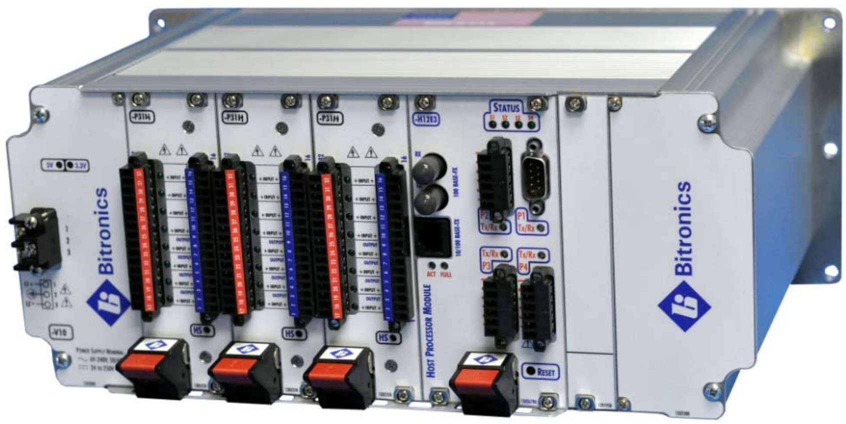
878 HDIO

High Density Input/Output Manual



May 22, 2017
ML0041 Document Revision E

NovaTech®
Bitronics ◆ D/3 ◆ Orion

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FIRMWARE VERSION

The following table provides the most recent firmware and software versions. For best results, the Configurator version used should match with the firmware version. A complete list of firmware and software versions is provided on the 70 Series Utilities CD.

Firmware Versions						
Description	**Bios Version**	**DSP Firmware**	**Host Firmware**	**Configurator**	**Utilities CD**	**Release Date**
M870 Family						
878 Product Release: New H12 Host Processor with and without E1 and E3 Ethernet options	N/A	1.33	4.01	4.01	4.01	12/13/12
Added support for IEC 61850 deadbands and inclusion of digital and virtual outputs as DNP3 points	N/A	1.33	4.02	4.02	4.02	4/26/13
878 Product Release: IEC trigger options DNP3 certification M871	N/A	1.33	4.07	4.04	4.04	10/28/13
878 Product Release: Support new P33 module	N/A	1.35	4.09	4.09	4.09	6/22/15
Maintenance Upgrade	N/A	1.35	4.10	4.10	4.10	3/10/16
M87x – Add double point status object for input bit pairs, add IEC61850 support for P33 module	N/A	1.35	4.11	4.11	4.11	6/15/16
Add .csv SER file; maintenance upgrade	N/A	1.35	4.13	4.13	4.13	2/16/17
BiView changes; maintenance upgrade	N/A	1.35	4.14	4.15	4.15	3/21/17

M87X MANUAL SET

ML0021 M87x User Manual
ML0025 70 SERIES Modbus Protocol
ML0026 70 SERIES DNP3 Protocol
ML0027 M870D Remote Display Manual – **Obsolete Product**
ML0034 70 SERIES IEC61850® Protocol Manual
ML0041 878 HDIO User Manual
ML0047 D650 Remote Display Manual

INSTALLATION AND MAINTENANCE

Bitronics LLC products are designed for ease of installation and maintenance. As with any product of this nature, installation and maintenance can present electrical hazards and should be performed only by properly trained and qualified personnel. If the equipment is used in a manner not specified by Bitronics LLC, the protection provided by the equipment may be impaired.

In order to maintain UL recognition, the following Conditions of Acceptability shall apply:

a) Terminals and connectors that shall be connected to live voltages are restricted to non-field wiring applications only.
b) After installation, all hazardous live parts shall be protected from contact by personnel or enclosed in a suitable enclosure.

WARRANTY AND ASSISTANCE

This product is warranted against defects in materials and workmanship for a period of one hundred and twenty (120) months from the date of their original shipment from the factory. Products repaired at the factory are likewise warranted for eighteen (18) months from the date the repaired product is shipped, or for the remainder of the product's original warranty, whichever is greater. Obligation under this warranty is limited to repairing or replacing, at our designated facility, any part or parts that our examination shows to be defective. Warranties only apply to products subject to normal use and service. There are no warranties, obligations, liabilities for consequential damages, or other liabilities on the part of Bitronics LLC except this warranty covering the repair of defective materials. The warranties of merchantability and fitness for a particular purpose are expressly excluded.

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SAFETY SECTION

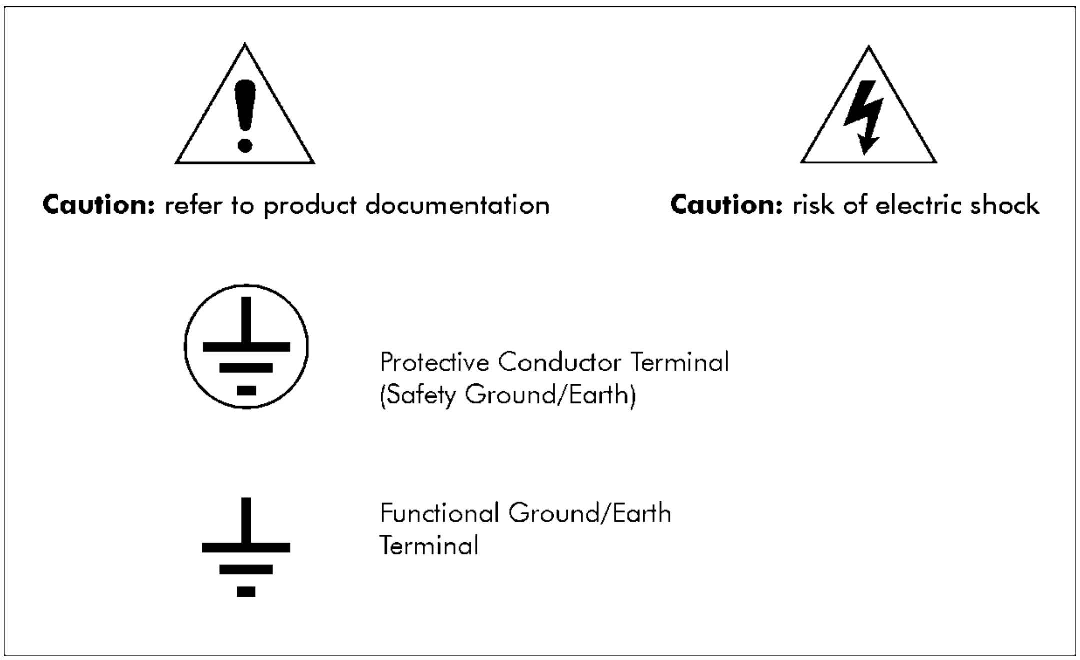
This Safety Section should be read before commencing any work on the equipment.

Health and safety

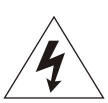
The information in the Safety Section of the product documentation is intended to ensure that products are properly installed and handled in order to maintain them in a safe condition. It is assumed that everyone who will be associated with the equipment will be familiar with the contents of the Safety Section.

Explanation of symbols and labels

The meaning of symbols and labels that may be used on the equipment or in the product documentation is given below.



Installing, Commissioning and Servicing



Equipment connections

Personnel undertaking installation, commissioning or servicing work on this equipment should be aware of the correct working procedures to ensure safety. The product documentation should be consulted before installing, commissioning or servicing the equipment.

Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.

If there is unlocked access to the equipment, care should be taken by all personnel to avoid electric shock or energy hazards.

Voltage connections should be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety. To ensure that wires are correctly terminated, the correct crimp terminal and tool for the wire size should be used.

Before energizing the equipment, it must be grounded (earthed) using the protective ground (earth) terminal, or the appropriate termination of the supply plug in the case of plug connected equipment. Omitting or disconnecting the equipment ground (earth) may cause a safety hazard.

The recommended minimum ground (earth) wire size is 2.5 mm^2 (#12 AWG), unless otherwise stated in the technical data section of the product documentation.

Before energizing the equipment, the following should be checked:

1. Voltage rating and polarity

2. Protective fuse rating

3. Integrity of ground (earth) connection (*where applicable*)

4. Equipment operating conditions

The equipment should be operated within the specified electrical and environmental limits.

Insulation and dielectric strength testing

Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, the voltage should be gradually reduced to zero, to discharge capacitors, before the test leads are disconnected.

Removal and insertion of modules

All M87x active circuitry is located on removable modules. Unless a Module is specifically intended for Hot Swap (see documentation), it must not be inserted into or withdrawn from equipment while it is energized, since this may result in damage. Hot Swap modules may be installed and removed under power. Refer to the appropriate section or manual to determine if the particular module is Hot Swap compatible. **For all other modules, remove all power from the unit before installing or removing any module.**

All Hazardous Voltages MUST be removed from the 878 before removing or installing the Power Supply Module.

All connections to a module must be removed before removing the module. Do not attempt to install a module with signals connected.

Fiber optic communication

Where fiber optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

WARNING: EMISSIONS – CLASS A DEVICE (EN55011)
This is a Class A industrial device. Operation of this device in a residential area may cause harmful interference, which may require the user to take adequate measures.

DECOMMISSIONING AND DISPOSAL

1. Decommissioning

The auxiliary supply circuit in the equipment may include capacitors across the supply or to ground (earth). To avoid electric shock or energy hazards, after completely isolating the supplies to the relay (both poles of any dc supply), the capacitors should be safely discharged via the external terminals before decommissioning.

2. Disposal

It is recommended that incineration and disposal to watercourses is avoided. The product should be disposed of in a safe manner. Any products containing batteries should have them removed before disposal, taking precautions to avoid short circuits. Particular regulations within the country of operation may apply to the disposal of lithium batteries.

1.0 DESCRIPTION

1.1 Introduction

The 878 High Density Input Output (HDIO) is derived from Bitronics M87x. It combines a modular-by-board chassis featuring a CompactPCI^{TM} card cage and a 486-based host processor.

1.2 Features

- Simultaneous support of multiple protocols over multiple physical links
- 486-class Host processor.
- Watchdog timer maximizes system reliability.
- 4 Configurable serial ports - Three RS232/RS485 ports and one DB9M Service RS232 port
- Fully compatible CompactPCI^{TM} backplane and system bus.
- Rugged all-aluminum housing.
- Choice of standard chassis (C07A5) with 3 option cPCI expansion bays, intermediate chassis (C10A7) with 5 option bays or extended model (C12A8) with 6 option bays.
- Option modules include digital I/O (P30A,P31 and P33), Ethernet (E1/E3, P10, P11, P12), Modbus Plus (P20) and transducer input (P40)

1.3 Specifications

Power Supply Input Voltage **(Refer to Section 6 on Power supply)**

Nominal:	24-250Vdc, 69-240Vac (50/60Hz)
Operating Range:	20-300Vdc, 55-275Vac (45-65Hz)
Burden:	50VA max, 20W max (C07A5) 70VA max, 25W max (C12A8 and C10A7)

Environmental	
Operating Temperature	-40C to 70C
Relative Humidity	0-95% non-condensing
Installation Category	IC III (Distribution Level) *Refer to definitions below.*
Pollution Degree	Pollution Degree 2 *Refer to definitions below.*
Enclosure Protection	IP20 to IEC60529:1989
Altitude	Up to and including 2000m above sea level
Intended Use	Indoor use; Indoor/Outdoor use when mounted in an appropriately rated protective enclosure to NEMA or IP protection classifications, as required for the installation.

(Refer to Section 9 on -P40 Tranducer input Module)

-P40 Transducer Input Module		
Inputs	8 bi-directional, jumper selectable for voltage or current range.	
0 – 10V Voltage Range	Overload Range:	-12.5 V to +12.5 Vdc
	Resolution:	0.381 mV
	Input Resistance:	10KΩ
0 – 1mA Current Range	Overload Range:	-2.5 mA to +2.5 mA
	Resolution:	0.0763 µA
	Input Resistance:	500Ω
4 – 20mA Current Range	Overload Range:	0 mA to +25 mA
	Resolution:	0.381 µA
	Input Resistance:	50Ω
Common Mode Input Range	+/- 9V, Input to Chassis	
Common Mode Error	Vcm DC	0.3% of FS @ 9Vp Common Mode
	Vcm 50/60Hz AC	0.1% of FS @ 9Vp Common Mode
Accuracy	0.25% of Full Scale Input	
Protection	Input terminals have internal transzorb clamp and 90V spark gap protection.	
Data Update Rate (Poll Rate)	100ms minimum (single P40 module); 500ms minimum (multiple P40 modules)	
Input / Output Capacitance, any	470pF	

-P40 Transducer Input Module	
Terminal to Case	
Power Supply Requirements	3.3Vdc, 5Vdc, +/-12Vdc (supplied from backplane)
Hot Swap	Complies with Hot Swap specification PICMG 2.1 R1.0 for Basic Hot Swap (requires Host Processor re-boot)
Connections	Removable Terminal Blocks, accepts #16-28AWG (1,4-0,09mm) wire. Recommended Torque Rating is 2.2 In-Lbs, 0.25 N-m. Standard 0.150" (3,81mm) header socket accepts other standard terminal types. Solid core wire is recommended, or stranded wire with the use of "bootlace ferrules," where these are available.
Package	CompactPCI™ (3U, 4HP) removable module

Definitions:

Installation Category (Overvoltage Category) III: Distribution Level, fixed installation, with smaller transient overvoltages than those at the primary supply level, overhead lines, cable systems, etc.

Pollution: Any degree of foreign matter, solid, liquid, or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation.

Pollution Degree 2: Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

1.4 Standards and Certifications

1.4.1 Environment

UL/CSA Recognized, File Number E164178 (does not apply for units with the P33 digital output option):

UL 61010-1, Edition 3, Issue Date 2012/05/11,
SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE - PART 1: GENERAL REQUIREMENTS.
UL 61010-2-030, Edition 1 - Issue Date 2012/05/11,
SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE - PART 2-030: PARTICULAR REQUIREMENTS FOR TESTING AND MEASURING CIRCUITS.

CSA C22.2 NO. 61010-1-12-CAN/CSA, Edition 3, Issue Date 2012/05/01,
CAN/CSA SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE - PART 1: GENERAL REQUIREMENTS.
CSA C22.2 NO. 61010-2-030-12-CAN/CSA, Edition 1, Issue Date 2012/05/01,
SAFETY REQUIREMENTS FOR ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL, AND LABORATORY USE - PART 2-030: PARTICULAR REQUIREMENTS FOR TESTING AND MEASURING CIRCUITS.

If applicable, the CE mark must be prominently marked on the case label.

European Community Directive on EMC (EMCD) 2014/30/EU, superseding Directive 2004/108/EC (which replaced former directive 89/336/EEC amended by 92/31/EEC, 93/68/EEC, 98/13/EC) and Directive 91/263/EC [TTE/SES]).
European Community Directive on Low Voltage (LVD) 2014/35/EU, superseding 2006/95/EC, (which replaced former Directive 73/23/EEC)

The object of the declaration described above is in conformity with the relevant Union harmonisation legislation: Directives 2004/108/EC & 2006/95/EC (until April 19th, 2016) and Directives 2014/30/EU &, 2014/35/EU (from April 20th, 2016).

<u>Product and Generic Standards</u>
The following product and generic standards were used to establish conformity:

Low Voltage (Product Safety):
IEC/EN 61010-1, Edition 3, Issue Date 2010
Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements

IEC/EN 61010-2-30, Edition 1 – Issue Date 2010
Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits

EMC:

EN 61326-1: 2013 (supersedes EN 61326-1: 2006),
IEC/EN 60255-26: 2013 + AC: 2013 (product standard used in part – reliance on basic EMC standards) (supercedes IEC 60255-25: 2000 and IEC 60255-26: 2008, which superceded EN 60255-26: 2006, which superceded EN50263: 2000) EN 61000-6-2: 2005 + AC: 2005 (supercedes EN 61000-6-2: 2005, which superceded EN 50082-2: 1995),
EN 61000-6-4: 2007 + A1: 2011 (IEC date 2010), (which superceded EN 50081-2: 1993).

Radiated Emissions Electric Field Strength
Basic EMC emissions standard (radiated emissions):
EN 55011: 2016, EN 55011: 2009 + A1: 2010, (which superceded EN 55011: 2007 + A2: 2007, which superceded EN 55011: 1998 + A1:1998 + A2:2002)
Group 1, Class A
Frequency: 30 - 1000 MHz

EN 55011 is applicable for the following EMC product and generic standards:
IEC/EN 60255-26: 2013 + AC: 2013 (supercedes IEC/EN 60255-25: 2000,
EN 61000-6-4: 2007 + A1:2011 (IEC date 2010)

AC Powerline Conducted Emissions
(Applicable on VT inputs - Bus1/ Bus 2 and AUX PWR (Universal Hi Range AC/DC Power supply)

Basic EMC emissions standard (AC powerline conducted emissions):
EN 55011: 2016, EN 55011: 2009 + A1: 2010, (which superceded EN 55011: 2007 + A2:2007, which superceded EN 55011: 1998 + A1: 1998 + A2: 2002)
Group 1, Class A
Frequency: 150 kHz – 30 MHz

EN 55011 is applicable for the following EMC product and generic standards:
IEC/EN 60255-26: 2013 + AC: 2013 (supercedes IEC/EN 60255-25: 2000,
EN 61000-6-4: 2007 + A1:2011 (IEC date 2010),

Conducted Emissions, Telecommunication ports (Ethernet port)
EN 55032: 2015 + AC: 2016-07,
EN 55032: 2012 + AC: 2013,
EN 55022: 2010 + AC: 2011,
Group 1, Class A
Frequency: 150 kHz – 30 MHz

1 MHz Burst Disturbance Test
IEC60255-22-1: 1988
Class III
Amplitude: 2.5 kV

Electrostatic Discharge (ESD)
EN61000-4-2: 2009 (supersedes EN 61000-4-2: 1995 / A1:1998 / A2: 2001)
Discharge voltage: ± 8 KV Air; ± 4 KV Contact (Additionally meets ± 6kv Contact)

Immunity to Radiated Electromagnetic Energy (Radio-Frequency)
EN61000-4-3: 2006 + A1:2008 + A2:2010, Class III (supersedes EN61000-4-3: 2002 +

A1:2002, which superseded IEC 61000-4.3: 1995; and ENV 50204: 1996, on Immunity to Radiated Electromagnetic Energy -Digital Radio Telephones 900 MHz & 1890 MHz).

Digital Radio Telephones
Frequency: 900 MHz/1890 MHz   Amplitude: 10.0/3.0 V/m   Modulation: 80% AM @ 1kHz

Electrical Fast Transient / Burst Immunity
EN 61000-4-4: 2012 (supersedes EN 61000-4-4: 2004 + A1:2010, which superceded IEC61000-4-4: 1995)
Burst Frequency: 5 kHz
Amplitude, Input AC Power Ports: Severity Level 4;   Amplitude ± 4 kV
Amplitude, Signal Ports: Severity Level 3; Amplitude ± 2 kV
Amplitude, Telecom Ports (Ethernet): ± 1 kV

Current/Voltage Surge Immunity
EN 61000-4-5: 2014 (supersedes EN 61000-4-5: 2006, which superceded EN610000-4-5: 1995 + A1:2001 and IEC 61000-4-5 : 1995)
Installation Class: 3
Open Circuit Voltage: 1.2 / 50 µs
Short Circuit Current: 8 /20 µs
Amplitude: 2 kV common mode, 1 kV differential mode

Immunity to Conducted Disturbances Induced by Radio Frequency Fields
EN 61000-4-6: 2014 (supercedes EN 61000-4-6: 2009, which superceded EN 61000-4-6: 2007, which superseded EN 61000-4-6: 1996 + A1:2001 and IEC61000-4-6: 1996)
Level: 3
Frequency: 150 kHz – 80 MHz
Amplitude: 10 V_{RMS}
Modulation: 80% AM @ 1kHz

Power Frequency Magnetic Fields
EN61000-4-8:2010
Amplitude: 30 A/m
Frequency: 50 and 60 Hz

AC Supply Voltage Dips and Short Interruptions
EN 61000-4-11: 2004 (supersedes IEC61000-4-11: 1994)
Duration: 10ms on auxiliary power supply, under normal operating conditions, without de-energizing.

Surge Withstand Capability Test For Protective Relays and Relay Systems
ANSI/IEEE C37.90.1: 1989

Vibration
IEC60255-21-1: 1988   Endurance Class: 1

Shock and Bump
IEC60255-21-2: 1988   Bump Class: 1

2.0 HOUSING AND BACKPLANE

The 878 chassis is a modular-by-board design, with a rugged aluminum housing specifically designed to meet the harsh conditions found in utility and industrial applications. The chassis features a passive backplane, an embedded and fully compatible CompactPCI™ (cPCI) bus. All active circuitry is located on removable modules. There are three types of modules: Power Supply, the Host Processor, and cPCI expansion modules. See Figure 1 (below) for the locations of the module bays in the standard chassis.

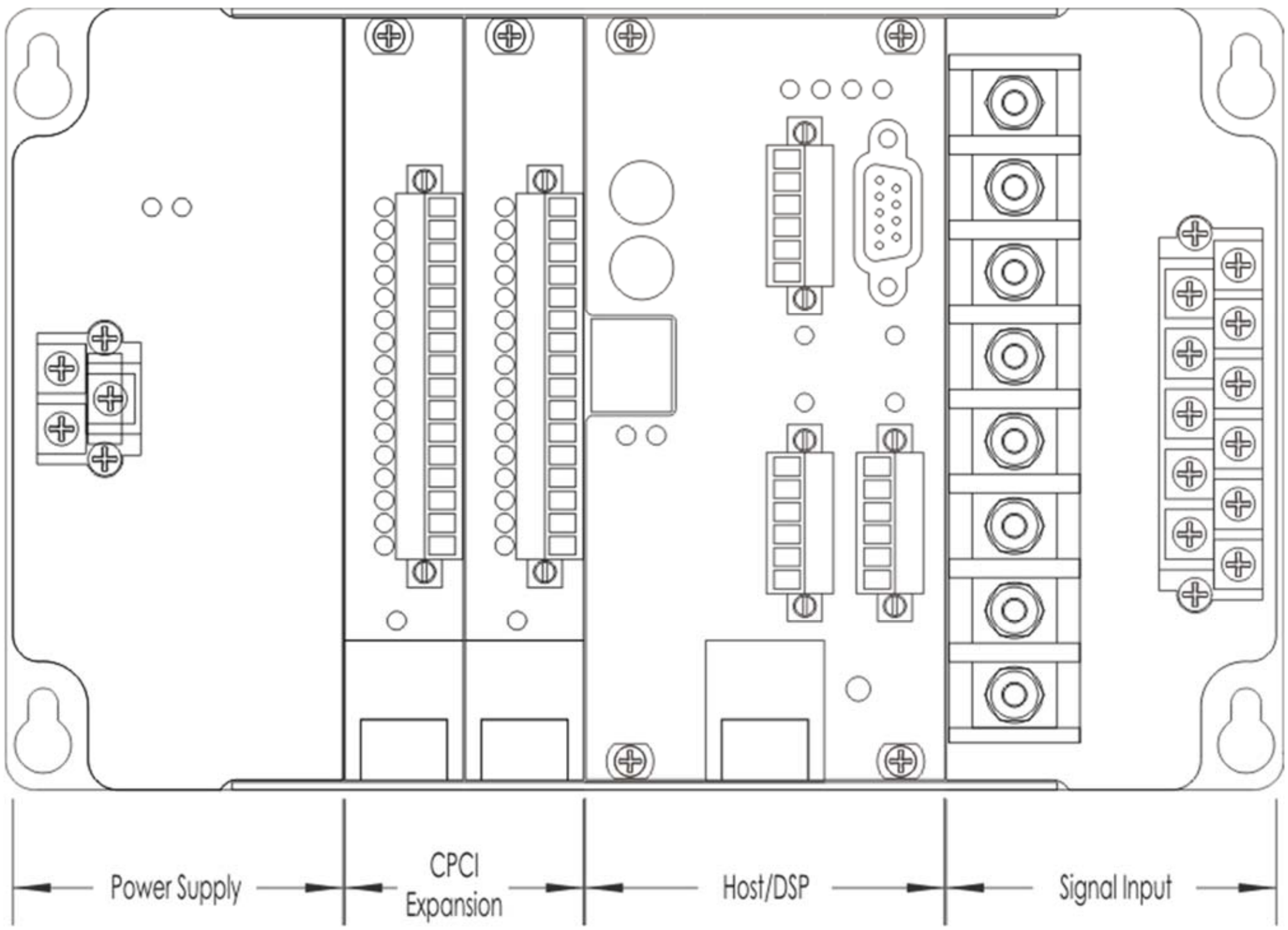


Figure 1 - Front View and Module Assignment (C07A5, M871 Shown, no signal input or DSP on 878)

The power supply bay utilizes a standard cPCI power connector. The Host Processor and the cPCI expansion bays have standard cPCI connectors. The expansion bays are fully compatible, both electrically and mechanically with cPCI standards. The Backplane board is an eight-layer circuit board, and contains a 5V, 33MHz cPCI bus. The standard bay assignment for the standard chassis (C07A5) is shown above. The 878 is also available in an intermediate chassis (C10A7) that adds two additional cPCI expansion bays, and an extended chassis, (C12A8) that adds three additional cPCI expansion bays. The H12 host processor with either of the combined Ethernet options (E1 or E3) as shown uses a wider front plate incorporating the first of the expansion slots to the left of the host/Ethernet module.

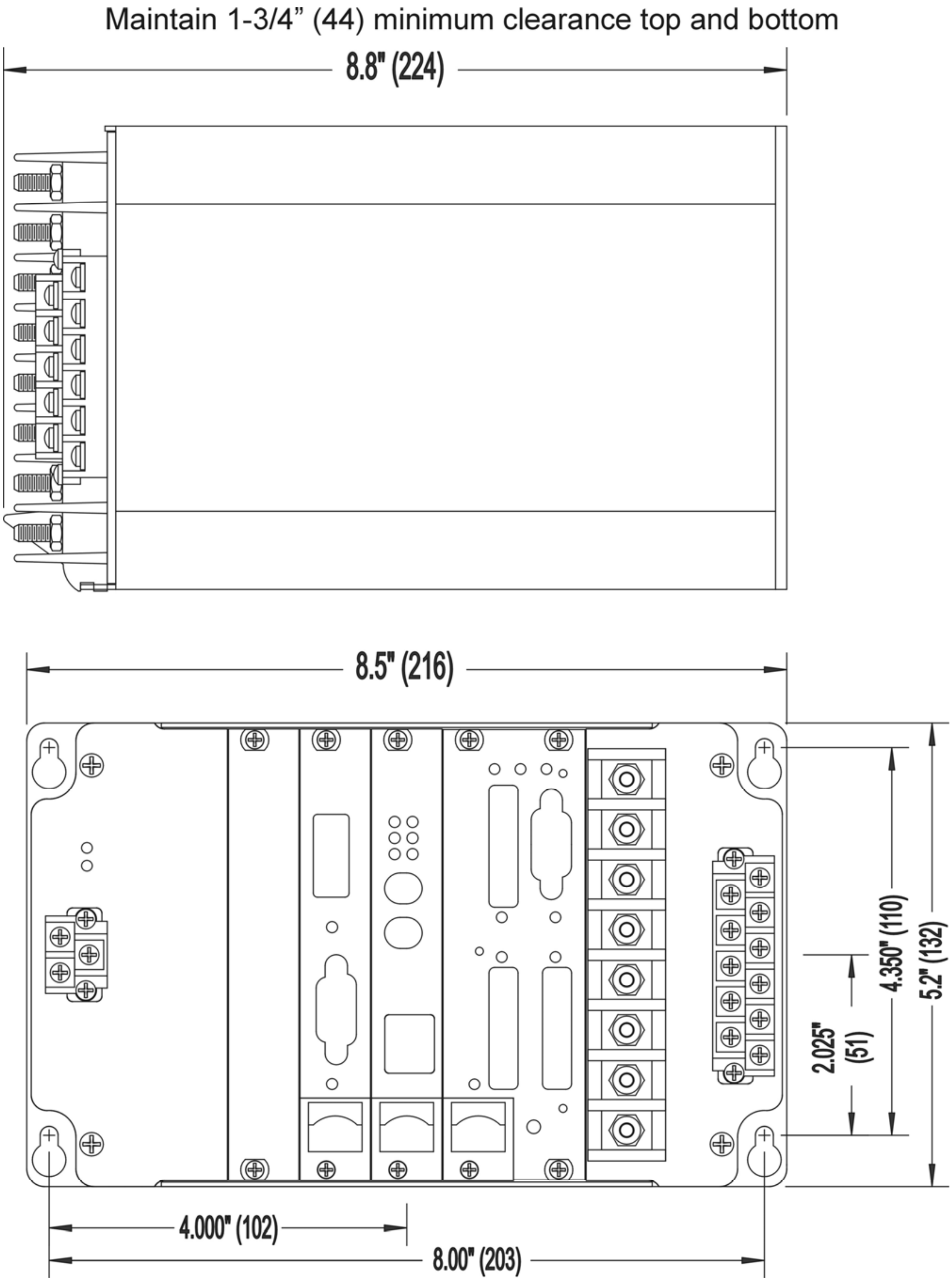


Figure 2 - Mounting and Overall Dimensions (C07A5)

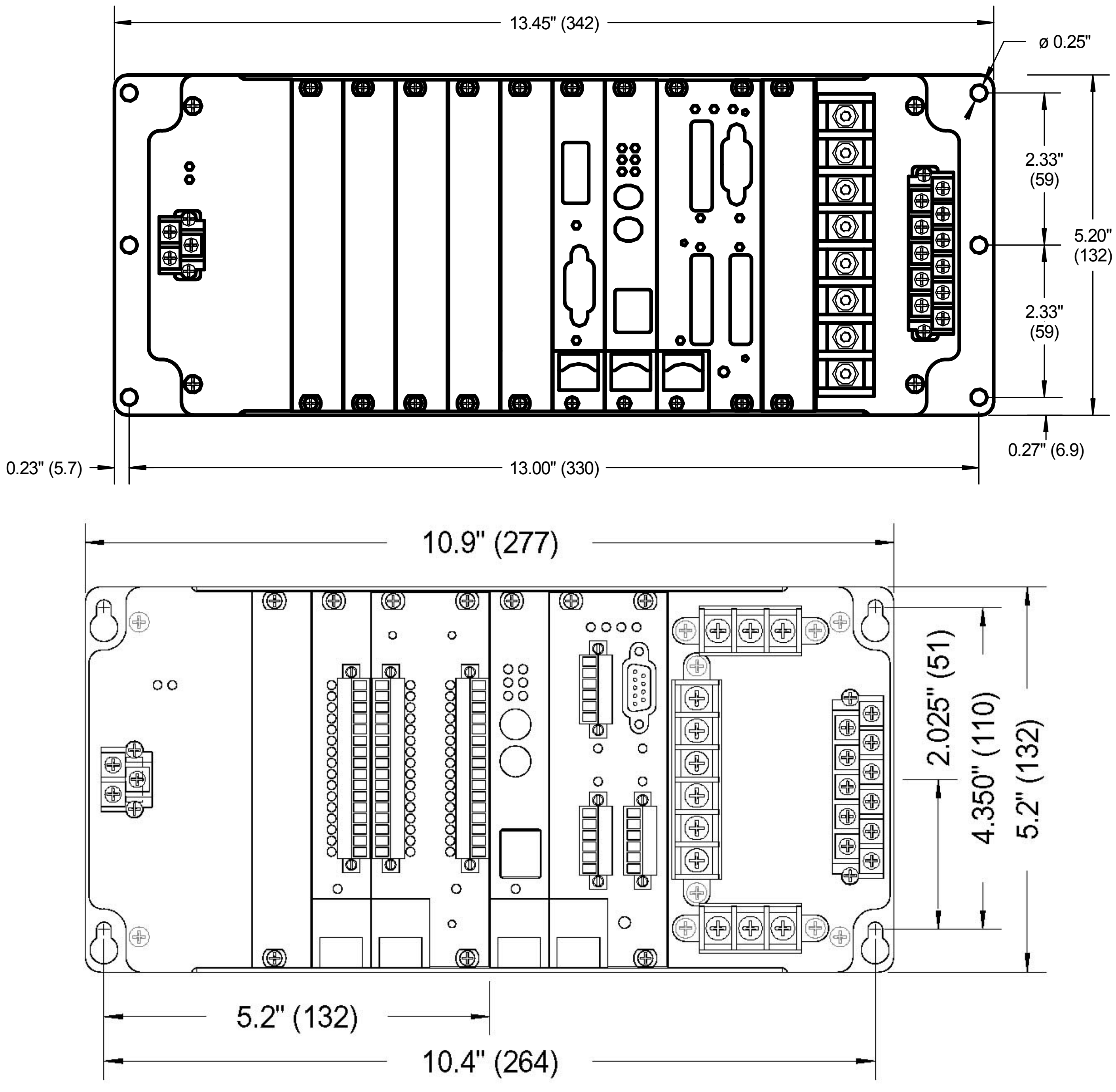


Figure 3 - Mounting and Overall Dimensions (C12A8 and C10A7)

2.1 Installation

WARNING - INSTALLATION AND MAINTENANCE SHOULD ONLY BE PERFORMED BY PROPERLY TRAINED OR QUALIFIED PERSONNEL.

