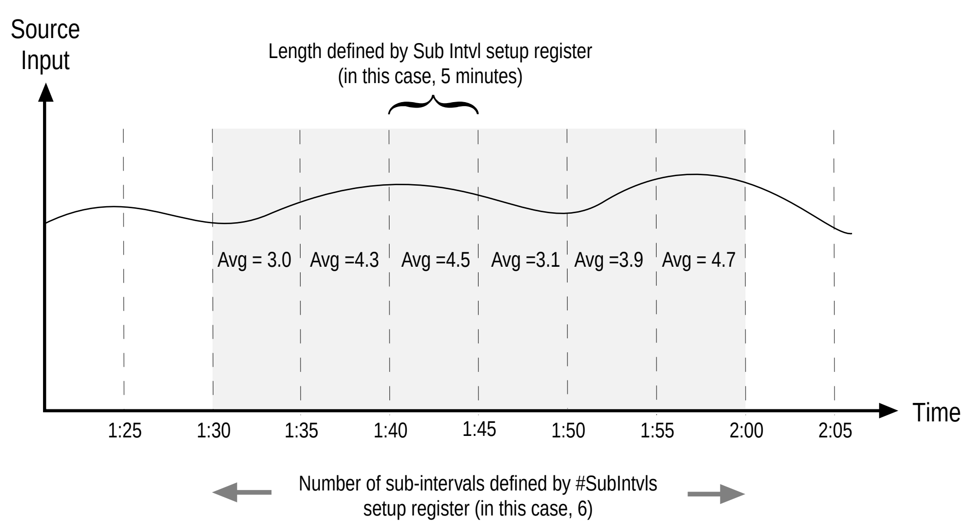
- *#SubIntvls*
  This numeric bounded register specifies the number of sub-intervals in the sliding window.

- *Pred Resp*
  This numeric bounded register specifies the speed of the predicted demand output. It allows you to set the sensitivity of the demand prediction. Specify 99 for the fastest prediction speed. If you specify 0 (the slowest prediction speed), the PredDemand output will follow the SWinDemand output. A value between 70 and 99 is recommended for a reasonably fast response.

Detailed Operation

Sliding Window Demand Calculation

The figure below illustrates how the Sliding Window Demand module calculates the value in the SWinDemand output register. In this case the Sync input is not linked (hence the Sub Intvl and #SubIntvls setup registers define the total demand interval).



The average demand for each of the six previous sub-intervals is calculated and these values are averaged across the number of sub-intervals (specified by the #SubIntvls setup register). In this example, the value in the SWinDemand output register from 2:00 to 2:05 is:

$$\frac{3.0 + 4.3 + 4.5 + 3.1 + 3.9 + 4.7}{6} = 3.92$$

The Sliding Window Demand module allows you to match the power utility's sliding window demand calculation technique. For sliding window measurements, the Sub Intvl register represents the length of the utility's demand sub-interval, while the #SubIntvl register represents the number of sub-intervals which make up the total demand interval. For example, with a 6 x 5 minute (30 minutes total) sliding window method, demand is the average power consumption over the last six 5-minute sub-intervals. This allows you to match virtually any type of sliding window measurement method used by the utilities (i.e. 2 x 15 minutes, 6 x 5 minutes, 1 x 30 minutes).

Alternatively, you can use external synchronization (Sync input linked) to calculate sliding demand values. In this case, a new sub-interval begins each time a pulse is received on the Sync input.

Predicted Demand Calculation

The Sliding Window Demand module predicts changes in demand based on the following formula:

$$\frac{(\text{Thermal Avg} \times \text{Time Left in Sub-Interval}) + (\text{Accumulated Value in Period}) + [\text{Prev SWD} \times (\text{\# of Sub-Intervals} - 1) \times \text{Sub-Interval length}]}{\text{Total Sliding Window Demand Period}}$$

The module automatically calculates the Thermal Average value used in the above formula. The rate at which the Thermal Average responds to demand changes depends directly on the sensitivity of the demand prediction, which is programmed into the Pred Resp setup register. If the Pred Resp value is high, the Thermal Average will respond quickly to changes in the module's Source input. This in turn results in a higher level of accuracy for predicted demand.

Responses to Special Conditions

The following table summarizes how the Sliding Window Demand module behaves under different conditions.

Condition	Response to Output Register
If the Source input is *Not Available*	All output registers are *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	All output registers are *Not Available*.

7700 ION Device Notes

The 7700 ION supports a total of 16 Sliding Window Demand modules. Sliding Window Demand modules are not high-speed capable.

The supported ranges or options and the factory default setting for each setup register are described in the table below.

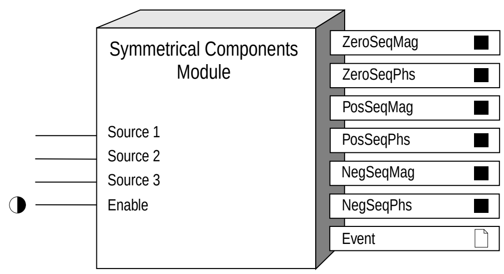
Setup Register	Supported Range or Options	Default Setting
Sub Intvl	60 to 5940 seconds	1800
#SubIntvls	1 to 15	1
Pred Resp	0 to 99	70

ION Symmetrical Components Module

The Symmetrical Components module provides information about unbalanced voltages and currents in a 3-phase power system. This allows you to identify or predict how electrical equipment might be affected. For example, some possible applications include:

- ♦ reducing induced, circulating currents in motor windings
- ♦ preventing equipment damage
- ♦ prolonging motor and transformer life

The Symmetrical Components module calculates the magnitude and phase angle of zero, positive and negative sequences for a particular harmonic.



Inputs

◑ All Symmetrical Components modules have one programmable input called the *Enable* input. When this register is set to ON, the module is enabled; when it is set to OFF, the module is disabled; it ceases to calculate zero, positive and negative sequences and stops updating the output registers. This input is optional; if you leave it unlinked the module will be enabled by default.

The Source inputs of the Symmetrical Components modules are fixed. They receive their values either from the 3 voltage inputs or the 3 current inputs.

Output Registers

NOTE

Symmetrical Components modules updates once per second. Use the Sag/Swell module for high speed disturbance detection.

■ *ZeroSeqMag*
This register contains the zero sequence magnitude of the selected harmonic.

■ *ZeroSeqPhs*
This register contains the zero sequence phase angle of the selected harmonic.

■ *PosSeqMag*
This register contains the positive sequence magnitude of the selected harmonic.

■ *PosSeqPhs*
This register contains the positive sequence phase angle of the selected harmonic.

- *NegSeqMag*
This register contains the negative sequence magnitude of the selected harmonic.

- *NegSeqPhs*
This register contains the negative sequence phase angle of the selected harmonic.

- *Event*
All events produced by the Symmetrical Components module are written into this register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

- All Symmetrical Components modules have one setup register called the *Harmonic* register. This numeric bounded register allows to select the harmonic for which sequences are calculated.

Detailed Operation

Ideally in a 3-phase power system, phases A, B, and C of voltage and current are equal in magnitude, separated by 120^0, and have a particular rotation. When this is not the case, the system is unbalanced and power use is inefficient.

For example, when unbalanced power is applied to a motor, some of the power contributes to turning the motor in the proper direction (positive sequences), some of the power may contribute to the motor actually turning backwards (negative sequences), and some of the power may just cause heating (zero sequences). The Symmetrical Components module analyzes the unbalance and determines the magnitudes and phase angles of the positive, negative and zero sequences. These values are stored in the output registers.

Responses to Special Conditions

The following table summarizes how the Symmetrical Components module behaves under different conditions.

Condition	Response of Output Register
When the device is started or powered-up (either the firat time, or after a shut-down)	All output registers are *Not Available*.
If the inputs are Not Available	All output registers are *Not Available*.
If the Enable input is OFF	All output registers are *Not Available*.
After the module is re-linked or its setup registers are changed	All output registers are *Not Available* once the change is completed.

7700 ION Device Notes

The 7700 ION supports a total of 2 Symmetrical Components modules (1 for voltage and 1 for current). Symmetrical Components modules are not high-speed capable.

The supported ranges or options and the factory default setting for the setup register are described in the table below.

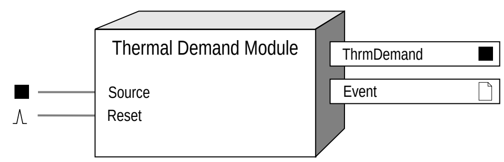
Setup Register	Supported Range or Options
Harmonic	Harmonic is fixed at the fundamental harmonic and cannot be changed by the user.

ION Thermal Demand Module

Power utilities generally bill commercial customers based on both their energy consumption (in KWh) and their peak usage levels, called *peak demand* (in KW). Demand is a measure of average power consumption over a fixed time interval, typically 30 minutes. Peak (or maximum) demand is the highest demand level recorded over the billing period. Thermal demand is one method of measuring demand.

The Thermal Demand module calculates thermal demand over a specified length of time. It uses a method which is equivalent to thermal averaging. For thermal averaging, the traditional demand indicator responds to heating of a thermal element in a Watt-Hour meter. You can adjust the Thermal Demand module's calculation to mimic this technique by changing the Time Const and Interval setup parameters.

Thermal demand values can be calculated for any numeric variable.



Inputs

All Thermal Demand modules have the following inputs:

■ *Source*
This is the input upon which the thermal demand calculation is performed. It must be a numeric register from any other module's outputs. Linking this input is mandatory.

⋏ *Reset*
This input resets the Thermal Demand module, setting the ThrmDemand output register to 0. It must be a pulse register from any other module's outputs. This input is optional; if you leave it unlinked it will by default never receive a pulse.

Output Registers

All Thermal Demand modules have the following output registers:

■ *ThrmDemand*
This numeric variable register contains the accumulated thermal demand.

- *Event*
  Any events produced by the Thermal Demand module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Reset	5	A module reset has occurred.
Setup Change	10	Input links, setup registers or labels have changed.
Information	25	*Not Available* input caused output to go *Not Available.*

For each event written into the Event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

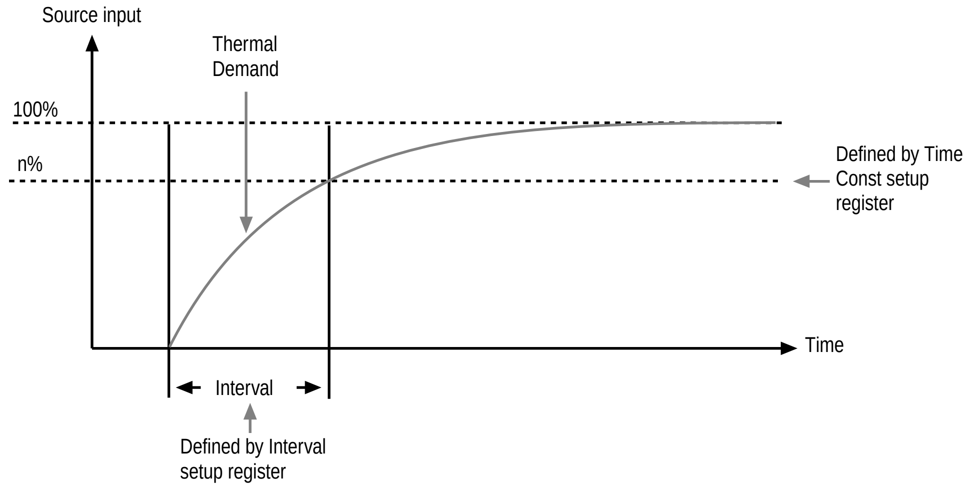
The setup registers of the Thermal Demand module allow you to adjust the thermal demand calculation to match a thermal averaging technique. All Thermal Demand modules have the following setup registers:

- *Interval*
  This register specifies the number of seconds in the thermal demand interval.

- *Time Const*
  This register specifies what percentage of the input value the ThrmDemand output register will contain after one interval.

Detailed Operation

The figure below illustrates the thermal demand calculation. When you change the values in the setup registers, the shape of the curve changes, allowing you to match a power utility's demand calculation technique.



Responses to Special Conditions

The following table summarizes how the Thermal Demand module behaves under different conditions.

Condition	Response of Output Register
If the Source input is *Not Available*	The ThrmDemand output register is *Not Available*.
When the device is started or powered-up (either the first time, or after a shut-down)	The ThrmDemand output register is *Not Available*.

7700 ION Device Notes

The 7700 ION supports a total of 16 Thermal Demand modules. Thermal Demand modules are not high-speed capable.

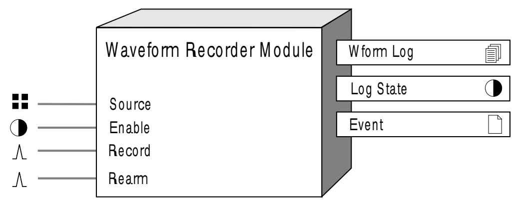
The supported ranges or options and the factory default setting for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Interval	60 to 5940 seconds	1800
Time Const	1 to 99%.	90%

ION Waveform Recorder Module

The Waveform Recorder module records and stores sample waveforms from a 3-phase power system along with a timestamp. It provides a powerful method for analyzing the conditions occurring before, during, and after a power fluctuation or failure. It allows you to analyze faults and surges, and it aids in fault location. The Waveform Recorder module can be configured to start recording under a specified circumstance and it can be enabled and disabled.

Possible applications of the Waveform Recorder module include power quality monitoring, fault analysis and prevention, and checking PT and CT configuration.



Inputs

All Waveform Recorder modules have the following inputs:

Source
This input can be linked to any of the outputs of the Data Acquisition module. Linking this input is mandatory.

Enable
This input enables or disables the Waveform Recorder module (by setting it to ON or OFF respectively). If you disable a Waveform Recorder module, it disregards the Record input. This input is optional; if you leave it unlinked the module will be enabled by default.

Record
When this register is pulsed, the waveform data in the Source input are copied to the Wform Log output register if the Enable input is ON and the Wform Log register is not full in STOP-WHEN-FULL mode. Linking this input is mandatory.

