# M650 Multifunction SCADA Meter

**User Manual**


September 27, 2017
ML0035 Document Revision O


NovaTech®
Bitronics ◆ D/3 ◆ Orion

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## 50 SERIES MANUAL SET

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| ML0039 | M651 Family User Manual |
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## VERSION HISTORY (ABRIDGED)

| | | |
|---|---|---|
| V1.010 | 2010-03-25 | M650M3x51x models with firmware download capability |
| V1.030 | 2010-05-14 | Add 0-1mA, add per-phase power demands to protocols |
| V1.040 | 2010-06-17 | Add M350 models, add configurable display screens |
| V1.050 | 2010-07-14 | Add secondary volts screens, more info to front panel menu |
| V1.060 | 2010-07-20 | Add support for B3 models |
| V1.070 | 2010-08-03 | Add support for 1A input and 4-20mA output |
| V1.090 | 2010-10-27 | Add support for M651 models |
| V2.010 | 2011-02-18 | Add support for configurable points/registers |
| V3.000 | 2011-09-08 | Add support for M653 models, split-core CTs, passwords, analog events, frozen counter events, binary events, Primary Units |
| V3.020 | 2011-09-28 | Production support changes |
| V3.030 | 2011-12-13 | Modbus and DNP serial address settings configurable in front panel menu; error reporting on front panel display |
| V3.060 | 2012-06-19 | Changed password default to none |
| V3.070 | 2012-08-28 | Bug fix |
| V3.080 | 2013-06-14 | Add support for loss compensation calculation |
| V3.090 | 2014-04-24 | Bug fix and support for the change to alphanumeric display on the M350 |
| V3.10 | 2015-08-31 | Bug fix for matching baud rate of display |
| V3.11 | 2016-01-06 | Lowered demand interval minimums |
| V3.12 | 2016-06-17 | Front panel lock only locks menu, allows energy resets |
| V3.13 | 2016-12-07 | Build no. displayed on index page; max CT ratio increased to 30,000:1 |
| V3.15 | 2017-09-06 | Added bus averages: Average L-L Volts, Average L-N Volts and Average Amps. |

 

## CERTIFICATION

Bitronics LLC certifies that the calibration of our products is based on measurements using equipment whose calibration is traceable to the United States National Institute of Standards Technology (NIST).

## 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) 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.

For assistance, contact Bitronics LLC at:

| | |
|---|---|
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**TRADEMARKS**

## SAFETY SECTION

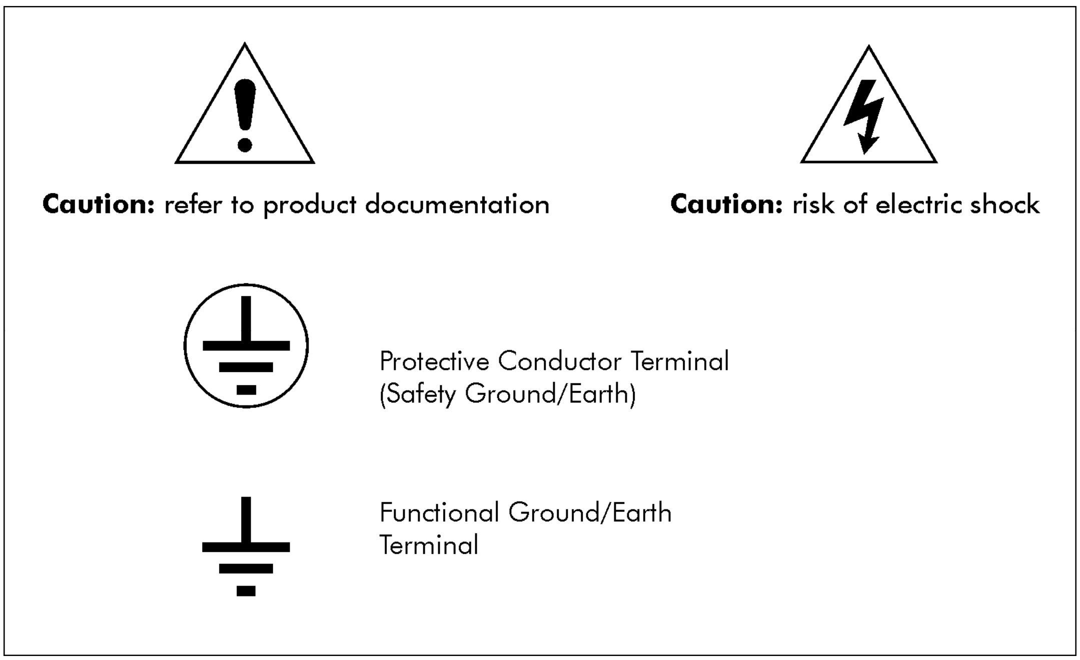
This Safety Section should be read before commencing any work on the equipment.

### 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.

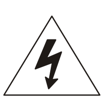
### Explanation of symbols and labels

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 and current 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:

Voltage rating and polarity

CT circuit rating and integrity of connections

Protective fuse rating

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

Equipment operating conditions

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

Current transformer circuits

Do not open the secondary circuit of a live CT since the high voltage produced may be lethal to personnel and could damage insulation.

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.

Do not attempt to perform installation, maintenance, service or removal of this device without taking the necessary safety precautions to avoid shock hazards. De-energize all live circuit connections before work begins.

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 meter (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 & SPECIFICATIONS

### 1.1 Introduction

The M650 family of multifunction SCADA meters provides a range of measurement and communications capabilities for 3-phase metering. They offer an outstanding display, superior communications flexibility and easy setup.