2.2 Initial Inspection

Bitronics instruments are carefully checked and "burned in" at the factory before shipment. Damage can occur however, so please check the instrument for shipping damage as it is unpacked. Notify Bitronics LLC immediately if any damage has occurred, and save any damaged shipping containers.

2.3 Protective Ground/Earth Connections

There are two chassis ground points that MUST be connected to Earth Ground (refer to Figure 7, pg. 42). The first is the Protective Ground (Earth) terminal (terminal 2) on the Power Supply input. The minimum Protective Ground (Earth) wire size is 2.5 mm^2 (#12 AWG). The second is the mounting flange. Bitronics LLC recommends that all grounding be performed in accordance with ANSI/IEEE C57.13.3-1983.

2.4 Instrument Mounting

The unit should be mounted with four #10-32 (M4) screws. *Make sure that any paint or other coatings on the panel do not prevent electrical contact.* The device is intended to be connected to earth ground at the mounting plate. See Section 2.3.

2.5 Surge Protection

Surge protection devices are incorporated into the power supply. See Section 2.3 for grounding/earthed recommendations. If the unit is to be powered from a VT, it is recommended that one side of the VT be grounded at the instrument following ANSI/IEEE C57.13.3-1983. See Section 6.5 for fuse recommendations.

2.6 Cleaning

Cleaning the exterior of the instrument shall be limited to the wiping of the instrument using a soft damp cloth applicator with cleaning agents that are not alcohol based, and are nonflammable and non-explosive.

2.7 Removal and Installation of Modules

All active circuitry is located on removable modules. Hot Swap modules may be installed and removed under power. Refer to the appropriate section or manual to determine if the particular module is Hot Swap compatible. **For all other modules, remove all power from the unit before installing or removing any module.**

All Hazardous Voltages MUST be removed from the 878 before removing or installing the Power Supply Module. The Power Supply may be withdrawn from the housing after removal of the front panel screws.

All connections to a module must be removed before removing the module. Do not attempt to install a module with signals connected. To remove a cPCI module, use the following procedure:

1. Remove power from the unit (except Hot Swap modules).
2. Unscrew the M2.5 Phillips front panel screws (note that these are captive screws). The screw in the handle has been left out intentionally.
3. Pull the red sliding release tab up and outward until handle is unlocked.
4. Push the handle downward (when viewed from the front) to lever out the module.
5. Once the module is disengaged from the backplane connector, carefully withdraw the module.
6. Be extremely careful when handling the module, especially the backplane connector.

To insert a cPCI module, use the following procedure:

1. Make sure the red sliding release tab is fully extended from the handle, and that the handle is in the downward position (when viewed from the front).
2. Line up the module with the card guides in the appropriate position (the Host/Analog-Digital Signal Processor Module MUST be inserted in the right most double width bay).
3. Use the handle to lever the module into the housing.
4. When the module is fully engaged, tighten the M2.5 Phillips front panel screws. The screw in the handle has been left out intentionally.

3.1 Host board

The Host CPU module consists of a 486-class microprocessor, four communications ports and a CompactPCI™ master bridge. The H12 host module utilizes a Compact Flash card, and offers optional Ethernet interfaces (E1 and E3).

3.1.1 Serial Port/Front Panel Board

The Serial Port/Front Panel Board consists of the four serial driver connectors, four status LED's, four bi-color serial port LED's, and a reset button. Port P1 is a PC-AT style 9-pin D connector for the dedicated RS-232 port, and ports P2, P3, and P4 are universal 150-mil, 6-pin removable connectors for the RS-232/RS-485 serial ports. P2, P3, and P4 are software (user) configurable for RS-232 or RS-485 mode. The RS-232 drivers support full and half duplex modes. See Figures 3-6 (pg. 16-19) for signal assignments.

3.1.1a Service Port (P1)

When connecting to the Service port DB9M (P1) from a PC, a null modem cable is required. The Service Port can be used with a PC running a terminal emulation program. Upon startup, the 878 default configuration sets P1 for 9600 baud, 8 data bits, no parity, 1 stop bit and no flow control handshaking. These parameters are user-configurable. A small number of messages are sent to P1 and the 878 then outputs system messages. Enter the command mode by pressing the ENTER key until the system outputs a prompting message. Allowable commands are:

Service Port\Zmodem Commands			
c:	dir	receive	time
cd	exit	reset	type
chp1	getlog	router	trigger dr1
chp2	Goose*	send	trigger dr2
d:	ip	serial	trigger wv1
date	mac	setlog	trigger wv2
del	nsap	subnet	ver
dio point	password	software	whoami
display on	pulse	receive	vio point
display off	reboot	status	

Note: * This command is for UCA Goose only and is now referred to as GSSE.

Type “help <command>” to find out more about a particular command. The more commonly used commands are:

ip - Set Internet Protocol (IP) address information in "dotted decimal" format. The IP address defaults to "192.168.0.254".

subnet – Set the Subnet mask. The Subnet mask defaults to "255.255.255.0".

router – Set the Gateway (Router) address. The Gateway (Router) address defaults to "192.168.0.1".

nsap - Set the OSI network address (NSAP) in "space delimited octet string" format. The default address is "49 00 01 42 49 09 01 01" which is a local address not attached to the global OSI network.

The correct value for your network should be obtained from the network administrator. The default values are valid for a device that is attached to a local intranet with optional access via a router (such as a device within a substation).

time - Set the time as 24-hour UTC time. Time is entered as HH:MM:SS. The factory default is set to GMT.

date – Set the date. Date is entered as MM/DD/YYYY.

serial - Display M87x serial number

exit - Exit command line mode and return to logging mode. If no commands are received for five minutes the device will revert to logging mode.

3.1.1b Standard Serial Ports (P2, P3, P4)

These ports can be set to RS-232 or RS-485, and support baud rates up to 115200. Set-up of the Serial Ports can be accomplished by using the 70 Series Configurator. The default configuration for the serial ports is:

Serial Port Default Settings					
Port	**Protocol**	**Parity**	**Baud**	**IED Address**	**Physical Media**
P1	Zmodem/Display/Log	None	9600		RS-232
P2	DNP 3.0	None	9600	1	RS-232
P3	Modbus	Even	9600	1	RS-232
P4	Zmodem/Display/Log	None	9600		RS-232

The configuration of these ports is stored internally in the "**COMM.INI**" file (Section 5.2). If, for any reason, the configuration of the serial ports is erroneously set, the factory default settings can be restored by using FTP. The file "**COMM.INI**" can be deleted, which will return all ports to the factory default setting. The settings can then be changed by using the 70 Series Configurator.

Host cable requirements for CE compliance:
On ports P2, P3, and P4, as well as a port that utilizes the externally mounted M87x Modulated IRIG-B Converter, install snap-on ferrite (Fair-Rite #0461164181 or equivalent) onto each cable by wrapping the cable through the ferrite opening two times before snapping the ferrite closed. Tie RS-485 cable shields (pin 5) to earth ground at one point in system.

The recommended torque rating for the terminal block wire fasteners on ports P2-P4 is 2.2 In-Lbs, 0.25 N-m.

3.1.1c Diagnostic Status LED's (S1, S2, S3, S4)

There are four LED's on the front panel: S1, S2, S3, and S4. They perform the following functions:

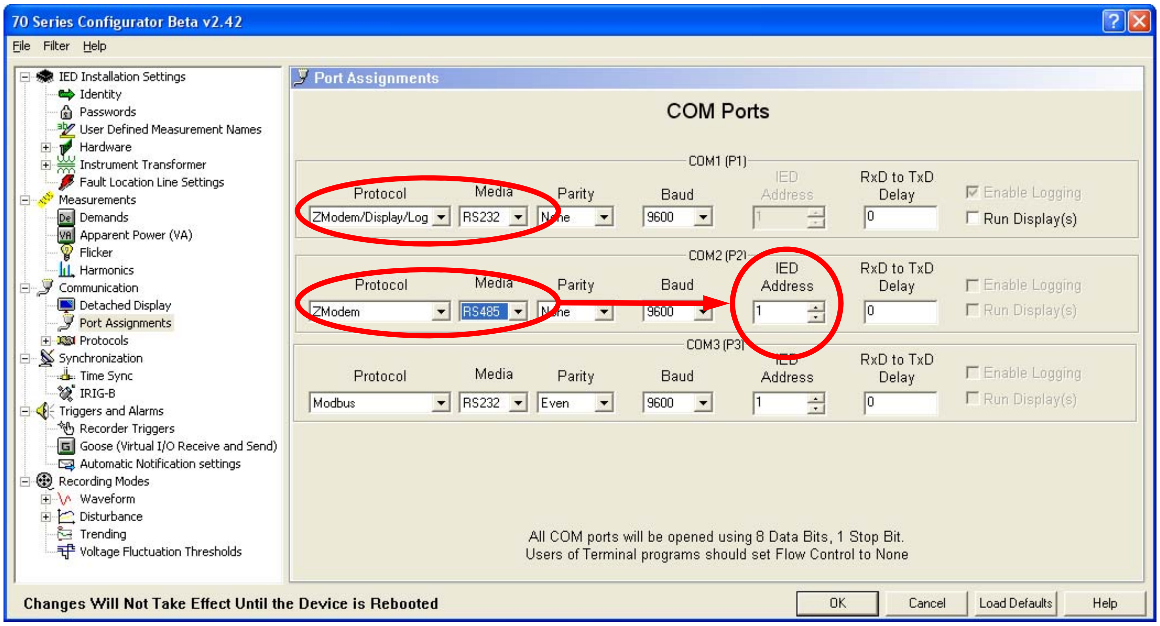
LED	Description
S1	On while flash memory is being written to, otherwise off.
S2	Not used. Flashes every 5 power-line cycles, indicates DSP operating properly on M87x.
S3	On while CPU is busy. Intensity indicates CPU utilization level.
S4	On during internal self-diagnostics after boot-up.

3.1.1d RS485 Connections

Note that various protocols and services have different port connection requirements. When making connections to serial ports for Modbus or DNP3 over RS485, 2-wire half duplex is required. This is because it is necessary to maintain a minimum time period (3 1/3 characters) from the time the transmitter shuts off to the next message on the bus in order to guarantee reliable communications. However, when using Zmodem or connecting to the remote display, asynchronous 2 way communications are required, and therefore a 4-wire full duplex (technically RS422) connection is needed. See figures 4 and 6 below for RS485 cable wiring and signal assignment diagrams showing both 2 and 4 wire.

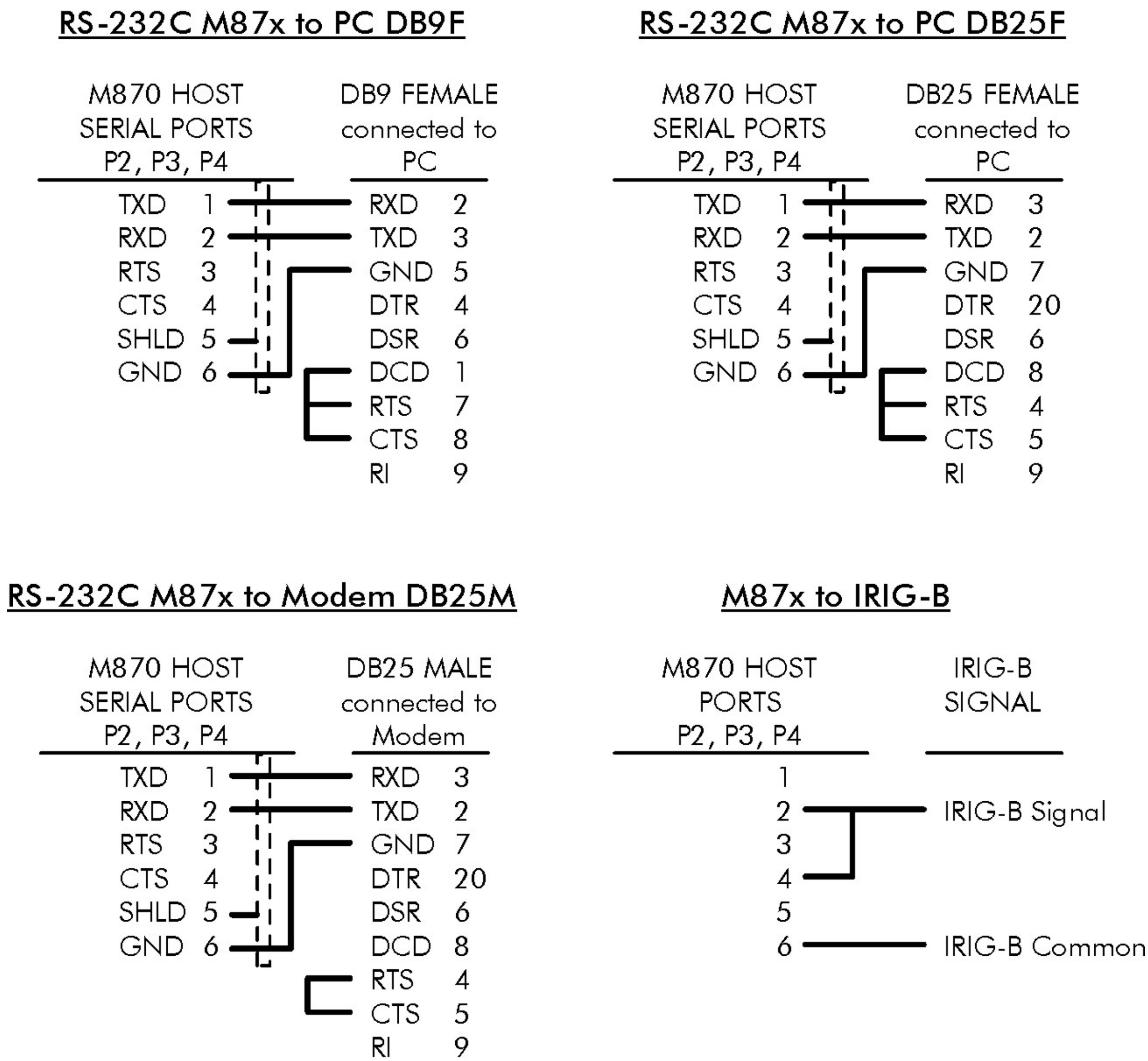
There are special considerations for multi-drop Zmodem connections. Zmodem protocol was developed for RS232 point-to-point connections so it does not support any standard convention for addressing. Therefore, it does not facilitate multi-drop communications buses. In order to make it possible to use one modem to establish remote communications with multiple 70 Series devices when the Ethernet option (preferred) is not fitted, the following proprietary convention is employed.

When using HyperTerminal or a dial-up modem with RS485, the port on the IED must be configured for "Zmodem" protocol, *not for "Zmodem/Display/Log".* This is done with the pull-down menu in the Configurator program, see illustration below. Selecting Zmodem also enables an address to be set for the selected COM port. When daisy-chaining multiple devices on RS485, each device must have a unique address.



Type the command "connect 01" (use the *actual* address assigned) to establish communications with the device in Zmodem protocol using RS485. *This command will not be echoed back as you type it.* After striking the enter key, the device will return a command prompt (for example c:\>, e:\data>, c:\config>, etc.) Once communications are established, you can now use the command-line interface, exactly as you would with a direct RS232 connection, to control the device (services supported by Zmodem protocol include: download recording files, control digital outputs, reset demands, set time and date, etc.). In order to disconnect from one device and connect to another on the same bus, type the command "exit" to end the session then type “connect 02” (or whatever address you want to connect to).

M87x RS-232 & IRIG-B Cable Connections



The rear port of the M870D Display and the Host port of the M87x must be set to RS-232, matching Baud rates and parity, and ZMODEM/Display/Log protocol.

The cable should be Belden 9842 or equivalent.
The maximum cable length for RS-232 is 50 ft. (15m)

Figure 3 - Typical RS-232 & IRIG-B Cable Wiring

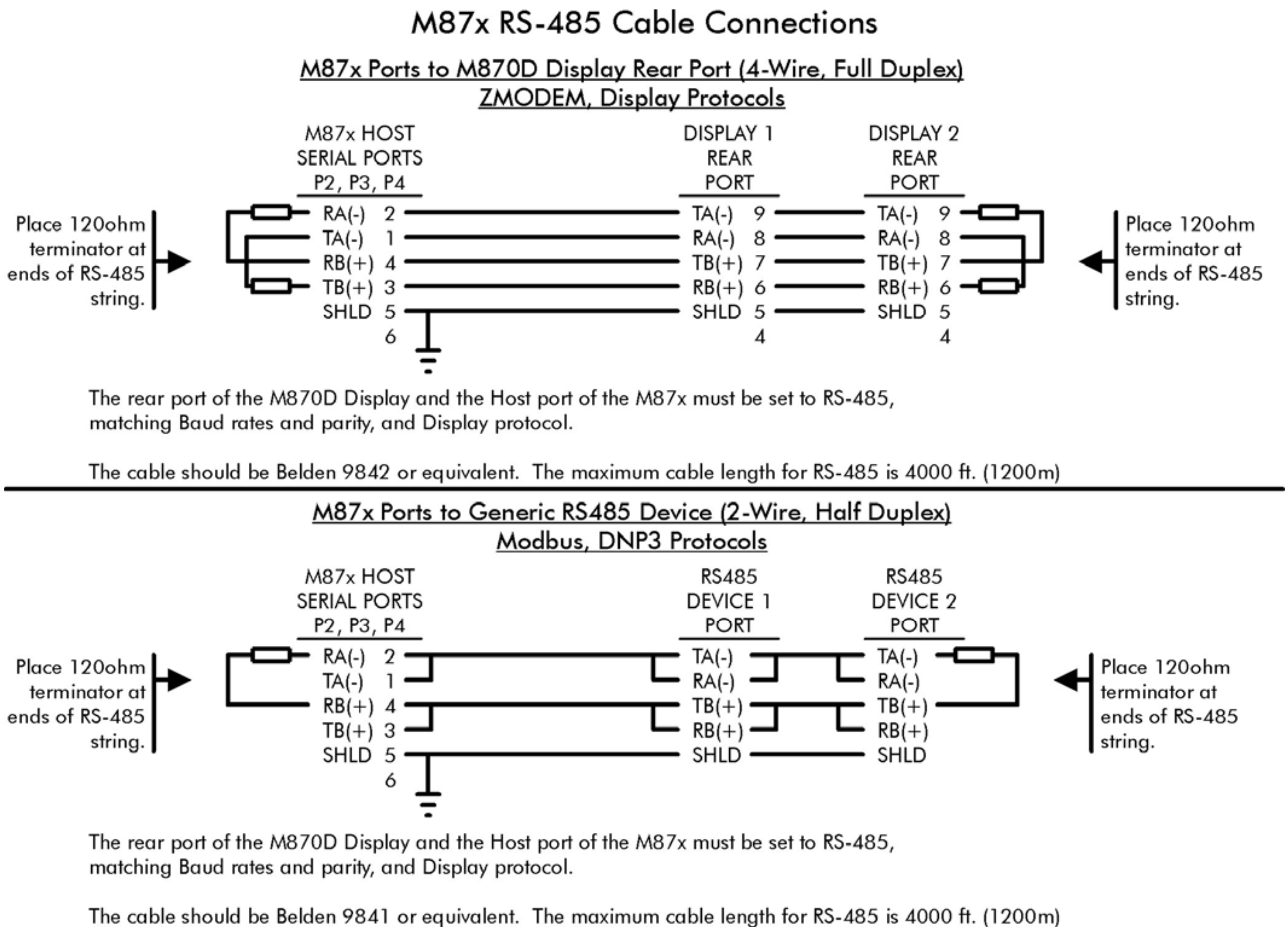
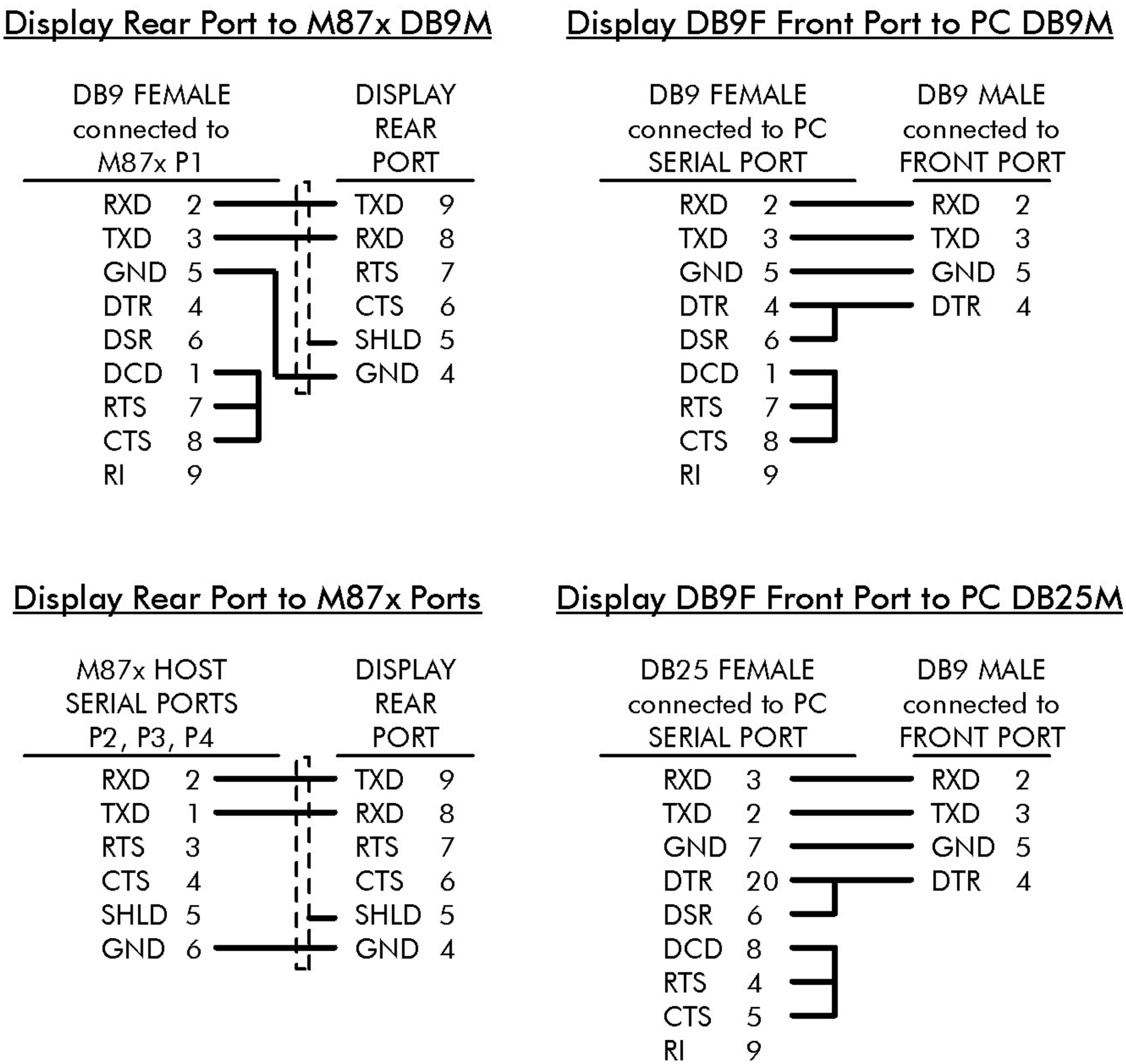


Figure 4 - Typical RS-485 Cable Wiring

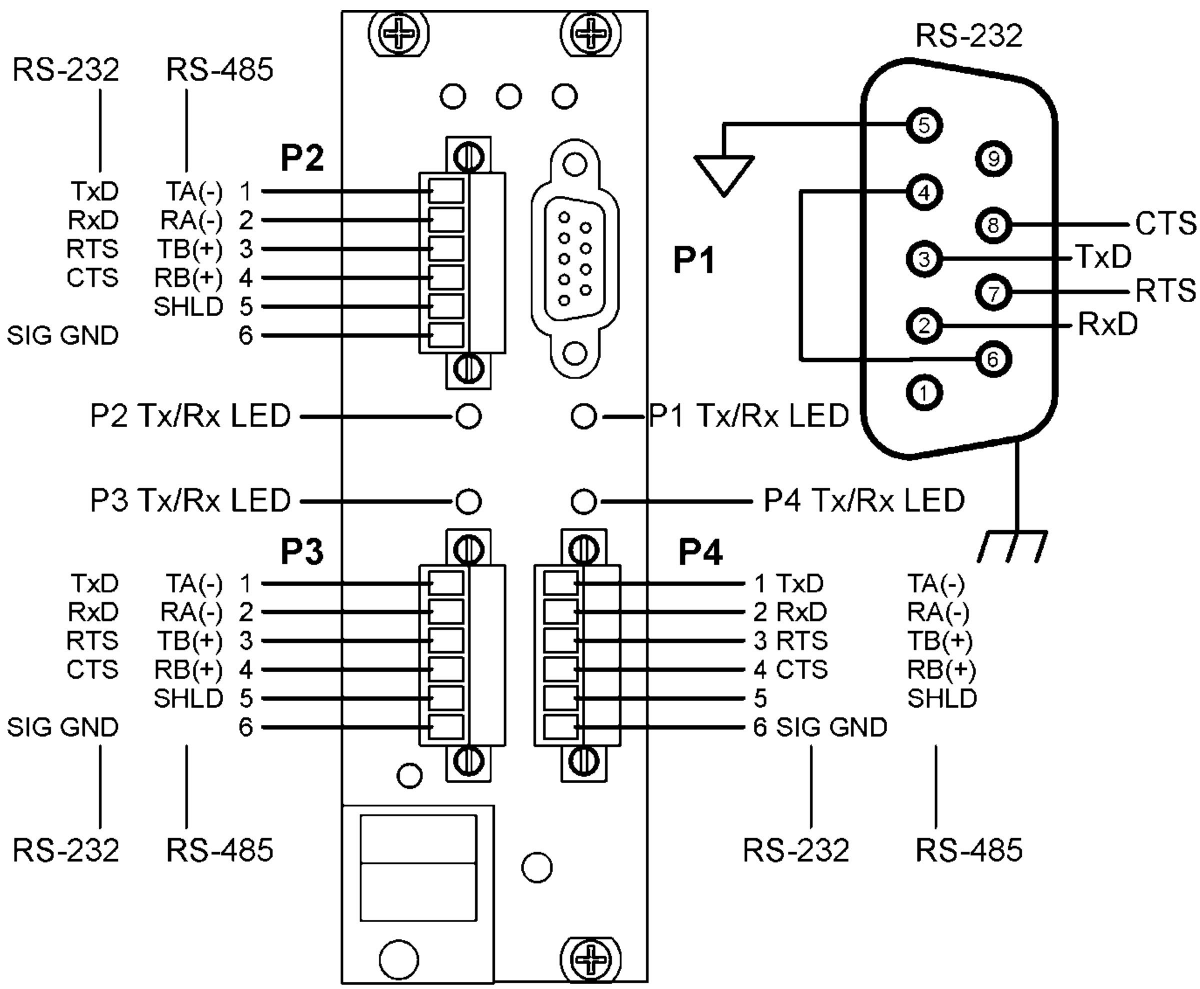
M870Display RS-232 Cable Connections

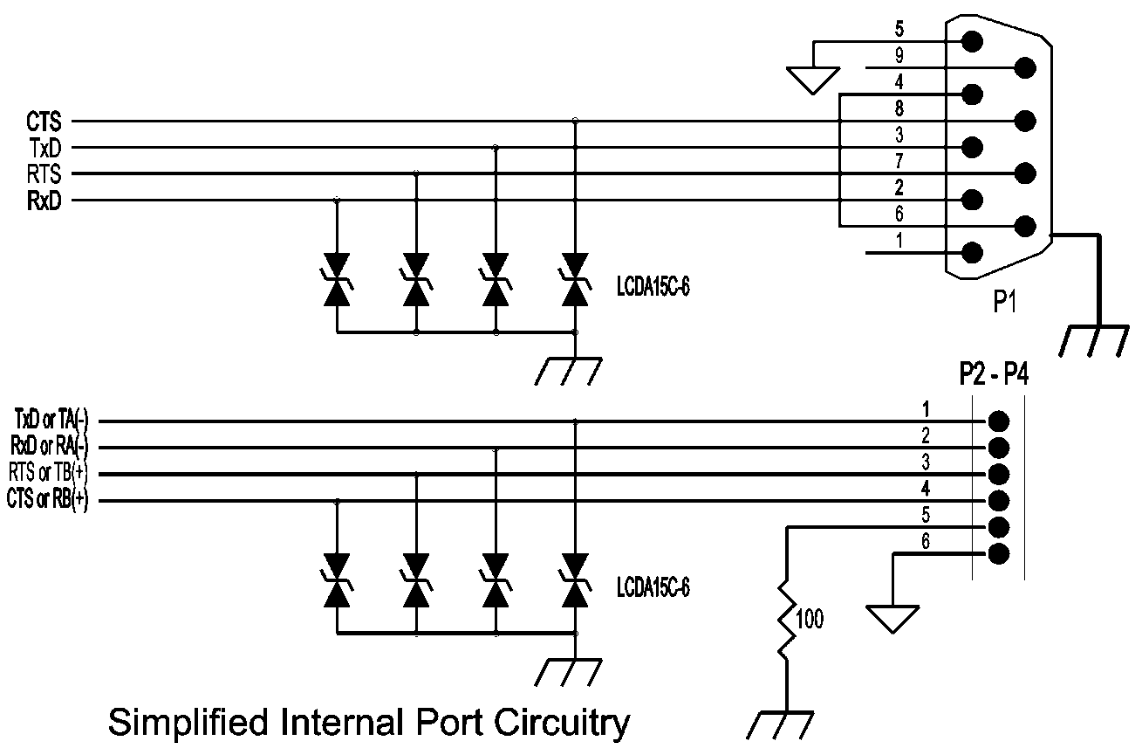


The rear port of the M870D Display and the Host port of the M87x must be set to RS-232, matching Baud rates and parity, and Display protocol.