Rearm
When this register is pulsed and the RecordMode setup register has been set to STOP-WHEN-FULL, the Waveform Recorder module will reset to allow full capacity. If the RecordMode setup register has been set to CIRCULAR, pulses on the Rearm input are ignored. Linking this input is mandatory if the module is used in STOP-WHEN-FULL RecordMode; if it is not linked when the module is in STOP-WHEN-FULL RecordMode, the Log Server cannot rearm the module, and no records will be uploaded after the initial retrieval. Rearm can be left unlinked only if CIRCULAR mode is used exclusively.

Output Registers

All Recorder modules have the following output registers:

Wform Log
This register contains a log of the Source input waveforms recorded at each Record point. It's capacity is determined by the setup registers.

Log State
This register indicates when the Wform Log register is full. If the RecordMode setup register is set to STOP-WHEN-FULL and the Wform Log register has reached its depth, this register is ON (it's default ON label is *Full*). When the RecordMode setup register is set to CIRCULAR, or when the RecordMode is set to STOP-WHEN-FULL but Wform Log register has not yet reached its depth, the Log State register is OFF (it's default OFF label is *Not Full*).

Event
Any events produced by the Waveform Recorder module are recorded in the Event register. Possible events and their associated priority numbers are shown in the table below.

Event Priority Group	Priority	Description
Setup Change	10	Input links, setup registers or labels have changed.

For each event written into the event register, the following information is included:

- A time stamp of when the event occurred.
- The priority of the event.
- The cause of the event.
- Any values or conditions associated with the cause.
- The effect of the event.
- Any values or conditions associated with the effect.

Setup Registers

The setup registers of the Waveform Recorder module determine how much information the module can store. All Waveform Recorder modules have the following setup registers:

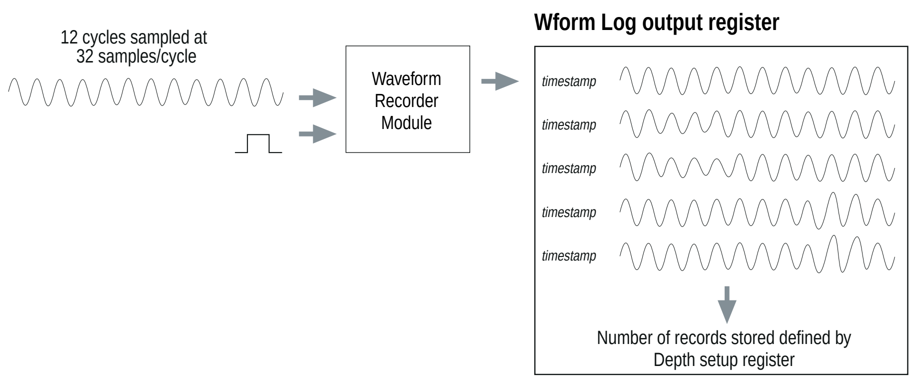
Depth
This register determines the maximum number of records in the output log. The higher you set this number, the more memory is required. Note that the format of the waveform data affects how much memory a single record uses. A large number of samples per cycle and a large number of cycles use more memory than a small number of samples per cycle and a small number of cycles.

- *RecordMode*
  This register determines the recording mode, defining what happens when the Wform Log output register is full. If you select CIRCULAR, the newest values get recorded and the oldest are dropped. If you select STOP-WHEN-FULL, the Waveform Recorder module stops writing new values into the Wform Log output register when it reaches capacity.

- *Format*
  This register defines the format of the resulting waveforms in the Wform Log output register. It specifies the number of samples per cycle and the number of cycles that are stored. For example, 128x14 specifies a format of 128 samples/cycle and 14 cycles stored.

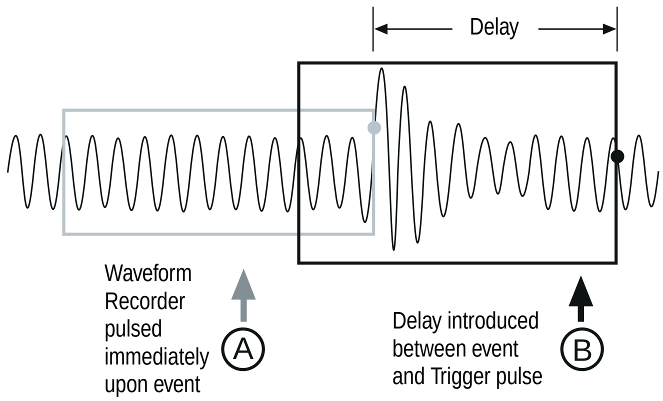
Detailed Operation

The figure below shows an example of a Waveform Recorder module recording the waveform on the Source input. Each time the Record input receives a pulse, the waveform data at the Source input are copied into the Wform Log output register along with a timestamp indicating when the Record input was pulsed.



The waveform information at the Source input spans a certain amount of time (depending on the format specified in the Format setup register) and it is constantly being monitored. This effectively provides a window of observation, allowing you to capture a series of cycles before, during and after an event.

You may need to introduce a delay before triggering the Waveform Recorder to ensure you capture the desired span of data. If the Waveform Recorder is triggered immediately upon an event, the cycle in which the event occurs and the preceding cycles are recorded but the post-event cycles are missed. The following illustrates how introducing a time-delay allows the window of observation to move until it contains the full range of event and post-event data.



NOTE

Refer to the One-Shot Timer module description for more information about introducing delays before triggering the Waveform Recorder.

WARNING

If you re-link any of the inputs or make any changes to the setup registers, the contents of the Wform Log output register are cleared. If you wish to save the information, ensure the data has first been uploaded before re-linking inputs or changing setup registers.

Responses to Special Conditions

The following table summarizes how the Waveform Recorder module behaves under different conditions.

Condition	Response of Output Register
When the device is started or powered-up (either the first time, or after a shut-down)	The output registers retain the value or state they held at shut-down.
If the Source input is *Not Available*	The output registers hold the last value obtained before the inputs became Not Available.
If the Enable input is OFF	The Wform Log register holds the logged data.

7700 ION Device Notes

The 7700 ION supports a total of 14 Waveform Recorder modules. All Waveform Recorder modules are high-speed capable.

The supported ranges or options and the factory default setting for each setup register are described in the table below.

Setup Register	Supported Range or Options	Default Setting
Depth	0 to 4 x 10^9	0
RecordMode	CIRCULAR or STOP-WHEN-FULL	CIRCULAR
Format	128x14, 64x14, 64x28, 32x12, 32x26, 32x40, 32x54, 16x22, 16x48, 16x72, 16x96, or NOT USED	16x22

Appendix A

Technical Specifications

The specifications that follow are subject to change without notice.

In this Chapter

Measurements (@ 50.0 Hz / 60.0 Hz @ 25°C) @ 1% to 125% of Rated Input (50 mA to 6.25 A) (1 second & 1 cycle update rates)

Parameter	Accuracy ±(%rdg + %range)		MGT Resolution (%range)*		Range	
	1 second	*1 cycle*	*1 second*	*1 cycle*	*1 second*	*1 cycle*
Voltage(l-n) in Wye, Vab, Vbc in Delta	0.1% + 0.01%	0.5%+0.05%	0.1%	0.1% + 1 LSD†	0 to $1x10^6$	0 to $1x10^6$
Voltage(l-l) in Wye, Vca in Delta	0.5% + 0.01%	1.0%+0.1%	0.1%	0.1% + 1 LSD	0 to $2x10^6$	0 to $2x10^6$
Frequency	0.01%	0.1%	0.01 Hz	0.01 Hz	20 Hz to 70 Hz	20 Hz to 70 Hz
Current (<5% FS)	1.0%	2.0%				
Current (≥5% to 125% FS)	0.1%+0.01%	0.5%+0.05%	0.1%	0.1% + 1 LSD	0 to $1x10^6$	0 to $1x10^6$
kVA (<5% FS)	1.0%	2.0%				
kVA (≥5% ≤ 125% FS)	0.2%+0.02%	1.0%	0.1%	0.1% + 1 LSD	0 to $3.3x10^7$	0 to $3.3x10^7$
kVAH	0.2% reading	–	0.1% of reading	–	0 to 10^{38}	–
kW (<5% FS)	1.0%	2.5%+0.25%	0.1%	0.1% + 1 LSD	0 to ± $3.3x10^7$	0 to ± $3.3x10^7$
kW @ Unity PF (≥5% ≤ 25% FS)	0.5%	2.5%+0.25%	0.1%	0.1% + 1 LSD	0 to ± $3.3x10^7$	0 to ± $3.3x10^7$
kW @ Unity PF (≥25% ≤ 125% FS)	0.3%	2.5%+0.25%	0.1%	0.1% + 1 LSD	0 to ± $3.3x10^7$	0 to ± $3.3x10^7$
kW @ ±0.5 PF (≥5% ≤ 25% FS)	0.6%	5.0%+0.5%	0.1%	0.1% + 1 LSD	0 to ± $3.3x10^7$	0 to ± $3.3x10^7$
kW @ ±0.5 PF (≥25% ≤ 125% FS)	0.4%	5.0%+0.5%	0.1%	0.1% + 1 LSD	0 to ± $3.3x10^7$	0 to ± $3.3x10^7$
kVAR (<5% FS)	1.0%	2.5%+0.25%	0.1%	0.1% + 1 LSD	0 to ± $3.3x10^7$	0 to ± $3.3x10^7$
kVAR (>5% FS)	0.55%+0.005%	2.5%+0.25%	0.1%	0.1% + 1 LSD	0 to ± $3.3x10^7$	0 to ± $3.3x10^7$
kWH, kVARH @ Unity PF ‡	IEC 0.5 Class @ 25°C	–	0.1% of reading	–	0 to ± 10^{38}	–
kWH, kVARH @ ±0.5 PF ‡	IEC 0.5 Class @ 25°C	–	0.1% of reading	–	0 to ± 10^{38}	–
Harmonics (to 60th)	1% Full Scale	–	0.1%	–	0.0001 to 100.00	–
K Factor	5% Full Scale	–	0.1%	–	0 to $1x10^6$	–
Power Factor @ Unity PF	0.55%+0.025%	3.5%+0.35%	0.01%	1%	-0.01 to -100.00, 100.00 to 0.01	-0 to 100 to 0
Power Factor @ 50 Lag & 50 Lead	0.75%+0.025%	6.0%+0.6%	0.01%	1%	-0.01 to -100.00, 100.00 to 0.01	-0 to 100 to 0
Symmetrical Components	1% Full Scale	–	0.1%	–	Mag: 0 to $1x10^6$ Phs: -180° to 180°	–

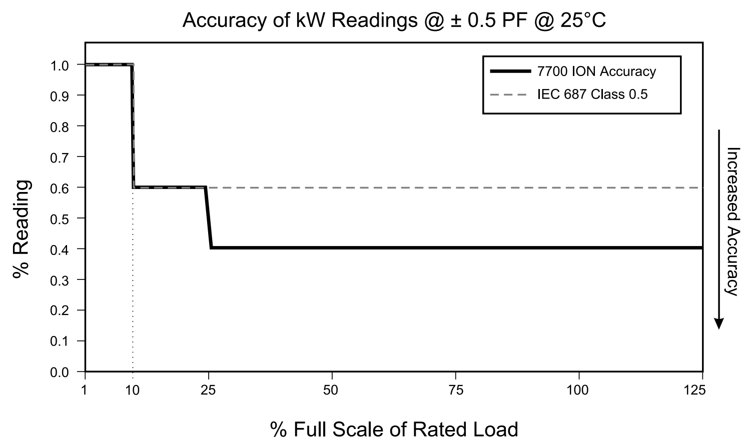
* Resolutions given are from the MGT. Higher resolution can be obtained via communications.

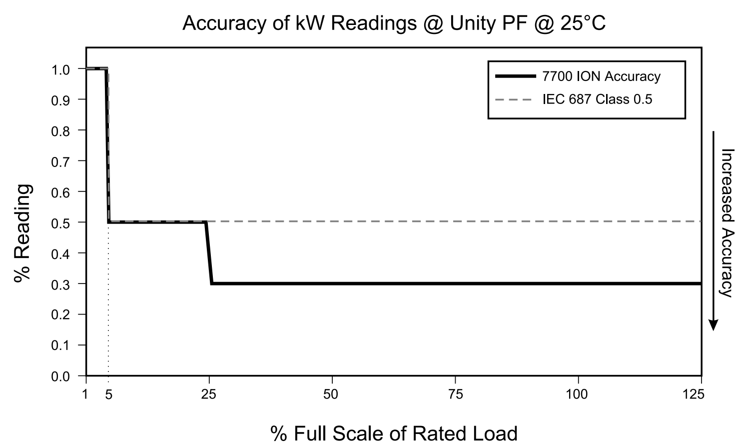
† LSD = least significant digit

‡ kWH Accuracy Specification meets or exceeds IEC 687 Class 0.5

kW Measurement Accuracy

The graphs below indicate the accuracy of the 7700 ION's kW measurements at 25°C at Power Factor values of 1.0, 0.5 lead and 0.5 lag. The graphs also compare 7700 ION accuracy with the IEC 687 Class 0.5 specification.