The following Model M650 Multifunction Meter types are covered in this manual:
B3 - Multifunction Standard, alphanumeric 3-Phase
M3 - Multifunction Advanced, alphanumeric 3-Phase

### 1.2 Features

1. Full basic measurement set with optional demand and harmonic values (M3)
2. 0.2% revenue accuracy
3. Updates every 100ms
4. DNP3 or Modbus protocol available via configurable RS-232/RS-485 serial port
5. Available Ethernet protocol support for DNP3 TCP/UDP or Modbus TCP
6. Web Based configuration via Ethernet service port
7. Wide-range universal power supply
8. Rugged aluminum case
9. One model covers all wiring options
10. Standard 4" round meter
11. 3-line at once, easy-to-read, long-life LED displays
12. Ultimate precision with five digits per line
13. Instant recognition of the displayed function from the alphanumeric display in engineering units
14. Easy setup and scrolling from front display with "Touch-Sense" buttons

### 1.3 Specifications

Power Supply Input (Auxiliary) Voltage – terminals L1(+) and L2(-)

Installation Category (Auxiliary Power Supply) – CAT II

| | |
|---|---|
| Nominal: | 48-250V dc, 69-240V ac (50/60Hz) |
| Operating Range: | 36-300V dc, 55-275V ac (45-65Hz) |
| Burden: | 8W max, 24VA max |
| Display: | 3 lines of 5 digits, Red LED, 0.56" High<br>1 line 8 character alphanumeric, Red LED, 0.20" High |
| Display Interface: | 4 buttons |

| Input Signals – Measurement Inputs | | | |
|---|---|---|---|
| CT Current Inputs | Configuration | All Input Options | 3 Inputs. 3 Phase Currents (IA, IB, IC). |
| | Nominal | Input Option 1 | 1A ac |
| | | Input Option 5 | 5A ac |
| | | Input Option C | 5A ac with split-core CTs |
| | Range | Input Option 1 | 0 to 2A rms continuous at all rated temperatures |
| | | Input Option 5 | 0 to 10A rms continuous at all rated temperatures |
| | | Input Option C | 0 to 10A rms continuous at all rated temperatures |
| | Overload | Input Option 1 | Withstands 30A ac continuous, 400Aac for 2 seconds |
| | | Input Option 5 | Withstands 30A ac continuous, 400Aac for 2 seconds |
| | | Input Option C | Not applicable |
| | Isolation | Input Option 1 | 2500V ac, minimum. |
| | | Input Option 5 | 2500V ac, minimum. |
| | | Input Option C | 2500V ac, minimum with external split-core current transformers. |
| | Burden | Input Option 1 | 0.016VA @ 1A rms, 60Hz (0.0016ohms @ 60Hz) |
| | | Input Option 5 | 0.04VA @ 5A rms, 60Hz (0.0016ohms @ 60Hz) |
| | | Input Option C | Not applicable |
| | Frequency | All Input Options | 45-65 Hz |
| VT (PT) Voltage Inputs | Configuration | | 4 Inputs, Measures 1 Bus, 3 or 4 Wire. 3 Phase Voltages (VA, VB, VC, VN). See Appendix A1 Connection Diagrams. |
| | Nominal | | 120Vac |
| | Range | | 0 to 150V rms |
| | System Voltage | | Intended for use on nominal system voltages up to 208 V rms, phase-to-phase (120V rms, phase-to-neutral). |
| | Common Mode Input Voltage | | Reads to 400V peak, any input-to-case (ground) |
| | Impedance | | >12M ohms, input-to-case (ground) |

| Input Signals – Measurement Inputs | | | |
|---|---|---|---|
| | Voltage Withstand | | 2.5kV rms 1min, input-to-case (ground)<br>2kV rms 1min, input-to-input |
| | Frequency | | 45-65 Hz |

| Sampling System | | |
|---|---|---|
| Sample Rate | 64 samples per cycle | |
| Data Update Rate | Amps, Volts | Available every 100 ms |
| | Watts, VAs, VARs, PF | Available every 100 ms |
| Number of Bits | 16 | |

| Accuracy<br>Accuracies are specified at nominal Frequency and 25C, (unless otherwise noted). Unless noted, all values are true RMS and include Harmonics to the 31st (minimum). | | |
|---|---|---|
| Voltage | | AC: Better than 0.1% of reading (20 to 150 V rms, input-to-case). (+/-25ppm/DegC) |
| Voltage Aux | Only included with meters manufactured with the monitoring option | AC/DC: Better than 1.0% of reading |
| Current | Input option 1 (Internal Isolation - 1A ac) | Better than 0.1% of reading +/- 20uA (>0.1A to 2.0A, -20C to 70C) |
| | | Better than 0.1% of reading +/- 50uA (0.01A to 0.1A, -20C to 70C) |
| | | Minimum reading 1mA |
| | Input option 5 (Internal Isolation - 5A ac) | Better than 0.1% of reading +/- 100uA (>0.5A to 10.0A, -20C to 70C) |
| | | Better than 0.1% of reading +/- 250uA (0.05A to 0.5A, -20C to 70C) |
| | | Minimum reading 5mA |
| | Input option C (External Split-Core CTs) | Better than 0.1% of reading +/- 100uA (>0.5A to 10.0A, -20C to 70C) |
| | | Better than 0.1% of reading +/- 250uA (0.05A to 0.5A, -20C to 70C) |
| | | Minimum reading 5mA |
| Frequency | +/- 0.001 Hertz | +/- 0.001 Hertz |
| Power | Meets or exceeds IEC 60687 0.2S | Meets or exceeds IEC 60687 0.2S |

| Communication Ports | |
|---|---|
| Serial (option*) | RS-232, RS-485, Software configurable ports |
| | Baud rate: 9600 bps to 115.2 kbps |
| Ethernet | Single port; copper 10/100 Base-TX (standard) |
| | Single port; LC fiber 100 Base-FX (option) |
| Analog Transducer Outputs (option*) | Refer to section 7.0 for specifications |

*Either the serial port or analog output may be ordered as an option, but not both

| Environmental | |
|---|---|
| Operating Temperature | -40C to 70C |
| Relative Humidity | 0-95% non-condensing |
| Measurement Inputs (VTs, CTs) Installation/Measurement Category | CAT III (Distribution Level) Refer to definitions below. |
| Pollution Degree | Pollution Degree 2 Refer to definitions below. |
| Enclosure Protection (to IEC60529: 2001) | Front Panel: IP 20, Rear: IP 20<br>When equipment is mounted in an appropriately rated protective enclosure to NEMA or IP protection classifications, as required for the installation. Ratings are applicable for enclosure category 2 (see definitions) |
| 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.<br>Class 1 equipment to IEC61140: 2001 |