The cable should be Belden 9842 or equivalent.
The maximum cable length for RS-232 is 50 ft. (15m)

Figure 5 – M870D RS-232 Cable Wiring





Simplified Internal Port Circuitry

Figure 6 - Host Port Signal Assignment

3.1.2 Self-Test Modes

The M87x has several self-tests built in to assure that the instrument is performing accurately. Refer to the appropriate protocol manual for details on how to retrieve the self-test information. The following table lists possible faults that would be detected by the self-tests. Most of these do not apply to the 878 because there is no signal input or DSP modules.

Self-Test Bits				
Bit #	**Description**	**Hardware**	**Effect**	**Default Value**
0(LSB)	Factory gain calibration of Analog-Digital Signal Processor Module checksum error.	A10 EEProm	Unit will continue to function using default values, at reduced accuracy.	A/D Gain = 1
1	Factory offset calibration of Analog-Digital Signal Processor Module checksum error.	A10 EEProm	Unit will continue to function using default values, at reduced accuracy.	A/D Offset = 0
2	Factory gain calibration of Signal Input Module checksum error.	S1x EEProm	Unit will continue to function using default values, at reduced accuracy.	CT/VT Gain = 1
3	Factory offset calibration of Signal Input Module checksum error.	S1x EEProm	Unit will continue to function using default values, at reduced accuracy.	CT/VT Offset = 0
4	Factory phase calibration of Signal Input Module checksum error.	S1x EEProm	Unit will continue to function using default values, at reduced accuracy.	CT/VT Phase = 0
5	Factory defined internal ratios of Signal Input Module checksum error. (Type of Signal Input Module)	S1x EEProm	Unit will continue to function. Assumes -S10 Signal Input Module	Volts Ratio = 60 :1 Amps Ratio = 14.136 :1
6	User defined external transformer ratio checksum error.	S1x EEProm	Unit will continue to function using default values (i.e. w/o user ratios).	User CT = 5:5, VT = 1:1
7	User gain correction values checksum error.	S1x EEProm	Unit will continue to function using default values (i.e. w/o user gain).	User Gain = 1
8	User phase correction values checksum error.	S1x EEProm	Unit will continue to function using default values (i.e. w/o user phase).	User Phase = 0
9	Factory defined board ID for Analog-Digital Signal Processor Module checksum error.	A10 EEProm	Assumes default Analog-Digital Signal Processor Module.	Module A10
10	Factory defined board ID for Signal Input Module checksum error.	S1x EEProm	Assumes default Signal Input Module.	Module -S10
11	User defined denominators for TDD measurement checksum error.	S1x EEProm	Assumes default TDD Denominator.	TDD Denom = 5A Secondary
12	DSP program integrity checksum error.	A1x DSP Ram	Host trips watchdog, unit reboots.	
13	DSP stack overflow.	A1x DSP Ram	Host trips watchdog, unit reboots.	
14	Invalid or missing Amp and/or Voltage Scale Factor.	H1x Flash File	Protocol will use default Scale Factor	Scale Factor = 1:1
15	Protocol configuration invalid.	H1x Flash File	M87x uses default protocol configuration	M87x register set

3.1.3 System Clock

The 878 has an internal System Clock with a capacitor backed RAM (typical data retention of 7 days at room temperature) when no power is applied to the unit. The clock and battery are located on the Host board. The time settings may be changed via the Serial Port (P1) or various communication protocols. Refer to Section 3.1.1a and the appropriate protocol manuals for details.

4.0 MEASUREMENTS

4.1 List of Available Measurements

Please note that the 878 has a much smaller list of available points than the M87x models

Available Measurements	
Accrued Digital IO Module #0-6, Input 1-16	Heartbeat
Accrued Digital IO Module #0-6, Output 1-8	IrigB Time Sync
Accrued DR1/DR2 Active, Completed, Started	Log Interval
Accrued Virtual IO, Inputs 1-32, Outputs 1-32	Meter Type
Best Clock	Misc. Packed Bits
Class 0 Response Setup	Network Time Sync
Digital IO Module #0-6 Debounce Time	Protocol Version
Digital IO Module #0-6 Input Point 1-16	SNTP Time Sync
Digital IO Module #0-6 Output Point 1-8	Tag Register
Digital IO Module #0-6 Status Output Point 1-8	Temperature
DNP Time Sync	Time Sync Error (µsec, msec, sec)
Factory Version Hardware	Transducer Input Module # 1-7, Input Point 1-8
Factory Version Software	Trigger Derivative 1-120
Health	

5.0 FUNCTIONAL DESCRIPTION

5.1 Passwords

The 878 has implemented the standard Bitronics password scheme. There are three different access levels:

Level 0: This access level provides read-only access to all settings and data, thus preventing modification of information that affects system security. The factory default password for level 0 is “AAAA”; this is the same as entering no password.

Level 1: This access level includes the read access of level 0. In addition, the user is permitted to delete recorder files, and reset energy and demand values. The factory default password for level 1 is “AAAA”; this is the same as entering no password.

Level 2: This access level includes all lower level functionality. The user is also granted full read/write/delete access on all files in the M87x, including the configuration files. The factory default password for level 2 is “AAAA”; this is the same as entering no password.

NOTE: The factory default is to allow level 2 access with no password. For the password scheme to take affect, the user must change the passwords with the 70 Series Configurator.

5.2 Configuration

Setup of the 878 is most easily performed using the 70 Series Configurator. This software runs on a PC and allows the PC to communicate to the 878 using a serial port or Ethernet connection. The 878 configuration is stored internally by means of several configuration files, located in the directory shown in the following table. Most of these are ASCII text files, and may be saved, copied, and deleted by any of the various methods of file manipulation, such as FTP, Zmodem, and the 70 Series Configurator.

If using IEC61850 protocol, the configuration of the IP and SNTP addresses will be determined based upon a selection the user makes by way of the radio button selections found on the 70 Series Configurator Identity page. The radio buttons provide the user with the flexibility to decide which software tool will control the IP and SNTP address configuration settings. Configuration settings are loaded upon reboot from either the Initialization (INI) files or the Micom Configuration Language (MCL) files, depending upon the radio button selected during configuration. The IP and SNTP addresses will be loaded either from the respective address settings stored in the INI file by the 70 Series Configurator or from the address settings stored in the MCL file by the IEC61850 IED Configurator. Addresses written into the MCL file will be written back into the INI file when the unit reboots. It is only possible to synchronize the addresses by reading the address information written into the MCL file back into the INI file upon reboot. (The IP and SNTP Addresses are rewritten to the INI file though the 70Series Configurator upon reboot since the IEC61850 IED Configurator does not have the ability to rewrite information once the configuration is written to the MCL file). There is a mechanism to automatically sychronize these addresses upon rebooting the 878, so that the current IP address for the 878 will be updated on the 70 Series Configurator Identity page. For the case when the radio button is selected as “IEC61850 IED Configurator (MCL file)” the IP networking information will appear in grey indicating the IEC61850 IED Configurator is the active tool. Only the 70

Series Configurator allows the user to select which configurator tool loads the IP and SNTP addresses.

The configuration files are stored in the 878 directory c:\Config. The 70 Series Configurator will generate the IED Capability Description (ICD) file and automatically store it on the 878 in directory c:\Config. If using IEC61850 protocol 2 additional files, an MCL file and an MC2 file, will be generated by the IEC61850 IED Configurator and will be stored on the 878 in the c:\Config directory. The MCL files are the Micom Configuration Language files and contain the information pertaining to the IEC61850 Configuration. The MCL file is stored as the active bank and contains the IEC61850 configuration and the MC2 file becomes the inactive bank, containing the previous IEC61850 configuration.

Filename	Directory	Description
COMM.INI	c:\CONFIG\	Contains serial port information.
DIO.INI	c:\CONFIG\	Contains Digital I/O data, i.e. the Digital I/O debounce time.
DISPLAY.BIN	c:\CONFIG\	Contains setup information for communicating with a remote display
DNP.BIN	c:\CONFIG\	Contains DNP configurable register information
IDENTITY.INI	c:\CONFIG\	Contains Identity info, i.e. device name of 878, IP address, NSAP address.
MODBUS.BIN	c:\CONFIG\	Contains Modbus configurable register information
PROTOCOL.INI	c:\CONFIG\	Contains Modbus and DNP protocol setup information.
SBO.INI	c:\CONFIG\	Contains UCA2.0 Select Before Operate parameters
VIO.INI	c:\CONFIG\	Contains Virtual Input/Output setting information.
TRIGGER.INI	c:\CONFIG\	Contains all trigger configuration info
HARDWARE.INI	c:\CONFIG\	Contains configured hardware info
SYS_CNFG.INI	c:\PERSIST\	Contains hardware found by unit

There are also several ".BIN" files in the "c:\CONFIG\" directory which contain information on the protocol register configuration for Modbus and DNP. These files are written by the 70 Series Configurator and are not editable by the user.

AFTER WRITING THE CONFIGURATION FILES, THE 878 MUST BE RESET (REBOOTED) BEFORE THE NEW CONFIGURATION WILL TAKE EFFECT.

5.3 Triggering

Triggers can be configured in the 70 Series to initiate several different actions:

Digital Outputs
Virtual Outputs
SOE Entries

Up to 120 triggers can be specified, of the following types:

5.3.1 Digital Input Trigger

A waveform or disturbance record or an SOE log entry can be triggered by using any of the digital inputs on the Digital Input/Output Module (Section 9). Any or all of the digital inputs can be used to trigger a record. Each input can be independently set to trigger on a state transition. Assigning the digital inputs to initiate a record MUST be performed by using the 70 Series Configurator.

An event triggered from the digital inputs will be subject to the debounce time setting for the digital input. Digital input traces in the Waveform Recorder files are the instantaneous status of the inputs, and do not reflect any debounce time settings. If a long debounce time is set, it is possible to see an event on the digital input that does not cause a trigger.

5.3.2 Edge and Level Triggers

The user can select between Edge and Level Triggers.

An Edge trigger exists for only an instant in time. The time before the trigger is defined the Pre-trigger period, and the time after the trigger is the Post-trigger period.

A Level trigger has duration in time. The trigger is valid as long as the trigger condition is met. The time before the trigger is still defined the Pre-trigger period, but the Post-trigger period does not begin until after the trigger condition is no longer valid.

5.3.3 Manual Trigger

Refer to the appropriate protocol manual for information. Manual Triggers may also be activated through BiView using Telnet, Zmodem, or under Modbus or DNP3 protocols (depending on what register set/ point list is chosen). When a manual trigger is initiated, it bypasses the standard trigger setup, and directly initiates the action specified by that command.

5.3.4 Logical Combinations of Triggers

Triggers can be logically combined in groups to perform actions. Each trigger is assigned to the same Virtual Output in the Configurator, and the type of logic function (AND or OR) is selected. That Virtual Output is then configured as a new trigger, with the appropriate action assigned. If "No Logic" is selected, then only one trigger can be assigned to a particular Virtual Output.

5.3.5 Cross Triggering Multiple 70 Series Units (Inter-triggering)

Under certain circumstances, it is advantageous that a 70 Series device that captures a record, also functions in a capacity to send out a pre-determined trigger condition. That trigger condition, which is based on values measured by the instrument, can be used for the purpose of cross triggering (also referred to as inter-triggering) other 70 Series devices. Cross triggering is an essential requirement for synchronizing the equipment in a substation, where it is necessary that multiple instruments sense the occurrence of particular conditions

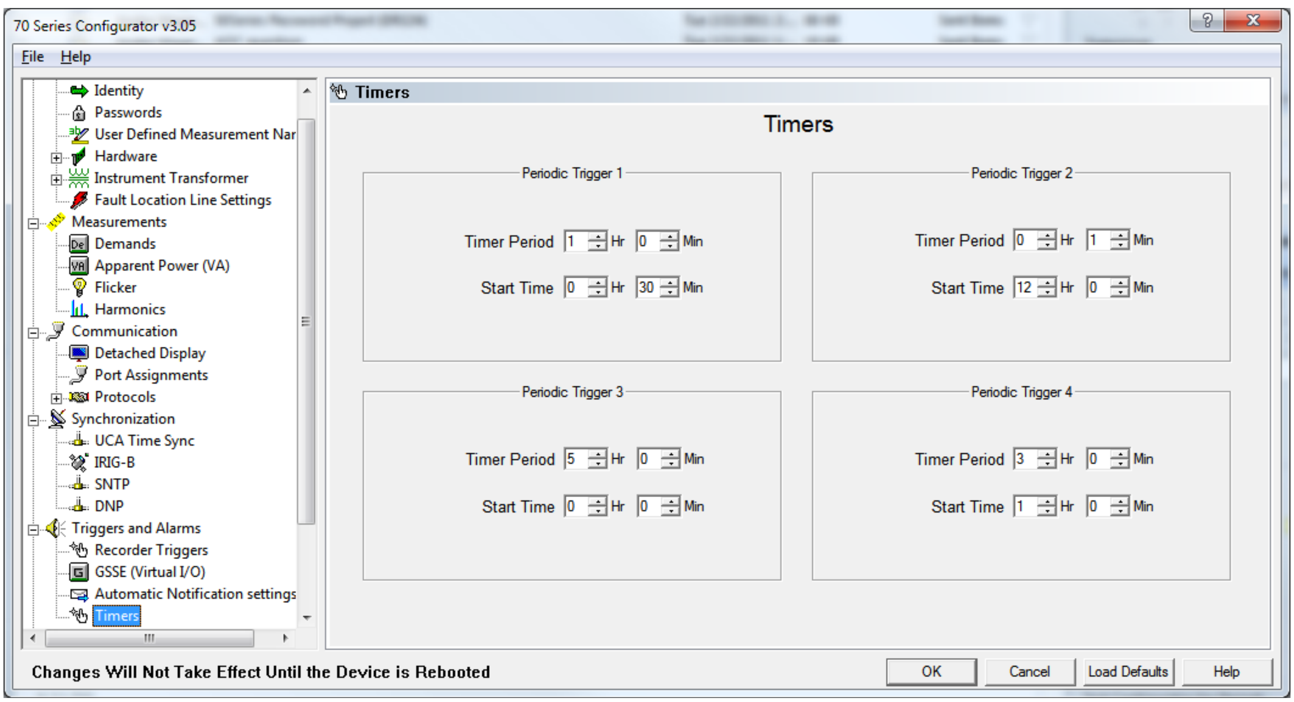
There are a number of ways to accomplish cross triggering across 70 Series devices. The cross triggering mechanism can be accomplished by way of a physical interconnection using Digital I/O, or by way of virtual messaging, which is communicated over an Ethernet network connection. Refer to Appendix A for examples of setting up cross triggering through either Digital I/O connections, GSSE messaging [through UCA], or GOOSE messaging [through IEC61850].

A P30 or P31 module is necessary to set up cross triggering using a Digital I/O interconnection method. An Ethernet option module is necessary in order to set up either GSSE messaging [through UCA] or GOOSE messaging [through IEC61850].

Units may both send and receive cross triggers from and to multiple other units.

5.3.6 Periodic Triggers

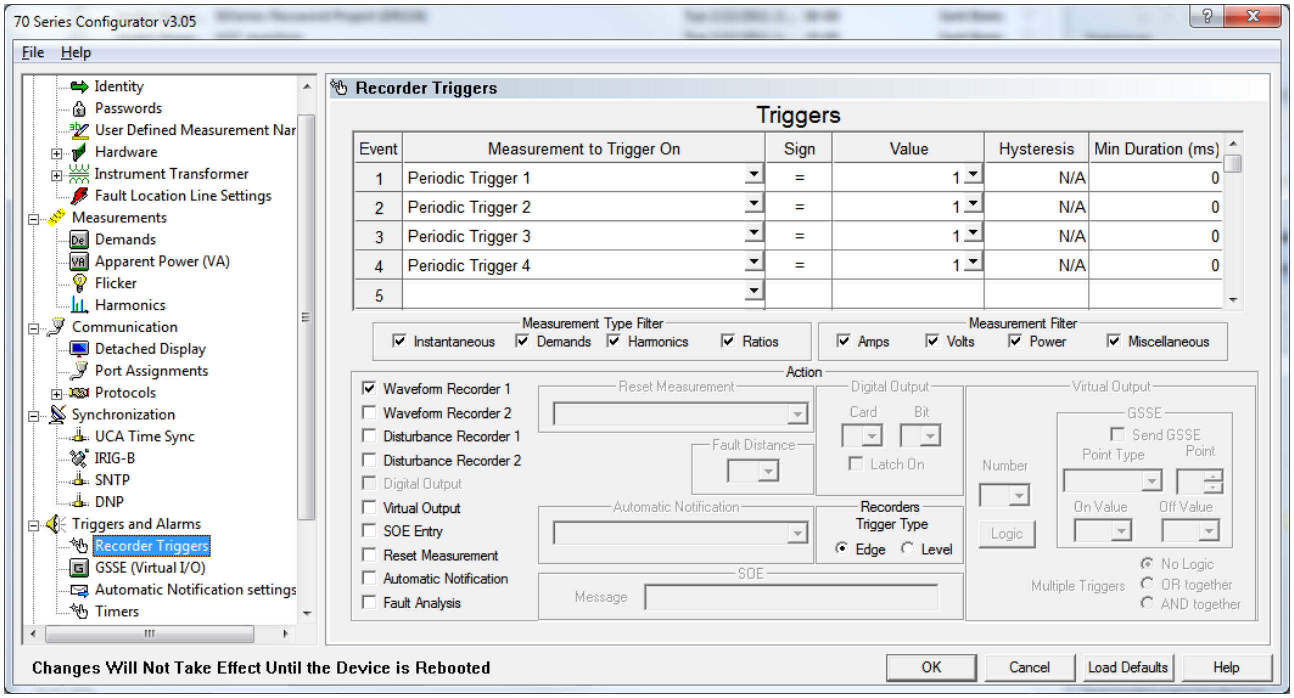
Four independent periodic triggers are available that can be used to initiate all of the actions listed in section 5.3 above. The timers for these triggers are configured to individually set the period and start time for each trigger on the Timers page of the 70 Series Configurator as shown below:



The period can be set in increments of minutes up to a maximum of 24 hours. Likewise, the time of day for the timer to start can be specified in increments of one minute.

Note that if the number of minutes in a day is not evenly divisible by the configured period, then the start time has little impact except at boot up. For example, if the period is configured for 7hrs and the start time is 0430hrs then the first day after the device starts the timer will activate at 0430hrs, 1130hrs, 1930hrs. And then on the second day, it will activate at 0230hrs, 0930hrs, 1630hrs, 2330hrs., etc.

The activation status of the timers is available as a binary point in the list of 'Measurements to Trigger On' in the Recorder Triggers page (see screen below). The point will transition from 0 to 1 at the timers scheduled activation. It will hold at 1 briefly and then return to 0. These 'Periodic Trigger' points can then be used to trigger any of the actions selected.



5.4 Sequence of Events (SOE) File

The 878 creates a record, in chronological order, of all events that occur, including:

Triggers
Health Check status errors
Change of state of status inputs and outputs
Creation of files
Change of configuration
Setting of clock
Record of Boot up

The SOE.LOG file is an ASCII text format file, and typically can be up to 5000 lines.

5.5 878 File System

Files are stored in the 878 on internal drives labeled "c:" and "d:". In addition the host module contains optional compact flash memory which is accessible as drive "e:". Both FTP and Zmodem may be used to access any drive. Trend Recorder files are stored on the d: drive on the host module. All other user accessible files will be stored on the c: drive unless the unit is equipped with optional compact flash memory. In this case these files are stored on the e: drive. The following directories are relevant to the user.

Directory	Function
c:\config	Location of Configuration files

Directory	Function
c:\upload	Location of restart.now file
c:\data or e:\data	Location of recorder compressed ZIP files
d:\data	Location of trend recorder files

5.5.1 FTP Server

The 878 incorporates an internet-compatible FTP (File Transfer Protocol) data server. This allows user access to any program or data file that exists on the 878. It has the following primary uses:

1. Allows remote software updates to be written to the 878.
2. Allows determination of the time of last software update.
3. Allows configuration ".INI" files to be written, copied, and deleted from the 878.
4. Allows Comtrade files to be read and deleted from the 878.

The 878 can support up to 50 simultaneous FTP connections.

5.5.1a Introduction to FTP

FTP protocol is a standard component of the Internet protocol suite and is used to transfer files between computer systems. Every Windows/Unix/Linux operating system contains an FTP Client program that allows simple access to FTP Servers such as the M87x. FTP is accessed from the command prompt (sometimes referred to as the DOS prompt). A (simplified) sample session appears on the screen as:

C:\windows> **FTP 192.168.0.254**
M87x server, enter user name: **anonymous**
Enter password: BITRONICS (Any password will work)
FTP> **binary**

Some Operating Systems default to ASCII mode for FTP. Entering "binary" ensures that the FTP connection will be in the binary mode necessary for communicating with the 878.

As shown above, the user specifies the IP address of the server, enters a username and password, and then is presented with the FTP prompt awaiting commands. The following commands are useful for communicating with the 878.

Command	Function
BINARY	Changes FTP to binary mode
CD..	Change current directory to parent directory
CD directoryname	Change current directory to directyname
DELETE filename.ext	Delete file from Server
DIR filename.ext	List directory contents
GET source file destination file	Read file from 878
PUT source file destination file	Write file to 878
QUIT	Exit FTP server and return to command prompt

Refer to your local operating system documentation for more details.

5.5.1b 878 FTP Implementation

The 878 FTP server has three privilege levels that determine the allowed FTP operations.

Description	Username	Password
Read files within the C:\DATA directory	“anonymous” or “guest”	Any
Read files on any drive or directory	Drive\directory	Level 0
Read, Write, or Delete files on any drive or directory	Drive\directory	Level 2

Access to Levels 1 and 2 require the user to enter the starting (root) directory as the "User Name". For this purpose, the drive name is treated as a directory. The entire "c" drive would be accessed by entering a User Name of "c" and the appropriate password. Access to a subdirectory, for example the configuration files, is obtained by entering a User Name of "c:config" and the password. Note that the FTP protocol does not allow access above the root directory.

The 878 will remotely restart if the file "c:\upload\restart.now" is written. Restart begins about 12 seconds after the file has been created.

It is recommended that FTP be operated in passive mode. The port numbers used are 20 and 21 (TCP).

Please consult customer service for information on using FTP for updating the 878 firmware or BIOS.

5.5.2 Zmodem, TELNET, and Command Line Interface

878 files may be written, read, and deleted by use of Zmodem and the Host module front panel serial ports (Section 3.1.1). Using the 70 Series Configurator, make sure the serial port you wish to use is set to Zmodem. By default, ports P1 and P4 are set to Zmodem @ 9600 Baud (Section 3.1.1b). Connect a terminal, or the serial port of a PC running a terminal emulator program (such as HyperTerminal™), to the serial port of the 878 configured for Zmodem. Make sure the terminal emulator is set-up to connect directly to the serial port of the PC, and that the baud rate matches that of the 878 port. Allowable commands are:

Service Port/Zmodem Commands			
c:	display off	receive	type
cd	exit	reset	trigger dr1
chp1	getlog	router	trigger dr2
chp2	Goose*	send	trigger wv1
d:	ip	serial	trigger wv2
date	mac	setlog	ver
del	nsap	software	vio point
dio point	password	status	whoami
dir	pulse	subnet	
display on	reboot	time	

Note: * This command is for UCA Goose only and is now referred to as GSSE.

NOTE 1: When connected to the 878 with a terminal emulator program, remember that the commands you type are operating on the 878, not the PC. The terms "RECEIVE" and "SEND" are therefore from the perspective of the 878.

NOTE 2: The location of files to be sent to the 878 from the PC must be set in the terminal emulator program.

NOTE 3: The RECEIVE command must be used before telling the terminal emulator program to transfer a file to the 878.

NOTE 4: Some terminal emulator programs cannot transfer more than one file using the "RECEIVE" command.

NOTE 5: For a complete list of commands, type “help” at the command prompt. For help with a specific command, type “help” followed by the command (i.e. “help send”).

5.6 IRIG-B

5.6.1 Overview

There is a great need in many power measurement and power quality applications for synchronizing numerous instruments from various manufacturers to within fractions of a second. These applications include failure analysis, sequence of event recording, distributed fault recording, and other synchronized data analysis. One means of synchronizing various instruments to the same clock source is to connect them to a master time device that generates a standard time code. This scheme can be expanded upon such that two devices half a world apart could be synchronized to within fractions of a second if each is connected to an accurate local time master.

There are several vendors who manufacturer these master time devices and there are many standardized time synchronization protocols. IRIG-B is one of the more commonly supported standard time code formats.

5.6.2 Introduction to IRIG Standards

IRIG (InteRange Instrumentation Group) standards consist of a family of serial pulse time clock standards. These standards were initially developed for use by the U.S. Government for ballistic missile testing. There are several Time Code Formats within the family such as A, B, E, G, and H. Each Time Code Format has its own unique bit rate.

There are sub-variations within each Time Code Format that specify the Format Designation, the Carrier/Resolution, and the Coded Expression formats. All standard IRIG serial time standards use the IRIG B000 configuration.

The first letter following IRIG specifies the Time Code Format and Rate Designation. The first number following the letter specifies the Format Designation, the second number specifies the Carrier/Resolution, and the third number specifies the Coded Expressions.

The 878's IRIG interface recognizes and decodes the following standard IRIG formats: IRIG B000, IRIG B002, and IRIG B003. Additionally, IRIG B120 and IRIG123 formats are recognized when using the M87x Modulated IRIG-B Converter, part number M870-MODIRIGBCV, connected to one of the Host module serial ports, P2, P3 or P4.

5.6.2a Time Code Format (Rate Generation)

There are six different IRIG Time Code Formats. The 878 supports Time Code Format B. Time Code Format B specifies a 100-bit frame and a 1 second time frame (10 milliseconds per bit). The 100 bits consist of:

- 1 - time reference bit,
- 7 - BCD bits of seconds information,
- 7 - BCD bits of minutes information,
- 6 - BCD bits of hours information,
- 10 - BCD bits of days information,
- 27 - optional control bits,
- 17 - straight binary bits representing seconds of day information
- 15 - index bits
- 10 - position identifier bits

5.6.2b Format Designation

There are two IRIG Format Designations:

- 0 - Pulse Width Coded
- 1 - Sine Wave, Amplitude Modulated.

The Pulse Width Coded format is essentially the envelope of the Amplitude Modulated format. The 878 supports the Pulse Width Coded format. The M87x Modulated IRIG-B Converter, part number M870-MODIRIGBCV, is necessary when connecting an IRIG-B signal of Amplitude Modulated format to one of the serial ports, P2, P3, or P4, on the 878.

5.6.2c Carrier/Resolution

There are six IRIG Carrier/Resolutions:

- 0 - No Carrier/Index Count Interval
- 1 - 100 Hz/10 ms
- 2 - 1 kHz/1 ms

3 - 10 kHz/0.1 ms
4 - 100 kHz/10 µs
5 - 1 MHz/1 µs

Since the 878 does not support the Sine Wave Amplitude Modulated Format Designation, only the No Carrier/Index Count IRIG Carrier/Resolution is applicable, when connected to an IRIG-B master using Pulse Width Coded Format. The M87x Modulated IRIG-B Converter serves as the signal demodulator, essentially converting from sine wave modulated into pulse width coded format.

5.6.2d Coded Expressions

There are four IRIG Coded Expressions:
0 - BCD, CF, SBS
1 - BCD, CF
2 - BCD
3 - BCD, SBS

The 878 only uses the BCD portion of the expression and as a result can accept any of the standard IRIG Coded Expressions.

5.6.3 878 IRIG-B Implementation

The 878 receives the IRIG-B serial pulse code via the serial ports on the Host CPU module (Section 3.1.1). The IRIG-B signal is decoded by the Host CPU module, and the resulting IRIG time is compared to the 878's time. The 878 processes the time errors and corrects its local time to coincide with the IRIG time.

5.6.3a 878 IRIG-B Receiver

As previously mentioned, the 878 receives the IRIG-B signal via the standard serial ports located on the Host CPU's front panel (Section 3.1.1). Port P2, P3, or P4 can be configured to accept IRIG-B. The ports can be configured via the 70 Series Configurator software utility.

5.6.3b 878 IRIG-B Decoder

The 878 IRIG Decoder parses the bit stream from the IRIG Receiver into registers that represent the number of days, minutes, and seconds since the beginning of the present year. The control bits and straight binary seconds portion of the IRIG pulse stream are ignored. The 878 transducer compares its present time to the IRIG time and stores the delta time error. These errors are calculated every IRIG frame (every second) and are accumulated into a sample buffer until the sample buffer is full. Once the buffer is full, the buffer is passed to the IRIG Time Qualifier.

5.6.3c 878 IRIG-B Time Qualifier

The 878 IRIG-B Time Qualifier processes the sample buffer of time errors from the IRIG-B Decoder. If the IRIG-B Time Qualifier detects several sequential time errors greater than 3 seconds, the IRIG-B Time Qualifier forces the 878 to immediately "jam" its clock to the present IRIG-B time.

If the time errors are less than 3 seconds, the IRIG-B Time Qualifier examines all the errors in the sample buffer. The error data is subjected to various proprietary criteria to determine an accurate time offset. If the sample buffer does not meet the qualifying criteria the sample buffer is discarded and no clock correction is performed. The IRIG-B Time Qualifier continues to examine and discard sample buffers from the IRIG-B Decoder until it finds one that meets the accuracy qualifications.

Once a sample buffer is qualified, the IRIG-B Time Qualifier calculates a clock correction value and slews the 878's clock to match the IRIG-B time. The slew time depends on the magnitude of the clock correction. The time required to slew the 878's clock to match the IRIG time is approximately 30 times the clock correction value.

Slewing the clock ensures that time always moves forward. The clock may speed up or slow down to attain proper synchronization, but it never moves backward. This ensures that the ordering of events is always preserved while changing the clock. Ordering of events cannot be guaranteed when the clock is jammed.

The IRIG-B Decoder does not sample the IRIG bit stream and build a sample buffer while the 878 clock is slewing. All IRIG frames received during the 878's clock slew are ignored until the slew has completed.

5.6.4 Determining the Correct Year

The IRIG-B standard provides days of year, minutes of day, and seconds of minute information. The IRIG standard does not provide any year information. IEEE-1344 specifies a bit pattern that is encoded into the IRIG control bit steam that specifies year information. The 878 IRIG driver is capable of decoding the IEEE-1344 year information from the control bits when connected to an IEEE-1344 compatible IRIG master. If the IRIG master that is connected to the 878 is not IEEE-1344 compatible, the IEEE-1344 compatibility configuration switch in the 878 COM port configuration should be turned off. This will prevent the 878 from incorrectly interpreting the control bits as year information.