High-Speed Measurements During Fault

@ 125% to 2000% of Rated Input (6.25A to 100A)

Parameter	**Accuracy** ±(%rdg)	**MGT Resolution** (%range)	**Range**
Current	5%	0.1%	0 to 10^6
kVA	5%	0.1%	0 to 3.3×10^7
kW, kVAR @ Unity PF	5%	0.1%	0 to $\pm 3.3\times10^7$
kW, kVAR @ 50 Lag and 50 Lead	5%	0.1%	0 to $\pm 3.3\times10^7$
Power Factor @ Unity PF	10%	0.01%	-0.01 to -100.0, 100.00 to 0.01
Power Factor @ 50 Lag and 50 Lead	10%	0.01%	-0.01 to -100.00, 100.00 to 0.01

On-Board Input Ratings

Input	Options	Specifications
Power Supply †	Standard:	100 to 240 VAC/ 47 to 440 Hz or 110 to 300 VDC, 1 A worst case load (56 W) @ 100 VAC @ 25°C
	P24/48 Option:	20 to 60 VDC @ 30 W worst case
Operating Temp.		-20°C to +50°C (-4°F to 122°F) ambient air
Storage Temp.		-30°C to +70°C (-22°F to +158°F)
Humidity		5% to 95% non-condensing
Voltage Inputs ‡	-120 Option:	120 VAC nominal F.S. input, 25% overrange
	-277 Option:	277 VAC nominal F.S. input, 25% overrange
	-347 Option:	347 VAC nominal F.S. input, 25% overrange
		Overload withstand for all options: 1500 VAC continuous, 2500 VAC for 1 second non-recurring
		Input Impedance for all options: 2 MΩ
Current Inputs ‡		5 Amps AC nominal F.S. input, 25% overrange
		20x fault capture capability
		Overload withstand for all options: 15 Amps continuous, 300 Amps for 1 second non-recurring
		Input Impedance: 2mΩ
		Worst Case Burden (@ 6.25 Amps): 0.0625 VA
Internal Digital Inputs		Standard self-excited, dry contact sensing, no external voltage source required. +30 VDC differential SCOM output to S1 through S8 inputs
		Minimum Pulse Width: 1 msec, Maximum Pulse Rate: 20 pulses/second
Internal Analog Input *(optional)*	0-1mA Option:	1 mA AC/DC nominal full scale input (1.25 mA AC/DC max.)
		Overload withstand: 50 mA continuous, 100 mA for 1 second non-recurring
		Input Impedance: 49.9Ω
		Accuracy: AC: ± 0.25% F.S. DC: ± (0.25% + 0.25%/Vcommon mode)* total error
		Maximum Common Mode: 8V
	0-20mA Option:	20 mA AC/DC nominal full scale input (25 mA AC/DC max.)
		Overload withstand: 35 mA continuous, 70 mA for 1 second non-recurring
7700 ION update time for all options: Once per second		Input Impedance: 100Ω
		Accuracy: AC: ± 0.25% F.S. DC: ± (0.25% + 0.1%/Vcommon mode) total error
		Maximum Common Mode: 20V
	0-1V Option:	1.0 VAC/VDC nominal full scale input (1.25 VAC/VDC max.)
		Overload withstand: 20 VAC/VDC continuous, 40 VAC/VDC for 1 second non-recurring
		Input Impedance: 49.9KΩ
		Accuracy: AC: ± 0.25% F.S. DC: ± (0.25% + 0.13%/Vcommon mode) total error
		Maximum Common Mode: 12V
	0-10V Option:	10.0 VAC/VDC nominal full scale input (12.5 VAC/VDC max.)
		Overload withstand: 20 VAC/VDC continuous, 40 VAC/VDC for 1 second non-recurring
		Input Impedance: 49.9KΩ
		Accuracy: AC: ± 0.25% F.S. DC: ± (0.25% + 0.025%/Vcommon mode) total error
		Maximum Common Mode: 25V

† Power Supply inputs comply with Installation Category II
‡ Measuring Inputs comply with Installation Category III
The 7700 ION is operable under Pollution Degree II

Optional Input/Output Modules

Analog Input Options

Inputs		Specifications	
Voltage Inputs			
GAIVDC1	0 to 1 VDC		
GAIVDC5	0 to 5 VDC	Input Impedance:	100 KΩ
GAIVDC10	0 to 10 VDC		
Current Inputs			
GAIIDC420	4 to 20 mA	Input Impedance:	130Ω
Common Specifications		Isolation (Input to Output):	2500 Vrms
		Resolution:	12 bits
(Voltage and		Accuracy @ 25°C:	±0.2% range
Current Modules)		Offset Drift:	±50 ppm/°C
		Gain Drift:	±55 ppm/°C
		Operating Temperature Range:	0°C to 60°C
		Storage Temperature Range:	-25°C to 85°C
		Common Mode Rejection:	> -100dB

NOTE

The 7700 ION update time is once per second.

Analog Output Options

Inputs		Specifications	
Voltage Outputs			
GAOVDC5	0 to 5 VDC	Sourcing Capability:	20 mA maximum @ 5 VDC
GAOVDC10	0 to 10 VDC	Sourcing Capability:	10 mA maximum @ 10 VDC
Current Outputs			
GAOIDC420	4 to 20 mA	Sourcing Capability:	20 mA maximum @ 450 Ω maximum loop resistance
Common Specifications		Isolation (Input to Output):	2500 Vrms
		Resolution:	12 bits
(Voltage and		Accuracy @ 25°C:	±0.6% range
Current Modules)		Offset Drift:	±45 ppm/°C
		Gain Drift:	±150 ppm/°C
		Short Circuit Protection:	Output signal can be shorted to ground without damaging the module
		Operating Temperature Range:	0°C to 60°C
		Storage Temperature Range:	-25°C to 85°C

NOTE

The 7700 ION update time is once per second.

Digital Input Options

AC Inputs	120VAC Option (GDIAC120)	240VAC Option (GDIAC240)
Nominal Input Voltage:	120 VAC	240 VAC
Input Voltage Range:	90 to 140 VAC/VDC	180 to 280 VAC/VDC
Input Current @ Max Input Voltage:	8 mA rms	6 mA rms
Nominal Input Resistance:	22 KΩ	60 KΩ
Pick Up Voltage:	> 90 VAC	> 180 VAC
Drop Out Voltage:	< 25 VAC	< 50 VAC
	Common Specifications	
Turn-on Time:	20 msec maximum	
Turn-off Time:	20 msec maximum	
On-state Voltage Drop:	0.45 VDC @ 50 mA maximum	
Optical Isolation (Input to Output):	4000 VAC rms	
Operating Temperature Range:	-40°C to 100°C	
Storage Temperature Range:	-40°C to 125°C	
Standards & Certification:	UL File # E58632, CSA File # LR38763, TUV Certificate #R9474066	
Transient Protection:	Meets ANSI/IEEE C37.90-1989 Surge Withstand Capability Test	
7700 Scan Time:	1 msec maximum, 5 msec minimum, max pulse rate = 20 pps	

DC Inputs	32VDC (GDIDC32)	32VDC (High Speed) (GDIDC32H)
Turn-on Time:	0.20 msec maximum	0.050 msec maximum
Turn-off Time:	0.40 msec maximum	0.075 msec maximum
	Common Specifications	
Nominal Input Voltage:	32 VDC	
Input Voltage Range:	3 to 32 VDC	
Input Current @ Max Input Voltage:	18 mA	
Nominal Input Resistance:	1.8 KΩ	
On-state Voltage Drop:	0.45 VDC @ 50 mA maximum	
Pick Up Voltage:	> 3 VDC	
Drop Out Voltage:	< 1 VDC	
Optical Isolation (Input to Output):	4000 VAC rms	
Operating Temperature Range:	-40°C to 100°C	
Storage Temperature Range:	-40°C to 125°C	
UL Recognition:	File # E58632 (except GDIDC32H)	
CSA Certification:	File # LR38763 (except GDIDC32H)	
Transient Protection:	Meets ANSI/IEEE C37.90-1989 Surge Withstand Capability Test (except GDIDC32H)	
7700 Scan Time:	1 msec maximum, 5 msec minimum, max pulse rate = 20 pps	

Digital Output Options

AC Outputs Solid State (Zero-Crossing Turn On)	120VAC, 3.5A N.O. (GDOAC120)	240VAC, 3.5A, N.O. (GDOAC240)
Nominal Line Voltage:	120 VAC	240 VAC
Load Voltage Range:	24 to 140 VAC	24 to 280 VAC
Minimum Peak Blocking Voltage:	400 VAC	600 VAC
Maximum Off-state Leakage @ 60Hz:	2 mA rms	4 mA rms
	Common Specifications	
Load Current Range (rms):	0.03 to 3.5 Amps	
Maximum Surge Current (peak):	80 Amps @ 60 Hz, 1 cycle; 25 Amps @ 60 Hz, 60 cycles	
Maximum Zero-voltage Offset:	8 Vpeak	
Turn-on Time (60 Hz):	8.3 msec maximum	
Turn-off Time (60 Hz):	8.3 msec maximum	
On-state Voltage Drop (peak):	1.5 Volts maximum	
Power Dissipation:	1.0 Watt/Amp typical	
Load Power Factor:	0.4 minimum	
Frequency Range:	25 Hz to 70 Hz	
Optical Isolation(Input to Output):	4000 VAC rms	
Operating Temperature Range:	-40°C to +100°C	
Storage Temperature Range:	-40°C to +125°C	
Standards and Certification:	UL File # E58632, CSA File # LR38763, TUV Certificate #R9474066	
Transient Protection:	Meets ANSI/IEEE C37.90-1989 Surge Withstand Capability Test	

DC Outputs (Solid State)	60VDC, 3.5A, N.O (GDODC60)	200VDC, 1.0A, N.O. (GDODC200)	60VDC, 3.5A, N.O., Low Leakage (GDODC60L)
Maximum Line Voltage:	60 VDC	200 VDC	60 VDC
Load Voltage Range:	3 to 60 VDC	4 to 200 VDC	3 to 60 VDC
Maximum Off-state Leakage @ 60 VDC:	1.5 mA	0.10 mA	0.01 mA
Turn-on Time:	20 μsec maximum	75 μsec maximum	75 μsec maximum
Turn-off Time:	50 μsec maximum	750 μsec maximum	500 μsec maximum
On-state Voltage Drop:	1.2 Volts maximum	1.75 Volts maximum	1.2 Volts maximum
Clamping Voltage:	80 VDC maximum	360 VDC maximum	80 VDC maximum
Power Dissipation:	1.0 Watt/Amp typical	1.5 Watt/Amp typical	1.0 Watt/Amp typical
	Common Specifications:		
Load Current Range (rms):	0.02 to 1.0 Amps		
Surge Current (peak):	5 Amps maximum for 1 second		
Transient Power Dissipation:	400 Watts @ 1 msec non-recurring		
Optical Isolation (Input to Output):	4000 VAC rms		
Operating Temperature Range:	-40°C to +100°C		
Storage Temperature Range:	-40°C to +125°C		
UL Recognition:	File # E58632 (except GDODC200)		
CSA Certification:	File # LR38763 (except GDODC200)		
Transient Protection:	Meets ANSI/IEEE C37.90-1989 Surge Withstand Capability Test		
7700 Update Time:	1-cycle maximum, 1-second minimum.		

DC Outputs (Mechanical)	100VDC, 0.5A, N.O. (GDODC100M)
Maximum Line Voltage:	100 VDC/130 VAC maximum
Contact Rating:	10 Watts maximum
Switching Current:	0.5 A maximum. Inductive loads require diode suppression.
Carrying Current:	0.01 to 1.5 A maximum. Inductive loads require diode suppression.
Contact Resistance:	100 mΩ maximum
Turn-on Time:	0.5 msec maximum
Turn-off Time:	0.5 msec maximum
Off-state Leakage Current:	2 μA maximum
Dielectric Isolation (Input to Output):	2000 VAC rms
Operating Temperature Range:	-20°C to +85°C
Storage Temperature Range:	-40°C to +125°C
Transient Protection:	none

Additional Specifications

NOTE

The power supply circuit includes a 250V, 3A time-lag IEC Type T fuse on the L/+ terminal.

Power Supply (7700 ION and External I/O Boards)

Standard: 100 to 240 VAC/ 47 to 440 Hz or 110 to 300 VDC, 1 A worst case loading @ 100 VAC @ 25°C, 56 W worst case

P24/48 Option: 20 to 60 VDC @ 30 W worst case

Environmental

Operating Temperature	-20°C to +50°C (-4°F to 122°F) ambient air
Storage Temperature	-30°C to +70°C (-22°F to +158°F)
Location	Indoor Use Only
Humidity	5% to 95% RH non-condensing
Maximum Operating Altitude	2000 m (6100 ft.)

Waveform Recording

Sampling Resolution: 16, 32, 64, or 128 samples / cycle from 20 to 70 Hz

Resolution: 13 bits (0.0125%)

MGT Display

Operating Temp.: 0°C to 50°C (32°F to 122°F) ambient air.

Storage Temp: -20°C to +70°C (-4°F to +158°F)

Humidity: 5% to 95% non-condensing

NRTL/C
Certified to UL 508
and UL 3101-1 *

CSA is a Nationally Recognized Test Laboratory (NRTL), accredited at the US Federal Government level by the Occupational Safety and Health Association (OSHA).

Standards Compliance

UL: CSA certified to UL 508 and UL 3101-1 *

CSA: CAN/CSA-C22.2 No.142-M1987 and CAN/CSA-C22.2 No.1010.1-92 *

Europe: Registered under CB Scheme to EN61010-1 *

Surge Withstand: All inputs pass ANSI/IEEE C37.90-1989 surge withstand and fast transient tests

FCC: Part 15 of FCC Rules for a Class A Digital Device

Quality Assurance Certification: ISO 9002 certified by QMI

User Programmable Log Capacity

Example configurations:

	Standard Memory				XMEM Option (Extended Memory)			
Event Log	500 Events	500 Events	500 Events	500 Events	500 Events	500 Events	500 Events	500 Events
Data Log	31 days[1]	31 days[1]	125 days[2]	125 days[2]	74 days[1]	74 days[1]	296 days[2]	296 days[2]
Waveform Log	2[3]	8[4]	2[3]	8[4]	6[3]	24[4]	6[3]	24[4]

[1] 16 parameters recorded every 15 minutes

[2] 16 parameters recorded hourly

[3] 6 channels @ 128 samples per cycle for 14 cycles

[4] 6 channels @ 16 samples per cycle for 22 cycles

* UL 3101-1, CSA No.1010.1 and EN61010-1 effective January 1, 1997

Ordering Information

Basic Model

7700 ION	with universal power supply (see specifications), MGT display, and optically isolated RS232C/RS485 communications card.