| Physical | | |
|---|---|---|
| Connections | Protective Conductor Terminal | 10-32 Studs for connection with protective earth ground. Recommended Torque: 12 In-Lbs, 1.36 N-m<br>Cable temperature rating: 85C minimum |
| | Current (CT) | Internal Isolation - Current Input Option 1 or 5. 10-32 Studs for current inputs. Recommended Torque: 12 In-Lbs, 1.36 N-m<br>Cable temperature rating: 85C minimum |
| | | External Split-Core CTs – Current Input Option C: Terminal Block accepts #22-12 AWG (0.35 to 3.3mm$^2$) wire, or terminal lugs up to 0.325" (8.26mm) wide.<br>Recommended Torque: 9 In-Lbs, 1.02 N-m<br>Cable temperature rating: 85C minimum |
| | Voltage (VT) & (AUX PWR) | Terminal Block accepts #22-10 AWG (0.35 to 5mm$^2$) wire, or terminal lugs up to 0.375" (9.53mm) wide. Precautions must be taken to prevent shorting of lugs at the terminal block. A minimum distance of 1/8" (3mm) is recommended between uninsulated lugs to maintain insulation requirements. Recommended Torque: 9 In-Lbs, 1.02 N-m<br>Cable temperature rating: 85C minimum |
| | Serial Port | 6 position removable terminal block, accepts 26-14AWG solid or 26-12 AWG stranded wire. Recommended Torque 7 in-lbs, 0.79 N-m.<br>Cable temperature rating: 85C minimum |
| | Ethernet | RJ45, 8 position modular jack, Category 5 for copper connection; 100m (328 ft.) UTP (unshielded twisted pair) cable. |
| Weight (typical) | 1.8 lbs (.8 kg) | |
| Size | Industry standard 4” round case, 7.0 inches long | |

Definitions:

**Enclosure Category 2:** Enclosures where no pressure difference relative to the surrounding air is present.

**Installation Category II (Overvoltage Category II)** or CAT II: Equipment is intended for connection to the fixed installation of a building. The power supply to the electronic equipment is separated from other circuits, usually by a dedicated transformer for the mains power supply.

**Measurement/Installation Category III (Overvoltage Category III) or CAT 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 Revenue

The M650 family of meters exceeds the accuracy requirements of ANSI C12.20 and IEC 60687 (or IEC62053-22).

| Type | Nominal Current | Certification |
|---|---|---|
| B3, M3 | 1A, 5A | ANSI C12.20, 0.2CA<br>IEC 62053-22, 0,2S<br>IEC 62053-23, 2S (Reactive) |

The M650 meters were tested for compliance with the accuracy portions of the standards only. The form factor of the M650 meters differs from the physical construction of revenue meters specified by the ANSI/IEC standards and no attempt has been made to comply with the standards in whole. Contact customer service for more information.

## 1.5 Environment

**UL/CSA Recognized, File Number E164178**
UL61010-1, Edition 3, Issue Date 2012/05/11
Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements

UL61010-2-30, Edition 1 – Issue Date 2012/05/11
Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2: 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. 61010-2-30-12-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 2004/108/EC and Directive 91/263/EC [TTE/SES].
European Community Directive on Low Voltage (LVD) 2014/35/EU, superseding 2006/95/EC

The object of the declaration described above is in conformity with the relevant Union harmonization 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 61010-1, Edition 3, Issue Date 2010
Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements
IEC 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 EN61326-1: 2006), EN 61000-6-2: 2005 + AC: 2005 (supersedes EN 61000-6-2:2005),
EN 61000-6-4: 2007 + A1:2011 (IEC date 2010)

<u>Radiated Emissions Electric Field Strength</u>
EN 55011: 2009 + A1: 2010
EN 55011: 2016
EN 61000-6-4: 2007 + A1:2011 (IEC date 2010
Group 1, Class A
Frequency: 30 - 1000 MHz

<u>AC Powerline Conducted Emissions</u>
EN 55011: 2009 + A1: 2010

EN 55011: 2016
EN 61000-6-4: 2007 + A1:2011 (IEC date 2010
Group 1, Class A
Frequency: 150 kHz – 30 MHz

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

Electrostatic Discharge (ESD)
EN61000-4-2: 2009
Discharge voltage: ± 8 KV Air; ± 4 KV Contact & Additionally meets ± 6 KV Contact

Immunity to Radiated Electromagnetic Energy (Radio Frequency)
EN 61000-4-3: 2006 + A1: 2008 + A2:2010, Class III
Frequency: 80 – 1000 MHz, Amplitude: 10.0 V/m, Modulation: 80% AM @ 1 kHz
Frequency: 1400 – 2000 MHz, Amplitude: 3.0 V/m, Modulation: 80% AM @ 1 kHz
Frequency: 2000 – 2700 MHz Amplitude: 1.0 V/m Modulation: 80% AM @ 1 kHz
Digital Radio Telephones:
Frequency: 900 MHz & 1890 MHz, Amplitude: 10.0 V/m, 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)
Burst Frequency: 5 kHz
Amplitude, AC Power Port: ± 4 KV (Severity Level 4), exceeds ± 2 KV requirement
Amplitude, Signal Port: ± 1 KV, Additionally meets ± 2 KV (Severity Level 3)
Amplitude, Telecom ports (Ethernet): ± 1 KV

Current/Voltage Surge Immunity
EN 61000-4-5: 2014 (supersedes EN 61000-4-5: 2006)
Open Circuit Voltage: 1.2 / 50 μs
Short Circuit Current: 8 / 20 μs
Amplitude, AC Power Port: ± 2 KV common mode, ± 1 KV differential mode

Immunity to Conducted Disturbances Induced by Radio Frequency Fields
EN 61000-4-6: 2014 (supersedes EN 61000-4-6: 2009)
Level: 3
Frequency: 150 kHz – 80 MHz
Amplitude: 10 V rms
Modulation: 80% AM @ 1 kHz

Power Frequency Magnetic Fields

EN 61000-4-8: 2010
Amplitude: 30A/m
Frequency: 50 and 60 Hz

AC Supply Voltage Dips and Short Interruptions
EN 61000-4-11: 2004

Surge Withstand Capability Test For Protective Relays and Relay Systems
ANSI/IEEE C37.90.1: 2002 (2.5 kV oscillatory wave and 4 kV EFT)

## 2.0 PHYSICAL CONSTRUCTION & MOUNTING

The M650 meters are packaged in rugged aluminum case specifically designed to meet the harsh conditions found in utility and industrial applications.

The Front panel view is shown in Figure 1. The mechanical dimensions are shown in Figure 2.