If the IRIG master is not IEEE-1344 compatible, the 878 assumes that the year stored in its non-volatile capacitor backed-up clock is correct. If the 878 back-up clock fails or the 878's year is incorrectly set, the IRIG-B Driver will assume that the year is the year reported by the 878's clock..

If the 878 is connected to an IRIG master that is not IEEE-1344 compatible and the year reported by the 878's clock is incorrect, the IRIG Driver may also set the 878's day incorrectly (due to leap year) when it tries to synchronize the device time to the IRIG time. The time, however, will still synchronize correctly. As a result, if the 878's backup fails (or the year was not set correctly), any data time-stamped by the 878 or any waveform captures stored may have the wrong year and day but will have the correct time accurate to several microseconds. This data can still be synchronized to other events from other devices by simply adding the correct day and year offsets to the time.

5.6.5 Methods of Automatic Clock Adjustments

The automated clock adjustments controlled by the IRIG interface include “jamming” the clock and “slewing” the clock. Depending on the magnitude of the 878’s absolute clock error the clock adjustment algorithms will either jam the clock by directly writing a new value into the clock registers or slew the clock smoothly by adding or subtracting small adjustments to the clock registers over a period of time.

5.6.6 Types of 878 Clock Synchronization

There are various degrees (or states) of time synchronization. Upon power up, the device relies on the value stored in the capacitor backed-up clock to set the correct time, and the crystal frequency correction constant stored in non-volatile memory to correct the crystal’s frequency. The 878 will keep time starting from the values read from the clock. There will be an accumulated time error based upon the frequency error of the Real Time Clock crystal. The crystal frequency correction constant provides a means for correcting for this error. If the 878 was never synchronized to an external source (i.e. IRIG-B or network synchronization protocol), the 878 will not have a value for the crystal frequency correction constant and the crystal error will be the 878’s clock error.

5.6.6a Frequency Adjustments and Free Wheeling

The 878 has the capability to add a correction factor to compensate for the crystal’s effective frequency error rate. This frequency adjustment is accomplished by first determining the crystal’s error rate and then correcting the clock to reflect that error. The IRIG-B interface serves as an external accurate time source to determine the crystal’s typical error rate. The frequency error is calculated and stored in non-volatile memory on the 878’s Host CPU board.

When an 878 is connected to an IRIG-B source, it will automatically calculate and store the crystal’s error in non-volatile memory on the Host CPU board. 878 transducers utilize this constant to maintain a more accurate clock. If the IRIG-B source is removed the 878 will no longer receive time corrections from the IRIG-B source, but the device clock will keep much better time due to the frequency correction constant. This mode of operation is referred to as “Free Wheeling.”

Although “Free Wheeling” with constant frequency compensation provides a more accurate 878 clock, it will still drift and is less accurate than having a constant IRIG-B source connected to the 878. The frequency error of the crystal will change with time and temperature. Having a permanent real time IRIG-B clock source allows for constant minute adjustments to the 878 clock.

5.6.6b Permanent IRIG-B Source Connection

Having a permanently connected IRIG-B source provides the most accurate 878 clock. In addition to correcting the frequency for the crystal error, the 878 will constantly receive corrections to compensate for any drift that may still occur. This provides for a typical clock error of less than 10 microseconds.

5.6.7 Stages of IRIG-B Synchronization and Accuracy

There are four basic stages of synchronization with an IRIG-B source: power-up, time lock, frequency lock, and final lock.

5.6.7a Power-Up Stage

Upon Power-up, the 878 obtains the time from its non-volatile capacitor backed-up clock. This clocks resolution is limited to seconds. Therefore, even if the clock was error free when it was turned off, the 878 could have an error of up to one second when it is powered-up. As mentioned previously, the typical crystal error rate is about 50 microseconds per second (50ppm). Therefore, if we assume that the 878 clock was keeping perfect time before it was reset (or powered down), it would typically be in error by:

(50 microseconds) x (number of seconds off) + 0.5 seconds after power is restored.

The 878 would start with this error and continue to drift by the frequency offset error. If the 878 were never connected to an IRIG-B source (or other clock synchronizing source), the drift would be equal to the crystal's frequency error. If the 878 previously stored a frequency correction constant in non-volatile memory, the device will include the compensation and drift by a smaller amount equal to the true crystal frequency error minus the correction constant.

5.6.7b Time Lock Stage

Once the 878 begins to receive IRIG-B frames, validates a sample buffer, and calculates a clock correction value, it will enter the Time Lock Stage of synchronization. If the clock correction value exceeds 120 seconds, the clock is jammed with the present IRIG-B time. Otherwise, the 878 clock is slewed to match the IRIG-B time.

The accuracy of this initial slew depends on whether a frequency correction constant was previously stored in non-volatile memory, and if so how accurate the constant is. The 878 will use this constant in the slew calculation to approximate the rate to change the clock to adjust to the specified IRIG-B correction error.

The 878 will remain in the Time Lock Stage for approximately five minutes plus the time required to perform the initial clock slew. The clock slew requires approximately 30 times the clock correction value. For example, if the initial clock correction error was 1.5 seconds, the Time Lock Stage would require approximately 6 minutes (5 minutes plus 45 seconds to slew).

The 878 enters the Frequency Lock Mode after completing the first IRIG-B clock correction. The M87x's clock is typically synchronized to within 1 millisecond of the true IRIG-B time after the Time Lock Stage is completed.

5.6.7c Frequency Lock Stage

The 878 enters the Frequency Lock Stage of synchronization when it receives the third valid clock correction value from the IRIG-B interface. At this time the 878 calculates a crystal frequency correction constant based on the clock correction value. The crystal frequency correction constant is stored in non-volatile memory to provide improved clock accuracy during "Free Wheeling" . The crystal frequency correction constant along with the clock correction value is used to slew the clock to synchronize to the IRIG-B source.

The Frequency Lock Stage requires approximately five minutes. Once the 878 slews its clock with the correct crystal frequency correction constant, the 878's clock is typically synchronized to within 50 microseconds of the IRIG-B time source. The M87x then enters the Final Lock Stage of synchronization.

5.6.7d Final Lock Stage

In the Final Lock Stage of synchronization, the 878 typically receives clock correction values from the IRIG-B interface every five minutes. The 878 continues to make slight adjustments to its crystal frequency correction constant to accommodate for small frequency drifts due to age and temperature. At this point, the 878 clock is typically synchronized to within less than 10 microseconds of the IRIG-B source.

5.6.8 Notes On Operation

1. A new crystal frequency correction constant will be written to non-volatile memory every four hours while a valid IRIG-B connection exists.

2. The capacitor backed-up clock will be corrected every hour while a valid IRIG-B connection exists.

3. Network Time Synchronization requests are refused while a valid IRIG-B connection exists.

5.6.9 IRIG-B Electrical Specifications

Absolute Maximum Input Voltage:	-25 Volts to +25 Volts
Receiver Input Threshold Low:	0.8 Volts (min)
Receiver Input Threshold High:	2.4 Volts (max)
Receiver Input Hysteresis:	0.6 Volts (typical)
Receiver Input Resistance:	5 kΩ (typical)

5.6.10 IRIG-B Port Wiring Instructions (Pulse Width Coded, IRIG-B master, Demodulated)

The IRIG-B master can be connected to Ports P2, P3, or P4 of the 878's Host CPU module when IRIG-B signals of format IRIG B000, IRIG B001, or IRIG B003 are used. The selected Port must be configured for IRIG-B via the 70 Series Configurator software utility. To connect the IRIG-B master to a Port (Figure 3, pg. 20):

- Connect the IRIG-B signal to terminals 2 and 4.
- Connect the IRIG-B signal common to terminal 6.
- Terminal 5 provides a connection to earth ground via a 100Ω resistor for shielding.

5.6.11 Modulated IRIG-B

The 878 may be used with Modulated IRIG-B systems, provided that the external Modulated IRIG-B adapter is used (P/N M870-MODIRIGBCV)

5.6.12 Setup Instructions for Use of the M87x Modulated IRIG-B Converter (Sine Wave, Amplitude Modulated, IRIG-B master)

The M87x Modulated IRIG-B Converter is a demodulating adapter used with the 878 Host module for connection from an IRIG-B master that uses an amplitude-modulated sine wave, and meets one of the input formats specified below. The setup required in order to use the M87x Modulated IRIG-B Converter is described by the following information, which includes the Converter specifications:

Input impedance:	>10KΩ
Input Format :	IRIG-B120, B123, 1kHz modulated sine wave, amplitude 3Vpp – 10Vpp, modulation ratio 3:1
Power:	Supplied by 878 serial port
Time skew:	600 µsec.
Use:	Plug Converter into 878 serial port (P2, P3, or P4). Fasten Converter to the 878 by tightening 2 hold down screws. The recommended torque rating is 2.2 In-Lbs, 0.25 N-m. Connect BNC to clock source.
Configuration:	On the “Port Assignment” page (previously “serial port” tab) set the appropriate port to IRIG-B. On the IRIG-B page set the Absolute Time Offset to 620 µsec. (This offset value includes the 600 µsec time skew attributed to the converter). The number used for the Absolute Time Offset may need to be increased, depending on time skew contributed by clock source and cable lengths. The remaining items on the IRIG-B page can initially be left at the default values. If there are problems with acquiring synchronization with the IRIG-B source, turning on the debug messages may help in diagnosing the problem. (Refer to section 3.1.1a; Debug messages are turned on when service port P1 is running in logging mode). Depending on the installation it may be necessary to relax some of the qualifying parameters to achieve synchronization. If necessary, first increase the Max Skew setting from 5 µsec to 8 – 10 µsec. If this does not help it may be necessary to reduce the Quality Factor from 0.7 to 0.5 or less.

5.7 Time Sync & Setting

The 70 Series IED utilizes an on-board clock to time stamp communications, SOE Log entries, and data samples in the Waveform, Disturbance, and Trend Recorders. A variety of external references may be used to synchronize the on-board clock to either local or Universal Coordinated Time (UTC) with a high degree of accuracy.

5.7.1 Time Sync Status Registers

Pre-defined status registers indicate the current state for each of the various time synchronization methods used in 70 Series IEDs
The following time sync registers will return status values of '0' if a time sync master is inactive and '1' if a time sync master is active:

Status Registers
IrigB Time Sync
Network Time sync *(UCA)*
SNTP Time Sync
DNP Time Sync

The 70 Series DNP and Modbus manuals define the status register locations within Appendix B for these time sync status points.

5.7.2 Manual time setting by Command-Line instruction

The command-line instruction is the manual method for setting the IED clock through service port P1. The "time" instruction in the command-line interface is used to set time for the IED's internal clock. Refer to section 3.1.1a in order to set the IED clock.

5.7.3 Unsolicited DNP Time set (DNP master sets the IED clock)

DNP Time set is supported by the 70 Series IED. The IED clock simply free-wheels at its characteristic rate between DNP time updates. Each DNP set-time instruction simply "sets" the clock as it is received. Setting the clock via DNP supersedes any other time-sync method that might be in use.

5.7.4 IRIG-B Time sync (time-synchronization via dedicated IED port)

Detailed information on IRIG-B time sync can be found starting in section 5.7. IRIG-B is expected to produce the greatest accuracy relative to other time sync methods currently supported. A status bit, named 'IrigB Time Sync', is set to indicate the IED is being synchronized via IRIG-B as long as the IED continues to receive valid IRIG updates. While this bit is set, time-sync signals received from *(UCA)* Network Time Sync, SNTP, and Requested DNP are ignored.

It should be noted that the IED host is not able to distinguish between the Modulated and Unmodulated IRIG-B signals applied to the input port. Demodulation is accomplished by a dedicated circuit. The host processor makes no determination as to which type of external IRIG-B signal is applied. Unmodulated IRIG-B would provide a slightly more accurate time signal then Modulated IRIG-B, due to additional time latency that is introduced in the de-modulation process.

5.7.5 *(UCA)* Network Time Synchronization - time synchronization over Ethernet

The 878 real-time clock may be synchronized to a UCA network time-sync master. The network time sync functions as described in IEEE TR-1550 Part 2 Appendix B and is roughly analogous to the IRIG-B described in Section 5.6, in that the 878 continually "trains" it's internal clock to eliminate errors. An algorithm progressively adjusts the on-board clock to improve its accuracy with subsequent time updates received from the master. This allows the 878 to "Free Wheel" accurately in the event the UCA network time-sync master is unavailable.

5.7.6 SNTP (Simple Network Time Protocol) - time synchronization over Ethernet

Time synchronization is supported using SNTP (Simple Network Time Protocol); this protocol is used to synchronize the internal real time clock in substation devices, (i.e., control systems, relays, IEDs). Up to 2 SNTP servers, using optional many-cast (or any-cast) mode of operation, are supported, along with configurable polling times. SNTP servers can be polled for configurable time, but only one at a time.

The SNTP page in 70 the Series Configurator software tool allows the user the option of selecting which tool will be used to load the SNTP (and IP) settings. Radio buttons are provided for that purpose. SNTP (and IP) settings can be loaded from either the 70Series Configurator (INI file) or the IEC61850 IED Configurator (MCL file). When using the 70Series Configurator, the initial default configuration will load SNTP settings from the 70Series Configurator (INI file). If IEC61850 protocol is used, it is possible for the user to change the radio button selected in order to indicate that the IEC61850 IED Configurator (MCL file) be used to load these settings instead. If the settings on the 70Series Configurator SNTP page grey out, it is an indication that the SNTP server addresses may have been set through the other Configurator's software.

Additionally on the SNTP page of the 70 Series Configurator software, the user may specify that an offset from the SNTP server time be applied when synchronizing. A common use for this feature is to allow the 70 Series device to operate in local time when synchronizing with an SNTP server operating in UTC time. To further support local time, the application of Daylight Savings adjustments may also be configured.

5.7.7 DNP Time sync (slave requesting DNP time be set)

A slave may request thatDNP time be set in order to have the DNP master set the DNP time.

5.8 Automatic Event Notification

The 70 Series is capable of sending an Automatic Notification via email, or over a serial port. The action of automatic notification may be selected in response to any of the available triggers, similar to triggering a recording or activating an output contact. The type of notification (email or serial) is selected in the "Automatic Notification settings" page of the Configurator.

5.8.1 Email Notifications

A valid SMTP (email) server IP address must be entered. This server must exist on the local network in order for emails to be sent. Email addresses can then be entered for up to 3 users.

5.8.2 Serial Notifications

The 70 Series can be configured to send text strings out a serial port P2 or P3. These text strings can be used for various purposes, including operating a modem. This could be used to send a page to a numeric pager, for example.

5.8.3 Data Sent

The 70 Series meter will send the user-configured string out the specified COM port. It is the user's responsibility to ensure the string is properly formatted to communicate through any port switches, modem switches, and/or modems. The user is also responsible for ensuring the string specified is meaningful to the user or device that will be receiving it.

If the 70 Series meter is not configured to have a COM port send notifications, then no serial notifications will be sent.

If the 70 Series meter has multiple COM ports configured to send notifications, then the notifications will be sent out each port configured for notifications.

5.8.4 Error Recovery

There is no provision to confirm that a message has been successfully transmitted to an end user or device. There may be a busy signal, an answering machine may take the call, or another device may be using the phone line.

5.8.5 Example

Here is an example of a string that can be configured to send the numeric message 123 to a pager with the phone # 610-555-1212, and then hang up:

ATDT6105551212,,,,,,,,,123,,,,ATH<cr>

Note that it is typically important to enter the <cr> (carriage return character) for the string to be properly recognized by the modem. Information on modem control characters is available from your modem manufacturer.

5.8.6 Control Characters

Control characters can be entered in the Configurator by typing "\x" followed by the hexadecimal representation of the ASCII code for the desired character. For example, the control-Z character is represented by a hexadecimal 1A; therefore, “\x1a” should be entered into the serial data string where a control-Z is desired.

If the characters “\x” are desired to appear in the serial data string rather than a control character, then this special sequence can be escaped by entering “\\x”. The characters “\x” will appear in the serial data string.

6.0 POWER SUPPLY V10

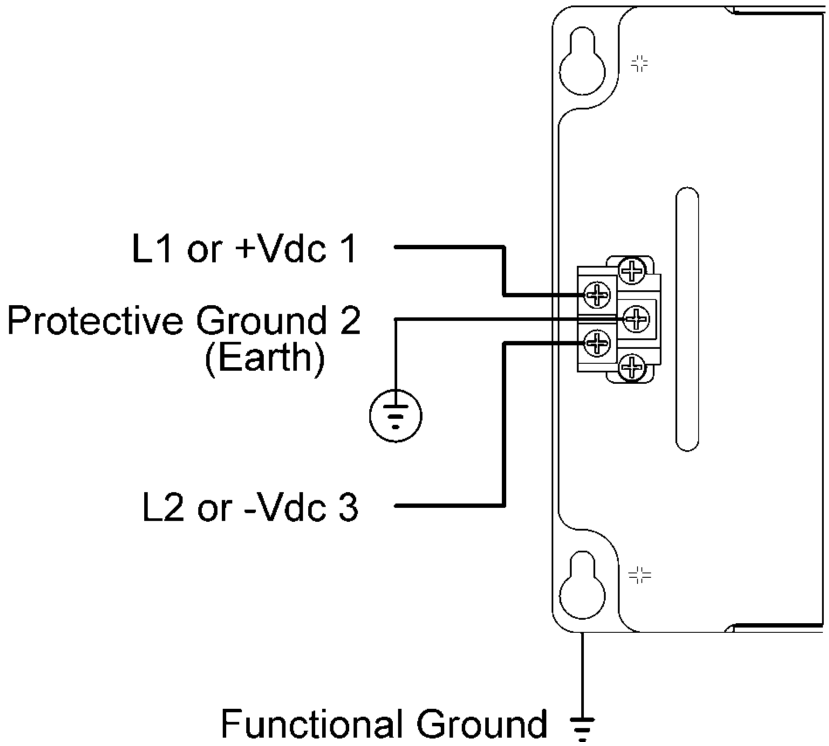


Figure 7 - Power Supply Connections

6.1 Introduction

The V10 power supply can operate from any voltage between 20-300Vdc or 55-275Vac (45-65Hz). It is therefore possible to power the 878 with AC or DC station power or an auxiliary VT, provided the voltage remains above 55Vac or 20Vdc. The power supply creates 3.3V, 5V, and +/-12Vdc outputs and consists of an isolated flyback converter that provides at least 12.5W of output power at 3.3Vdc and/or 5Vdc.

6.2 Features

- 25W minimum output power from the combined 5V and 3.3V supplies.
- +/-12Vdc capable of delivering up to 500mA.
- Standard cPCI power connector.
- Removable terminal block accepts bare wire or terminal lugs.
- 5Vdc and 3.3Vdc power indicator LEDs.

6.3 Specifications

Input (Auxiliary) Voltage

Nominal: 24-250Vdc, 69-240Vac (50/60Hz)

Operating Range: 20-300Vdc, 55-275Vac (45-65Hz)

Output Voltage: 3.3Vdc, 5Vdc, and +/-12Vdc

Maximum Output Power and Current (5V and 3.3V supplies are independent):

Nominal	Max Output Power			Max Output Current		Min Interruption Ride-Through*
Vin	3.3V	5V	Total	3.3V	5V	ms
24Vdc	12.5W	12.5W	25W	3.75A	2.5A	2.5ms
48Vdc	17.5W	17.5W	35W	5.3A	3.5A	6.5ms
69Vac	17.5W	17.5W	35W	5.3A	3.5A	10ms
125Vdc	17.5W	17.5W	35W	5.3A	3.5A	35ms
120Vac	17.5W	17.5W	35W	5.3A	3.5A	50ms
250Vdc	17.5W	17.5W	35W	5.3A	3.5A	140ms
230Vac	12.5W	12.5W	25W	3.75A	2.5A	220ms
240Vac	12.5W	12.5W	25W	3.75A	2.5A	230ms

* M871 -V10 -S10 -H10 -A10 -P11 -P30 (all relays energized)

The +12Vdc output is derived from the 3.3Vdc output, and the -12Vdc output is derived from the 5Vdc output. The +/- 12Vdc outputs are capable of providing up to 500mA, however, they must be de-rated to avoid exceeding the maximum power limits of the 3.3Vdc and 5Vdc outputs respectively.

6.3.1 Environmental

Operating Temperature: -40C to 70C

Relative Humidity: 0-95% non-condensing

Installation Category: IC III (Distribution Level), Pollution Degree 2. *Refer to definition on page 8.*

6.3.2 Physical

Input Connections: Removable terminal block accepts #26-12 AWG (0,15-3,3mm^2) wire, or terminal lugs up to 0.325" (8,25mm) wide. Recommended minimum wire size is #18 AWG (0,5 mm^2). Recommended Torque Rating for the terminal block wire fasteners is 10 In-Lbs, 1.13N-m. Precautions must be taken to prevent shorting of lugs at the terminal block. A minimum distance of 0.1” (2.5mm) is recommended between un-insulated lugs to maintain insulation requirements. Standard 0.200" (5,08mm) header socket accepts other standard terminal types.

Backplane Connections: Standard cPCI-specified power connector

6.4 Power Supply and Protective Ground (Earth) Connections

Power and chassis ground is applied to three screws on a barrier strip on the front of the Power Supply input module. **Connection of the chassis ground is required (see Section 2.3)**. There are two chassis ground points that **MUST** be connected to Earth Ground. One is the Protective Ground (Earth) terminal (terminal 2) on the Power Supply input, and the other is the mounting flange. Bitronics LLC recommends that all grounding be performed in accordance with ANSI/IEEE C57.13.3-1983.

6.5 Overcurrent Protection

To maintain the safety features of this product, a 3 Ampere time delay (T) fuse must be connected in series with the ungrounded/non-earthed (hot) side of the supply input prior to installation. The fuse must carry a voltage rating appropriate for the power system on which it is to be used. A 3 Ampere slow blow UL Listed fuse in an appropriate fuse holder should be used in order to maintain any UL product approval.

6.6 Supply/Mains Disconnect

Equipment shall be provided with a Supply/Mains Disconnect that can be actuated by the operator and simultaneously open both sides of the mains input line. The Disconnect should be UL Recognized in order to maintain any UL product approval. **The Disconnect should be acceptable for the application and adequately rated for the equipment.**

7.0 ETHERNET MODULE P10, P11, P12 OR E1, E3 OPTION WITH H12 HOST

7.1 Introduction

The CompactPCI™ high-speed Ethernet interface is available as an option for the M87x as either a stand-alone module when used with the H11, or consolidated with the H12 host module (H12E1 or H12E3). Both the stand-alone board and the consolidated options meet or exceed all requirements of ANSI/IEEE Std 802.3 (IEC 8802-3:2000) and additionally meet the requirements of the EPRI Substation LAN Utility Initiative "Statement of Work" version 0.7. The Ethernet interface is also compliant with IEC 61850 Part 3 and Part 8-1 TCP/IP T-profile for physical layer 1 (Ethernet copper interface) and physical layer 2 (for P12 with 100 Megabit fiber). These documents define an interface designed to inter-operate with other devices with little user interaction ("Plug-and-Play").

M87x instruments with the H11 host module are offered with three versions (P1x) of the Ethernet interface board:

- The P10 features a 10/100 Megabit (Mb) RJ45 (copper) interface (10BASE-T and 100BASE-TX) which automatically selects the most appropriate operating conditions via auto-negotiation.
- The P11 has the features of P10 plus a 10 Mb fiber-optic port (10BASE-FL) operating at 820 nm (near infra-red) using ST connectors.
- The P12 has the features of P10, plus a 100 Mb fiber-optic port (100BASE-FX) operating at 1300 nm (far infra-red) using ST connectors.

All interfaces are capable of operating either as half-duplex (compatible with all Ethernet infrastructure) or full-duplex interfaces (which allow a potential doubling of network traffic). Note that only one port may be connected to a network at one time.

With the H12 host module, the E1 consolidated option mirrors the functionality and performance of the P10, while the E3 option performs like the P12 module.

The 70 Series IEDs come preconfigured for TCP/IP interface with an IP address, a SUBNET mask, and a ROUTER (GATEWAY) address. They also have a preconfigured NSAP address for an OSI network. It is very important that the network have no duplicate IP or NSAP addresses. Configuration of these addresses may be accomplished by using UCA, by using the 70 Series Configurator, or via a front panel serial port using a terminal emulator such as HyperTerminal™ or ProComm™. Please refer to sections 3.1.1 and 5.5.2 that provide additional information and commands for changing these addresses.

If using the IEC61850 protocol the IP address may be configured from either the 70 Series Configurator software or from the IEC61850 IED Configurator software. A user radio button selection is provided on the 70 Series Configurator Identity page, giving a user the flexibility to decide which software tool will control the IP address configuration setting, which is loaded upon reboot. IP address configuration settings will be stored in either the INI file or MCL file. The INI files are loaded by the 70 Series Configurator and the MCL file is loaded by the IEC61850 IED Configurator.

The units are pre-configured for TCP/IP with an IP address/subnet mask/gateway address of:

192.168.0.254 / 255.255.255.0 / 192.168.0.1

and for OSI with an NSAP of:

49 00 01 42 49 09 01 01

The 70 Series IEDs use the following port numbers for each type of protocol:

PROTOCOL	PORT NUMBER
DNP	20000 (TCP, UDP)
FTP (recommend passive mode)	20, 21 (TCP)
Modbus	502 (TCP)
MMS (UCA & 61850)	102 (TCP)
SMTP (electronic mail)	25 (TCP)
SNTP (network time sync)	123 (UDP)
Telnet	23 (TCP)

7.2 Features

- 10/100 Megabit auto-negotiable copper interface with RJ-45 connector (P1x, E1, E3).
- Optional 10 Megabit fiber optic interface with ST connector for 62/125um glass fiber (P11)
- Optional 100 Megabit fiber optic interface with ST connector for 62/125um glass fiber (P12 and E3)
- Compliant to IEEE 802.3-1996 and IEEE 802.3u-1995
- Compliant to UCA Utility Initiative Statement Of Work Rev 7
- Compliant with IEC61850 Part 3 and Part 8-1 TCP/IP T-profile physical layer option 1 (copper)
- Compliant with IEC61850 Part 3 and Part 8-1 TCP/IP T-profile physical layer option 2 (100 Mb fiber - P12 only).
- Fully automatic port switching with manual override capability
- Six indicator LEDs (P1x)/Two indicator LEDs (E1, E3)
- Protected, utility-grade copper interface

7.3 Specifications (For P1x Modules Unless Otherwise Noted)

Ethernet Connection:

(-P10/ E1) 10/100 Megabit (Mb) RJ45 (copper) interface (10BASE-T and 100BASE-TX)

(-P11) 10/100 Megabit (Mb) RJ45 (copper) interface (10BASE-T and 100BASE-TX) 820 nm 10 Mb fiber-optic port (10BASE-FL).

(-P12/E3) 10/100 Megabit (Mb) RJ45 (copper) interface (10BASE-T and 100BASE-TX) 1300 nm 100 Mb fiber-optic port (100BASE-FX).

Indicator LEDs:	P1x: Link, 10/100Mb, Collision, Duplex, Transmit, Receive E1: Activity, Link; E3: Activity, Duplex
Bus Interface:	Standard 5V CompactPCI™ Backplane
Power Requirements:	50mA @ 3.3Vdc and 500mA @ 5Vdc (supplied from backplane)
Hot Swap (P1x only):	Complies with Hot Swap specification PICMG 2.1 R1.0 for Basic Hot Swap (requires Host Processor re-boot).

This product contains fiber optic transmitters that meet Class I Laser Safety requirements in accordance with the US FDA/CDRH and international IEC-825 standards.

7.4 Environmental

Operating Temperature:	-40 to 70C
Relative Humidity:	0-95% non-condensing
Installation Category:	IC III (Distribution Level), Pollution Degree 2. *Refer to definition on page 8.*

7.5 Physical

Connections:	RJ45 (copper), ST connectors (62/125um glass fiber)
Package:	CompactPCI™ (3U, 4HP) removable module (P1x only) Option integrated into H12 host module (E1, E3 options)

7.6 Hot Swap (HS) Compatibility (P1x Modules)

The blue Hot Swap LED located on the front panel is illuminated to indicate when it is permissible to extract a board in systems that support the *Full* Hot Swap System Model. The 878 currently supports the *Basic* Hot Swap System Model. The Basic Hot Swap System Model does not illuminate the blue LED. The blue LED will turn on briefly when a card is inserted into an energized device or when the device is reset. If the blue LED remains illuminated after insertion into an M87x or remains illuminated after the S10 Host module has booted, the associated card is malfunctioning.

7.7 Hardware Configuration

Configuration of the Ethernet interface is not normally required. The 878 is normally able to detect and adapt to any type of equipment attached to it. Under very rare circumstances, the user will need to manually configure the link for P1x modules using a jumper block on the Ethernet interface board. For the vast majority of cases, the factory default jumper settings (which is equivalent to having no jumpers installed) will provide the best possible link speed and reliability. The factory default locations for the two jumpers are 1-2 and 5-6. Section 8.13.1 details other jumper setting suitable for special situations.

7.8 Cabling

The Ethernet interface uses a RJ-45 connector for copper interfaces and ST connectors for the optional fiber interfaces. "Straight-through" copper cables rated Category 5 (Cat5) or above up to 100 meters (328 feet) in length can be used The cable used for the P1x modules MUST be 100Ω STP (shielded twisted pair) for proper EMI/RFI performance. For the E1 or E3 options UTP (unshielded twisted pair) cable is satisfactory for the network connection. If a connection to a non-networked PC is desired, a "cross-over" cable can be used between the Ethernet card and the PC. Category 3 (Cat3) cable is not recommended due to the lack of upgradeability to 100 Mb Ethernet. Fiber-optic cable up to 2000 meters (6500 feet) in length (412 meters or 1350 feet for 100 Mb half-duplex) can be used. The cable should be multimode glass with a 62.5 mm core and 125 mm cladding (62/125), ST connectors for the 878 end and proper terminations for the network end (either ST or SC). The 878 supports only one Ethernet connection.

7.9 Connections

Copper network connections are made by simply plugging in the two cable ends. Ensure that the network end terminates in a port that is not labeled "uplink". An optical connection is made by connecting the TX port of the Ethernet interface to the RX port of the network hub or switch. The RX port then connects to the TX port. Use of external equipment using SC connectors is possible by using properly terminated cable or adapters. A few seconds after connection, green LINK indicators at each device should illuminate to indicate a proper connection has been established.

7.10 Troubleshooting the Connection

If a link is not established, verify that the RX and TX signals are not swapped (either by misapplying a "cross-over" cable or an "uplink" port or swapping the optical cables). If a connection is still not made, refer to Section 7.13.2 for suggestions.

7.11 Indicators

The Ethernet interface has six LEDs for use by users on the P1x modules, but only two LEDs on the E1 or E3 option.

LED			FUNCTION
P1x	**E1**	**E3**	
LK	LNK		Indicates a valid Physical connection. Must be on before any communicates takes place.
100			On when operating at 100 Mb, off for 10 Mb. Valid only when LINK is on.
COL			Flashes when an Ethernet collision occurs. See explanation below.
FULL		FULL	On when operating in full-duplex mode, off for half-duplex.
TX			Flashes when packet is being transmitted
RX			Flashes when any packet is being received (even packets not addressed to this
	ACT	ACT	Flashes activity when packets are transmitted and received

The collision LED, in particular, is a good indication of network health. It lights whenever the M87x and another device attempt to use the link at the same time (by definition, full duplex links cannot have collisions). Collisions are an expected part of normal half-duplex

Ethernet operations and the hardware transparently retries up to 16 times to send the message. If collisions occur more often than about once per second, it indicates a very heavily loaded network which is probably delivering messages late. If a large number of collisions occur, it is suggested that either the network speed be increased to 100 Mb or the hubs replaced with Ethernet switches.