Meter Options (must be specified with 7700 ION when ordering)

-120	To monitor 69/120, 120/208, or 120/240 (single phase) Volts systems
-277	To monitor 240/416, or 277/480 Volts systems
-347	To monitor 347/600 Volts systems
-50Hz	Optimized for use on 50 Hz systems
-60Hz	Optimized for use on 60 Hz systems
-P24/48	20 to 60 VDC power supply (instead of universal power supply)
-TROP	Tropicalization (conformal coating) treatment
-TRAN	No Modular Graphics Terminal Display
-XMEM	Additional 512K of NVRAM

Display

MGT	Modular Graphics Terminal with 10 ft. cable (for ordering MGT separately)
-50ft	50 ft. cable instead of 10 ft. cable
-200ft	200 ft. cable instead of 10 ft. cable
SWITCHBOX	Selector switch to connect up to 4 7700-ION-TRAN meters to a single MGT
-10ft	10ft cable for use with SWITCHBOX
-50ft	50ft cable for use with SWITCHBOX
-200ft	200ft cable for use with SWITCHBOX

Internal Analog Input Options

(Use separate line item on Purchase Order — see next page for example)

Auxiliary Analog Inputs Board

AUX 1mA	4 0-1mA Auxiliary Analog Inputs
AUX 20mA	4 0-20mA Auxiliary Analog Inputs
AUX 1V	4 0-1VAC/VDC Auxiliary Analog Inputs
AUX 10V	4 0-10VAC/VDC Auxiliary Analog Inputs

Note: All four on-board Analog Inputs must have the same range. Multiple boards must be purchased if different ranges are required.

External Input/Output Expansion Options

(Use separate line item on Purchase Order — see next page for example)

IOCA	I/O card for I/O Port A with ribbon cable (3 feet)
IOCB	I/O card for I/O Port B with ribbon cable (3 feet), and universal power supply (see power supply specifications)
-P24/48	Option for IOCA or IOCB

Analog Input Devices

GAIVDC1	0 to 1 VDC Analog Input Device
GAIVDC5	0 to 5 VDC Analog Input Device
GAIVDC10	0 to 10 VDC Analog Input Device
GAIIDC420	4 to 20 mA Analog Input Device

Analog Output Devices

GAOVDC5	0 to 5 VDC Analog Output Device
GAOVDC10	0 to 10 VDC Analog Output Device
GAOIDC420	4 to 20 mA Analog Output Device

Digital Input Devices

GDIAC120	120 VAC Digital Input Device
GDIAC240	240 VAC Digital Input Device
GDIDC32	32 VDC Digital Input Device
GDIDC32H	32 VDC High Speed Digital Input Device

Digital Output Devices

GDOAC120	120 VAC, 3.5A, N.O. Solid State Relay
GDOAC240	240 VAC, 3.5A, N.O. Solid State Relay
GDODC60	60 VDC, 3.5A, N.O. Solid State Relay
GDODC200	200 VDC, 1.0A, N.O. Solid State Relay
GDODC60L	60 VDC, 3.5A, Low Leakage, N.O. Solid Relay
GDODC100M	100 VDC, 0.5A, N.O. Mechanical Relay

Ordering Example

This example specifies a 7700 ION for a 347/600 Volts, 60 Hz system. It includes an I/O card A with 60 VDC power supply, an I/O card B with 60 VDC power supply, six 0 to 1 VDC Analog Input Devices, six 4 to 20 mA Analog Output Devices, eight 120VAC Digital Input Device, and four 120VAC Digital Output Devices:

1	7700ION -347 -60Hz
1	IOCA -P24/48
1	IOCB -P24/48
6	GAIVDC1
6	GAOIDC420
8	GDIAC120
4	GDOAC120

Warranty

Three years limited parts and labor, FOB Saanichton, B.C., Canada.

External I/O Device Part Number Summary

The following table summarizes the manufacturer's part numbers for external I/O devices used with the 7700ION.

ORDERING OPTION	DESCRIPTION	MANF. PART #
Digital AC Outputs		
GDOAC120	120 VAC, 3.5A, N.O. Solid State Relay	70G-OAC5
GDOAC240	240 VAC, 3.5A, N.O. Solid State Relay	70G-OAC5A
Digital DC Outputs		
GDODC60	60 VDC, 3.5 A, N.O. Solid State Relay	70G-ODC5
GDODC200	200 VDC, 1.0A, N.O. Solid State Relay	70G-ODC5A
GDODC60L	60 VDC, 1.0 A, Low Leakage, N.O. Solid Relay	70G-ODC5B
GDODC100M	100 VDC, 0.5A, N.O. Mechanical Relay	70G-ODC5R
Digital AC Inputs		
GDIAC120	120 VAC Digital Input Device	70G-IAC5
GDIAC240	240 VAC Digital Input Device	70G-IAC5A
Digital DC Inputs		
GDIDC32	32 VDC Digital Input Device	70G-IDC5
GDIDC32H	32 VDC High Speed Digital Input Device	70G-IDC5B
Analog Outputs		
GAOVDC5	0 to 5 VDC Analog Output Device	73G-OV5
GAOVDC10	0 to 10 VDC Analog Output Device	73G-OV10
GAOIDC420	4 to 20 mA Analog Output Device	73G-OI420
Analog Inputs		
GAIVDC1	0 to 1 VDC Analog Input Device	73G-IV1
GAIVDC5	0 to 5 VDC Analog Input Device	73G-IV5
GAIVDC10	0 to 10 VDC Analog Input Device	73G-IV10
GAIIDC420	4 to 20 mA Analog Input Device	73G-II420

Appendix B

7700 ION Register Handles

This appendix contains the hexadecimal register handles for all of the modules available in the 7700 ION.

In this Chapter

Module **Page**

Explanation of Symbols

- Enumerated register
- Numeric register
- Boolean register
- Numeric bounded register
- Pulse register
- Calendar register
- Waveform register
- Event register
- Event log register
- Numeric array register
- Log register
- String register

Analog Input Modules

		Output Registers		Setup Registers		
Module Name	Handle	ScaledValu	Event	Zero Scale	Full Scale	Port
ANI #1	0180	5850	1100	7006	7018	798D
ANI #2	0181	5851	1100	7007	7019	798E
ANI #3	0182	5852	1100	7008	701A	798F
ANI #4	0183	5853	1100	7009	701B	7990
ANI #5	0184	5854	1100	700A	701C	7991
ANI #6	0185	5855	1100	700B	701D	7992
ANI #7	0186	5856	1100	700C	701E	7993
ANI #8	0187	5857	1100	700D	701F	7994
ANI #9	0188	5858	1100	700E	7020	7995
ANI #10	0189	5859	1100	700F	7021	7996
ANI #11	018A	585A	1100	7010	7022	7997
ANI #12	018B	585B	1100	7011	7023	7998
ANI #13	018C	585C	1100	7012	7024	7999
ANI #14	018D	585D	1100	7013	7025	799A
ANI #15	018E	585E	1100	7014	7026	799B
ANI #16	018F	585F	1100	7015	7027	799C
ANI #17	0190	5860	1100	7016	7028	799D
ANI #18	0191	5861	1100	7017	7029	799E

Analog Output Modules

		Output Registers		Setup Registers			
Module Name	**Handle**	**Normalized**	**Event**	**Zero Scale**	**Full Scale**	**OutputMode**	**Port**
ANO #1	0200	5862	1100	702A	7048	*N/A*	799F
ANO #2	0201	5863	1100	702B	7049	*N/A*	79A0
ANO #3	0202	5864	1100	702C	704A	*N/A*	79A1
ANO #4	0203	5865	1100	702D	704B	*N/A*	79A2
ANO #5	0204	5866	1100	702E	704C	*N/A*	79A3
ANO #6	0205	5867	1100	702F	704D	*N/A*	79A4
ANO #7	0206	5868	1100	7030	704E	*N/A*	79A5
ANO #8	0207	5869	1100	7031	704F	*N/A*	79A6
ANO #9	0208	586A	1100	7032	7050	*N/A*	79A7
ANO #10	0209	586B	1100	7033	7051	*N/A*	79A8
ANO #11	020A	586C	1100	7034	7052	*N/A*	79A9
ANO #12	020B	586D	1100	7035	7053	*N/A*	79AA
ANO #13	020C	586E	1100	7036	7054	*N/A*	79AB
ANO #14	020D	586F	1100	7037	7055	*N/A*	79AC
ANO #15	020E	5870	1100	7038	7056	*N/A*	79AD
ANO #16	020F	5871	1100	7039	7057	*N/A*	79AE
ANO #17	0210	5872	1100	703A	7058	*N/A*	79AF
ANO #18	0211	5873	1100	703B	7059	*N/A*	79B0
ANO #19	0212	5874	1100	703C	705A	*N/A*	79B1
ANO #20	0213	5875	1100	703D	705B	*N/A*	79B2
ANO #21	0214	5876	1100	703E	705C	*N/A*	79B3
ANO #22	0215	5877	1100	703F	705D	*N/A*	79B4
ANO #23	0216	5878	1100	7040	705E	*N/A*	79B5
ANO #24	0217	5879	1100	7041	705F	*N/A*	79B6
ANO #25	0218	587A	1100	7042	7060	*N/A*	79B7
ANO #26	0219	587B	1100	7043	7061	*N/A*	79B8
ANO #27	021A	587C	1100	7044	7062	*N/A*	79B9
ANO #28	021B	587D	1100	7045	7063	*N/A*	79BA
ANO #29	021C	587E	1100	7046	7064	*N/A*	79BB
ANO #30	021D	587F	1100	7047	7065	*N/A*	79BC

And/Or Modules

		Output Registers			Setup Registers	
Module Name	**Handle**	**Result**	**Trigger**	**Event**	**Mode**	**EvLog Mode**
ANDOR #1	0B00	6087	692E	1100	7976	797E
ANDOR #2	0B01	6088	692F	1100	7977	797F
ANDOR #3	0B02	6089	6930	1100	7978	7980
ANDOR #4	0B03	608A	6931	1100	7979	7981
ANDOR #5	0B04	608B	6932	1100	797A	7982
ANDOR #6	0B05	608C	6933	1100	797B	7983
ANDOR #7	0B06	608D	6934	1100	797C	7984
ANDOR #8	0B07	608E	6935	1100	797D	7985

Arithmetic Modules

		Output Registers								
Module Name	**Handle**	**Calc #1**	**Calc #2**	**Calc #3**	**Calc #4**	**Calc #5**	**Calc #6**	**Calc #7**	**Calc #8**	**Event**
ARITH #1	1500	5B3C	5B44	5B4C	5B54	5B5C	5B64	5B6C	5B74	1100
ARITH #2	1501	5B3D	5B45	5B4D	5B55	5B5D	5B65	5B6D	5B75	1100

		Setup Registers							
Module Name	**Handle**	**Formula #1**	**Formula #2**	**Formula #3**	**Formula #4**	**Formula #5**	**Formula #6**	**Formula #7**	**Formula #8**
ARITH #1	1500	1305	130D	1315	131D	1325	132D	1335	133D
ARITH #2	1501	1306	130E	1316	131E	1326	132E	1336	133E

Clock Module

		Output Register				Setup Registers			
Module Name	Handle	Universal Time	Local Time	DST	Event	TZ Offset	DST Start	DST End	DST Offset
CLK #1	1580	5B7C	5B7D	6113	1000	722E	722F	7230	7231

Communications Modules

		Output Register	Setup Registers							
Module Name	Handle	Event	Comm Mode	Baud Rate	HshakeMode	RTS Level	CTS Level	RTS Delay	Unit ID	Protocol
COM #1	0C00	1100	7986	7987	7988	7989	798A	71E8	71E9	7A4F
MGT	0C01	1100	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
COM #2	0C02	1100	*N/A*	7A4D	*N/A*	*N/A*	*N/A*	7232	7234	7A50
COM #3	0C03	1100	*N/A*	7A4E	*N/A*	*N/A*	*N/A*	7233	*7235*	7A51
ETHERNET	0C04	1100	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*7236*	7A52

Counter Modules

		Output Registers		Setup Registers	
Module Name	Handle	Accumulatr	Event	Multiplier	Count Mode
CNT #1	0A80	5AD2	1100	71DC	796C
CNT #2	0A81	5AD3	1100	71DD	796D
CNT #3	0A82	5AD4	1100	71DE	796E
CNT #4	0A83	5AD5	1100	71DF	796F
CNT #5	0A84	5AD6	1100	71E0	7970
CNT #6	0A85	5AD7	1100	71E1	7971
CNT #7	0A86	5AD8	1100	71E2	7972
CNT #8	0A87	5AD9	1100	71E3	7973
CNT #9	0A88	5ADA	1100	71E4	7974
CNT #10	0A89	5ADB	1100	71E5	7975

Data Acquisition Module

		Output Registers										
Module Name	Handle	V1	V2	V3	I1	I2	I3	I4	AUX1	AUX2	AUX3	AUX4
DA #1	0C80	0F07	0F08	0F09	0F0A	0F0B	0F0C	0F0D	0F0E	0F0F	0F10	0F11

Data Recorder Modules

		Output Registers			Setup Registers		
Module Name	Handle	Rec Log	Log State	Event	Depth	RecordMode	EvLog Mode
REC #1	0800	0F80	60AF	1100	719C	7918	N/A
REC #2	0801	0F81	60B0	1100	719D	7919	N/A
REC #3	0802	0F82	60B1	1100	719E	791A	N/A
REC #4	0803	0F83	60B2	1100	719F	791B	N/A
REC #5	0804	0F84	60B3	1100	71A0	791C	N/A
REC #6	0805	0F85	60B4	1100	71A1	791D	N/A
REC #7	0806	0F86	60B5	1100	71A2	791E	N/A
REC #8	0807	0F87	60B6	1100	71A3	791F	N/A
REC #9	0808	0F88	60B7	1100	71A4	7920	N/A
REC #10	0809	0F89	60B8	1100	71A5	7921	N/A
REC #11	080A	0F8A	60B9	1100	71A6	7922	N/A
REC #12	080B	0F8B	60BA	1100	71A7	7923	N/A
REC #13	080C	0F8C	60BB	1100	71A8	7924	N/A
REC #14	080D	0F8D	60BC	1100	71A9	7925	N/A
REC #15	080E	0F8E	60BD	1100	71AA	7926	N/A
REC #16	080F	0F8F	60BE	1100	71AB	7927	N/A
REC #17	0810	0F90	60BF	1100	71AC	7928	N/A
REC #18	0811	0F91	60C0	1100	71AD	7929	N/A
REC #19	0812	0F92	60C1	1100	71AE	792A	N/A
REC #20	0813	0F93	60C2	1100	71AF	792B	N/A