**Figure 1 – M650 Front View**

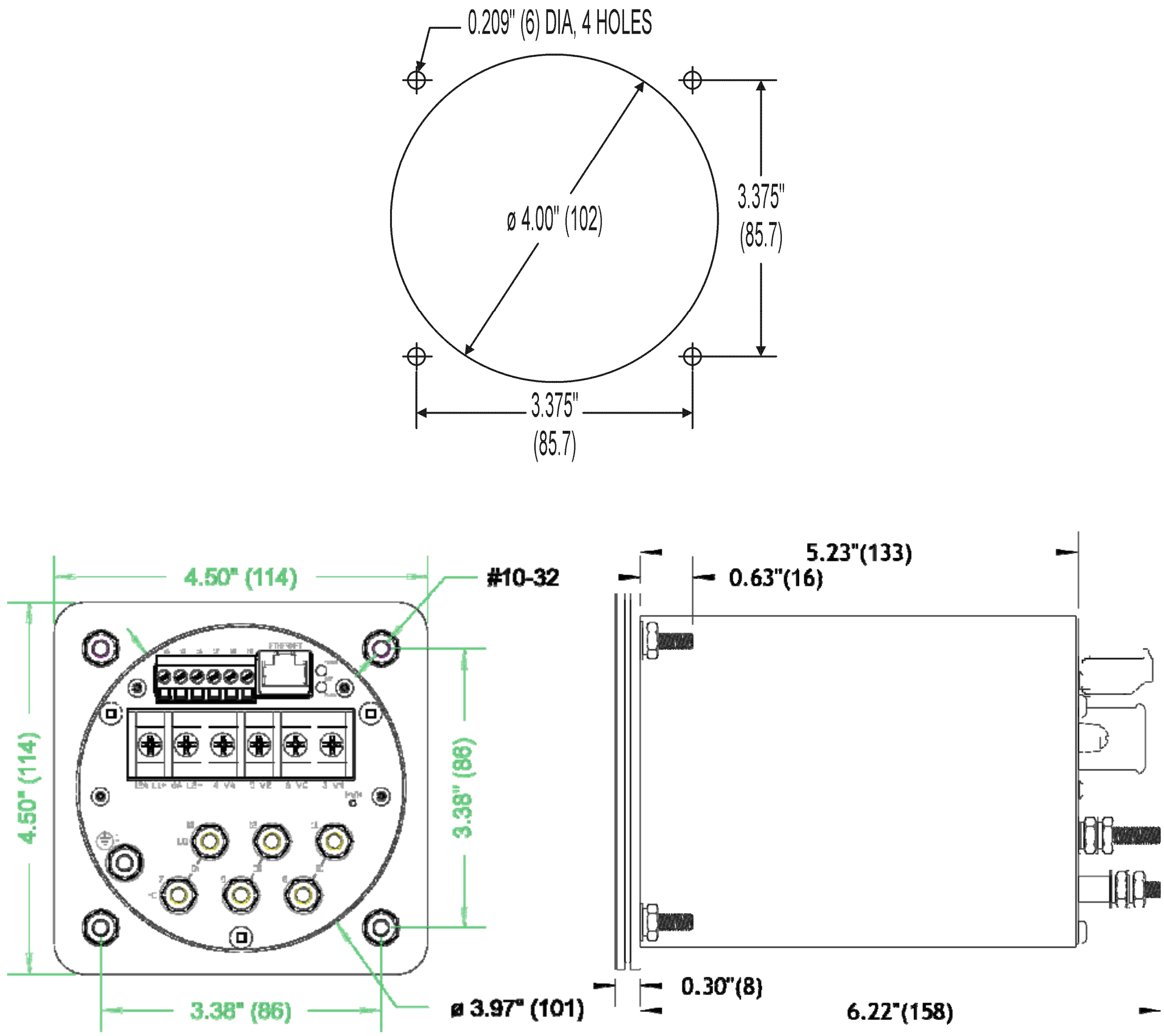



**Figure 2 - Mounting and Overall Dimensions M650**
(back panel may vary as a result of options ordered)

## 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

The device must be connected to Protected Earth Ground. The minimum Protective Ground wire size is 2.5 $mm^2$ (#12 AWG). Bitronics LLC recommends that all grounding be performed in accordance with ANSI/IEEE C57.13.3-1983.

## 2.4 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.

## 2.5 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.**

## 2.6 Instrument Mounting

The instrument may be mounted into a standard 4" round panel opening as shown in Figure 2. The unit will mount through the 4-inch round panel opening from the front. Align the four #10-32 studs attached to the flange with their appropriate mounting holes, as shown by the panel hole pattern. Use four #10-32 nuts with lock washers applied onto the studs from the back side of the panel. *Make sure that any paint or other coatings on the panel do not prevent electrical contact.*

**WARNING – DO NOT** over tighten the nuts on the mounting studs, **HAND** tighten with a standard nut driver, 12 inch-pounds (1.36 N-m) is recommended, **MAXIMUM** torque is 15 inch-pounds (1.69 N-m).

Several instruments may be mounted on a 19" Rack panel if desired. Three units will fit side by side on a standard 5.25" high panel. Figure 2 indicates the dimensions of the panel hole cutout. Leave adequate space surrounding the instrument when determining mounting arrangements.

### 2.7 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 non-flammable and non-explosive.

## 3.0 BACK PANEL & WIRING

The rear views of the M650 are shown in figures 3A and 3B with the option port shown (removable terminal block at the top), which may be selected at order time, as either, the serial communication option, the 0-1mA analog transducer output option, or the 4-20mA analog transducer output option. However, it is also possible to have a meter without this option port.
See Appendix A1 for detailed wiring diagrams covering the CT/VT measurement inputs. Refer to the appropriate section in this user manual when wiring either the serial communication option, or either analog transducer output option, whichever applies to the option port for your meter.