7.12 Software Configuration

The 878 is able to determine the capabilities of the network equipment if the equipment supports auto-negotiation. If auto-negotiation is not supported, the 878 will be able to determine the network speed through a process known as parallel detection, but it cannot determine the duplex capability. In order to allow the 878 to operate in half or full-duplex, the user must supply the choice for the cases where the mode cannot be determined. Each communication protocol will supply a method to individually set the 10 Mb and 100 Mb duplex values for these cases. Half-duplex is always the safest choice since it is compatible with all legacy equipment. Full-duplex allows a potential doubling of the network speed and an extension of the 100 Mb fiber length. Consult your network administrator before setting the duplex configuration to full since this can cause serious network problems if misapplied.

7.13 Technical Details

Bitronics has secured a block of Ethernet addresses from the IEEE. They are of the form:

00-D0-4F-xx-xx-xx

The actual unique 48-bit address is marked on the circuit board above the jumper block.

The remainder of this section may be skipped by casual users and is pertinent only to P1x modules. The Ethernet board uses an AMD 79C972 ("Pcnet Fast+") media access controller (MAC) which interfaces directly to shared PCI memory on the cPCI bus. It interfaces to a National DP83843 ("PHYTER") Physical Layer Controller (PHY) via an on-board MII interface. The PHY interfaces directly to the magnetics module of the copper interface and the 100BASE-FX optical transceiver. It indirectly interfaces to the 10 Mb optics via a Micro Linear ML4669 10BASE-FL to 10BASE-T adapter. The user jumper block connects to the PHYTER AN0/AN1 pins and allows all 9 combinations of these pins to be used. The Ethernet software driver allows access to a modified copy of the 16-bit PHYSTS (PHY status) within the PHY for link type determination.

The Ethernet driver automatically manages link state changes. If the link is ever determined to be lost, it continuously searches for a new link. This search begins by resetting the PHY to allow the jumper block setting to be used. If this fails to provide a link, the PHY is configured to auto-negotiate while advertising all combinations or 100BASE-TX, 10BASE-T, half-duplex, and full-duplex. This will attempt linkage using both auto-negotiation and parallel detection. If this fails and 10BASE-FL is supported, the PHY is reconfigured for forced 10 Mb mode to allow the 4669 to transmit an optical link idle signal (some network vendor’s equipment refuse to generate the optical link idle unless they receive a link idle). If 100BASE-FX is supported, the PHY is reconfigured for forced 100 Mb mode using the PECL signals and an unscrambled data stream.

Once a link is established, the link type is tested. If the link was established through auto-negotiation, which did not provide an indication of duplex capability, it is set according to the user configuration as described in the previous section.

7.13.1 Jumper Settings (P1x)

The jumper block allows setting of the Ethernet card to emulate less capable equipment or to force speed and/or duplex of the network interface. For most systems, the factory default (no jumpers) will provide the best connection. Use of other modes should be done only after careful consideration.

JUMPER			MODE
100FX	AN1	AN0	
none	1-3	none	Force 10BASE-T (or 10BASE-FL) half duplex
none	3-5	none	Force 10BASE-T (or 10BASE-FL) full duplex
none	none	2-4	Force 100BASE-TX (or 100BASE-FX) half duplex
none	none	4-6	Force 100BASE-TX (or 100BASE-FX) full duplex
none	none	none	Auto-negotiate 10BASE-T half+full duplex, 100BASE-TX half+full duplex (FACTORY DEFAULT)
none	1-3	2-4	Auto-negotiate 10BASE-T half+full duplex
none	1-3	4-6	Auto-negotiate 100BASE-TX half+full duplex
none	3-5	2-4	Auto-negotiate 10BASE-T half-duplex + 100BASE-TX half-duplex
none	3-5	4-6	Auto-negotiate 10BASE-T half
7-8	none	2-4	Force 100BASE-FX half duplex
7-8	none	4-6	Force 100BASE-FX full duplex

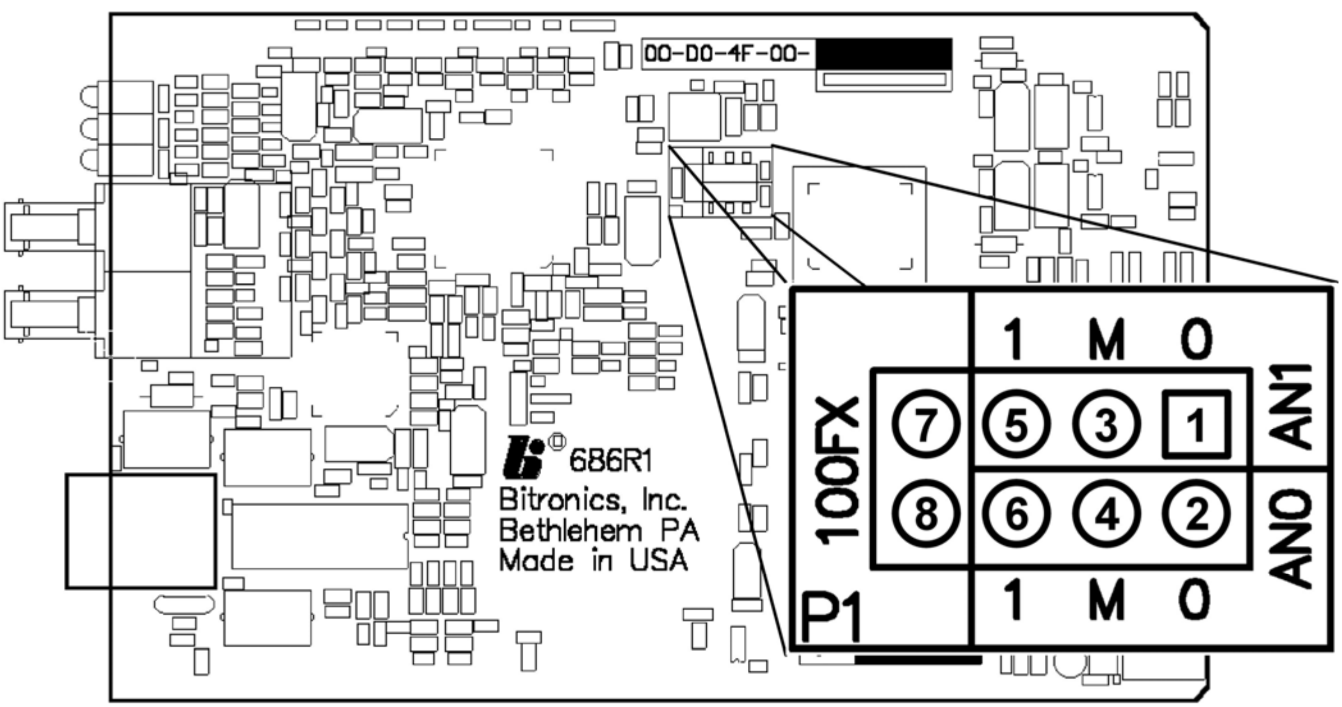


Figure 8 - Ethernet Board Jumper Locations (Rev 1 and Later Boards)

7.13.2 Troubleshooting

If the Link LED fails to illuminate, this is an indication that there is trouble with the connection and communication will not proceed without solving the problem. If a copper connection is used between the 878 and the hub/switch, check the following items:

- Verify that the connectors are fully engaged on each end.
- Verify that the cable used is a "straight-through" cable connected to a "normal" port. Alternatively, a "cross-over" cable *could* be connected to an "uplink" port (this could later cause confusion and is not recommended).
- Verify that both the 878 and hub/switch are powered.
- Try another cable.
- If a long CAT-5 cable is used, verify that is has never been kinked. Kinking can cause internal discontinuities in the cable.
- Try removing the jumpers (the factory default).

If a fiber-optic connection is used:

- Verify that the hub/switch matches the Ethernet card port. A 100BASE-FX port will NEVER inter-operate with the 10BASE-FL port (fiber auto-negotiation does not exist).
- Try swapping the transmit and receive connector *on one end*.
- Verify that the hub/switch uses the proper optical wavelength (10BASE-FL should be 820 nm and 100BASE-FX should be 1300 nm). Note that the Ethernet card may take up to 12 seconds before it enables the 10BASE-FL transmitter, but it leaves the transmitter on for about 5 seconds before giving up.

If a copper connection is used to an off-board fiber converter:

- Verify that the LINK LED on the converter is lit on at least one side. Both sides need to be lit for a valid connection to be established.
- At least one brand of converters will not output an optical idle unless it receives a forced 10 Mb copper link pulse (for some reason, auto-negotiation pulses confuse it). Some hubs/switches will not output an optical idle unless they receive an optical idle. This then inhibits the converter from outputting a copper link pulse enabling the 878 to link. In this condition, no device completes the link. To get around this condition, some device needs to start a valid signal to "get the ball rolling". The 878 Ethernet card can be manually configured via jumpers for either "Force 10BASE-T half duplex" or "Force 10BASE-T full duplex" which guarantees that the converter will see a valid 10 Mb copper link pulse. This then causes it to output an optical idle which the hub/switch turns around to an output optical idle which the converter then turns into a copper idle signal which then allows the Ethernet card to link and everything works. See the above section for the proper jumper settings. This method even works if a fiber-to-copper converter is also used at the hub end (i.e., using copper Ethernet interfaces on both ends with a fiber-optic cable between them).
- Follow the suggestions for the all copper and all fiber system troubleshooting.

If both the LINK LED and the RX LED are both constantly on and the hub/switch indicates that it is not transmitting, the system is in the "false link" state. One known cause is using a non-auto negotiating 100BASE-TX hub/switch and setting the jumpers for "force 10BASE-T" mode. Moving the jumpers back to the factory default locations will cure this problem.

7.13.3 PHYSTS Register Contents (P1x)

The Ethernet software driver supplies to the upper protocol layers a modified copy of the PHYSTS register of the PHY controller chip at the time a link is established. Many of the bits in the register are of no use to the 878 user. Bit 0 is the least significant bit.

BIT	DESCRIPTION
9	1=Auto-negotiation enabled for the 878
3	1=Link partner auto-negotiable, 0=network hub/switch does not support auto-negotiation
2	1=Full Duplex, 0=half duplex (differs from PHYTER register definition) (reflects duplex LED)
1	1=10 Mb speed in use, 0=100 Mb speed (if 100 LED on, then this bit is zero)
0	1=Link valid (follows Link LED).

7.13.4 Statistics Gathered by Ethernet Driver

The Ethernet driver gathers various statistics (stats) on transmit and receive activity. These can be useful to diagnose network problems or to simply determine network loading. The stats are gathered into a contiguous group of 4-byte unsigned integers. The first integer represents the number of receive stats. The second integer is a constant representing the number of transmit stats. This is followed by all receive stats, then all transmit stats. This format was chosen to allow extending the number of stats without affecting software that read old stats. For example, regardless of the number of receive stats, the first transmit stat will be offset by 2+number of receive stats. In the "C" programming language, this means the first receive stat would be at array[2] and the first transmit stat would be at array[array[0]+2]. The array content is:

ARRAY	OFFSET	DESCRIPTION
0	-	Number of receive statistics (constant == 14)
1	-	Number of transmit statistics (constant == 9)
2	0	Total received bytes (only multicast frames which pass logical address filter are counted)
3	1	Total received frames (multicast frames rejected by logical address filter are not counted)
4	2	Multicast bytes received (this is mainly OSI ES/IS Hello messages)
5	3	Multicast frames received
6	4	Broadcast bytes received (this is normally IP ARP messages)
7	5	Broadcast frames received
8	6	Broadcast frames accepted by hardware hash filter but rejected by software
9	7	Frames with CRC errors (does not included packets with non-integral number of bytes)
10	8	Frames with CRC errors and non-integral number of bytes
11	9	Frames with FIFO overflow (this are really bad errors indicating system malfunction)
12	10	Frames discarded because byte count exceeded Ethernet maximum of 1518
13	11	Frames with "BUFF" error (this is a really bad error indicating system malfunction)
14	12	Frames dropped because memory not available (this is a really bad error)
15	13	Frames dropped because infrequent interrupt response (this is a really bad error)
16	0	Total transmitted bytes
17	1	Total transmitted frames
18	2	Frames not sent on first try due to another device transmitting in half-duplex (deferred)
19	3	Frames never sent due to "excessive deferral" (this is a really bad network error)
20	4	Frames sent after one collision
21	5	Frames sent after between 1 and 16 collisions
22	6	Frames never sent due to more than 16 collisions ("excessive collisions").
23	7	Frames only partially sent due to transmit underflow (really bad system error)
24	8	Frames with late collisions (probably due to full-duplex network and we are half-duplex)

8.0 DIGITAL INPUT / OUTPUT MODULE P30A, P31, P33

8.1 Introduction

The high speed Digital I/O module features 8 (P30A) or 16 (P31) inputs that are fully isolated from each other and the case. The terminals of 4 of these are shared with 4 output relays. Other than the terminals themselves, the output relay circuits are completely independent of the inputs. The P33 has no inputs and 8 output relays.

Because the output relay terminals are shared with inputs, they may be monitored to provide feedback verifying proper operation of output commands. Protection and control industry standard-type output relays ensure system reliability.

The inputs are jumper-selectable for input level and threshold (thresholds of 15Vdc or 70Vdc). The outputs are jumper-selectable for "normal" output state (Normally Open or Normally Closed) and for relay condition (energized or de-energized). The input LED indicator is green when an input is driven high, and the output LED is amber when an output is activated (relay activated).

The Digital I/O Module inputs can be read by the Host Processor Board and/or the Analog-Digital Signal Processor Board. Input transition times are time-stamped. Outputs can be turned on or off by the Host Processor based on commands received over communication links, or by internal states generated by energy pulses, recorders, etc.

The Analog-Digital Signal Processor Board reads the state of the digital inputs every time it samples the analog inputs, and the sample rate of the digital inputs is tied to the frequency of the analog inputs. The Waveform and Disturbance Recorders may be configured to record the status of the digital inputs.

Consult the appropriate Protocol manual for information on reading the digital inputs or setting the digital outputs.

8.2 Features

- Two input ranges, for nominal system voltages of up to 100V or from 100 to 300V.
- Inputs protected against continuous overload to 300Vdc on low input range.
- All Input / Output terminals protected with internal transient limiting devices.
- Protection and control industry standard-type output relays and circuitry ensure system reliability.
- Outputs on the P30A/P31 have "wrap-around" inputs to allow confirmation of circuit operation.
- 2000Vac, 1min isolation, I/O to Case; 1500Vdc, 1min isolation, I/O to I/O
- Removable terminal block for ease of installation

8.3 Specifications

Inputs: 8 (P30A) or 16 (P31) uni-directional, isolated inputs (4 are shared with output relays) jumper selectable for voltage range. Input terminals have internal 510V clamp.

Low Input Voltage Range
- Input Range: 0 to 100Vdc
- Threshold Voltage: 15V dc +/-1V (at 25C)
- Input Resistance: 33kΩ

High Input Voltage Range
- Input Range: 0 to 300Vdc
- Threshold Voltage: 70Vdc +/-3.5V (at 25C)
- Input Resistance: 153kΩ

Input Channel-to-Channel Time Resolution: 200µs (maximum)

Outputs: 8 isolated outputs on P33; 4 isolated outputs, terminals shared with 4 inputs (P30A, P31); jumper selectable for Normally Closed (NC) or Normally Open (NO) operation and for energized or de-energized condition. Output terminals have internal 510V clamp.

Output Maximum Switched Current (Resistive)

Voltage	Tripping (C37.90 Resistive)	Continuous Carry	Break (Inductive)
24Vdc	30A	5A	8A
48Vdc	30A	5A	700mA
125Vdc	30A	5A	200mA
250Vdc	30A	5A	100mA

Input De-bounce Time: Selectable, from 60ns to 260s in 60 ns steps.

Output Operate Time (time from command by Host, does not include protocol delays)
- Assert (Close time with "N.O." jumper): 8ms
- Release (Open time with "N.O." jumper): 3ms

Input Delay Time (from terminals): <100µs

Indicator LEDs
- Inputs: Green, on when input voltage exceeds threshold.
- Outputs: Amber, on when relay coil is energized.

Isolation
- I/O Terminals to Case: 2000Vac, 1min
- I/O Channel to Channel: 1500Vdc, 1min

Input / Output Capacitance, any Terminal to Case: 1400pF

Power Supply Requirements: 3.3Vdc, 5Vdc, +/-12Vdc (supplied from backplane)

Hot Swap: P30A, P31 complies with Hot Swap specification PICMG 2.1 R1.0 for Basic Hot Swap (requires Host Processor re-boot)

8.4 Environmental

Operating Temperature: -40C to 70C

Relative Humidity: 0-95% non-condensing

Installation Category: IC III (Distribution Level), Pollution Degree 2. *Refer to definition on page 8.*

8.5 Physical

Connections: Removable Terminal Blocks, accepts #16-28AWG (1,4-0,09mm) wire. Recommended Torque Rating is 2.2 In-Lbs, 0.25 N-m. Standard 0.150" (3,81mm) header socket accepts other standard terminal types. Solid core wire is recommended, or stranded wire with the use of "bootlace ferrules," where these are available.

Package: P30A: CompactPCI™ (3U, 4HP) removable module
P31: CompactPCI™ (3U, 8HP) removable module
P33: CompactPCI™ (3U, 4HP) removable module

8.6 Hot Swap (HS) Compatibility

The blue Hot Swap LED located on the front panel is illuminated to indicate when it is permissible to extract a board in systems that support the *Full* Hot Swap System Model. The 878 currently supports the *Basic* Hot Swap System Model. The Basic Hot Swap System Model does not illuminate the blue LED. The blue LED will turn on briefly when a card is inserted into an energized device or when the device is reset. If the blue LED remains illuminated after insertion into an 878 or remains illuminated after the Host module has booted, the associated card is malfunctioning.

8.7 Description

8.7.1 P30A

The Digital I/O Module consists of two circuit boards, the CompactPCI™ Interface Board (692), and the I/O Board (693). The Interface Board contains the CompactPCI™ backplane connector and interface circuitry, front panel LEDs, and jumper blocks for output relay power-up configuration.

The I/O Board contains the analog input and isolation circuitry, output relay and drive circuitry, as well as input protection and EMI/RFI suppression.

8.7.2 P31

The P31 Digital I/O Module consists of four circuit boards, the CompactPCI™ Interface Board (692), the LED Daughterboard (717), and two I/O Boards (693 supports pins 1-16, and 716 for pins 17-32). The Interface Board assembly contains the CompactPCI™ backplane connector and interface circuitry, front panel LEDs, and jumper blocks for output relay power-up configuration.

The I/O Boards (693 and 716) contain the analog input and isolation circuitry, input protection and EMI/RFI suppression, as well as output relay and drive circuitry (693 only).

8.7.3 P33

The P33 Digital Output Module consists of two circuit boards, the main board (803) contains the CompactPCI™ Interface and all of the output circuitry. Moveable jumpers are located on this board that are used to set each relay output as either normally open (NO) or normally closed (NC). Daughterboard (803A) consists of the LED's used to indicate the relay status. An LED is turned on when its respective relay coil is energized.

8.8 System Design Considerations

8.8.1 Input / Output Impedance

On the P30A and P31, all of the output relay terminals are shared with the circuitry for a digital input. As a result, there is always an impedance across the output relay contacts, even when the relay is not energized. The value of the impedance depends on the configuration of the input, or more specifically, the setting for the input threshold. The input circuitry is shown in Figure 9. ***THIS PARALLEL IMPEDANCE WILL CAUSE A CURRENT TO FLOW THROUGH ANY LOADS THAT ARE CONTROLLED BY THE RELAY WHEN THE RELAY CONTACTS ARE OPEN. IT IS IMPORTANT TO CONSIDER THIS CURRENT WHEN SELECTING THE INPUT THRESHOLD, AND WHEN DESIGNING SYSTEMS USING THE OUTPUT RELAYS.***

If the input is set for a low threshold (15V), then the impedance across the relay terminals is 33kΩ. On a 125Vdc system, this equates to a maximum of 3.8mA, depending on the impedance of any loads in the loop. If the input is set for a high threshold (70V), then the impedance across the relay terminals is 153kΩ. On a 125Vdc system, this equates to a maximum of 817μA, depending on the impedance of any loads in the loop.

8.8.2 Input Assignments

Due to the shared nature of some of the I/O circuitry, careful planning should be used in assigning the inputs and outputs of the P30A/P31 module. The user is reminded that the first four inputs on either module are shared with the four outputs. ***SERIOUS SYSTEM AND/OR PRODUCT DAMAGE COULD RESULT FROM HAVING AN OUTPUT RELAY OPERATE WHILE CONNECTED TO AN INPUT.*** For this reason, it is recommended that the user assign inputs 5-8 (those not shared with inputs) prior to using the first four inputs.

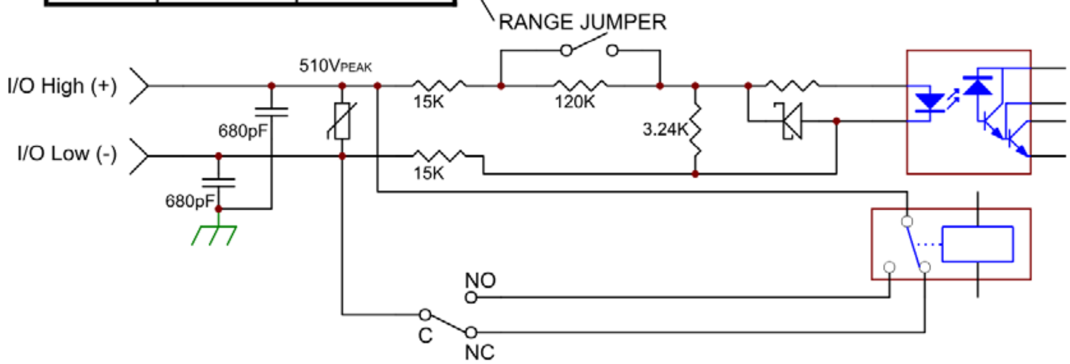
The output relays can be completely disabled on a per-channel basis enabling the safe operation of the first four inputs if desired. See section 8.10.4.

8.9 Debounce Time Setting

The Digital Input Module can filter the inputs to compensate for “chattering” relays, etc. The debounce time may be set using the 70 Series Configurator software, via the various protocols. An input transition is not recognized until the input remains in the new state for a time longer than the debounce time. Values between 60 ns and 4 minutes are acceptable.

An event triggered from the digital inputs will be subject to the debounce time setting for the digital input. Digital input traces in the Waveform and Disturbance files are the instantaneous status of the inputs, and DO NOT reflect any debounce time settings. If a long debounce time is set, it is possible to see an event on the digital input that does not cause a trigger.

JUMPER	MAX INPUT	THRESHOLD
ON	100Vdc	15Vdc
OFF	300Vdc	70Vdc



Simplified Input/Output Circuitry - Inputs 5 to 16 do not have Output Relay and Jumper

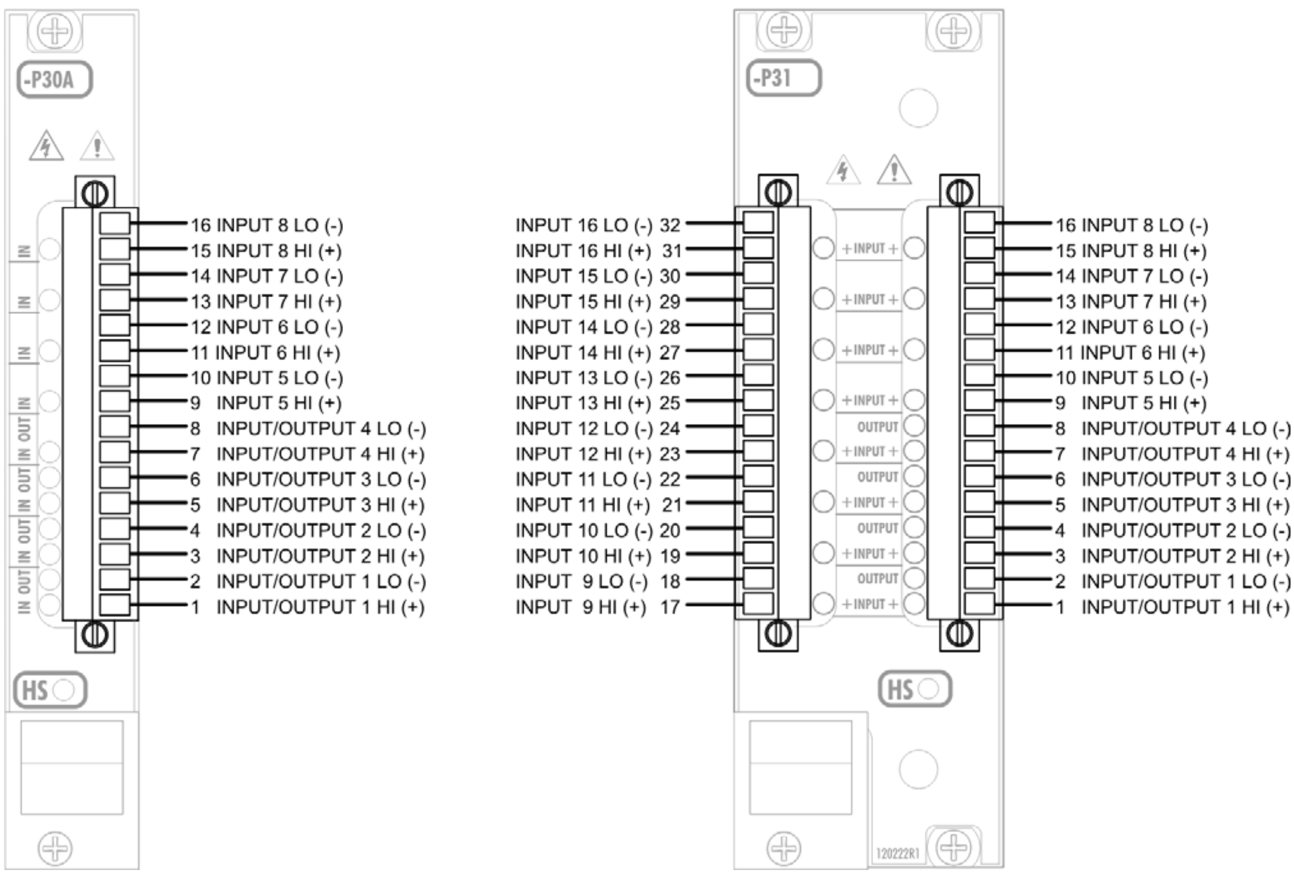
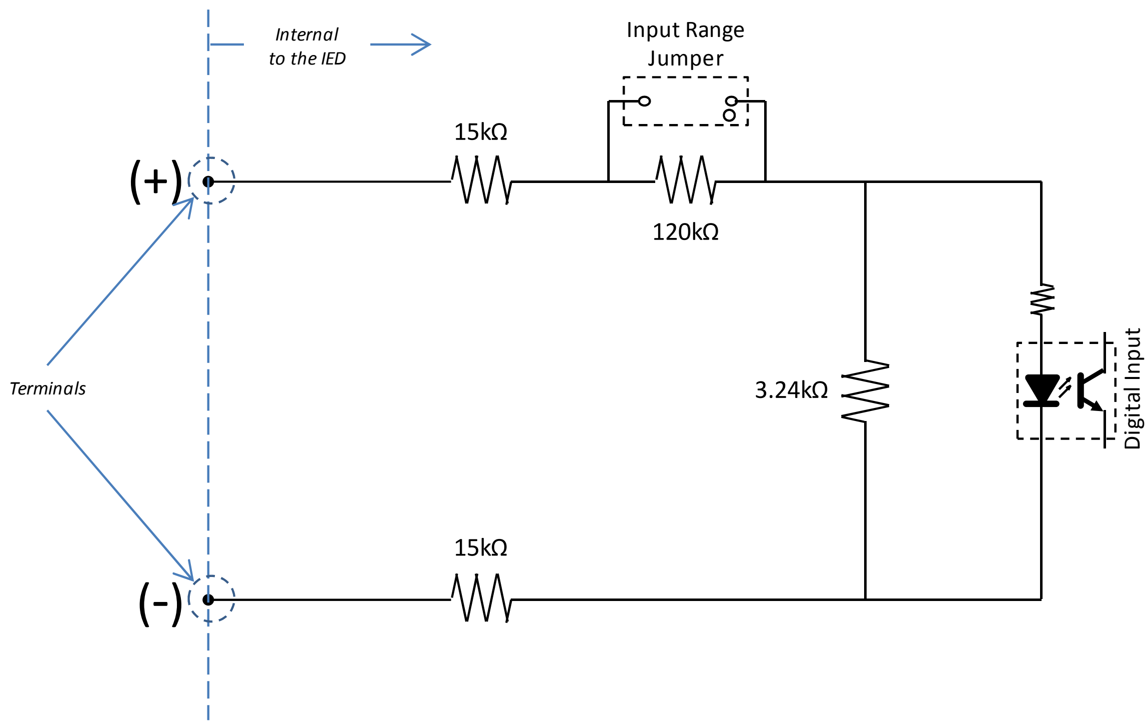


Figure 9 - Simplified Input / Output Circuitry and Terminal Assignment

Points 5-8 on P30A and 5-16 on P31 DIO Cards: Input-Only



Jumper in the “High-Range” or “Stored” position. Input configured for 125V and higher dc systems. Input senses logical 1 when more than 70V is applied, logical 0 below 70V dc.