Diagnostics Module

		Output Registers						
Module Name	Handle	Battery Minites	A/D Status	Total Log Mem	Free Log Mem	FreeContLogMem	Cycle time	Calc Time
DIA #1	0D80	5AE4*	5AE5*	5AE6	5AE7	5AE8	5AE9*	5AEA*

		Output Registers					
Module Name	Handle	1-sec Time	Cyc Period	Calc Period	1-sec Period	# Unused labels	Proc power Used (%)
DIA #1	0D80	5AEB*	5AEC*	5AED*	5AEE*	5AEF	5AF0

* Customer Support Use

Digital Input Modules

		Output Registers			Setup Registers				
Module Name	Handle	State	Trigger	Event	Input Mode	EvLog Mode	Polarity	Debounce	Port
DI #1	0280	6001	6800	1100	7806	782C	7852	7066	79DB
DI #2	0281	6002	6801	1100	7807	782D	7853	7067	79DC
DI #3	0282	6003	6802	1100	7808	782E	7854	7068	79DD
DI #4	0283	6004	6803	1100	7809	782F	7855	7069	79DE
DI #5	0284	6005	6804	1100	780A	7830	7856	706A	79DF
DI #6	0285	6006	6805	1100	780B	7831	7857	706B	79E0
DI #7	0286	6007	6806	1100	780C	7832	7858	706C	79E1
DI #8	0287	6008	6807	1100	780D	7833	7859	706D	79E2
DI #9	0288	6009	6808	1100	780E	7834	785A	706E	79E3
DI #10	0289	600A	6809	1100	780F	7835	785B	706F	79E4
DI #11	028A	600B	680A	1100	7810	7836	785C	7070	79E5
DI #12	028B	600C	680B	1100	7811	7837	785D	7071	79E6
DI #13	028C	600D	680C	1100	7812	7838	785E	7072	79E7
DI #14	028D	600E	680D	1100	7813	7839	785F	7073	79E8
DI #15	028E	600F	680E	1100	7814	783A	7860	7074	79E9
DI #16	028F	6010	680F	1100	7815	783B	7861	7075	79EA
DI #17	0290	6011	6810	1100	7816	783C	7862	7076	79EB
DI #18	0291	6012	6811	1100	7817	783D	7863	7077	79EC
DI #19	0292	6013	6812	1100	7818	783E	7864	7078	79ED
DI #20	0293	6014	6813	1100	7819	783F	7865	7079	79EE
DI #21	0294	6015	6814	1100	781A	7840	7866	707A	79EF
DI #22	0295	6016	6815	1100	781B	7841	7867	707B	79F0
DI #23	0296	6017	6816	1100	781C	7842	7868	707C	79F1
DI #24	0297	6018	6817	1100	781D	7843	7869	707D	79F2
DI #25	0298	6019	6818	1100	781E	7844	786A	707E	79F3
DI #26	0299	601A	6819	1100	781F	7845	786B	707F	79F4
DI #27	029A	601B	681A	1100	7820	7846	786C	7080	79F5
DI #28	029B	601C	681B	1100	7821	7847	786D	7081	79F6
DI #29	029C	601D	681C	1100	7822	7848	786E	7082	79F7
DI #30	029D	601E	681D	1100	7823	7849	786F	7083	79F8
DI #31	029E	601F	681E	1100	7824	784A	7870	7084	79F9
DI #32	029F	6020	681F	1100	7825	784B	7871	7085	79FA

Digital Input Modules, Continued

		Output Registers			Setup Registers				
Module Name	**Handle**	**State**	**Trigger**	**Event**	**Input Mode**	**EvLog Mode**	**Polarity**	**Debounce**	**Port**
DI #33	02A0	6021	6820	1100	7826	784C	7872	7086	79FB
DI #34	02A1	6022	6821	1100	7827	784D	7873	7087	79FC
DI #35	02A2	6023	6822	1100	7828	784E	7874	7088	79FD
DI #36	02A3	6024	6823	1100	7829	784F	7875	7089	79FE
DI #37	02A4	6025	6824	1100	782A	7850	7876	708A	79FF
DI #38	02A5	6026	6825	1100	782B	7851	7877	708B	7A00

Digital Output Modules

		Output Registers			Setup Registers			
Module Name	**Handle**	**State**	**Mode**	**Event**	**EvLog Mode**	**Polarity**	**PulseWidth**	**Port**
DO #1	0300	6027	6045	1100	7878	7896	708C	79BD
DO #2	0301	6028	6046	1100	7879	7897	708D	79BE
DO #3	0302	6029	6047	1100	787A	7898	708E	79BF
DO #4	0303	602A	6048	1100	787B	7899	708F	79C0
DO #5	0304	602B	6049	1100	787C	789A	7090	79C1
DO #6	0305	602C	604A	1100	787D	789B	7091	79C2
DO #7	0306	602D	604B	1100	787E	789C	7092	79C3
DO #8	0307	602E	604C	1100	787F	789D	7093	79C4
DO #9	0308	602F	604D	1100	7880	789E	7094	79C5
DO #10	0309	6030	604E	1100	7881	789F	7095	79C6
DO #11	030A	6031	604F	1100	7882	78A0	7096	79C7
DO #12	030B	6032	6050	1100	7883	78A1	7097	79C8
DO #13	030C	6033	6051	1100	7884	78A2	7098	79C9
DO #14	030D	6034	6052	1100	7885	78A3	7099	79CA
DO #15	030E	6035	6053	1100	7886	78A4	709A	79CB
DO #16	030F	6036	6054	1100	7887	78A5	709B	79CC
DO #17	0310	6037	6055	1100	7888	78A6	709C	79CD
DO #18	0311	6038	6056	1100	7889	78A7	709D	79CE
DO #19	0312	6039	6057	1100	788A	78A8	709E	79CF
DO #20	0313	603A	6058	1100	788B	78A9	709F	79D0
DO #21	0314	603B	6059	1100	788C	78AA	70A0	79D1
DO #22	0315	603C	605A	1100	788D	78AB	70A1	79D2

Digital Output Modules, Continued

		Output Registers			Setup Registers			
Module Name	Handle	State	Mode	Event	EvLog Mode	Polarity	PulseWidth	Port
DO #23	0316	603D	605B	1100	788E	78AC	70A2	79D3
DO #24	0317	603E	605C	1100	788F	78AD	70A3	79D4
DO #25	0318	603F	605D	1100	7890	78AE	70A4	79D5
DO #26	0319	6040	605E	1100	7891	78AF	70A5	79D6
DO #27	031A	6041	605F	1100	7892	78B0	70A6	79D7
DO #28	031B	6042	6060	1100	7893	78B1	70A7	79D8
DO #29	031C	6043	6061	1100	7894	78B2	70A8	79D9
DO #30	031D	6044	6062	1100	7895	78B3	70A9	79DA

Event Log Controller Module

		Output Register	Setup Registers		
Module Name	Handle	Event Log	Depth	Protection	Cutoff
ELC #1	0B80	1000	71E6	71E7	7305

External Boolean Control Modules

Module Name	Handle	Result ◑
EXT BOOL #1	1180	608F
EXT BOOL #2	1181	6090
EXT BOOL #3	1182	6091
EXT BOOL #4	1183	6092
EXT BOOL #5	1184	6093
EXT BOOL #6	1185	6094
EXT BOOL #7	1186	6095
EXT BOOL #8	1187	6096
EXT BOOL #9	1188	6097
EXT BOOL #10	1189	6098
EXT BOOL #11	118A	6099

Module Name	Handle	Result ◑
EXT BOOL #12	118B	609A
EXT BOOL #13	118C	609B
EXT BOOL #14	118D	609C
EXT BOOL #15	118E	609D
EXT BOOL #16	118F	609E
EXT BOOL #17	1190	609F
EXT BOOL #18	1191	60A0
EXT BOOL #19	1192	60A1
EXT BOOL #20	1193	60A2
EXT BOOL #21	1194	60A3
EXT BOOL #22	1195	60A4

Module Name	Handle	Result ◑
EXT BOOL #23	1196	60A5
EXT BOOL #24	1197	60A6
EXT BOOL #25	1198	60A7
EXT BOOL #26	1199	60A8
EXT BOOL #27	119A	60A9
EXT BOOL #28	119B	60AA
EXT BOOL #29	119C	60AB
EXT BOOL #30	119D	60AC
EXT BOOL #31	119E	60AD
EXT BOOL #32	119F	60AE

External Numeric Control Modules

Module Name	Handle	Result ■
EXT NUM #1	0D00	5ADC
EXT NUM #2	0D01	5ADD
EXT NUM #3	0D02	5ADE
EXT NUM #4	0D03	5ADF
EXT NUM #5	0D04	5AE0
EXT NUM #6	0D05	5AE1
EXT NUM #7	0D06	5AE2
EXT NUM #8	0D07	5AE3

External Pulse Control Modules

Module Name	Handle	Result
EXT PULSE #1	1200	68AE
EXT PULSE #2	1201	68AF
EXT PULSE #3	1202	68B0
EXT PULSE #4	1203	68B1
EXT PULSE #5	1204	68B2
EXT PULSE #6	1205	68B3
EXT PULSE #7	1206	68B4
EXT PULSE #8	1207	68B5
EXT PULSE #9	1208	68B6
EXT PULSE #10	1209	68B7
EXT PULSE #11	120A	68B8
EXT PULSE #12	120B	68B9
EXT PULSE #13	120C	68BA
EXT PULSE #14	120D	68BB
EXT PULSE #15	120E	68BC
EXT PULSE #16	120F	68BD
EXT PULSE #17	1210	68BE
EXT PULSE #18	1211	68BF
EXT PULSE #19	1212	68C0
EXT PULSE #20	1213	68C1
EXT PULSE #21	1214	68C2
EXT PULSE #22	1215	68C3
EXT PULSE #23	1216	68C4
EXT PULSE #24	1217	68C5
EXT PULSE #25	1218	68C6
EXT PULSE #26	1219	68C7
EXT PULSE #27	121A	68C8
EXT PULSE #28	121B	68C9
EXT PULSE #29	121C	68CA
EXT PULSE #30	121D	68CB
EXT PULSE #31	121E	68CC
EXT PULSE #32	121F	68CD
EXT PULSE #33	1220	68CE
EXT PULSE #34	1221	68CF
EXT PULSE #35	1222	68D0

Module Name	Handle	Result
EXT PULSE #36	1223	68D1
EXT PULSE #37	1224	68D2
EXT PULSE #38	1225	68D3
EXT PULSE #39	1226	68D4
EXT PULSE #40	1227	68D5
EXT PULSE #41	1228	68D6
EXT PULSE #42	1229	68D7
EXT PULSE #43	122A	68D8
EXT PULSE #44	122B	68D9
EXT PULSE #45	122C	68DA
EXT PULSE #46	122D	68DB
EXT PULSE #47	122E	68DC
EXT PULSE #48	122F	68DD
EXT PULSE #49	1230	68DE
EXT PULSE #50	1231	68DF
EXT PULSE #51	1232	68E0
EXT PULSE #52	1233	68E1
EXT PULSE #53	1234	68E2
EXT PULSE #54	1235	68E3
EXT PULSE #55	1236	68E4
EXT PULSE #56	1237	68E5
EXT PULSE #57	1238	68E6
EXT PULSE #58	1239	68E7
EXT PULSE #59	123A	68E8
EXT PULSE #60	123B	68E9
EXT PULSE #61	123C	68EA
EXT PULSE #62	123D	68EB
EXT PULSE #63	123E	68EC
EXT PULSE #64	123F	68ED
EXT PULSE #65	1240	68EE
EXT PULSE #66	1241	68EF
EXT PULSE #67	1242	68F0
EXT PULSE #68	1243	68F1
EXT PULSE #69	1244	68F2
EXT PULSE #70	1245	68F3

Module Name	Handle	Result
EXT PULSE #71	1246	68F4
EXT PULSE #72	1247	68F5
EXT PULSE #73	1248	68F6
EXT PULSE #74	1249	68F7
EXT PULSE #75	124A	68F8
EXT PULSE #76	124B	68F9
EXT PULSE #77	124C	68FA
EXT PULSE #78	124D	68FB
EXT PULSE #79	124E	68FC
EXT PULSE #80	124F	68FD
EXT PULSE #81	1250	68FE
EXT PULSE #82	1251	68FF
EXT PULSE #83	1252	6900
EXT PULSE #84	1253	6901
EXT PULSE #85	1254	6902
EXT PULSE #86	1255	6903
EXT PULSE #87	1256	6904
EXT PULSE #88	1257	6905
EXT PULSE #89	1258	6906
EXT PULSE #90	1259	6907
EXT PULSE #91	125A	6908
EXT PULSE #92	125B	6909
EXT PULSE #93	125C	690A
EXT PULSE #94	125D	690B
EXT PULSE #95	125E	690C
EXT PULSE #96	125F	690D
EXT PULSE #97	1260	690E
EXT PULSE #98	1261	690F
EXT PULSE #99	1262	6910
EXT PULSE #100	1263	6911
EXT PULSE #101	1264	6912
EXT PULSE #102	1265	6913
EXT PULSE #103	1266	6914
EXT PULSE #104	1267	6915
EXT PULSE #105	1268	6916

External Pulse Control Modules, Continued

Module Name	Handle	Result ∧
EXT PULSE #106	1269	6917
EXT PULSE #107	126A	6918
EXT PULSE #108	126B	6919
EXT PULSE #109	126C	691A
EXT PULSE #110	126D	691B
EXT PULSE #111	126E	691C
EXT PULSE #112	126F	691D
EXT PULSE #113	1270	691E
EXT PULSE #114	1271	691F
EXT PULSE #115	1272	6920
EXT PULSE #116	1273	6921
EXT PULSE #117	1274	6922
EXT PULSE #118	1275	6923
EXT PULSE #119	1276	6924
EXT PULSE #120	1277	6925
EXT PULSE #121	1278	6926
EXT PULSE #122	1279	6927
EXT PULSE #123	127A	6928
EXT PULSE #124	127B	6929
EXT PULSE #125	127C	692A
EXT PULSE #126	127D	692B
EXT PULSE #127	127E	692C
EXT PULSE #128	127F	692D