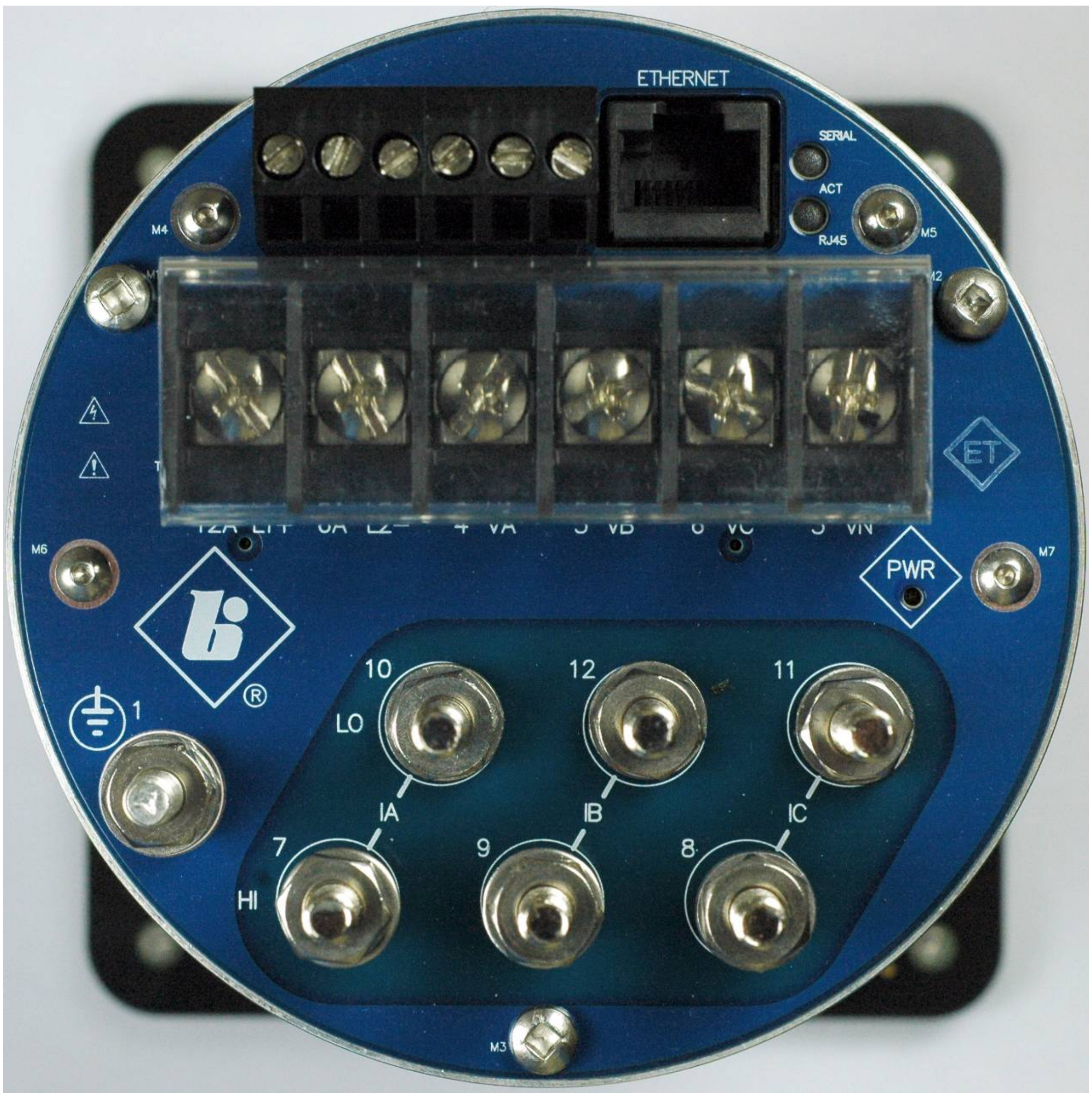



**Figure 3A – Rear View M650 (shown with Current (CT) Inputs with internal isolation (#10-32 stud terminals) – Current Input Option 1 or 5)**

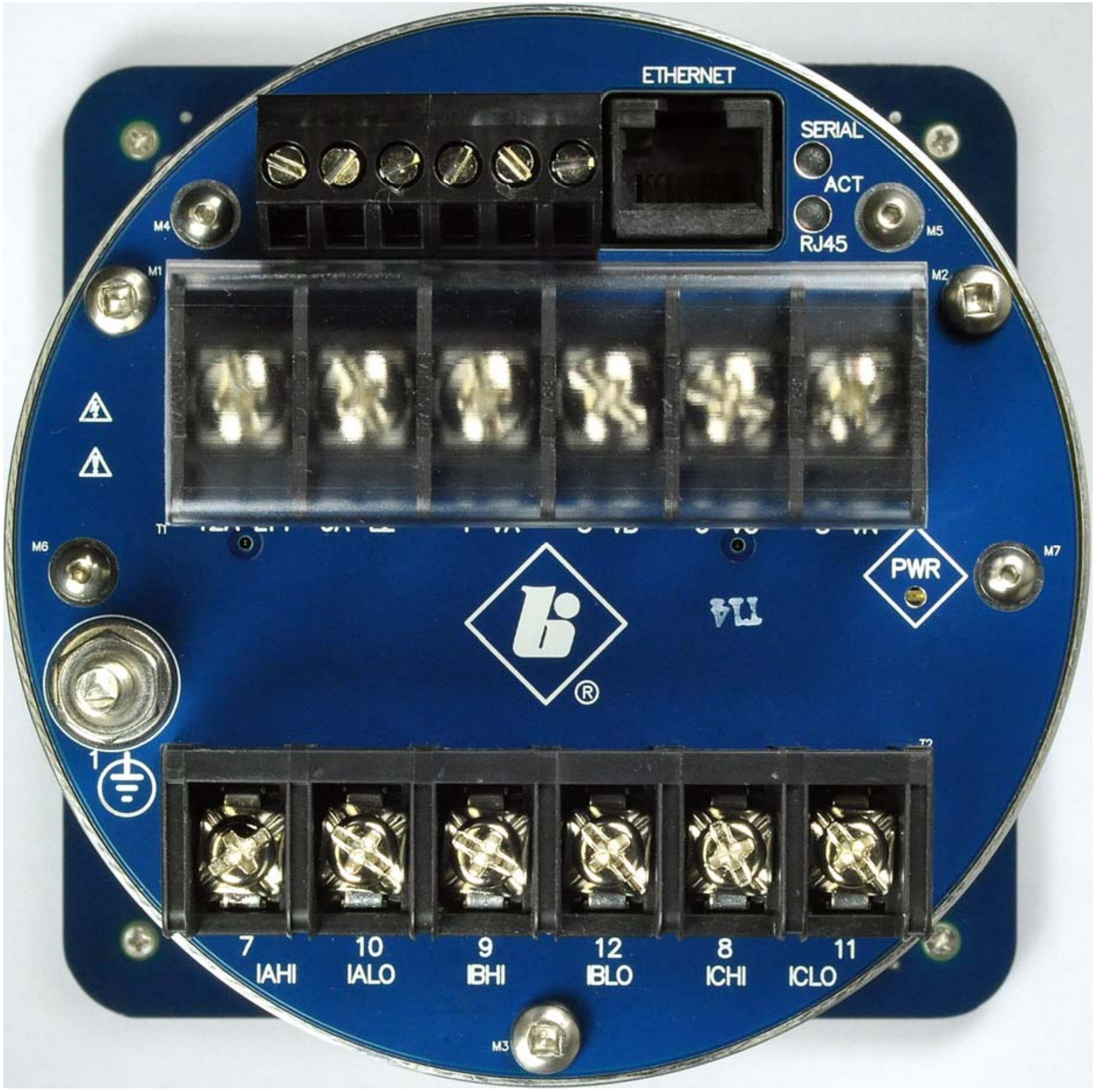



**Figure 3B – Rear View M650 (shown with 6 position terminal block for External Split-Core CTs – Current Input Option C)**