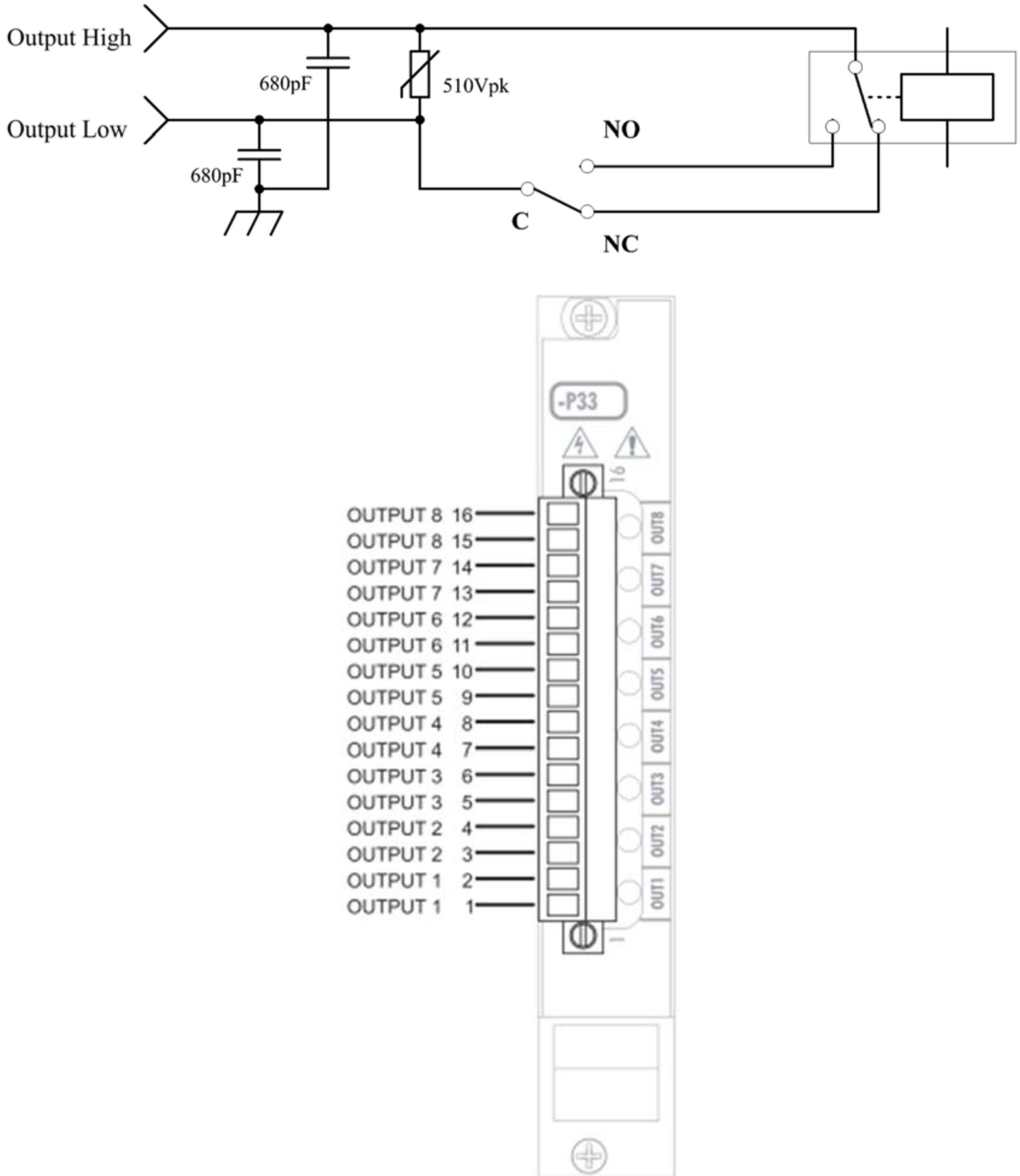


Figure 10 – Simplified Output Circuitry and Terminal Assignment P33

8.10 Setting Digital I/O Module Jumpers

8.10.1 Disassembly of the P30A Module

To set the jumpers on either board of the Digital I/O Module, the boards must first be separated:

1. Remove the three screws as shown:

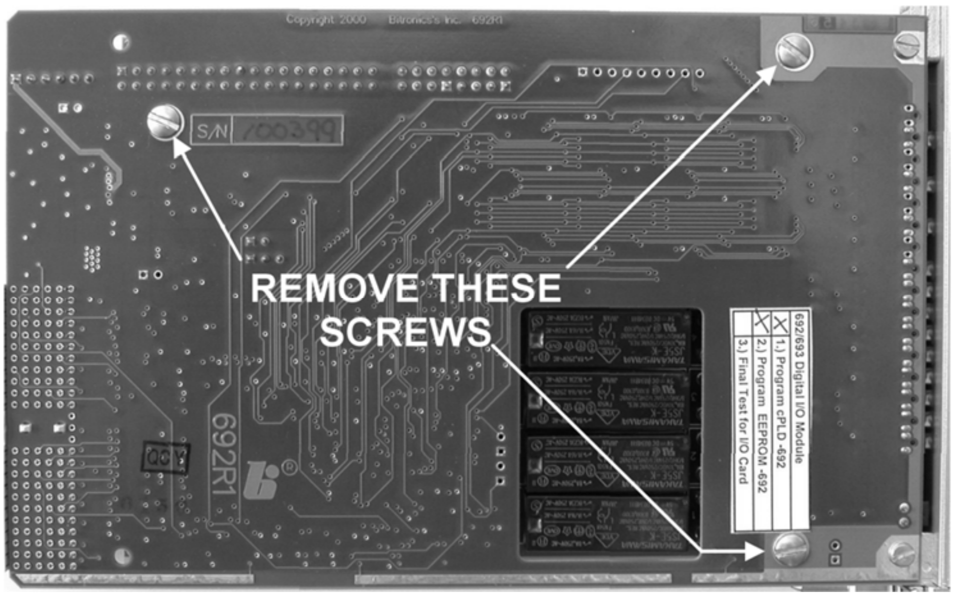


Figure 11- P30A Module Disassembly

2. Gently pull apart the boards by the inter-board connector near the back of the module.

Reassembly is performed in the reverse order.

8.10.2 Disassembly of the P31 Module

1. Remove the six screws (three per side) indicated in Figure 11, and set aside the shields labeled PCB 712. Identify the main circuit boards that comprise the P31 assembly. They are labeled 693, 692, and 716.
   a. PCB 693 contains:
      - Terminal block for I/O points 1-8 (pins labeled 1-16 in blue).
      - Range jumpers for input points 1-8.
      - Normally open/normally closed jumpers for output points 1-4.
   b. PCB 692 contains:
      - Power-up condition jumpers for output points 1-4.
   c. PCB 716 contains:
      - Terminal block for I/O points 9-16 (pins labeled 17-32 in red).
      - Range jumpers for input points 9-16.

2. Note: If you only need access to the jumpers for configuring the digital output relays, there is no need to remove PCB 716, and you may skip this step. Otherwise, (for

access to the range jumpers for input points 9-16) remove the two screws indicated in Figure 12. Locate P8 (the 16 pin array connecting PCB 716 to PCB 692) and gently pry the pins from the header.

3. For access to the range jumpers for input points 1-8, the normally open / normally closed jumpers for output points 1-4, and the power-up (energized / de-energized) condition jumpers, locate P1 (the 36 pin array connecting PCB 693 to PCB 692) and gently pry the pins from the header. Reassembly is performed in the reverse order.

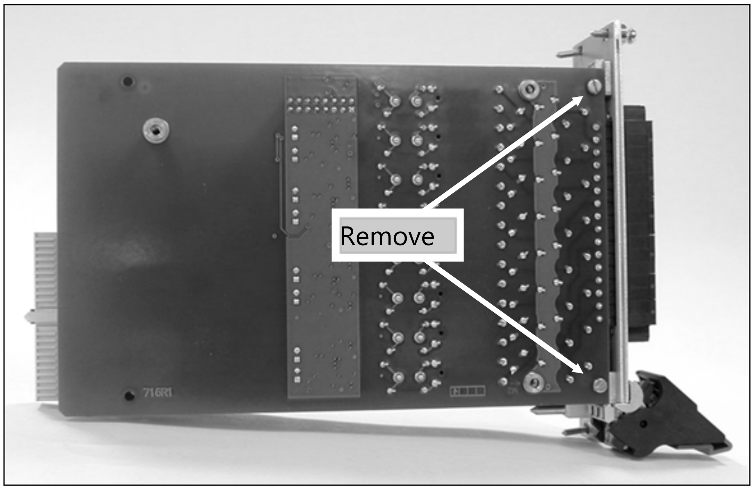


Figure 12- P31 Module Disassembly

8.10.3 CompactPCI™ Interface Board (692) Jumper Settings

The CompactPCI™ Interface Board (692) has jumper blocks (P7) to set the output relay power-up configuration, which is the state (coil energized or de-energized) at which the relays go to when power is first applied to the module. The actual contact state is determined by the relay Normally Open (NO) or Normally Closed (NC) jumper (Section 8.10.4). By default, no P7 jumpers are installed at the factory, which sets the output contact state to de-energized (open when configured for NO), which should be sufficient for most applications. If it is necessary to change the power-up configuration, jumpers may be installed on P7 as follows:

Power Up Configuration					
Jumper	**Function**	**ON**	**OFF**	**Output Relay NO**	**Output Relay NC**
P7	PUC1		X	Output 1 set to OPEN	Output 1 set to CLOSED
P7	PUC1	X		Output 1 set to CLOSED	Output 1 set to OPEN
P7	PUC2		X	Output 2 set to OPEN	Output 2 set to CLOSED
P7	PUC2	X		Output 2 set to CLOSED	Output 2 set to OPEN
P7	PUC3		X	Output 3 set to OPEN	Output 3 set to CLOSED
P7	PUC3	X		Output 3 set to CLOSED	Output 3 set to OPEN
P7	PUC4		X	Output 4 set to OPEN	Output 4 set to CLOSED
P7	PUC4	X		Output 4 set to CLOSED	Output 4 set to OPEN

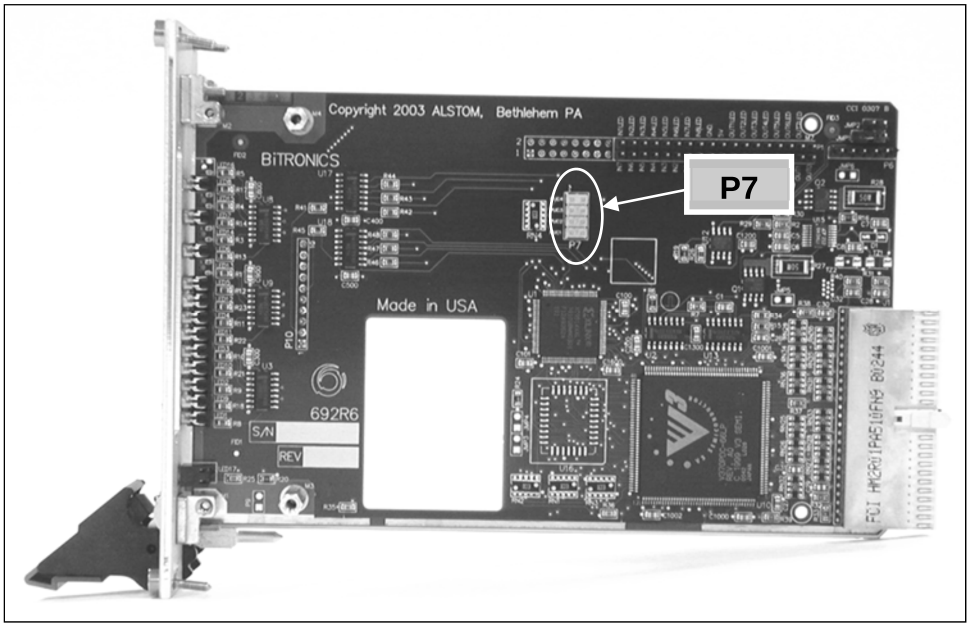


Figure 13 – P7 Jumper Location

8.10.4 I/O Board (693) Jumper Settings

There are several jumpers for setting the input range and threshold on the I/O board and for the normal state of the output relay contacts. The board and jumper locations are shown in Figures 14 and 15. Range jumpers for Inputs 1-8 are located on PCB 693; inputs 9-16 (P31 only) are on PCB 716. The jumpers are red in color for high visibility. . Refer to the beginning of this section for the procedure to access the jumpers.

When the input jumper is installed, the input is in LOW RANGE mode. Removing the jumper places the input in HIGH RANGE mode. ***THE FACTORY SETTING IS HIGH RANGE (JUMPER IS PLACED IN THE STORAGE POSITION). REFER TO SECTION 8.8.***

The relay outputs can be set for Normally Open (NO) or Normally Closed (NC) operation. To enable Normally Open operation, which is the factory setting, place the jumper from "C" (common) to "NO". To enable Normally Closed operation, place the jumper from "C" to "NC".

The relay outputs can be disabled if desired by placing the jumper vertically, from the "NC" to the "NO" contacts, or by removing the jumper entirely. This may be desirable if only the inputs are going to be used on these terminals, and the user wishes to guarantee the outputs do not operate (see figure 16).

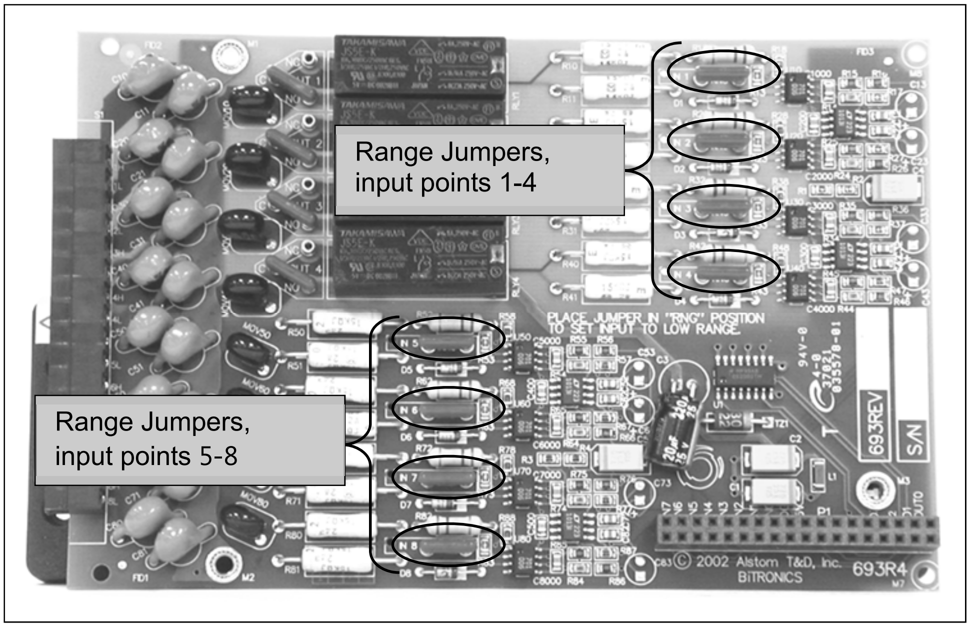
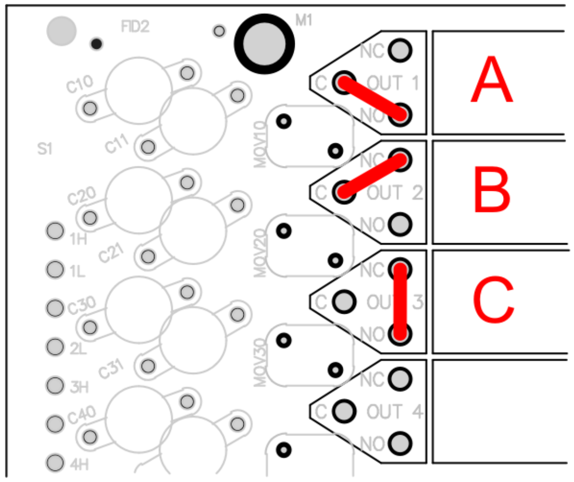


Figure 14 - Jumper Locations for Digital Input / Output Module (693)

Figure 15 - Jumper Locations for Digital Input / Output Module (716)



A - Normally Open
B - Normally Closed
C- Relay Disconnected (Storage)

Figure 16- Relay Output Configuration Jumper

8.10.5 Health Status Digital Output Setting (Optional assignment of Digital Output 1 of Module 0)

Digital Output 1 of Module 0 may be assigned to operate when the value of the Health variable is <1. To set up Digital Output 1 in this manner, it is necessary that the Relay Output 1 Connection Jumper be set for Normally Closed operation. Therefore, during normal operation, the unit is actively holding the contacts of the output relay open (no alarm). If an erroneous operation is detected, or there is a power supply failure, the contacts of the output relay will close (alarm).

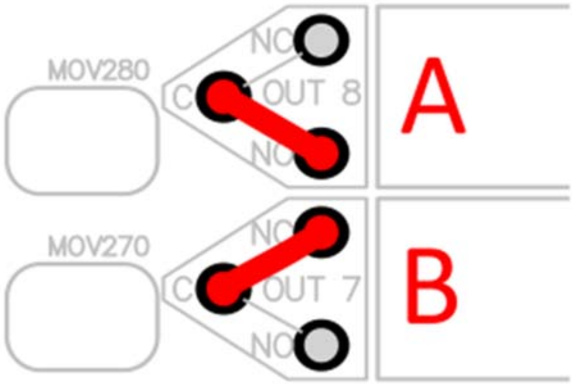
The function of this output may be assigned for Health status by using the 70 Series Configurator, along with the Normally Closed jumper connection installed for Relay output 1.

8.10.6 Disassembly of the P33 Module

No additional disassembly is required, aside from removing the module from the chassis, to access the relay jumpers.

8.10.7 Digital Output Board (803) Jumper Settings

There are several jumpers for setting the normal state of the output relay contacts. The board and jumper locations are shown in Figure 17.



A - Normally Open - Default
B - Normally Closed

Figure 17 - Relay Output Configuration Jumper

9.0 TRANSDUCER INPUT MODULE P40

9.1 Introduction

The Transducer Input Module features 8 separate inputs each with two terminals, one which provides a unique return path for each input. This permits the inputs configured as current inputs to be series connected to multiple transducer input devices and inputs configured as voltage inputs to be parallel connected to multiple transducer input devices. The input terminal assignments are shown in figure 18.

The inputs are jumper-selectable for three different transducer input formats. The inputs can be jumpered for either 0–1 mA or 4-20 mA current inputs or for 0–10V voltage inputs. Both the 0-1 mA and 0 -10 V formats are bipolar (bi-directional) such that they span (-)1mA to (+)1mA and (-)10V to (+)10V respectively. Each format allows for input over-range such that inputs exceeding the normal range can still be reported accurately. The reportable range for each input type is approximately: (+/-) 2.5 mA for 0-1mA inputs; (+/-) 12.5V for the 0-10V inputs; and 0 to 25mA for 4-20mA inputs.

Each transducer input can be independently configured for any of the three input formats. This permits one Transducer Input Module to be used to read eight analog inputs with any mix of the three standard current and voltage formats. Transducer Input Modules can only be ordered pre-configured for one standard input type (all inputs are pre-configured at the factory for one input type), however, each input on every Transducer Input Module is calibrated to support all format types. Changing an input's type is easy and only requires changing that input's jumper setting. The jumper settings are documented in section 10.8.1, below.

Each transducer input is sampled by a 24-Bit delta sigma analog to digital converter, adjusted by a factory set pre-stored gain and offset calibration constant, and then converted to a 16-Bit integer value. The Host Processor Board updates the transducer input values in the floating point database every 500msec by reading each input's 16-Bit integer value and converting it to a floating point value. By default the floating point value represents the actual current (in mA) or voltage (in volts) present at the input. The Host Processor can be configured (via the Mx70 Series Configurator software) to independently scale each transducer input's floating point value. The scaling is accomplished by assigning a floating point value to the extreme values of the transducer input's format. Input scaling is described in detail in section 10.8.2, below.

Consult the appropriate Protocol manual for information on reading the transducer inputs and the available calculation types.

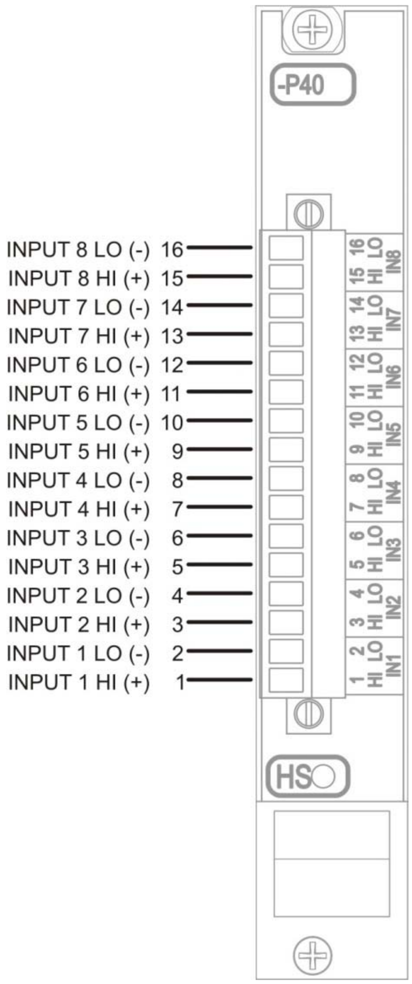


Figure 18 - Terminal Assignment

9.2 Features

- Each input has jumper selectable ranges for support of 0 to (+/-)10 volt, 0 to (+/-)1mA, and 4-20mA transducer input formats.
- All input terminals protected with internal transient limiting devices and spark gap protection.
- Module meets CompactPCI Hardware Hot Swap specification.
- Design includes local microcontroller with 24-bit sigma delta analog-to-digital converter.
- Robust local microcontroller design incorporates local watchdog and continuously monitors offset and gain calibration constants integrity via checksum calculation.
- Removable terminal block for ease of installation

9.3 Specifications

Inputs: 8 bi-directional, jumper selectable for voltage or current range. Input terminals have internal transorb clamp and 90V spark gap protection.

0 – 10V Voltage Range

Overload Range:	-12.5 V to +12.5 Vdc
Resolution:	0.381 mV
Input Resistance:	10KΩ

0 – 1mA Current Range

Overload Range:	-2.5 mA to +2.5 mA
Resolution:	0.0763 μA
Input Resistance:	500Ω

4 – 20mA Current Range

Overload Range:	0 mA to +25 mA
Resolution:	0.381 μA
Input Resistance:	50Ω

Common Mode Input Range: +/- 9V, Input to Chassis

Common Mode Error

Vcm DC:	0.3% of FS @ 9Vp Common Mode
Vcm 50/60Hz AC:	0.1% of FS @ 9Vp Common Mode

Accuracy: 0.25% of Full Scale Input

Data Update Rate (poll rate): 100 ms minimum (single P40 Transducer input module)
500 ms minimum (multiple P40 Transducer input modules)

Input Capacitance, any Terminal to Case: 470pF

Power Supply Requirements: 3.3Vdc, 5Vdc, +/-12Vdc (supplied from backplane)

Hot Swap: Complies with Hot Swap specification PICMG 2.1 R1.0 for Basic Hot Swap (requires Host Processor re-boot)

9.4 Environmental

Operating Temperature: -40C to 70C

Relative Humidity: 0-95% non-condensing

Installation Category: IC III (Distribution Level), Pollution Degree 2. *Refer to definition on page 8.*

9.5 Physical

Connections:	Removable Terminal Blocks, accepts #16-28AWG (1.4-0.09mm) wire. Recommended Torque Rating is 2.2 In-Lbs, 0.25 N-m. Standard 0.150" (3.81mm) header socket accepts other standard terminal types.
Recommended Wire:	Twisted pair, solid core wire (preferred), or stranded wire with the use of "bootlace ferrules," where these are available.
Package:	CompactPCI™ (3U, 4HP) removable module

9.6 Hot Swap (HS) Compatibility

The blue Hot Swap LED located on the front panel is illuminated to indicate when it is permissible to extract a board in systems that support the *Full* Hot Swap System Model. The 878 currently supports the *Basic* Hot Swap System Model. The Basic Hot Swap System Model does not illuminate the blue LED. The blue LED will turn on briefly when a card is inserted into an energized device or when the device is reset. If the blue LED remains illuminated after insertion into an 878 or remains illuminated after the Host module has booted, the associated card is malfunctioning.

9.7 Description

The Transducer Input Module is a one board design that contains the CompactPCI™ backplane connector and interface circuitry, jumper blocks for the input type selection, the input transient protection circuitry, an analog-to-digital converter, a local microcontroller and the input terminal block.

9.8 System Design Considerations

9.8.1 Input Type Jumper Settings

Transducer Input Modules are ordered by specifying an input type and the module is shipped from the factory with all inputs configured for that specified transducer input type. The input type configuration is determined by jumper settings and can easily be re-configured in the field. Each input of the Transducer Input Module can be independently configured to support either the 0 to 1mA, 4 to 20mA, or 0 to 10V transducer input formats.

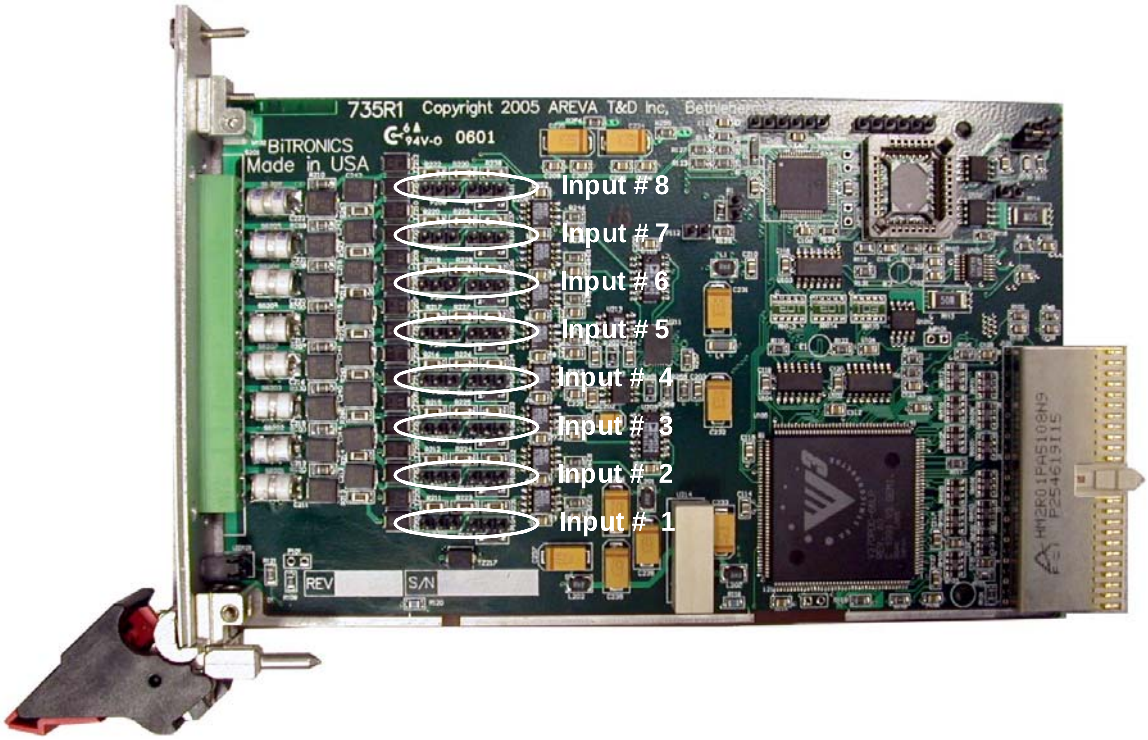


Figure 19 – P40 Input Type Jumper Locations

Each input has two configurable jumper blocks. One jumper block configures the hardware (the actual input circuitry), the other jumper control block configures the firmware and software driver (informs drivers of the status of the hardware selection). It is extremely important that when reconfiguring any input, that both the hardware jumper setting and firmware jumper setting for that input match (select the same input type).

Figure 19 (P40 Input Type Jumper Locations) shows the location of each input's jumper block pair. Each jumper block pair consists of two three pin headers and each header is shipped with a shorting block. The position of the shorting block on the header determines the input type configuration. Figure 18 (P40 Input Type Jumper Configuration) demonstrates the shorting block positions for the three valid input configuration options.

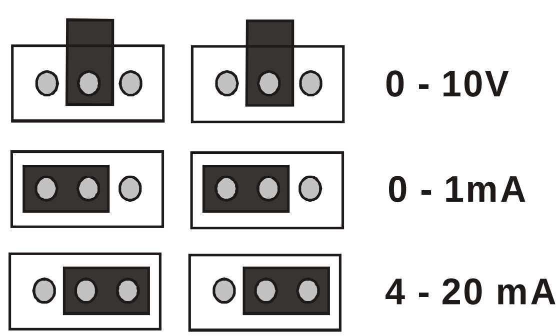


Figure 19 – P40 Input Type Jumper Configuration

9.8.2 Transducer Input Scaling Configuration

The floating point values for the Transducer Input points on all present Transducer Input Modules will appear in the 878 floating point database. By default, values for Transducer Inputs configured as voltage inputs will be in volts and values for Transducer Inputs configured as currents will be in milliamps. Database points for which there are no corresponding Transducer Input points will report as zero.

The 70 Series Configurator software provides for gain and offset scaling for each Transducer Input. This permits transducer inputs to appear in primary units. The 70 Series Configurator allows the user to enter two specific primary values for the associated transducer input values and automatically calculates the correct offset and gain corrections. See Figure 20 (70 Series Configurator Software Transducer I/O Configuration Screen).

In the screen snap shot shown in Figure 20, the first Transducer Input card has the first three inputs configured for type 0-1mA, inputs 4 through 6 configured for type 4-20mA inputs, and the remaining two inputs configured as type 0-10V inputs. All inputs except for 5 and 6 will appear in the database in default units (milliamps for inputs 1 through 4 and volts for inputs 7and 8).

9.8.3 Setting the Data Update Rate (Poll rate) for P40 Transducer Inputs

The poll rate is now settable through the Transducer Input page. Poll rate has been added as a settable value starting with the release of Configurator v3.02. A poll rate as low as 100 ms can now be set for certain applications. Refer to the specifications when setting the poll rate for Transducer Inputs on 878. See Figure 21, which shows an example of settings made using the 70 Series Configurator Software on the Transducer Input page.

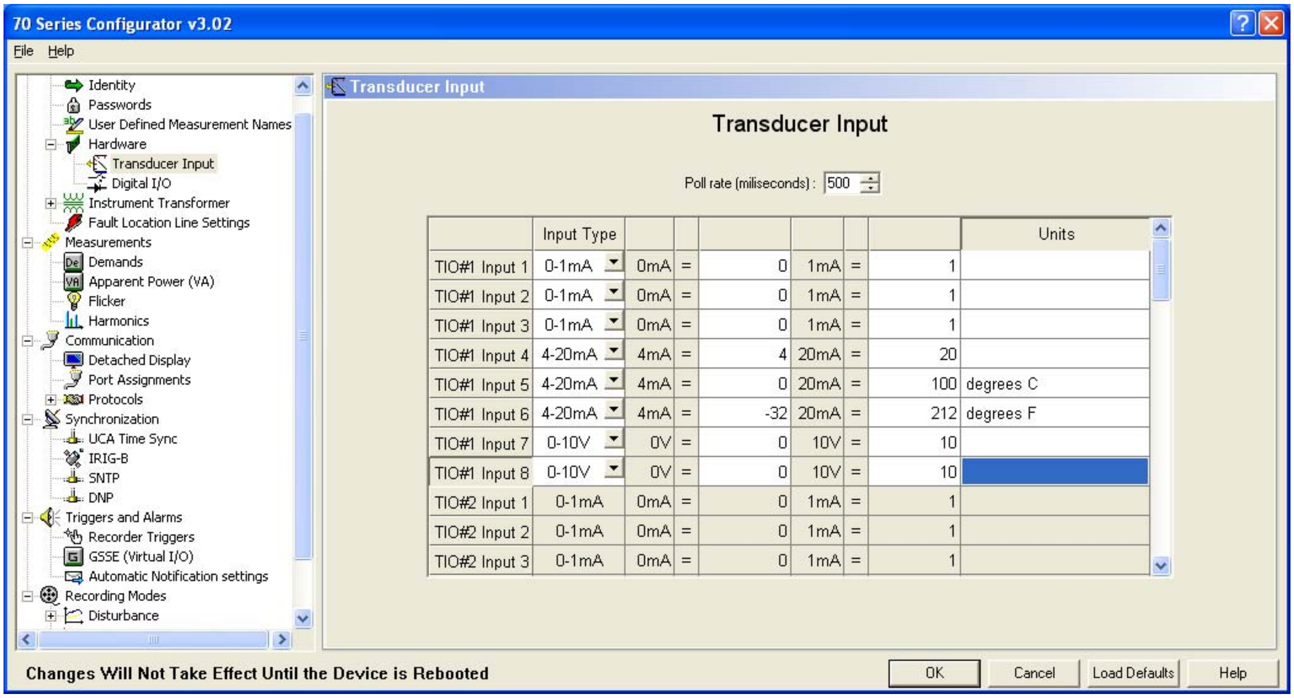


Figure 20 – 70 Series Configurator Software Transducer Input Configuration Screen

Suppose the device connected to input 5 is a temperature transducer with an output range from 4 to 20mA that corresponds to a temperature of 0 to 100 degrees C. Configuring the 4mA setting to report as 0 and the 20mA setting to report as 100 will scale the value in the 878 database to the primary units of the transducer. If this same transducer is connected to input 6 and the scalings are changed to -32 and 212 respectively, the value will appear in the 878 database in degrees F.