Factory Modules

		Output Registers								
Module Name	Handle	Device Type T	Compliance T	Options T	Revision T	Serial Number T	Owner T	Tag1 T	Tag2 T	V Nominal ■
FAC #1	3	1300	1301	1302	1303	1304	1345	1346	1347	71EB

		Setup Registers							
Module Name	Handle	I Nominal ■	I4 Nominal ■	I20 Nominal ■	V1 cal ■	V2 cal ■	V3 cal ■	I1 cal ■	I2 cal ■
FAC #1	3	71EC	71ED	71EE	71EF	71F0	71F1	71F2	71F3

		Setup Registers							
Module Name	Handle	I3 cal ■	I4 cal ■	I1x20 cal ■	I2x20 cal ■	I3x20 cal ■	CT1a Smooth T	CT1b Smooth T	CT1c Smooth T
FAC #1	3	71F4	71F5	71F6	71F7	71F8	71F9	71FA	71FB

		Setup Registers							
Module Name	Handle	CT2a Smooth T	CT2b Smooth T	CT2c Smooth T	CT3a Smooth T	CT3b Smooth T	CT3c Smooth T	I1 off ■	I2 off ■
FAC #1	3	71FC	71FD	71FE	71FF	7200	7201	7202	7203

		Setup Registers							
Module Name	Handle	I3 off ■	I4 off ■	V force ■	I force ■	I4 force ■	Vx force ■	Vx1 cal ■	Vx2 cal ■
FAC #1	3	7204	7205	7206	7207	7208	7209	720A	720B

Factory Modules, Continued

		Setup Registers						
Module Name	Handle	Vx3 cal	Vx4 cal	Vx1 dc	Vx2 dc	Vx3 dc	Vx4 dc	Nom Freq
FAC #1	3	720C	720D	720E	720F	7210	7211	798B

FFT Modules

		Output Registers	
Module Name	Handle	FFT	Event
FFT #1	0700	0F00	1100
FFT #2	0701	0F01	1100
FFT #3	0702	0F02	1100
FFT #4	0703	0F03	1100
FFT #5	0704	0F04	1100
FFT #6	0705	0F05	1100
FFT #7	0706	0F06	1100

Harmonics Analyzer Modules

		Output Registers												
Module Name	**Handle**	**HD01**	**HD02**	**HD03**	**HD04**	**HD05**	**HD06**	**HD07**	**HD08**	**HD09**	**HD10**	**HD11**	**HD12**	**HD13**
		■	■	■	■	■	■	■	■	■	■	■	■	■
HA #1	0780	5900	5901	5902	5903	5904	5905	5906	5907	5908	5909	590A	590B	590C
HA #2	0781	5942	5943	5944	5945	5946	5947	5948	5949	594A	594B	594C	594D	594E
HA #3	0782	5984	5985	5986	5987	5988	5989	598A	598B	598C	598D	598E	598F	5990
HA #4	0783	59C6	59C7	59C8	59C9	59CA	59CB	59CC	59CD	59CE	59CF	59D0	59D1	59D2
HA #5	0784	5A09	5A0A	5A0B	5A0C	5A0D	5A0E	5A0F	5A10	5A11	5A12	5A13	5A14	5A15
HA #6	0785	5A4C	5A4D	5A4E	5A4F	5A50	5A51	5A52	5A53	5A54	5A55	5A56	5A57	5A58
HA #7	0786	5A8F	5A90	5A91	5A92	5A93	5A94	5A95	5A96	5A97	5A98	5A99	5A9A	5A9B

		Output Registers												
Module Name	**Handle**	**HD14**	**HD15**	**HD16**	**HD17**	**HD18**	**HD19**	**HD20**	**HD21**	**HD22**	**HD23**	**HD24**	**HD25**	**HD26**
		■	■	■	■	■	■	■	■	■	■	■	■	■
HA #1	0780	590D	590E	590F	5910	5911	5912	5913	5914	5915	5916	5917	5918	5919
HA #2	0781	594F	5950	5951	5952	5953	5954	5955	5956	5957	5958	5959	595A	595B
HA #3	0782	5991	5992	5993	5994	5995	5996	5997	5998	5999	599A	599B	599C	599D
HA #4	0783	59D3	59D4	59D5	59D6	59D7	59D8	59D9	59DA	59DB	59DC	59DD	59DE	59DF
HA #5	0784	5A16	5A17	5A18	5A19	5A1A	5A1B	5A1C	5A1D	5A1E	5A1F	5A20	5A21	5A22
HA #6	0785	5A59	5A5A	5A5B	5A5C	5A5D	5A5E	5A5F	5A60	5A61	5A62	5A63	5A64	5A65
HA #7	0786	5A9C	5A9D	5A9E	5A9F	5AA0	5AA1	5AA2	5AA3	5AA4	5AA5	5AA6	5AA7	5AA8

		Output Registers												
Module Name	**Handle**	**HD27**	**HD28**	**HD29**	**HD30**	**HD31**	**HD32**	**HD33**	**HD34**	**HD35**	**HD36**	**HD37**	**HD38**	**HD39**
		■	■	■	■	■	■	■	■	■	■	■	■	■
HA #1	0780	591A	591B	591C	591D	591E	591F	5920	5921	5922	5923	5924	5925	5926
HA #2	0781	595C	595D	595E	595F	5960	5961	5962	5963	5964	5965	5966	5967	5968
HA #3	0782	599E	599F	59A0	59A1	59A2	59A3	59A4	59A5	59A6	59A7	59A8	59A9	59AA
HA #4	0783	59E0	59E1	59E2	59E3	59E4	59E5	59E6	59E7	59E8	59E9	59EA	59EB	59EC
HA #5	0784	5A23	5A24	5A25	5A26	5A27	5A28	5A29	5A2A	5A2B	5A2C	5A2D	5A2E	5A2F
HA #6	0785	5A66	5A67	5A68	5A69	5A6A	5A6B	5A6C	5A6D	5A6E	5A6F	5A70	5A71	5A72
HA #7	0786	5AA9	5AAA	5AAB	5AAC	5AAD	5AAE	5AAF	5AB0	5AB1	5AB2	5AB3	5AB4	5AB5

Harmonics Analyzer Modules - Continued

		Output Registers												
Module Name	Handle	HD40 ■	HD41 ■	HD42 ■	HD43 ■	HD44 ■	HD45 ■	HD46 ■	HD47 ■	HD48 ■	HD49 ■	HD50 ■	HD51 ■	HD52 ■
HA #1	0780	5927	5928	5929	592A	592B	592C	592D	592E	592F	5930	5931	5932	5933
HA #2	0781	5969	596A	596B	596C	596D	596E	596F	5970	5971	5972	5973	5974	5975
HA #3	0782	59AB	59AC	59AD	59AE	59AF	59B0	59B1	59B2	59B3	59B4	59B5	59B6	59B7
HA #4	0783	59ED	59EE	59EF	59F0	59F1	59F2	59F3	59F4	59F5	59F6	59F7	59F8	59F9
HA #5	0784	5A30	5A31	5A32	5A33	5A34	5A35	5A36	5A37	5A38	5A39	5A3A	5A3B	5A3C
HA #6	0785	5A73	5A74	5A75	5A76	5A77	5A78	5A79	5A7A	5A7B	5A7C	5A7D	5A7E	5A7F
HA #7	0786	5AB6	5AB7	5AB8	5AB9	5ABA	5ABB	5ABC	5ABD	5ABE	5ABF	5AC0	5AC1	5AC2

		Output Registers											
Module Name	Handle	HD53 ■	HD54 ■	HD55 ■	HD56 ■	HD57 ■	HD58 ■	HD59 ■	HD60 ■	HD61 ■	HD62 ■	HD63 ■	Total HD ■
HA #1	0780	5934	5935	5936	5937	5938	5939	593A	593B	593C	593D	593E	593F
HA #2	0781	5976	5977	5978	5979	597A	597B	597C	597D	597E	597F	5980	5981
HA #3	0782	59B8	59B9	59BA	59BB	59BC	59BD	59BE	59BF	59C0	59C1	59C2	59C3
HA #4	0783	59FA	59FB	59FC	59FD	59FE	59FF	5A00	5A01	5A02	5A03	5A04	5A05
HA #5	0784	5A3D	5A3E	5A3F	5A40	5A41	5A42	5A43	5A44	5A45	5A46	5A47	5A48
HA #6	0785	5A80	5A81	5A82	5A83	5A84	5A85	5A86	5A87	5A88	5A89	5A8A	5A8B
HA #7	0786	5AC3	5AC4	5AC5	5AC6	5AC7	5AC8	5AC9	5ACA	5ACB	5ACC	5ACD	5ACE

		Output Registers			
Module Name	Handle	Tot EvenHD ■	Tot OddHD ■	K Factor ■	Event
HA #1	0780	5940	5941	N/A	1100
HA #2	0781	5982	5983	N/A	1100
HA #3	0782	59C4	59C5	N/A	1100
HA #4	0783	5A06	5A07	5A08	1100
HA #5	0784	5A49	5A4A	5A4B	1100
HA #6	0785	5A8C	5A8D	5A8E	1100
HA #7	0786	5ACF	5AD0	5AD1	1100

Integrator Modules

		Output Registers				Setup Registers			
Module Name	Handle	Result	Trigger	Rollover	Event	Divisor	Int Mode	Valu/Pulse	RollValue
INT #1	0500	58B0	6826	6948	1100	7104	78D8	7114	721E
INT #2	0501	58B1	6827	6949	1100	7105	78D9	7115	721F
INT #3	0502	58B2	6828	694A	1100	7106	78DA	7116	7220
INT #4	0503	58B3	6829	694B	1100	7107	78DB	7117	7221
INT #5	0504	58B4	682A	694C	1100	7108	78DC	7118	7222
INT #6	0505	58B5	682B	694D	1100	7109	78DD	7119	7223
INT #7	0506	58B6	682C	694E	1100	710A	78DE	711A	7224
INT #8	0507	58B7	682D	694F	1100	710B	78DF	711B	7225
INT #9	0508	58B8	682E	6950	1100	710C	78E0	711C	7226
INT #10	0509	58B9	682F	6951	1100	710D	78E1	711D	7227
INT #11	050A	58BA	6830	6952	1100	710E	78E2	711E	7228
INT #12	050B	58BB	6831	6953	1100	710F	78E3	711F	7229
INT #13	050C	58BC	6832	6954	1100	7110	78E4	7120	722A
INT #14	050D	58BD	6833	6955	1100	7111	78E5	7121	722B
INT #15	050E	58BE	6834	6956	1100	7112	78E6	7122	722C
INT #16	050F	58BF	6835	6957	1100	7113	78E7	7123	722D

Maximum Modules

		Output Registers		
Module Name	Handle	Maximum ■	Trigger	Event
MAX #1	0600	58E0	6856	1100
MAX #2	0601	58E1	6857	1100
MAX #3	0602	58E2	6858	1100
MAX #4	0603	58E3	6859	1100
MAX #5	0604	58E4	685A	1100
MAX #6	0605	58E5	685B	1100
MAX #7	0606	58E6	685C	1100
MAX #8	0607	58E7	685D	1100
MAX #9	0608	58E8	685E	1100
MAX #10	0609	58E9	685F	1100
MAX #11	060A	58EA	6860	1100
MAX #12	060B	58EB	6861	1100
MAX #13	060C	58EC	6862	1100
MAX #14	060D	58ED	6863	1100
MAX #15	060E	58EE	6864	1100
MAX #16	060F	58EF	6865	1100
MAX #17	0610	58F0	6866	1100
MAX #18	0611	58F1	6867	1100
MAX #19	0612	58F2	6868	1100
MAX #20	0613	58F3	6869	1100
MAX #21	0614	58F4	686A	1100
MAX #22	0615	58F5	686B	1100
MAX #23	0616	58F6	686C	1100
MAX #24	0617	58F7	686D	1100
MAX #25	0618	58F8	686E	1100
MAX #26	0619	58F9	686F	1100
MAX #27	061A	58FA	6870	1100
MAX #28	061B	58FB	6871	1100
MAX #29	061C	58FC	6872	1100
MAX #30	061D	58FD	6873	1100
MAX #31	061E	58FE	6874	1100
MAX #32	061F	58FF	6875	1100

Minimum Modules

		Output Registers		
Module Name	Handle	Minimum ■	Trigger	Event
MIN #1	0580	58C0	6836	1100
MIN #2	0581	58C1	6837	1100
MIN #3	0582	58C2	6838	1100
MIN #4	0583	58C3	6839	1100
MIN #5	0584	58C4	683A	1100
MIN #6	0585	58C5	683B	1100
MIN #7	0586	58C6	683C	1100
MIN #8	0587	58C7	683D	1100
MIN #9	0588	58C8	683E	1100
MIN #10	0589	58C9	683F	1100
MIN #11	058A	58CA	6840	1100
MIN #12	058B	58CB	6841	1100
MIN #13	058C	58CC	6842	1100
MIN #14	058D	58CD	6843	1100
MIN #15	058E	58CE	6844	1100
MIN #16	058F	58CF	6845	1100
MIN #17	0590	58D0	6846	1100
MIN #18	0591	58D1	6847	1100
MIN #19	0592	58D2	6848	1100
MIN #20	0593	58D3	6849	1100
MIN #21	0594	58D4	684A	1100
MIN #22	0595	58D5	684B	1100
MIN #23	0596	58D6	684C	1100
MIN #24	0597	58D7	684D	1100
MIN #25	0598	58D8	684E	1100
MIN #26	0599	58D9	684F	1100
MIN #27	059A	58DA	6850	1100
MIN #28	059B	58DB	6851	1100
MIN #29	059C	58DC	6852	1100
MIN #30	059D	58DD	6853	1100
MIN #31	059E	58DE	6854	1100
MIN #32	059F	58DF	6855	1100