### 3.1 Auxiliary Power

The M650 meters are powered by connections to L1(+) and L2(-). A Blue LED Power (PWR) indicator is provided on the rear panel to indicate that the unit is powered ON. It is located on the right of the rear panel.

There is an option that allows the voltage across the Auxiliary Power input voltage across terminals L1(+) and L2(-) to be monitored. This monitoring option is only found in 50 Series SCADA meters that have been manufactured with this monitoring option.

Refer to the order guide to verify whether the meter is made with this monitoring option. 'V Aux' will appear on the display as a measurement for meters equipped with this monitoring option.

### 3.1.1 Specifications (per section 1.3)

Power Supply Input (Auxiliary) Voltage – terminals L1(+) and L2(-)

| | |
|---|---|
| Nominal: | 48-250V dc, 69-240V ac (50/60Hz) |
| Operating Range: | 36-300V dc, 55-275V ac (45-65Hz) |

## 3.2 VT Inputs – VA, VB, VC, VN (See Appendix A1 and Section 1.3)

The M650 meter voltage (VT) signal inputs are connected to terminals 3-6 (see Appendix A1 for specific wiring configurations). Voltage signals are measured using a 12M ohm resistor divider with a continuous voltage rating of 7kV. This ideal impedance provides a low burden load for the VT circuits supplying the signals. Grounding of VT & CT signals per ANSI/IEEE C57.13.3-1983 is recommended. The polarity of the applied signals is important to the function of the instrument.

## 3.3 CT Inputs – IA, IB, IC (See Appendix A1 and section 1.3)

The instrument can be connected directly to a current transformer (CT). The Current (CT) signal inputs are connected to terminals 7-12.

Several hardware options are offered for the M650 current inputs. Distinctions are based on the current option ordered and the physical constructions.

The 1 Amp and 5 Amp current inputs, current input options 1 and 5 respectively, feature 10-32 terminals to assure reliable connections. This results in a robust current input (CT) connection with negligible burden to ensure that the user's external CT circuit can't ever open-circuit, even under extreme fault conditions. Grounding of CT signals per ANSI/IEEE C57.13.3-1983 is required.

**Current inputs, option 1:** 1 Amp input with internal current isolation transformer, constructed with 10-32 studs as the current terminals. (**See Figure 3A for the physical construction shown for the current terminals**). It is intended that this meter connect to the output from the secondary of permanently installed Current Transformers (CTs).

**WARNING:** DO NOT loosen existing 10-32 hardware that secures the current input studs to the back panel. When making connections to the current input studs, use #10 ring lugs. Fasten ring lugs with the 10-32 bagged hardware (flat washer, lock washer, and nut) provided. DO NOT OVERTORQUE. HAND Tighten with a standard nut driver. 12 inch-pounds (1.36 N-m) is recommended, MAXIMUM torque is 15 inch-pounds (1.69 N-m).

**Current inputs, option 5:** 5 Amp input with internal current isolation transformer, constructed with 10-32 studs as the current terminals. (**See Figure 3A for the physical construction shown for the current terminals**). It is intended that this meter connect to the output from the secondary of permanently installed Current Transformers (CTs).

**WARNING:** DO NOT loosen existing 10-32 hardware that secures the current input studs to the back panel. When making connections to the current input studs, use #10 ring lugs. Fasten ring lugs with the 10-32 bagged hardware (flat washer, lock washer, and nut) provided. DO NOT OVERTORQUE. HAND Tighten with a standard nut driver. 12 inch-pounds (1.36 N-m) is recommended, MAXIMUM torque is 15 inch-pounds (1.69 N-m). .

**Current inputs option C:** This option is used with external Split core CTs. External split core CT secondary wires connect to the current terminal block **(see figure 3B)**. The Current inputs for this model are touch safe. No internal current isolation is provided within the meter. DO NOT CONNECT Hazardous Live voltages to the current input terminal block. Only connect the external Split Core CT secondary current outputs to the meter's current input terminal block. Isolation is provided from the external Split Core CTs. Recommended torque is 9 In-Lbs, 1.02 N-m

### 3.4 Serial Ports (See section 4.2)

The M650 meters are equipped with an optional serial port. The port is software (user) configurable for RS-232 or RS-485. The RS-232 drivers support full and half duplex modes. See Figures 7-8 for signal assignments.

### 3.5 Ethernet

The M650 Ethernet port meets or exceeds all requirements of ANSI/IEEE Std 802.3 (IEC 8802-3:2000) and additionally meets the requirements of part 8-1 TCP/IP T-profile for physical layer 1 (Ethernet copper interface).

M650 meters are offered with a standard Ethernet 10/100 Megabit (Mb) RJ45 (copper) interface (10BASE-T and 100BASE-TX) which automatically selects the most appropriate operating conditions via auto-negotiation. This interface is 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 the meters come with the port setup as a service port, with Modbus TCP/IP or DNP3 TCP/IP or UDP software offered as an option. An option to replace the standard RJ45 port with a LC 100BASE-FX fiber port also exists operating at 1300 nm (far infra-red, full-duplex). If needed, adapters are available to convert the LC to ST connectors, the same that are used in the Bitronics 70 Series.