APPENDIX A - CROSS TRIGGERING

Cross-Triggering

There are many possible uses for the Input / Output functions available from 70 Series Recorders, but Cross-Triggering deserves special attention since it is prerequisite to the application of distributed recording.

Intelligent Electronic Devices (IEDs) like microprocessor-based relays or 70 Series Recorders are generally used to measure the electrical parameters associated with a particular load, such as a feeder for example. In contrast, most dedicated Sequence-of-Events (SOE) Recorders or Digital Fault Recorders (DFRs) collect measurements from all points of interest throughout an entire substation or load center. Those devices generally produce recordings that include the activity of all points in a single document facilitating analysis by showing everything on a common time scale. A consolidated document like that can be produced by time-synchronized distributed IEDs by combining files captured by each of the recorders.

In order to consolidate all the recordings from IEDs distributed throughout a substation, all the IEDs must first be made to trigger simultaneously whenever an event of interest is sensed by any one unit in the substation. That mechanism is referred to as Cross-Triggering. Recordings are then downloaded and combined by software designed for that purpose (described elsewhere). This appendix will concentrate on methods available for cross-triggering distributed IEDs.

70 Series Recorders support two mechanisms for cross-triggering one another. These mechanisms are vendor-independent so may be used in combination with protective relays and other IEDs to the extent that status and control points are available or that protocols are supported by the other devices.

1. **Hard-wired, using discrete digital I/O.** Contacts wired in parallel on a dedicated cable pass a voltage signal to the status inputs on each IED when an event is sensed. The status input on each device can then be configured to trigger a recording.
2. **Ethernet:**
   a. **using GOOSE.** Status points are communicated across an Ethernet LAN using the IEC-61850 standard. The principal advantage of GOOSE messaging is that it does not require a separate dedicated control cable for physical contacts.
   b. **using GSSE.** Status points are communicated across an Ethernet LAN. The principal advantages of GSSE are interoperability with legacy equipment and simplicity of configuration. All 70 Series firmware released from April 2004 to June 2008 supported UCA. The term “GOOSE” when used in the UCA context is equivalent to GSSE as defined by IEC-61850. GSSE messaging can be set up with the 70 Series Configurator alone. The IED Configurator is not required for GSSE.

The 70 Series Recorder provides considerable flexibility in how a user could customize these methods to fit the constraints of any particular application. An exhaustive description of all possible variations is not practical, but it is useful to provide an example of each method in a typical application.

Example 1. Discrete Digital I/O:

Please refer to Figure A1 for wiring, Figure A2 through A4 for configuration, and Figure 11, section 9.9 for the pin-out of the Digital I/O cards and internal resistor values that are not shown in Figure A1.

Note: Standard Digital I/O cards (P30A and P31) incorporate an internal parallel current path on all digital outputs which conducts through a resistance even when the output contacts are open. This is normally used as a parallel digital input circuit but it makes the standard card unsuitable for cross-triggering because it tends to pull-up the switched conductor when contacts are open. **To use cross-triggering as shown in this example, be sure to specify optional P30AW (8-point) and P31W (16-point) Digital I/O cards when ordering M87x models.**

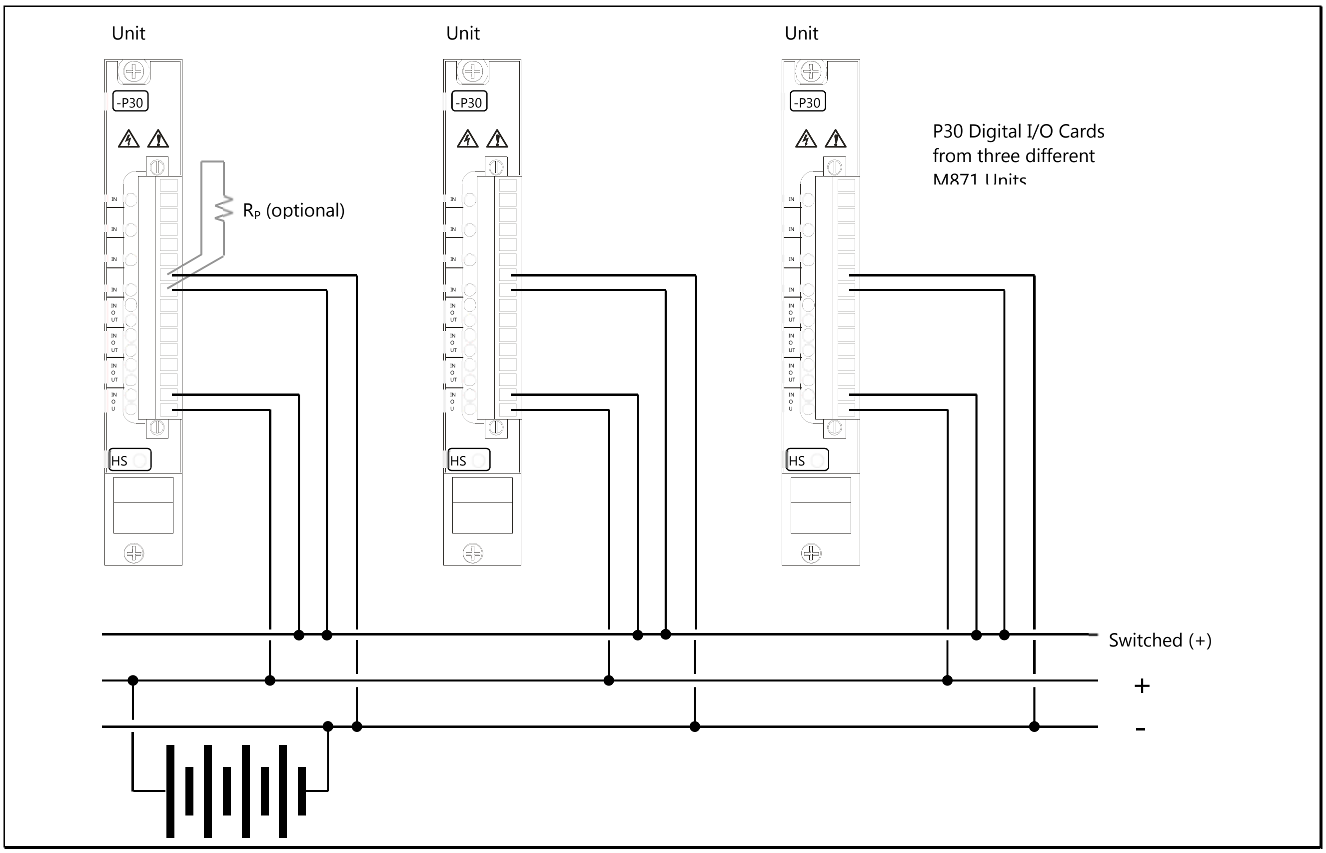


Figure A 1

<u>Wiring</u>:

Figure A1 illustrates one digital output (lower pair, pins 1 and 2 on a P30AW card) from each of three M871 units wired in parallel. Closing the Output 1 contact on any M871 will energize the switched conductor. The upper pair, pins 9 and 10, are digital inputs wired in parallel between the switched and negative conductors. All three units will sense a status change on Input 5 whenever the switched conductor is energized or de-energized. All digital inputs on the M871 incorporate an internal current limiting resistor so no external resistor is required to prevent shorting (+) to (-) when digital outputs operate. It may be advisable, however, to place one pull-down resistor (R_P, in Figure A1) between the switched and negative conductors to prevent chatter on the inputs. Acceptable values for R_P depend on the application, but something in the 100kΩ to 500kΩ range should generally be safe in most cases.

Configuration:

Figure A2 illustrates a typical configuration that will initiate an oscillography recording and an SOE Log entry when the current exceeds a threshold on any of the three phases.

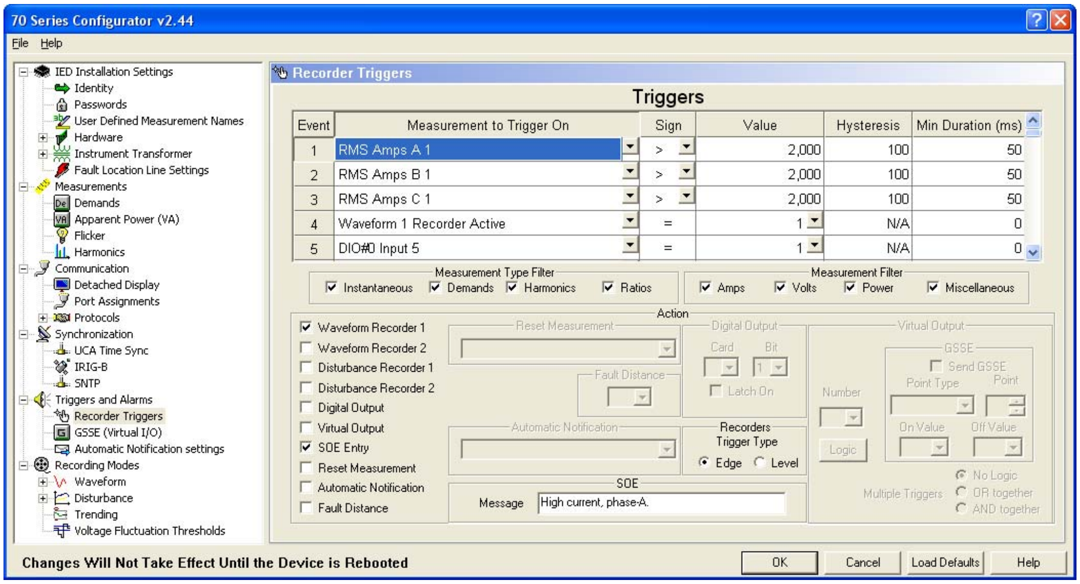


Figure A 2

Since a high current on one feeder would not normally be sensed by any other IEDs in a substation, a cross-trigger is necessary to initiate the oscillography recorders on all other IEDs. Figure A3 shows how any condition that triggers Waveform Recorder 1 also operates Digital Output 1 which initiates the cross-trigger. In this example, the contact dwells in the closed position for the length of time that Waveform Recorder 1 is running. (The characteristics of WR1 are set on a different page of the 70 Series Configurator.)

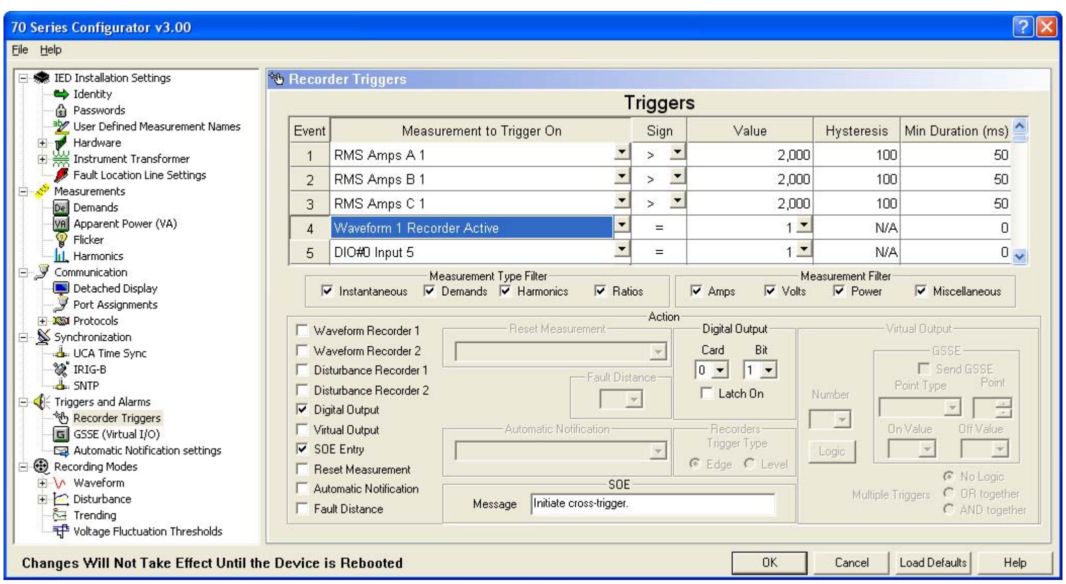


Figure A 3

Figure A4 shows the action taken when a cross-trigger on Digital Input 5 is sensed. In general, receiving a cross-trigger from another device should have the same effect as triggering on something sensed directly by the IED.

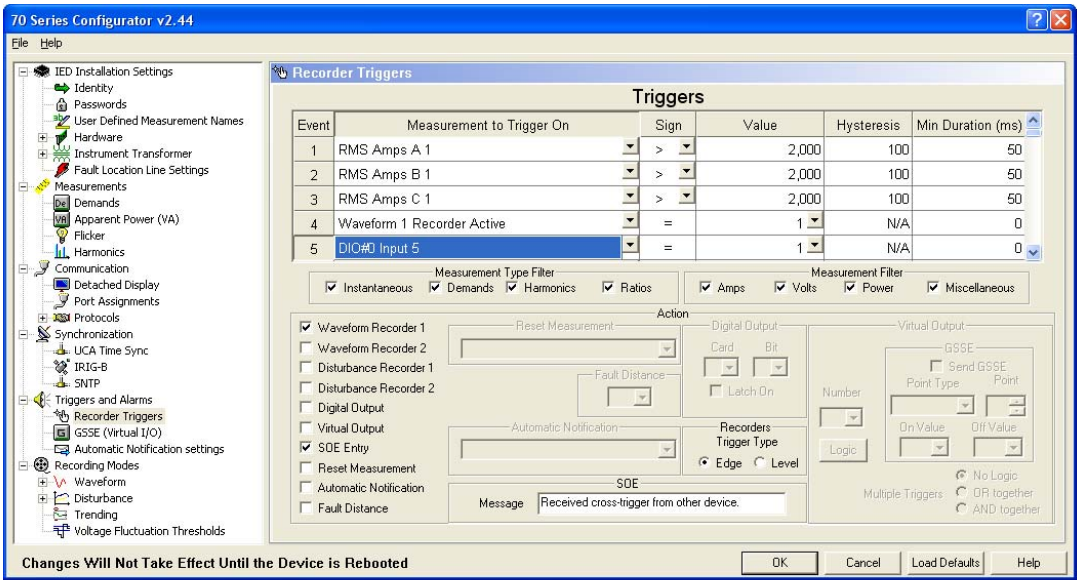


Figure A 4

Example 2. Ethernet, using GOOSE:

GOOSE is a function defined within the context of the IEC-61850 standard but there is no requirement to make use of any other aspect of 61850 just to use GOOSE for cross-triggering 70 Series IEDs. Due to the level of multi-vendor support for IEC-61850, cross-triggering between 70 Series IEDs, microprocessor based relays, and other devices may be an advantage of using GOOSE for cross-triggering. If a broader use of IEC-61850 is not intended, however, the user may find cross-triggering via GSSE (see Example 3) just as effective and somewhat simpler to set up.

In a broader application of IEC-61850, GOOSE could be used for much more than what is described in this example, but when applied simply for cross-triggering, it can be envisioned as a method to communicate a binary status over an Ethernet medium, exactly analogous to status and control performed by discrete I/O points (see Example 1). GOOSE messages are reliable enough to be used for controlling interlocks and protective relay blocking schemes, and can be propagated even faster than discrete digital contacts because of the time that it takes for moving mechanical parts to operate.

GOOSE operates by means of publication and subscription to unsolicited, unacknowledged, multicast (sometimes anycast) messages on an Ethernet LAN, so GOOSE messages can not pass through a router into another network. In its simplest form, such a network could consist of as little as an Ethernet switch and the inter-triggered IEDs connected via conventional Cat. 5 cables. There is no need to uplink into any wider LAN or to operate with any other clients or servers on the network (except for the purpose of configuring the IEDs). So in a substation, security could be accomplished easily just by restricting physical access to the network.

Otherwise, when used in a secure general purpose network, GOOSE messaging can coexist unobtrusively with other network traffic including file transfer services useful for collecting the recordings captured by the IEDs.

Connection:

The M87x must be fitted with one of the available Ethernet options and be connected to a Local Area Network (LAN). The minimum hardware requirement for an M87x to support 61850 is 64MB SDRAM on the Host Processor. Older units built with 16MB SDRAM can either be upgraded with a new Host Processor Card (H11 or H12), or else cross-triggering could be accomplished via GSSE (see Example 3) instead of GOOSE.

Configuration:

As implemented on the 70 Series IED, IEC-61850 requires two separate software programs to configure. These are the *IED Configurator* (used to set up functions specific to 61850, like defining Datasets, GOOSE publication and subscription, etc.) and the *70 Series Configurator* (for trigger logic, recorder settings, and other legacy functions). Both programs are supplied at no cost with the M87x and are also available for download from the company's public FTP site.

The following steps illustrate a typical configuration:

1. In the *70 Series* Configurator, Figure A5 shows how any event of interest measured directly by an M871 is configured to initiate an oscillography recording and make an SOE Log entry. (Only Phase-A Amps is shown, but the Trigger window scrolls vertically and can hold up to 120 separate independent events.)

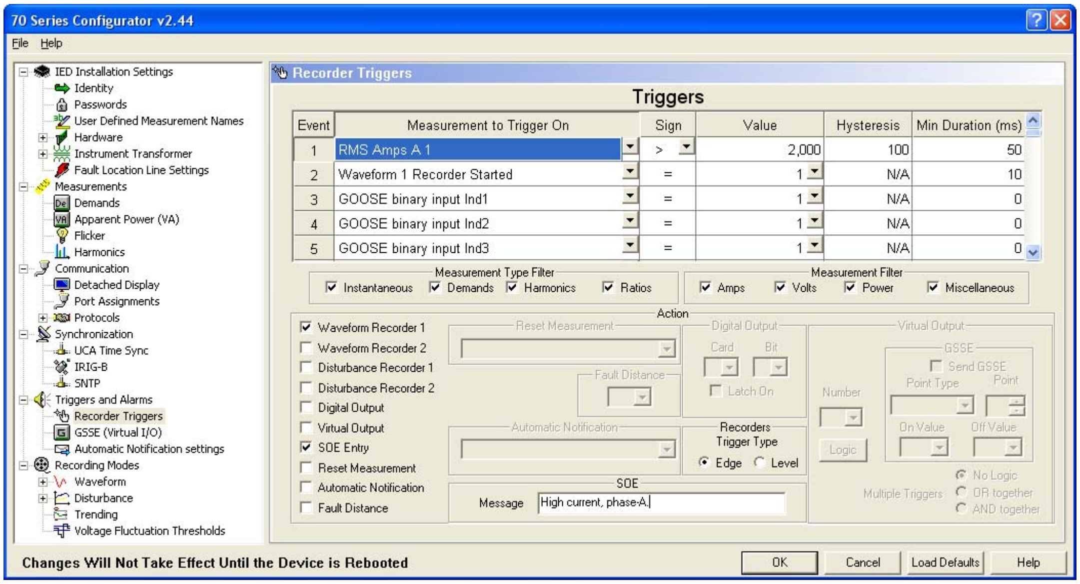


Figure A 5

2. The condition “Waveform Recorder 1 Started” is represented by a soft bit which is an element in the IEC-61850 Object Model (Records/WrxRDRE1.ST.RcdStr.stVal). Other soft bits are available to represent recorders WR2, DR1 and DR2 as needed (see 70 Series IEC-61850 manual, MICS document). The *IED* Configurator will be used in steps 4 and 5 below to make the M871 publish a GOOSE message when this bit changes status. The bit is set when WR1 begins recording. It remains set until it is re-initialized.

   Note: No self-initializing bits are defined by the 61850 object model so an entry must be made in the 70 Series Configurator to re-initialize the bit a short time after it is set. Event 2 in Figure A6 illustrates that instruction. The choice of a particular duration (Event 2, far right column) as the dwell time before the bit is reset is more-or-less arbitrary, but should generally be shorter than the run-time of the recorder. No new cross-trigger can be sent via GOOSE until the bit is re-initialized and WR1 has completed recording.

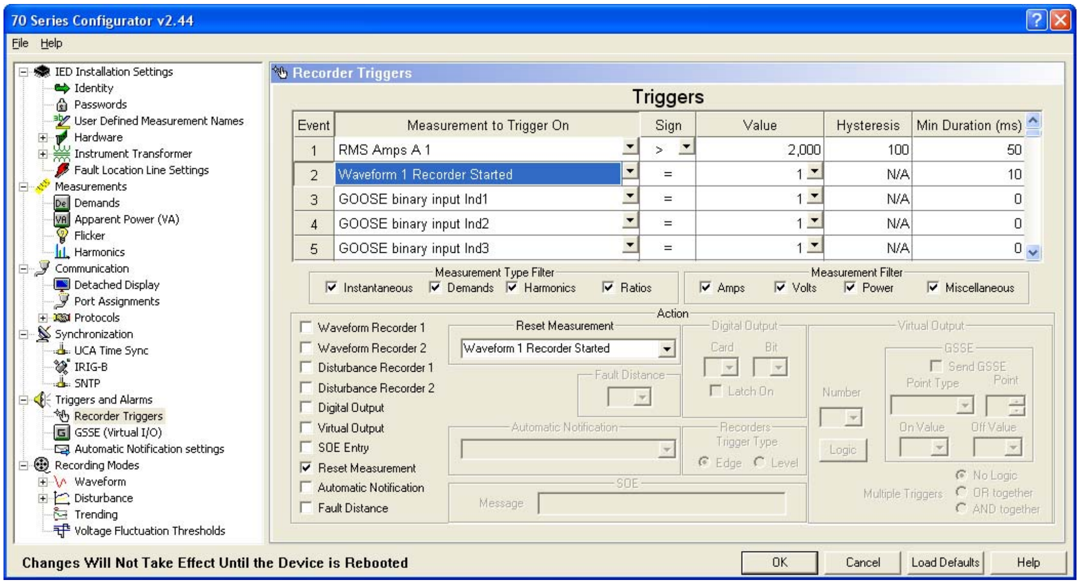


Figure A 6

3. When a cross-trigger is received from another unit, it comes in the form of a GOOSE subscription (set up in the *IED* Configurator in step 7, below). GOOSE subscriptions are represented in the *70 Series* Configurator by binary inputs that can be used to trigger WR1 and make an entry in the SOE Log. In this example, events 3, 4, and 5 shown in Figure A7 are the binary inputs received by subscribing to the GOOSE messages published by three other M871s on the network. This completes the settings that are made in the *70 Series* Configurator.

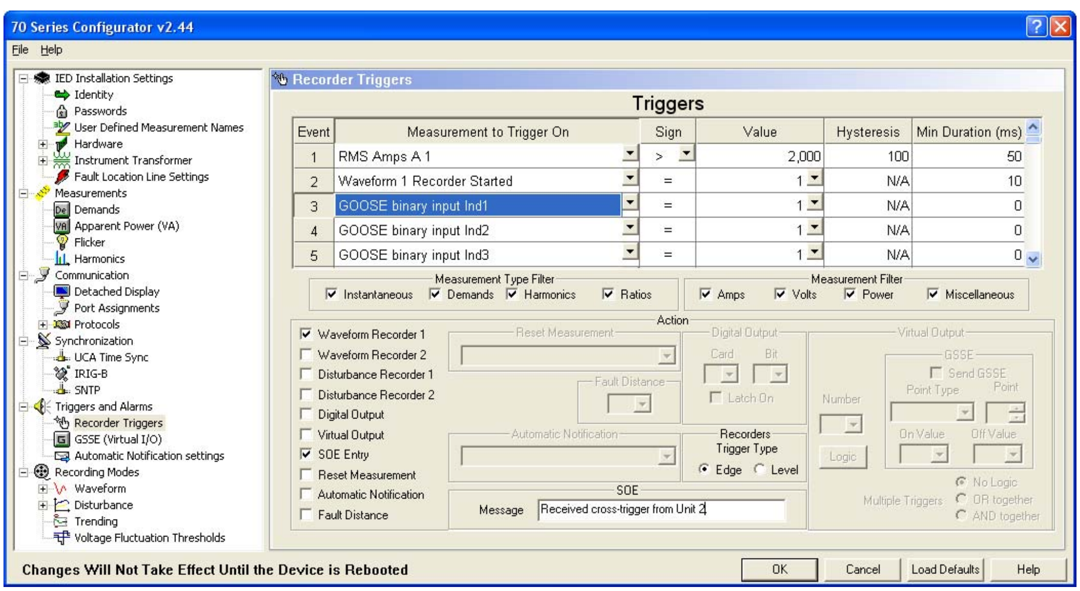


Figure A 7

4. The following settings must be made in the *IED* Configurator: Configuring an M871 to publish a GOOSE is a two step process. Figures A8 and A9 illustrate the first step, defining a Dataset that includes the soft bit described in step 2, above (Records/WrxRDRE1.ST.RcdStr.stVal).

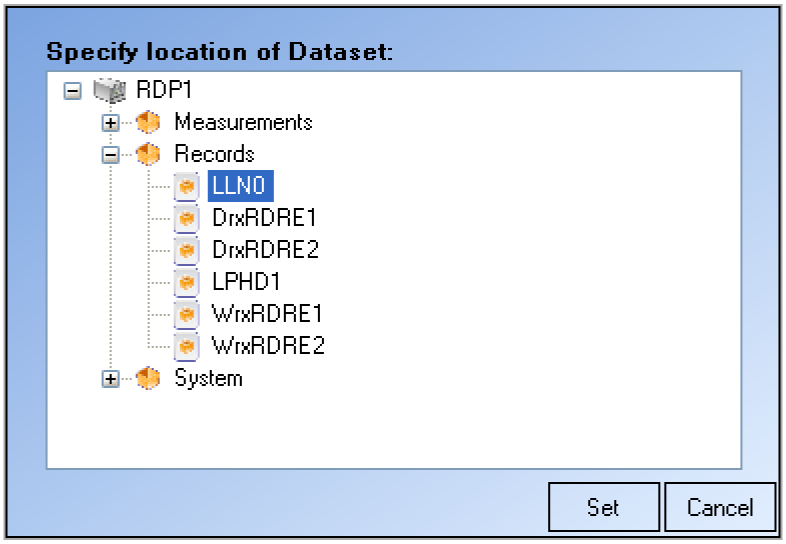


Figure A 8

Note: In order to be used for GOOSE publication, the Dataset must be defined under System\LLN0 as shown in Figure A9.

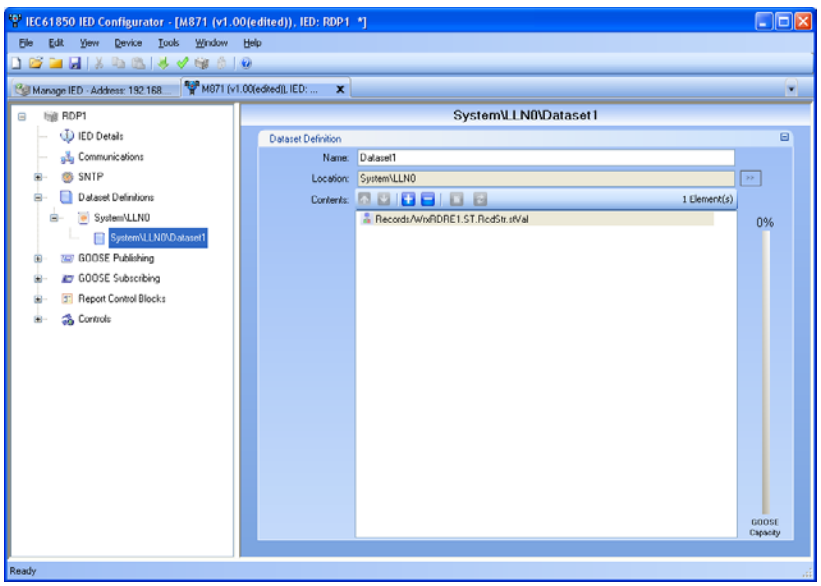


Figure A 9

5. The second step in publication is defining a GOOSE message, Figure A10. Up to eight independent GOOSE publications may be defined for each device. Only one is required for cross-triggering any number of other devices. System\LLN0\gcb01 is used in this example. All default entries shown in Figure A10 should generally be used in most cases, but the user must select the dataset defined in step 4, above, from the pull-down menu in the box Dataset Reference. Then the Configuration Revision must be incremented to at least 1 (usually incremented automatically by the IED Configurator). This Revision number must match the corresponding GOOSE subscription settings on all the other inter-triggered IEDs on the network (see step 7, below).

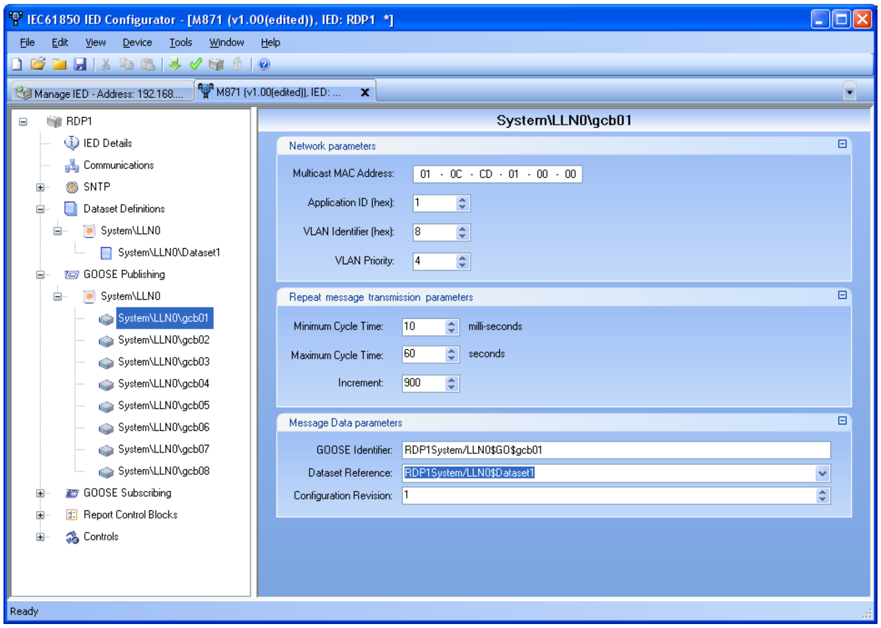


Figure A 10

6. Each IED only needs to publish one GOOSE to cross-trigger any number of other devices. When setting up subscriptions, however, the device must subscribe to every other device from which a cross-trigger may be expected. For example, in a substation with four inter-triggered M871 units, each unit would publish one and subscribe to three GOOSE messages. Up to thirty-two separate status points may be defined for each device. These status points correspond to elements in the Dataset transmitted by the GOOSE message.