Modbus Slave Read Modules

		Output Registers					
Module Name	Handle	Modbus Value #1 ■	Modbus Value #2 ■	Modbus Value #3 ■	Modbus Value #4 ■	Modbus Value #5 ■	Modbus Value #6 ■
MSR #1	1680	5B7E	5B82	5B86	5B8A	5B8E	5B92
MSR #2	1681	5B7F	5B83	5B87	5B8B	5B8F	5B93
MSR #3	1682	5B80	5B84	5B88	5B8C	5B90	5B94
MSR #4	1683	5B81	5B85	5B89	5B8D	5B91	5B95

		Output Registers					
Module Name	Handle	Modbus Value #7 ■	Modbus Value #8 ■	Modbus Value #9 ■	Modbus Value #10 ■	Modbus Value #11 ■	Modbus Value #12 ■
MSR #1	1680	5B96	5B9A	5B9E	5BA2	5BA6	5BAA
MSR #2	1681	5B97	5B9B	5B9F	5BA3	5BA7	5BAB
MSR #3	1682	5B98	5B9C	5BA0	5BA4	5BA8	5BAC
MSR #4	1683	5B99	5B9D	5BA1	5BA5	5BA9	5BAD

		Output Registers					
Module Name	Handle	Modbus Value #13 ■	Modbus Value #14 ■	Modbus Value #15 ■	Modbus Value #16 ■	Modbus Value #17 ■	Modbus Value #18 ■
MSR #1	1680	5BAE	5BB2	5BB6	5BBA	5BBE	5BC2
MSR #2	1681	5BAF	5BB3	5BB7	5BBB	5BBF	5BC3
MSR #3	1682	5BB0	5BB4	5BB8	5BBC	5BC0	5BC4
MSR #4	1683	5BB1	5BB5	5BB9	5BBD	5BC1	5BC5

		Output Registers					
Module Name	Handle	Modbus Value #19 ■	Modbus Value #20 ■	Modbus Value #21 ■	Modbus Value #22 ■	Modbus Value #23 ■	Modbus Value #24 ■
MSR #1	1680	5BC6	5BCA	5BCE	5BD2	5BD6	5BDA
MSR #2	1681	5BC7	5BCB	5BCF	5BD3	5BD7	5BDB
MSR #3	1682	5BC8	5BCC	5BD0	5BD4	5BD8	5BDC
MSR #4	1683	5BC9	5BCD	5BD1	5BD5	5BD9	5BDD

Modbus Slave Read Modules, Con't.

		Output Registers					
Module Name	Handle	Modbus Value #25 ■	Modbus Value #26 ■	Modbus Value #27 ■	Modbus Value #28 ■	Modbus Value #29 ■	Modbus Value #30 ■
MSR #1	1680	5BDE	5BE2	5BE6	5BEA	5BEE	5BF2
MSR #2	1681	5BDF	5BE3	5BE7	5BEB	5BEF	5BF3
MSR #3	1682	5BE0	5BE4	5BE8	5BEC	5BF0	5BF4
MSR #4	1683	5BE1	5BE5	5BE9	5BED	5BF1	5BF5

		Output Registers					Setup Registers
Module Name	Handle	Modbus Value #31 ■	Modbus Value #32 ■	Modbus Base ■	Modbus Link ■	Event	Format
MSR #1	1680	5BF6	5BFA	5BFE	5C02	1100	7A53
MSR #2	1681	5BF7	5BFB	5BFF	5C03	1100	7A54
MSR #3	1682	5BF8	5BFC	5C00	5C04	1100	7A55
MSR #4	1683	5BF9	5BFD	5C01	5C05	1100	7A56

		Setup Registers					
Module Name	Handle	Base Addr ■	Scaling	In Zero ■	In Full ■	Out Zero ■	Out Full ■
MSR #1	1680	7237	7A57	723B	723F	7243	7247
MSR #2	1681	7238	7A58	723C	7240	7244	7248
MSR #3	1682	7239	7A59	723D	7241	7245	7249
MSR #4	1683	723A	7A5A	723E	7242	7246	724A

One-Shot Timer Modules

		Output Registers			Setup Register
Module Name	**Handle**	**State** ◑	**Trigger**	**Event**	**Duration** ▣
OST #1	0A00	607B	68A2	1100	71D0
OST #2	0A01	607C	68A3	1100	71D1
OST #3	0A02	607D	68A4	1100	71D2
OST #4	0A03	607E	68A5	1100	71D3
OST #5	0A04	607F	68A6	1100	71D4
OST #6	0A05	6080	68A7	1100	71D5
OST #7	0A06	6081	68A8	1100	71D6
OST #8	0A07	6082	68A9	1100	71D7
OST #9	0A08	6083	68AA	1100	71D8
OST #10	0A09	6084	68AB	1100	71D9
OST #11	0A0A	6085	68AC	1100	71DA
OST #12	0A0B	6086	68AD	1100	71DB

Periodic Timer Modules

		Output Registers		Setup Registers	
Module Name	Handle	Trigger	Event	Period	Sync Mode
PRT #1	0980	688E	1100	71BC	7958
PRT #2	0981	688F	1100	71BD	7959
PRT #3	0982	6890	1100	71BE	795A
PRT #4	0983	6891	1100	71BF	795B
PRT #5	0984	6892	1100	71C0	795C
PRT #6	0985	6893	1100	71C1	795D
PRT #7	0986	6894	1100	71C2	795E
PRT #8	0987	6895	1100	71C3	795F
PRT #9	0988	6896	1100	71C4	7960
PRT #10	0989	6897	1100	71C5	7961
PRT #11	098A	6898	1100	71C6	7962
PRT #12	098B	6899	1100	71C7	7963
PRT #13	098C	689A	1100	71C8	7964
PRT #14	098D	689B	1100	71C9	7965
PRT #15	098E	689C	1100	71CA	7966
PRT #16	098F	689D	1100	71CB	7967
PRT #17	0990	689E	1100	71CC	7968
PRT #18	0991	689F	1100	71CD	7969
PRT #19	0992	68A0	1100	71CE	796A
PRT #20	0993	68A1	1100	71CF	796B

Power Meter Modules

		Output Registers											
Module Name	**Handle**	**Vln a** ■	**Vln b** ■	**Vln c** ■	**Vln avg** ■	**Vll ab** ■	**Vll bc** ■	**Vll ca** ■	**Vll avg** ■	**I a** ■	**I b** ■	**I c** ■	**I avg** ■
1sPM	0100	5800	5801	5802	5803	5804	5805	5806	5807	5808	5809	580A	580B
HSPM	0102	5828	5829	582A	582B	582C	582D	582E	582F	5830	5831	5832	5833
MVPM	0101	5B23	5B24	5B25	5B26	5B27	5B28	5B29	5B2A	5B2B	5B2C	5B2D	5B2E

		Output Registers											
Module Name	**Handle**	**KW a** ■	**KW b** ■	**KW c** ■	**KW total** ■	**KVAR a** ■	**KVAR b** ■	**KVAR c** ■	**KVAR total** ■	**KVA a** ■	**KVA b** ■	**KVA c** ■	**KVA total** ■
1sPM	0100	580C	580D	580E	580F	5810	5811	5812	5813	5814	5815	5816	5817
HSPM	0102	5834	5835	5836	5837	5838	5839	583A	583B	583C	583D	583E	583F
MVPM	0101	5B2F	5B30	5B31	5B32	5B33	5B34	5B35	5B36	5B37	5B38	5B39	5B3A

		Output Registers											
Module Name	**Handle**	**PFsigned a** ■	**PFsigned b** ■	**PFsigned c** ■	**PFsign tot** ■	**PFlead a** ■	**PFlead b** ■	**PFlead c** ■	**PFlead tot** ■	**PFlag a** ■	**PFlag b** ■	**PFlag c** ■	**PFlag tot** ■
1sPM	0100	5818	5819	581A	581B	581C	581D	581E	581F	5820	5821	5822	5823
HSPM	0102	5840	5841	5842	5843	5844	5845	5846	5847	5848	5849	584A	584B
MVPM	0101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

		Output Registers						
Module Name	**Handle**	**V unbal** ■	**I unbal** ■	**I4** ■	**I residual** ■	**Phase Rev** ◑	**Line Freq** ■	**Event** 🗋
1sPM	0100	5824	5825	5826	N/A	6000	5827	1100
HSPM	0102	584C	584D	584E	N/A	N/A	584F	1100
MVPM	0101	N/A	N/A	5B3B	N/A	N/A	N/A	1100

		Setup Registers									
Module Name	**Handle**	**Volts Mode** ☰	**PT Pri m** ▣	**PT Sec** ▣	**CT Prim** ▣	**CT Sec** ▣	**I4 CT Prim** ▣	**I4 CT Sec** ▣	**V1 Polarity** ▣	**V2 Polarity** ▣	**V3 Polarity** ▣
1sPM	0100	7800	7000	7001	7002	7003	7004	7005	7A4A	7A4B	7A4C
HSPM	0102	7800	7000	7001	7002	7003	7004	7005	7A4A	7A4B	7A4C
MVPM	0101	7800	7000	7001	7002	7003	7004	7005	7A4A	7A4B	7A4C

Power Meter Modules - Continued

		Setup Registers						
Module Name	Handle	I1Polarity	I2Polarity	I3Polarity	I4Polarity	PhaseOrder	Nom Freq	PhaseLbls
1sPM	0100	7801	7802	7803	7A49	7804	N/A	7805
HSPM	0102	7801	7802	7803	7A49	7804	N/A	7805
MVPM	0101	7801	7802	7803	7A49	7804	N/A	7805

Pulse Merge Modules

		Output Registers		Setup Register
Module Name	Handle	Event	Pulse Out	Event Log Mode
PMG #1	1280	1100	6936	7A3D
PMG #2	1281	1100	6937	7A3E
PMG #3	1282	1100	6938	7A3F
PMG #4	1283	1100	6939	7A40
PMG #5	1284	1100	693A	7A41
PMG #6	1285	1100	693B	7A42
PMG #7	1286	1100	693C	7A43
PMG #8	1287	1100	693D	7A44

Pulser Modules

		Output Register	Setup Registers			
Module Name	Handle	Event	PulseWidth	OutputMode	Polarity	Port
PUL #1	0380	1100	70AA	78B4	78BE	7A01
PUL #2	0381	1100	70AB	78B5	78BF	7A02
PUL #3	0382	1100	70AC	78B6	78C0	7A03
PUL #4	0383	1100	70AD	78B7	78C1	7A04
PUL #5	0384	1100	70AE	78B8	78C2	7A05
PUL #6	0385	1100	70AF	78B9	78C3	7A06
PUL #7	0386	1100	70B0	78BA	78C4	7A07
PUL #8	0387	1100	70B1	78BB	78C5	7A08
PUL #9	0388	1100	70B2	78BC	78C6	7A09
PUL #10	0389	1100	70B3	78BD	78C7	7A0A

Sag/Swell Modules

		Output Registers								
Module Name	**Handle**	**Dist State**	**Dist Start**	**Dist End**	**Dist Duration**	**Dist V1 Min**	**Dist V1 Max**	**Dist V1 Ave**	**Dist V1 Delta**	**Dist V2 Min**
Sag Swell	1400	60D1	693E	6940	5AFD	5AFF	5B01	5B03	5B05	5B07

		Output Registers							
Module Name	**Handle**	**Dist V2 Max**	**Dist V2 Ave**	**Dist V2 Delta**	**Dist V3 Min**	**Dist V3 Max**	**Dist V3 Ave**	**Dist V3 Delta**	**Sub V1 Trig**
Sag Swell	1400	5B09	5B0B	5B0D	5B0F	5B11	5B13	5B15	6942

		Output Registers							
Module Name	**Handle**	**Sub V1 Ave**	**Sub V1 Duration**	**Sub V2 Trig**	**Sub V2 Ave**	**Sub V2 Duration**	**Sub V3 Trig**	**Sub V3 Ave**	**Sub V3 Duration**
Sag Swell	1400	5B17	5B19	6944	5B1B	5B1D	6946	5B1F	5B21

		Output Registers	Setup Registers				
Module Name	**Handle**	**Event**	**Swell Limit**	**Sag Limit**	**Change Criterion**	**Nominal Voltage**	**Event Priority**
Sag Swell	1400	1100	7214	7216	7218	721A	721C

Scheduler Modules

		Output Registers							
Sch Status #1	**Handle**	**Sch Status #1**	**Sch Start #1**	**Sch End #1**	**Sch Status #2**	**Sch Start #2**	**Sch End #2**	**Sch Status #3**	**Sch Start #3**
Sched	1480	60D3	6958	6960	60DB	6968	6970	60E3	6978

		Output Registers							
Module Name	**Handle**	**Sch End #3**	**Sch Status #4**	**Sch Start #4**	**Sch End #4**	**Sch Status #5**	**Sch Start #5**	**Sch End #5**	**Sch Status #6**
Sched	1480	6980	60EB	6988	6990	60F3	6998	69A0	60FB

		Output Registers							
Module Name	**Handle**	**Sch Start #6**	**Sch End #6**	**Sch Status #7**	**Sch Start #7**	**Sch End #7**	**Sch Status #8**	**Sch Start #8**	**Sch End #8**
Sched	1480	69A8	69B0	6103	69B8	69C0	610B	69C8	69D0

		Output Registers	Setup Registers
Module Name	**Handle**	**Event**	**Calendar**
Sched	1480	1100	1380