### 3.5.1 Network settings

The M650 meters come preconfigured for interconnection to an HTML web server with default settings for IP address, SUBNET mask, and ROUTER (GATEWAY) address.

| Network Default (Preconfigured) Settings | | |
|---|---|---|
| IP Address | Subnet mask | Router (Gateway) Address |
| 192.168.0.171 | 255.255.255.0 | 192.168.0.1 |

It is very important that the network have no duplicate IP addresses, so an IP address conflict is NOT created for your network. It is recommended to perform your initial setup for network addresses using the front buttons on the meter, unless it is known that the default (preconfigured) IP address is not already an assigned address on your network. Changing the stored Configuration of these network addresses may be accomplished by using one of the following methods

Enter Network addresses using the meter's front buttons:

Refer to the section in this manual on "Navigating the M650's setup menu from the Front panel" for further instruction regarding the button sequence you will use to scroll through the menu structure. This will provide a handy menu tree.

Activate the setup mode using the front buttons on the meter by pressing the Up + Toggle (Exit) buttons simultaneously. Scroll to menu selection "1.3", "Network", in order to change the Network settings. Enter an IP address that you know is an unassigned address for your network. You can ping the IP address to make sure it is not already in use on your network. You may also want to check with your network administrator to make sure the IP address you plan on using is available to use on your network. After entering the Network addresses exit out of the menu, and when prompted to save the new configuration settings, press the button directly under the SAVE prompt identified as "Y" (Yes). Reboot the meter for the configuration changes to take effect.

Enter the IP Address for the meter through a standard web browser:

Before entering an IP address with this method make sure the current IP address and the new IP address to be assigned to the meter will not cause IP address conflicts on your local network. To connect to the web server enter the meter's current IP Address in your web browser's address bar. When the web server screen appears click on the "Settings" tab. Type the new Network settings (IP address, Subnet mask, Gateway) in the appropriate fields and click the "**Apply**" button to send the new network settings to the meter. Reboot the meter for the configuration change to take effect.

The M650 uses the following port numbers for each type of protocol:

| Protocol | Port Number |
|---|---|
| DNP3 | 20000 (TCP, UDP) |
| HTML | 80 (TCP) |
| Modbus | 502 (TCP) |

Determining the IP Address if unknown:

Although the IP address can be obtained via the display, for versions that don't have a display (M651, M661, PPX II), Bitronics has created a utility program to request the IP address for a specific MAC address on an Ethernet network. This program can be used with the M650 as well. The program is available on the company website (http://www.novatechweb.com/downloads/inarp/).
The program uses the Inverse Address Recognition Protocol to perform the lookup and thus is called inarp. The InARP protocol definition can be found at www.apps.ietf.org/rfc/**rfc2390**.html. The inarp utility can also scan an Ethernet network for a range of MAC addresses, providing the IP address for any devices which respond.

The general form of inarp is defined below, followed by some usage examples.

inarp usage:

```
 inarp [-i <if_ipaddr>] [-n <cnt>] [-p <ms>] [-v] <mac-spec>

  where
    <if_ipaddr> := interface ip address (default is 1st Ethernet interface)
         <cnt> := count of addresses to poll (default 1)
          <ms> := period between polls (100ms)
     <mac-spec> := <6ByteMac> | <[3-5]ByteMac> | <macRangeName>
     <6ByteMac> := xx:xx:xx:xx:xx:xx - <cnt> can specify a range to scan
     <5ByteMac> := xx:xx:xx:xx:xx - default <cnt> is 256
       ...
     <3ByteMac> := xx:xx:xx - default <cnt> is 16,777,216
  <macRangeName> := "50series"
                 50Series MAC base (00:d0:4F:03), default <cnt> is 65,536
            -v := request verbose information

  CTRL-C stops a scan.
```

The inarp utility requires the WinPcap and Packet libraries which are bundled in the WinPcap "Installer for Windows." This can be downloaded from www.winpcap.org.

Installation requires Administrator privileges.

Examples:

to poll the 1st IPv4 interface,
inarp -v 50series
CTRL-C stops the scan

to poll the IPv4 interface associated with 192.168.1.1, use
inarp -v -i 192.168.1.1 50series

or to poll a specific mac, use
inarp -v -i 192.168.1.1  00:D0:4F:03:00:15



### 3.5.2 Indicators – Ethernet (ACT) & Serial LEDs

There are 2 LEDs on the rear panel to indicate activity is occurring on the communication ports. These LEDs are useful in determining that there is activity occurring on the ports. The "ACT" LED will flash to indicate there is activity on the Ethernet port.  It will also indicate that a link has been established.  The Serial LED flashes to indicate there is activity occurring for the serial port.

A troubleshooting guide is found in Appendix A2, which may be useful in establishing Ethernet connections.

### 3.5.3 Firmware upgrades and saving and loading configuration files – Ethernet service port

New versions of firmware may be released by Bitronics from time to time, either to add new functionality or to correct errors in code that may have escaped detection prior to commercial release.  Consult the factory for detailed information pertaining to the availability of firmware upgrades.  In cases such as this, it is desirable to support a mechanism for new firmware to be installed remotely.  The ability to upgrade Firmware is done over the Ethernet port.  The M650 family utilizes a page in the Web Server interface to upload and install new firmware.

The complete M650 configuration, which includes all user-configurable parameters, can be saved in a single file on your computer. This allows you to save a backup of your configuration and to restore it at a later time, as needed. This also allows you to configure one M650 and then transfer the configuration to multiple other M650's.

Before initiating the firmware upgrade, if you are planning to use a configuration that has already been setup in the M650, then you should first go to the Load/Store Settings page and click on the Get File button to save the IED configuration to your computer (if you will be using a default configuration this step is not necessary).  Use the File Save dialog window to select the location on your computer to save the configuration file. Once you have saved the file, it is recommended that you load the file back to the M650 to validate that it was saved correctly. Click the Browse or

Choose File button and use the File Open dialog window to select the configuration file you just saved. Click the Submit button. If the “Configuration upload success” message appears, the configuration file is confirmed to have saved correctly.  Once the configuration file is saved to your computer, or even if you don’t need to save the configuration, you should restore the meter to the factory defaults.  On the Load/Store settings page, select Restore All Defaults to bring the meter back to default settings.

To upload the new firmware, first obtain a copy of the firmware image.  The firmware image is a binary file, less than 1 MB in length, that can be attached to email, distributed on a CD, or downloaded from an FTP site as circumstances dictate.  Place a copy of the firmware image on your computer then access the upload page from the Firmware Upload link on the Configuration Settings page.

This will take you to the Firmware Upload page, which looks like the screen capture in Figure 4.