   Refer to the points named **System\GosGGIO1\Ind1.stVal** through **System\GosGGIO1\Ind32.stVal** in Figure A11. These are the points in the *IED* Configurator that correspond to the points in the *70 Series* Configurator which were described in step 3, above. In the 70 Series Configurator these points are named **GOOSE binary input Ind1** through **GOOSE binary input Ind32**. See Figure A7, Events 3, 4, 5, etc.

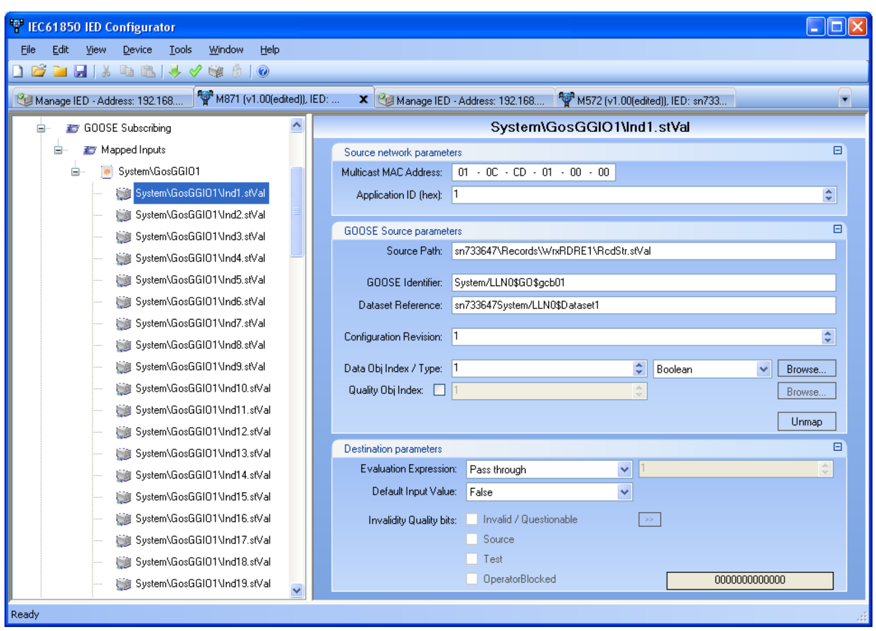


Figure A 11

7. The IED Configurator makes it relatively simple to configure subscriptions when the MCL files for all devices are open at the same time and the GOOSE publications have already been configured on each of the other devices. See Figure A12. By clicking on the Browse button, a window appears allowing the user to select the status point (green dot shown in Figure A12). Selecting the point (**Records/WrxRDRE1.ST.RcdStr.stVal**) causes a subscription to be configured for the GOOSE message that contains that status point. After selecting that point, next click on **System\GosGGIO1\Ind2.stVal** (see left side of Figure A11) and repeat step 7 selecting the same status point from the second M871 for the second subscription, and again with **System\GosGGIO1\Ind3.stVal** for the third subscription, etc. until a subscription has been made to each of the other IEDs on the network.

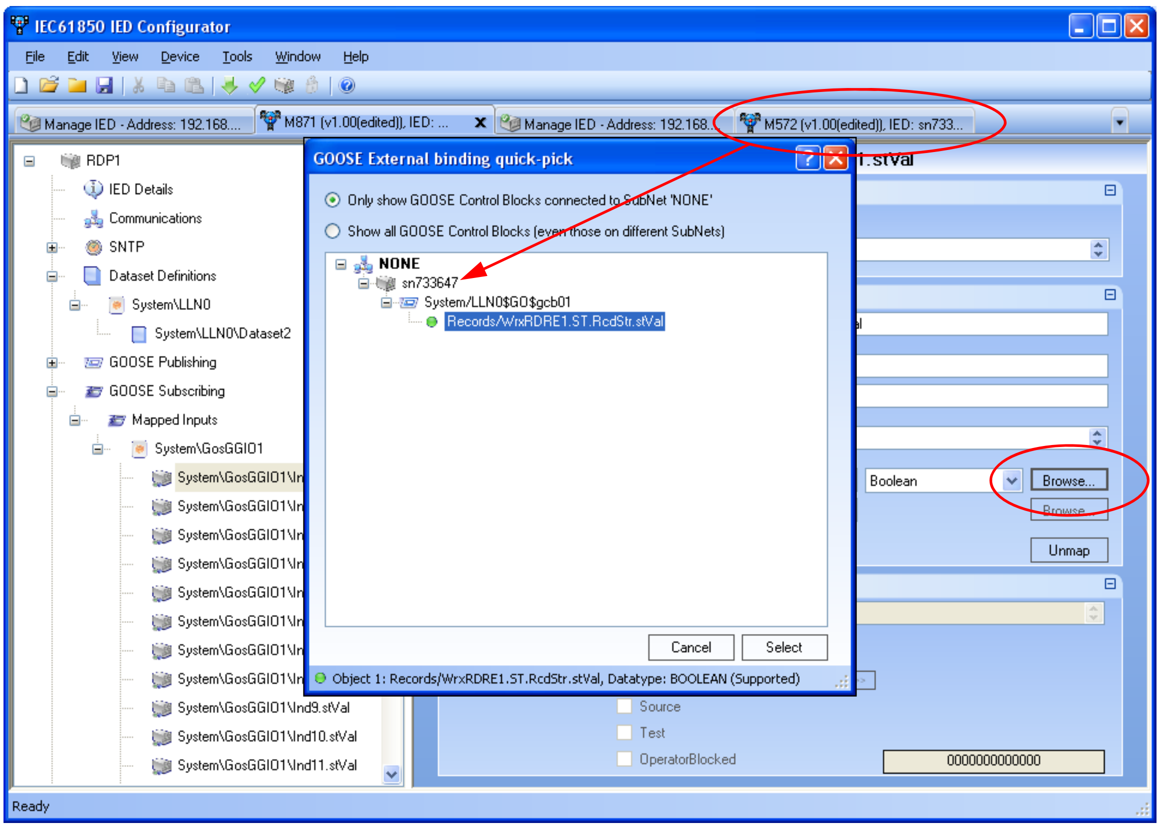


Figure A 12

8. Under **Destination Parameters** (see Figure A11 near bottom) verify that the pull-down menu labeled **Evaluation Expression** indicates **Pass through**. This completes the configuration settings for GOOSE subscription.

Example 3. Ethernet, using GSSE:

The GSSE service, as defined by IEC-61850, is identical to what has been called GOOSE in connection with UCA2.0 in past years. In order to reduce confusion as far as possible, all previous references to GOOSE in the UCA context have been replaced by the expression GSSE in 70 Series documentation because IEC-61850 supersedes UCA as a communications standard.

The use of GSSE to perform cross-triggering carries all the practical advantages of GOOSE and is simpler to set up, but has much narrower multi-vendor support. It is, however, available on all 70 Series IED firmware versions released since April 2004, so GSSE may be a better choice when it is either unnecessary to trigger other devices, or when triggering other vendors' devices might as easily be accomplished with discrete digital I/O while using GSSE among the 70 Series IEDs installed.

As with GOOSE, there is no need to make use of any other aspect of 61850 or UCA protocols just to use GSSE for cross-triggering.

GSSE can generally be envisioned as a way to communicate a binary status over an Ethernet medium, exactly analogous to status and control performed by discrete I/O points (see Example 1). GSSE messages are reliable enough to be used for controlling interlocks and protective relay blocking schemes, and can be propagated even faster than discrete digital contacts because of the time that it takes for moving mechanical parts to operate.

GSSE operates by means of transmitting and receiving unsolicited, unacknowledged, multicast messages on an Ethernet LAN, so GSSE messages can not pass through a router into another network. In its simplest form, such a network could consist of as little as an Ethernet switch and the inter-triggered IEDs connected via conventional Cat. 5 cables. There is no need to uplink into any wider LAN or to operate with any other clients or servers on the network (except for the purpose of configuring the IEDs). So in a substation, security could be accomplished easily just by restricting physical access to the network.

Otherwise, when used in a secure general purpose network, GSSE messaging can coexist unobtrusively with other network traffic including file transfer services useful for collecting the recordings captured by the IEDs.

Connection:

The M87x must be fitted with one of the available Ethernet options and be connected to a Local Area Network (LAN). There is no other minimum hardware requirement for an M87x to support GSSE. Older units that support UCA but not 61850 can exchange cross-triggers via GSSE from newer units that support 61850.

Configuration:

All settings required for cross-triggering with GSSE are made in the 70 Series Configurator. The following steps illustrate a typical configuration:

1. In the 70 Series Configurator, Figure A13 shows how any event of interest measured directly by an M871 is configured to initiate an oscillography recording and make an SOE Log entry. (Only Phase-A Amps is shown, but the Trigger window scrolls vertically and can hold up to 120 separate independent events.)

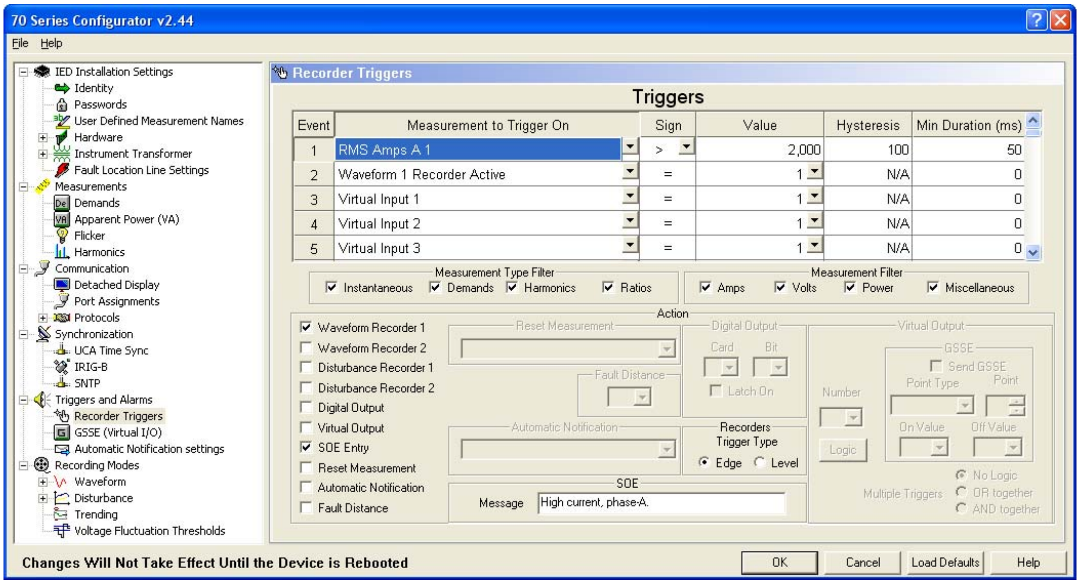


Figure A 13

2. The condition "Waveform Recorder 1 Active" is used to drive a Virtual Output that is linked to a GSSE message as illustrated in Figure A14. A Virtual Output can be driven by individual conditions (like RMS Amps A1 > 2000, in this example) or it could be the result of a combination of several conditions defined through rudimentary triggering logic.

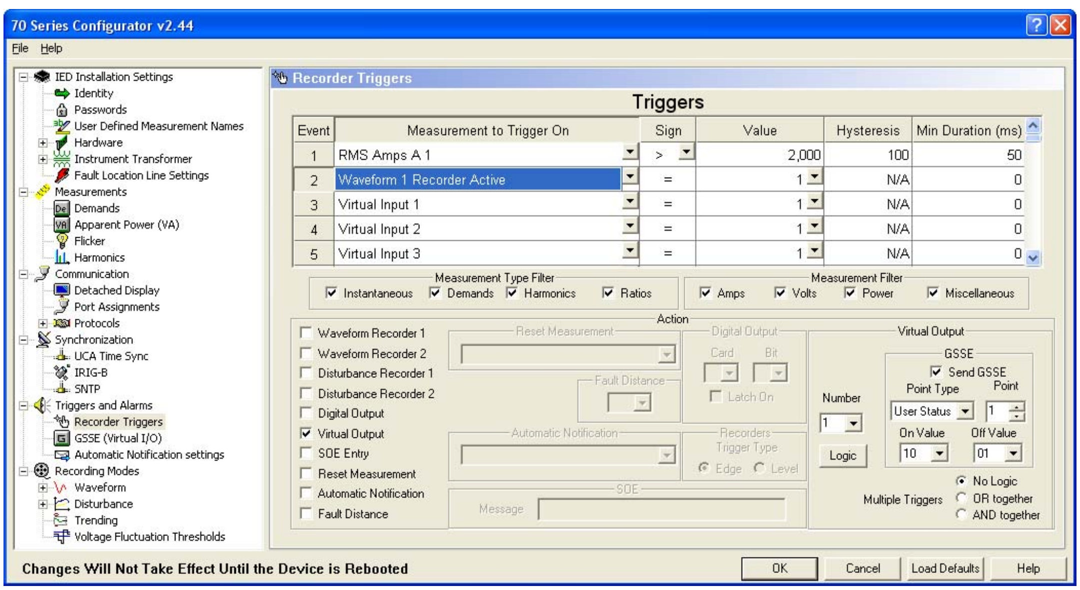


Figure A 14

Note: "Waveform Recorder 1 Active" can be considered to be a self-initializing condition since it transitions from 0 to 1 when the recorder starts then returns to 0 (its initialized state) when the recording is completed. Therefore, no deliberate step is necessary to re-initialize a soft bit, as was required for "Waveform Recorder 1 Started" in step 2 of Example 2.

3. On the GSSE (Virtual I/O) page, define a GSSE Tx Name ("Unit_1" in this example) which is unique to the device sending the GSSE message as illustrated near the

bottom of Figure A15.

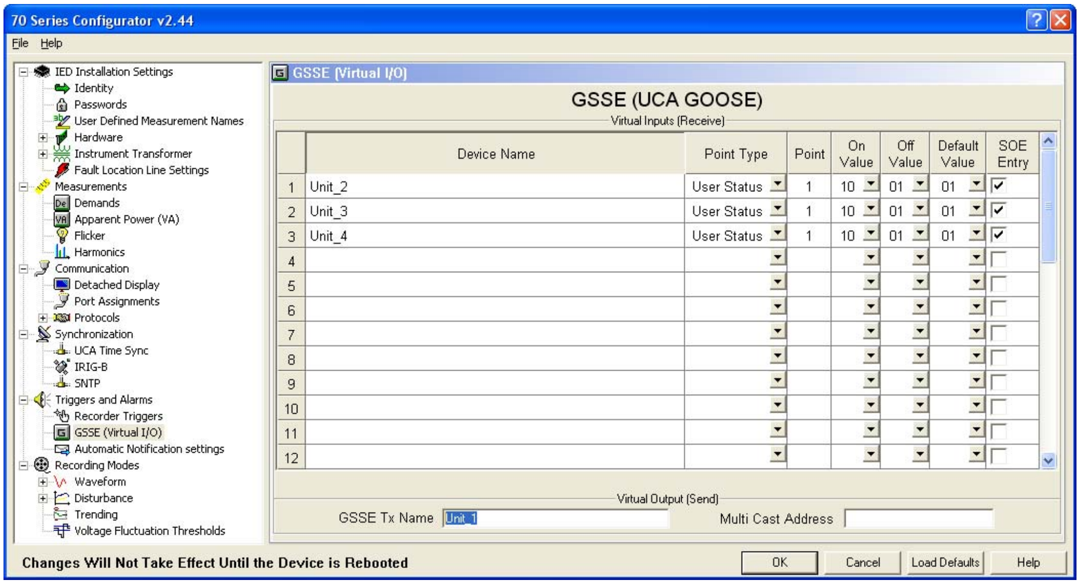


Figure A 15

4. When a cross-trigger is received from another unit, it comes in the form of a GSSE message. Each unique GSSE message must be associated with specific numbered Virtual Input as seen on top half of the GSSE (Virtual I/O) page of the 70 Series Configurator shown in Figure A15. Each device only needs to transmit one GSSE to cross-trigger any number of other devices. When setting up for receiving a cross-trigger, however, the device must be configured to receive GSSE messages from every other device from which a cross-trigger may be expected. For example, in a substation with four inter-triggered M871 units, each unit would transmit one GSSE and be configured to receive GSSE messages from all three other units. Up to thirty-two separate Virtual Inputs may be defined for each device.
5. On the Recorder Triggers page of the 70 Series Configurator, each of the Virtual Inputs defined in step 4, above, is then used to initiate the oscillography recorder and make an entry in the SOE Log. See Figure A16. This completes the configuration settings for cross-triggering by means of GSSE.

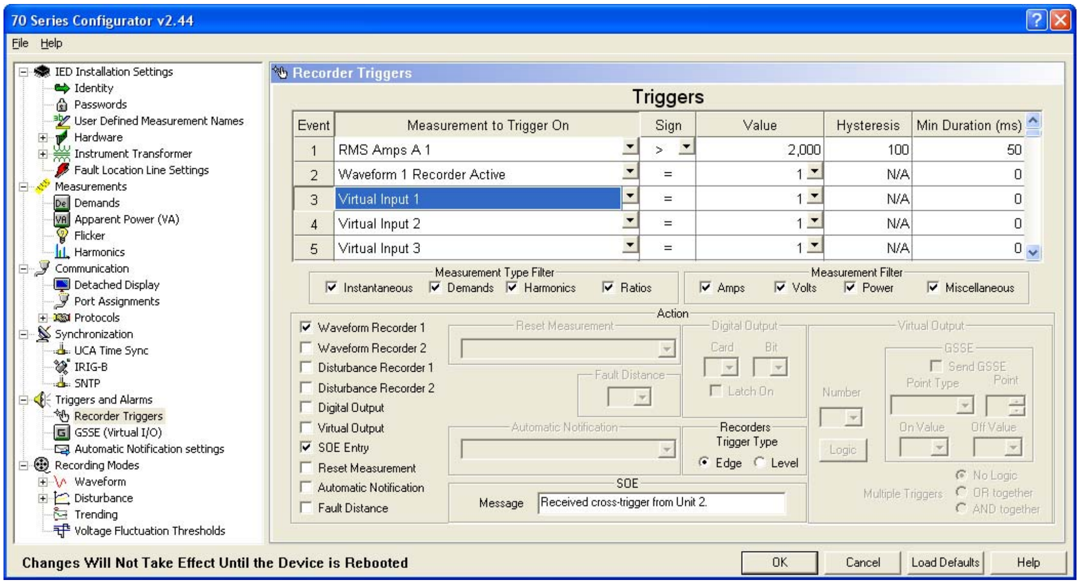

70 Series Configurator v2.44
File Help
IED Installation Settings
Identity
Passwords
User Defined Measurement Names
Hardware
Instrument Transformer
Fault Location Line Settings
Measurements
Demands
Apparent Power (VA)
Flicker
Harmonics
Communication
Detached Display
Port Assignments
Protocols
Synchronization
UCA Time Sync
IRIG-B
SNTP
Triggers and Alarms
Recorder Triggers
GSSE (Virtual I/O)
Automatic Notification settings
Recording Modes
Waveform
Disturbance
Trending
Voltage Fluctuation Thresholds
Recorder Triggers
Triggers
Event
Measurement to Trigger On
Sign
Value
Hysteresis
Min Duration (ms)
1 RMS Amps A 1 > 2,000 100 50
2 Waveform 1 Recorder Active = 1 N/A 0
3 Virtual Input 1 = 1 N/A 0
4 Virtual Input 2 = 1 N/A 0
5 Virtual Input 3 = 1 N/A 0
Measurement Type Filter
Instantaneous
Demands
Harmonics
Ratios
Measurement Filter
Amps
Volts
Power
Miscellaneous
Action
Waveform Recorder 1
Waveform Recorder 2
Disturbance Recorder 1
Disturbance Recorder 2
Digital Output
Virtual Output
SOE Entry
Reset Measurement
Automatic Notification
Fault Distance
Reset Measurement
Digital Output
Card
Bit
Latch On
Fault Distance
Automatic Notification
Recorders Trigger Type
Edge
Level
SOE
Message
Received cross-trigger from Unit 2.
Virtual Output
Number
Logic
GSSE
Send GSSE
Point Type
Point
On Value
Off Value
Multiple Triggers
No Logic
OR together
AND together
Changes Will Not Take Effect Until the Device is Rebooted
OK
Cancel
Load Defaults
Help

Figure A 16

APPENDIX B - FIRMWARE VERSION HISTORY

V4.01	Support for H12 and H12 Ethernet (E1, E3) modules
V4.02	Support for IEC 61850 deadbands
V4.07	Support for IEC 61850 configuration option and DNP3 certification Maintenance upgrade
V4.09	Support for the P33 Module
V4.10	Maintenance upgrade

Bitronics
A NovaTech Company

Measurement Products

Change of Company Name / Ownership

Product Technical Compliance, Type Test Certificates & Declarations of Conformity

Areva's Transmission & Distribution Measurement Unit based in Bethlehem Pennsylvania, USA was purchased by NovaTech LLC on July 1, 2008, and henceforth continues to operate as an affiliate of NovaTech LLC under the company name of:

Bitronics LLC
261 Broadhead Road
Bethlehem, PA 18017, USA

The change of ownership and company name at the Bethlehem location has resulted in the Measurement organization and it's operations remaining substantially the same. In regards to product technical compliance and performance claims, the following points indicate business continues as usual for the Bethlehem site:

- Technical Staff have been retained.
- Instruments will continue to be designed in Bethlehem.
- Production processes are unchanged.
- Measurement products are retained.
- A revision on product labels to indicate Bitronics as the company name shall be implemented.
- A strategic partnership agreement has been entered with Areva T&D, such that Bitronics LLC will manufacture products to be globally distributed under the AREVA T&D MICOM brand. A revision to product labels is anticipated.

Continuing to the subject addressing some of the necessary technical documentation, which is relied upon, the intent is to utilize existing product Type Test Certificates and Declarations of Conformity. The change of company name will not be implemented retroactively on these types of documents. Instead the change of company name to Bitronics will appear on new documents moving forward, that are created after July 1, 2008. Existing product approvals will be relied upon.

André Wagner

Andre Wagner – R&D Manager

Date: Oct 2, 2008

Issue 1

261 Brodhead Road, Bethlehem, PA 18017 USA Phone: 610.997.5100 Fax: 610.997.5450 www.novatechweb.com

Declaration of Conformity (for CE marked models of M87x)

The Declaration of Conformity, DOC B001 that appears in this manual is applicable for M87x models that are CE marked. The CE mark, if applicable, will be located on the case label found on the side of the product.

If the CE mark is not contained on the product, then the Declaration of Conformity, DOC B001, is not applicable for those particular products that do not bear the CE mark.

Bitronics
A NovaTech Company

EC Declaration of Conformity

This declaration of conformity is issued under the sole responsibility of the manufacturer.

We, the undersigned:

Manufacturer:	**Bitronics LLC** 261 Brodhead Road Bethlehem, PA 18017-8698, USA **T** +610.997.5100 **F** +610.997.5450 **E** bitronics@novatechweb.com	**Authorized Representative in the European Union:**	**NovaTech Europe BVBA** Kontichsesteenweg 71 2630 Aartselaar, Belgium **T** +32.3.458.0807 **F** +32.3.458.1817 **E** info.europe@novatechweb.com

hereby declare that the following product(s):

Product type:	M870 Series
Description:	M87x IEDs / Multi-Function Recording Transducers and Event Monitors
Models:	M871 - **using chassis C07A5, C10A7, or C12x8 with any of the following modules or components:** A10, H10, H11, H12, P10, P11, P12, P20, P30A, P31, P32, P40, S10uc, S11uc, S12uc, V10, M870-MODIRIGBCV.
	M872 - **using chassis C10A7, or C12x8 with any of the following modules or components:** A10, H10, H11, H12, P10, P11, P12, P20, P30A, P31, P32, P40, S13uc, S14uc, S15uc, S16uc, S17uc, V10, M870-MODIRIGBCV.
	878 - **using chassis C07A5, C10A7, or C12x8 with any of the following modules or components:** H10, H11, H12, P10, P11, P12, P20, P30A, P31, P32, P40, V10, M870-MODIRIGBCV.

Conform(s) with the protection requirements of the following directive(s):

1. European Community Directive on EMC (EMCD) 2014/30/EU, superceding 2004/108/EC, and Directive 91/263/EC [TTE/SES]. Fulfilment of the essential requirements set out in Annex I has been demonstrated.
2. European Community Directive on Low Voltage (LVD) 2014/35/EU, superceding 2006/95/EC. Fulfilment of the safety objectives referred to in Article 3 and set out in Annex I has been demonstrated.

The object of the declaration described above is in conformity with the relevant Union harmonisation legislation: Directives 2004/108/EC & 2006/95/EC (until April 19th, 2016) and Directives 2014/30/EU &, 2014/35/EU (from April 20th, 2016).

Reference Number : DOC B001 **Issue :** R

Date of issue : 21-December-2016

Form BIDOC_H

The requirements for the following directive(s) were deternined to be not applicable

Directive #	Subject of Directive	Reason Directiive is Not Applicable
2011/65/EU	Restriction of the Use of Certain Substances in electrical equipment (RoHS)	Not applicable - large scale fixed installation is exempt per Article 2, clause 4e (utility substation equipment which is designed in)
2012/19/EU	Waste Electrical and Electronic (WEEE)	Not applicable - large scale fixed installation is exempt per Article 2, clause 4c (utility substation equipment which is designed in)

Reference Number : DOC B001 **Issue :** R

Date of issue : 21-December-2016

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The following route(s) were used to establish conformity:

1. **2014/30/EU: (EMCD) In accordance with** Article 14, Annex II (internal production control) supported by a Technical File, superceding 2004/108/EC, **i**n accordance with Article 7, Annex II.

Technical Construction File No. :	RFI/TCFT1/43054JD02 including Annex/Appendices
Date Revised :	14-Dec-2016 or later- New Legislative Framework & EMC Directive (original issue dated 07-January-2003); (piror re-issue dated 30-November-2012)
Conformity Assessment Body : (C.A.B.)	Radio Frequency Investigation Ltd Ewhurst Park, Ramsdell, Basingstoke, Hampshire, England. RG26 5RQ. Underwriters Laboratories, Inc., Melville Division 1285 Walt Whitman Road, Melville, NY 11747-3081 USA
Compliance Certificate / Test Report:	RFI/CBCB2/43054JD03 E164178, 03ME15424, M871, MA/EMC; E164178, 03ME15424/04ME06474, M877, MA/EMC; E164178, 04CA42217, M871 in C12X8, MA/EMC; E164178, 06CA09838, M87x IRIG-B Converter, EMC, File MC15156; E164178, 06CA43637, M872 with P40 Module in C10A7, MA/EMC; E164178, 1001052984, M87x, M57x, M870D, M570Dx EMC 09CA09082; E164178, 12ME06094, M87x with H12, EMC, incl. tests by MFG.

2. **2014/35/EU: (LVD)** Self Certification supported by a Technical File, in accordance with Article 12, Annex III (internal production control), superceding 2006/95/EC.

Technical File No. :	TF B001
Date Revised :	21-Dec-2016 or later - New Legislative Framework & LVD Directive (original issue dated 02-December-2002); (re-issue dated 01-October-2013 covered transition to IEC 61010-1 Ed. 3)
Conformity Assessment Body : (C.A.B.)	UL Northbrook, 333 Pfingsten Rd, Northbrook, IL 60062-2096, USA
Compliance Certificate / Test Report:	CB Certificate No. US-22412-UL issued by National Certification Body: UL (US), 333 Pfingsten Rd., IL 60062, Northbrook, USA / CB Test Report E164178-A3-CB-1-Original and E164178-A3-CB-1-Correction-1, Models M87x, or 87x, Product Safety Assessment, Project 13ME04905 & SR40508.20439.

Reference Number : DOC B001 **Issue :** R

Date of issue : 21-December-2016

Form BIDOC_H

The following standards were used for reference and to establish conformity :

IEC/EN 61010-1, Edition 3, 2010 UL 61010-1, Edition 3, 2012/05/11 CAN/CSA No. 22.2, No. 61010-1-12, Ed. 3, 2012/05/01	Safety requirements for electrical equipment for measurement, control, and laboratory use. Part 1: General requirements
IEC/EN 61010-2-030, Edition 1, 2010 UL 61010-2-030, Edition 1, 2012/05/11 CAN/CSA No. 22.2, No. 61010-2-030-12, Ed. 1, 2010/05/10	Safety requirements for electrical equipment for measurement, control and laboratory use. Part 2-030: Particular requirements for testing and measuring circuits
EN 61326-1: 2013	Electrical Equipment for measurement, control and laboratory use -- EMC requirements
IEC/EN 60255-26: 2013 + AC: 2013 product standard used in part - reliance on basic standards	Electrical relays, Electromagnetic compatibility requirements for measuring relays and protection equipment
EN 61000-6-4: 2007 + A1: 2011	Electromagnetic compatibility Part 6-4: Generic emission standard – Industrial environment.
EN 61000-6-2: 2005 + AC: 2005	Electromagnetic compatibility (EMC) Part 6-2: Generic standards - Immunity for Industrial environments
EN 55011: 2009 + A1: 2010, EN 55011: 2016, Group 1 Class A	Radiated Emissions Electric Field Strength, AC Powerline Conducted Emissions
EN 55022: 2010 + AC: 2011 EN 55032: 2012 + AC: 2013 EN 55032: 2015 + AC: 2016-07 Group 1 Class A (Conducted on Ethernet port)	Electromagnetic compatibility of multimedia equipment - Emission Requirements
EN 61000-4-2: 2009	Electrostatic Discharge (ESD)
EN 61000-4-3: 2006 + A1:2008 + A2: 2010, Class III	Immunity to Radiated Electromagnetic Energy (Radio Frequency)
EN 61000-4-4: 2012, Severity Level 4	Electrical Fast Transient / Burst Immunity
EN 61000-4-5: 2014, Installation Class 3	Surge Immunity
EN 61000-4-6: 2014, Level 3	Immunity to Conducted Disturbances induced by Radio Frequency Fields
EN 61000-4-8: 2010	Immunity to Power Frequency Magnetic Fields
EN 61000-4-11: 2004	AC Supply Voltage Dips and Short interruptions
IEC 60255-22-1: 1988, Class III	Electrical disturbance tests for measuring relays and protection equipment. Part 1. 1 MHz Burst disturbance tests.

Signed for and on behalf of the Company :	Alan Staatz, Vice President, Engineering *Alan Staatz* Novatech, LLC / Lenexa Kansas USA

CE Marking Year 2002, 2004, 2005, 2006, 2009, 2012, 2013, 2016

Reference Number : DOC B001 Issue : R

Date of issue : 21-December-2016

Form BIDOC_H

Revision	Date	Changes	By
A	02/07/2013	Initial Release	E. DeMicco
B	04/23/2013	Corrected error regarding S2 LED flashing	E. DeMicco
C	10/28/2013	Revised Section 1.4.3. UL/IEC 61010-1 ed. 2 is replaced by to UL/IEC 61010-1 (ed.3) and IEC 6101-2-030 (ed.1). Revised associated sub-section 1.3. New DoC.	R.Fisher, E. DeMicco
D	3/9/16	Revised for P33 support, section 8	E. DeMicco
E	5/22/17	Updated manual for new DoC; changes to 1.4.1; revised 8.3 for isolation specification on I/O channel to channel from 2000 Vac to 1500 Vdc. Updated firmware version history.	E. DeMicco R. Fisher

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