Setpoint Modules

		Output Registers		Setup Registers							
Module Name	Handle	Status	Trigger	Event	High Limit	Low Limit	SusUntlON	SusUntlOFF	Input Mode	Eval Mode	Ev Priority
SP #1	0680	6063	6876	1100	7124	713C	7154	716C	78E8	7900	7184
SP #2	0681	6064	6877	1100	7125	713D	7155	716D	78E9	7901	7185
SP #3	0682	6065	6878	1100	7126	713E	7156	716E	78EA	7902	7186
SP #4	0683	6066	6879	1100	7127	713F	7157	716F	78EB	7903	7187
SP #5	0684	6067	687A	1100	7128	7140	7158	7170	78EC	7904	7188
SP #6	0685	6068	687B	1100	7129	7141	7159	7171	78ED	7905	7189
SP #7	0686	6069	687C	1100	712A	7142	715A	7172	78EE	7906	718A
SP #8	0687	606A	687D	1100	712B	7143	715B	7173	78EF	7907	718B
SP #9	0688	606B	687E	1100	712C	7144	715C	7174	78F0	7908	718C
SP #10	0689	606C	687F	1100	712D	7145	715D	7175	78F1	7909	718D
SP #11	068A	606D	6880	1100	712E	7146	715E	7176	78F2	790A	718E
SP #12	068B	606E	6881	1100	712F	7147	715F	7177	78F3	790B	718F
SP #13	068C	606F	6882	1100	7130	7148	7160	7178	78F4	790C	7190
SP #14	068D	6070	6883	1100	7131	7149	7161	7179	78F5	790D	7191
SP #15	068E	6071	6884	1100	7132	714A	7162	717A	78F6	790E	7192
SP #16	068F	6072	6885	1100	7133	714B	7163	717B	78F7	790F	7193
SP #17	0690	6073	6886	1100	7134	714C	7164	717C	78F8	7910	7194
SP #18	0691	6074	6887	1100	7135	714D	7165	717D	78F9	7911	7195
SP #19	0692	6075	6888	1100	7136	714E	7166	717E	78FA	7912	7196
SP #20	0693	6076	6889	1100	7137	714F	7167	717F	78FB	7913	7197
SP #21	0694	6077	688A	1100	7138	7150	7168	7180	78FC	7914	7198
SP #22	0695	6078	688B	1100	7139	7151	7169	7181	78FD	7915	7199
SP #23	0696	6079	688C	1100	713A	7152	716A	7182	78FE	7916	719A
SP #24	0697	607A	688D	1100	713B	7153	716B	7183	78FF	7917	719B

Sliding Window Demand Modules

		Output Registers			Setup Registers		
Module Name	**Handle**	**SWinDemand** ■	**PredDemand** ■	**Event** 🗋	**Sub Intvl** ▣	**#SubIntvls** ▣	**Pred Resp** ▣
SWD #1	0400	5880	5890	1100	70B4	70C4	70D4
SWD #2	0401	5881	5891	1100	70B5	70C5	70D5
SWD #3	0402	5882	5892	1100	70B6	70C6	70D6
SWD #4	0403	5883	5893	1100	70B7	70C7	70D7
SWD #5	0404	5884	5894	1100	70B8	70C8	70D8
SWD #6	0405	5885	5895	1100	70B9	70C9	70D9
SWD #7	0406	5886	5896	1100	70BA	70CA	70DA
SWD #8	0407	5887	5897	1100	70BB	70CB	70DB
SWD #9	0408	5888	5898	1100	70BC	70CC	70DC
SWD #10	0409	5889	5899	1100	70BD	70CD	70DD
SWD #11	040A	588A	589A	1100	70BE	70CE	70DE
SWD #12	040B	588B	589B	1100	70BF	70CF	70DF
SWD #13	040C	588C	589C	1100	70C0	70D0	70E0
SWD #14	040D	588D	589D	1100	70C1	70D1	70E1
SWD #15	040E	588E	589E	1100	70C2	70D2	70E2
SWD #16	040F	588F	589F	1100	70C3	70D3	70E3

Symmetrical Components Modules

		Output Registers						Setup Registers
Module Name	**Handle**	**ZeroSeqMag** ■	**ZeroSeqPhs** ■	**PosSeqMag** ■	**PosSeqPhs** ■	**NegSeqMag** ■	**NegSeqPhs** ■	**Harmonic** ▣
SYM #1	0E80	5AF1	5AF2	5AF3	5AF4	5AF5	5AF6	N/A
SYM #2	0E81	5AF7	5AF8	5AF9	5AFA	5AFB	5AFC	N/A

Thermal Demand Modules

		Output Registers		Setup Registers	
Module Name	Handle	ThrmDemand	Event	Interval	Time Const
		■	🗋	▣	▣
TD #1	0480	58A0	1100	70E4	70F4
TD #2	0481	58A1	1100	70E5	70F5
TD #3	0482	58A2	1100	70E6	70F6
TD #4	0483	58A3	1100	70E7	70F7
TD #5	0484	58A4	1100	70E8	70F8
TD #6	0485	58A5	1100	70E9	70F9
TD #7	0486	58A6	1100	70EA	70FA
TD #8	0487	58A7	1100	70EB	70FB
TD #9	0488	58A8	1100	70EC	70FC
TD #10	0489	58A9	1100	70ED	70FD
TD #11	048A	58AA	1100	70EE	70FE
TD #12	048B	58AB	1100	70EF	70FF
TD #13	048C	58AC	1100	70F0	7100
TD #14	048D	58AD	1100	70F1	7101
TD #15	048E	58AE	1100	70F2	7102
TD #16	048F	58AF	1100	70F3	7103

Waveform Recorder Modules

		Output Registers			Setup Registers			
Module Name	Handle	Wform Log	Log State	Event	Depth	RecordMode	EvLog Mode	Format
RECW #1	0880	0F94	60C3	1100	71B0	792C	N/A	7938
RECW #2	0881	0F95	60C4	1100	71B1	792D	N/A	7939
RECW #3	0882	0F96	60C5	1100	71B2	792E	N/A	793A
RECW #4	0883	0F97	60C6	1100	71B3	792F	N/A	793B
RECW #5	0884	0F98	60C7	1100	71B4	7930	N/A	793C
RECW #6	0885	0F99	60C8	1100	71B5	7931	N/A	793D
RECW #7	0886	0F9A	60C9	1100	71B6	7932	N/A	793E
RECW #8	0887	0F9B	60CA	1100	71B7	7933	N/A	793F
RECW #9	0888	0F9C	60CB	1100	71B8	7934	N/A	7940
RECW #10	0889	0F9D	60CC	1100	71B9	7935	N/A	7941
RECW #11	088A	0F9E	60CD	1100	71BA	7936	N/A	7942
RECW #12	088B	0F9F	60CE	1100	71BB	7937	N/A	7943

Appendix C

7700 ION Revenue Meters

This appendix provides an overview of the 7700 ION-RMxxxx Revenue Meter.

The fundamental functions of a revenue meter are to provide measurements that are within industry-accepted limits for accuracy over a defined range of operating conditions, and to provide adequate protection against unauthorized alteration of these measured quantities. International and national standards ensure industry-accepted accuracy limits. A combination of national and utility-based standards regulate protection against unauthorized quantity alteration.

Types of 7700 ION-RM Meters

Different versions of the 7700 ION-RM revenue meter are available to suit your specific application. Each variety of the 7700 ION-RM can be distinguished by the type of certification it has achieved.

Type	Certification Achievement	Current Inputs	Revenue Metering Security Systems
RMICAN (unsealed)	Canadian Revenue Metering Standards	Rated for 0.1 Amps to 10 Amps AC	Enabled
RMANSI (unsealed)	Accuracy complies with the ANSI C12.16 Revenue Metering Standard	Rated for 0.1 Amps to 10 Amps AC	Enabled

The RMKEY Programming Key

The Revenue Meter Programming Key (RMKEY) is a 3”x4” circuit board. When the RMKEY is inserted into the 7700 ION-RM Revenue Meter, the key disables the meter security systems to facilitate programming. This key is used by utility meter shop personnel who wish to program the meter in-house. Each utility purchases one RMKEY. (If desired, users can purchase a spare key). The RMKEY can be used in any 7700 ION-RM Revenue Meter.

To configure a 7700ION-RM Revenue Meter with the RMKEY:

1. Install the RMKEY programming key into the VAUX slot of the meter.
2. Program/configure the meter as required.
3. Remove the RMKEY from the meter. The action of removing the RMKEY causes all meter security systems to become enabled.
4. Replace the meter cover and install the lead/wire seals through the sealing tabs. The 7700 ION-RM Revenue Meter is now ready for service.

CT & PT Selection

Consult your local Revenue Metering authorities to obtain standards for CT and PT selection for revenue metering applications.

Security Mechanisms

To meet Government regulations and Utility security requirements, the 7700 ION-RM revenue meter incorporates three types of security systems:

- a traditional “anti-tamper” mechanical seal on the 7700ION base module.
- a password-based security system that permits password protected minimum/maximum resets.
- a hardware-based security system that uses the “RM PROGRAMMING KEY”.

Traditional “Anti-Tamper” Seals

The 7700ION base module incorporates two sealing tabs through which traditional lead/wire seals can be inserted. When utilized, these lead/wire seals effectively prevent unauthorized personnel from gaining access to meter internals.

Password Protected Min/Max Register Resets

The 7700ION meter front panel (MGT display panel) incorporates a password that must be entered in order to reset any of the minimum/maximum register values. The password must therefore be used to reset peak demand register values.

Hardware-based Security

All revenue-related quantities are “locked” in the revenue version of the 7700ION-RM meter. Of particular importance is the fact that basic meter configuration parameters including service-type, PT ratio and CT ratio are locked. The RMKEY facilitates meter programming prior to sealing and is described in the section *The RMKEY* .

Protected Quantities

The 7700 I ON-RM revenue meters are equipped with a comprehensive security system that provides protection against unauthorized alteration or tampering of “revenue-related quantities”. The quantities protected by the 7700 ION -RM meter are as follows:

- kWh (import, export, net, total)
- kVARh (import, export, net, total)
- kVAh (total)
- kW demand (TD and SD min , max)
- kVAR demand (TD and SD min , max)
- kVA demand (TD and SD min, max)
- kWh pulse output
- kVArh pulse output
- kVAh pulse output
- Historical trend recording of any of the above quantities.

Protected or "Locked" Modules

Since the design of the 7700 ION meter is based on the modular and highly-configurable ION architecture, it is necessary to "lock" all revenue-related ION modules, ION links and ION setup-registers in order to protect quantities from unauthorized alteration. These locks are automatically enabled (at the factory) for all 7700 ION-RM meters. To prevent modification of any links and registers, the following modules are locked:

- Power Meter Module (high-accuracy).
- Integrator Modules #1 to #9 inclusive.
- Pulser Module #1 to #3 inclusive.
- Sliding Window Demand Module #1 to #3 inclusive.
- Thermal Demand Module #1 to #3 inclusive.
- Minimum Module #27 to #32 inclusive.
- Maximum Module #27 to #32 inclusive.
- Data Recorder Module #1.

Customer Checklist for the 7700 ION-RMXXXX

COMPANY:	CONTACT NAME:
STREET:	PHONE:
PROV/STATE:	FAX:
CITY:	P.O. NUMBER:
COUNTRY:	**INDUSTRY CANADA REGISTRATION # * :**

The following information MUST be supplied at time of order:

Network Type	☐ 3 Wire DELTA ☐ 4 Wire STAR
Service Type	☐ 2 Element DELTA ☐ 2 ½ Element STAR ☐ 3 Element STAR
Network Voltage	☐ VAC Line-to-Neutral **AND** ☐ VAC Line-to-Line
Voltage Transformer Ratio	[:] Primary/Secondary Rating (ex. 12000:120)
Current Transformer Ratio	[:] Primary/Secondary Rating (ex. 5000:5)

Voltage Input Rating (select one)	☐ 120 ☐ 277
Current Input Rating (select one)	☐ Industry Canada Class 10 ☐ ANSI Class 10 ☐ IEC (In=5 I_{MAX}=6.25) ☐ IEC (In=5 I_{MAX}=10)
Frequency (select one)	☐ 50 Hz ☐ 60 Hz
Auxiliary Power Input	All meters are equipped with a Universal AC/DC Power Supply 85-240 VAC and 110-300 VDC
Demand Parameter (select multiple)	☐ kW DEMAND ☐ kVAR DEMAND ☐ kVA DEMAND
Demand Method (select multiple)	☐ BLOCK DEMAND ☐ THERMAL DEMAND ☐ SLIDING WINDOW DEMAND
Demand Period (select both)	☐ **MINUTES** Length of Period **TIMES (x)** ☐ NUMBER of Sub-Periods (UPDATE)
Demand Synchronization Method	SYNC to Internal Clock
Mounting Type	☐ Panel Mount
Energy Pulse Outputs (requires optional IOCA card and relay modules)	Output #1 = ☐ kWh/PULSE ☐ Pulse Width (milliseconds) Output #2 = ☐ kVARh/PULSE Output #3 = ☐ kVAh/PULSE
Nameplate Information PLEASE PRINT CLEARLY	OWNER INFO: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ INFO 2: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐ INFO 3: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

*All factory-sealed Revenue Meters destined for use in Canada must be registered with the regional ***Industry Canada Legal Metrology Branch*** office. This registration process is the responsibility of the end customer or main contractor, and results in an ***Industry Canada*** "E" number being issued for each energy/demand meter.

Data Recorder #1 (Sealed)

Fill in the parameters to be recorded by the Data Recorder module #1.

Channel 1 Parameter =	(DEFAULT = V_{LN} avg)
Channel 2 Parameter =	(DEFAULT = I_{LN} avg)
Channel 3 Parameter =	(DEFAULT = kW total)
Channel 4 Parameter =	(DEFAULT = kVAR total)
Channel 5 Parameter =	(DEFAULT = kVA total)
Channel 6 Parameter =	(DEFAULT = PF Signed total)
Channel 7 Parameter =	(DEFAULT = FREQ)
Channel 8 Parameter =	(DEFAULT = kWh import)
Channel 9 Parameter =	(DEFAULT = kWh export)
Channel 10 Parameter =	(DEFAULT = kVARh import)
Channel 11 Parameter =	(DEFAULT = kVARh export)
Channel 12 Parameter =	(DEFAULT = kVAh total)
Channel 13 Parameter =	User Selectable (CNT #1)
Channel 14 Parameter =	User Selectable (CNT #2)
Channel 15 Parameter =	User Selectable (CNT #3)
Channel 16 Parameter =	User Selectable (CNT #4)

Notes

1. For compatibility with the UTS MV-90 billing software, Data Recorder #1 must be configured as a 16-channel recorder.

2. Data Recorder #1 is locked when it is sealed. Channel assignments must therefore be specified **prior** to sealing.