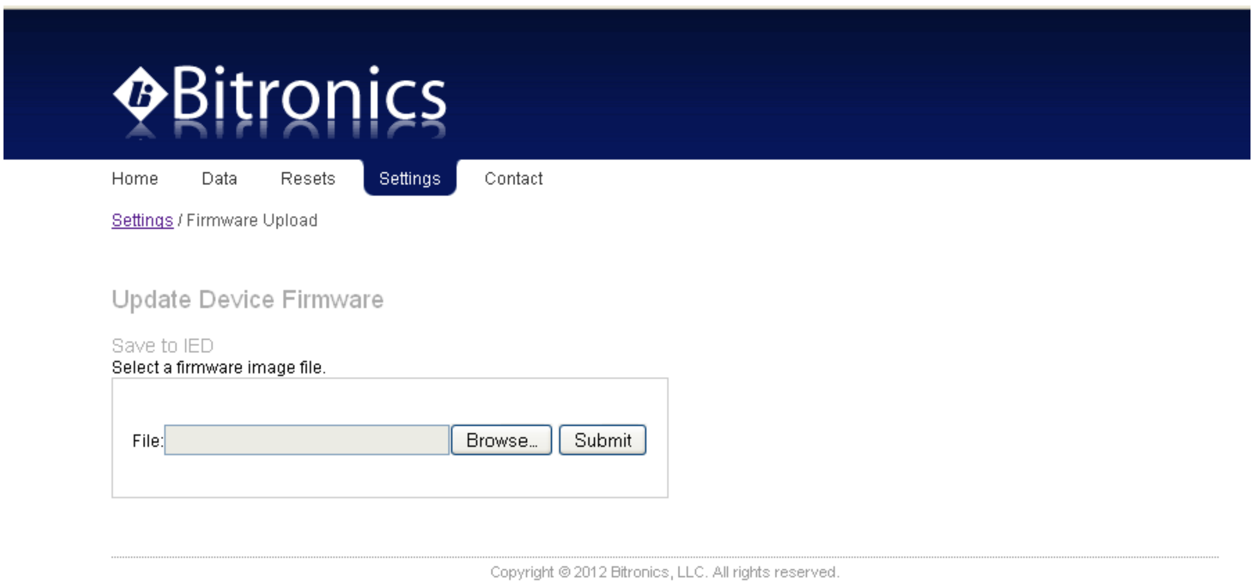



**Figure 4 – Bitronics M650 Firmware Upload Page**

Once the Firmware Upload page is visible, use the Browse button to locate the firmware image on your computer.  Next use the Submit button to initiate the file transfer and installation process.  The instrument must be rebooted to make the new firmware active.  At the completion of the file transfer and installation process, the instrument will prompt you to reset the instrument remotely by displaying the dialog box below after the firmware has been successfully installed.


It is strongly recommended that you clear your web browser’s cache (delete the temporary internet files) after updating the firmware so that the new content will be loaded into your browser. Please refer to your browser’s help file on how to clear the cache. A useful keyboard shortcut common to Internet Explorer, Firefox and Chrome is CONTROL + SHIFT + DELETE, which will take you directly to the relevant dialog panel.  Carefully select the items to be cleared. Be sure to check the boxes that clear “temporary internet files”, “cache” or “website data” and uncheck any boxes that preserve data.

If you had a previously saved configuration that you wish to now load to your M650, you should now go back to the Load/Store Settings page and go to the top box “Select a configuration file”.  Click on the box “Load network settings from file” and then browse to find the configuration file you wish to load.  Once selected, click on Submit, and then you will need to reboot the unit.

# 4.0 OPERATION

## 4.1 Display

The M650 meters can display several per-phase and total quantities for the circuit being monitored. In order to make all quantities available, the display scrolls from quantity to quantity approximately every 5 seconds. The quantities are refreshed once a second. The Alphanumeric display at the bottom of the instrument indicates to the user what quantity is being displayed. The Alphanumeric display also provides the user with primary engineering units (Watts, kWatts, MWatts, etc.). Listed on the following pages are standard screens available in the M650 (note that demand and harmonic summary screens are only available in model M3). Configurable screen enable settings allow the user to enable or disable each of the display screens, in order to view only a selected subset of all the measurements the meter is capable of displaying. Refer to the section in this manual on Setup Mode for instructions on programming Screen Enable Settings (Setup menu - [1.6] Scrn Ena).

The following screens are enabled by default:

Amps A,B,C
Volts AN,BN,CN
Volts AB,BC,CA
Total Watts / Total Vars
VAs Total / Power Factor
Frequency
Demand Amps A,B,C

The Default HOME screen is:

Amps A,B,C.

INSTANTANEOUS DISPLAY SCREENS

| | Format | Quantity |
|---|---|---|
| 1. | 00000 | Phase A Amperes |
| | 00000 | Phase B Amperes |
| | 00000 | Phase C Amperes |
| | AmpsΦ | |
| 2. | 00000 | Residual Amperes [1] |
| | □□□□□ | Unused |
| | □□□□□ | Unused |
| | AmpsR | |
| 3. | 00000 | Phase A Volts [1] |
| | 00000 | Phase B Volts |
| | 00000 | Phase C Volts |
| | xVolts | |
| 4 | 00000 | Phase A-B Volts |
| | 00000 | Phase B-C Volts |
| | 00000 | Phase C-A Volts |
| | xVolts | |
| 5. | 00000 | Phase A Watts [1] |
| | 00000 | Phase B Watts |
| | 00000 | Phase C Watts |
| | xWatts Φ | |
| 6. | 00000 | Phase A VARs [1] |
| | 00000 | Phase B VARs |
| | 00000 | Phase C VARs |
| | xVAR Φ | |
| 7. | 00000 | Total Watts |
| | 00000 | Total VARs |
| | □□□□□ | Unused |
| | xW·xVAR | |

8. 00000 Phase A VAs [1]
00000 Phase B VAs
00000 Phase C VAs
xVA Φ

9. 00000 Phase A PF [1]
00000 Phase B PF
00000 Phase C PF
PF Φ

10. 00000 Total VAs
00000 3Φ PF
□□□□□ Unused
xVAs·PF

11. 00.000 Frequency
□□□□□ Unused
□□□□□ Unused
Hz

12. 12345 } Positive
6789A. } kWh
□□□□□ Unused
+kWh

13. 12345 } Negative
6789A. } kWh
□□□□□ Unused
-kWh

14. 12345 } Positive
6789A. } kVARh
□□□□□ Unused
+kVARh

15. 12345 } Negative
6789A. } kVARh
□□□□□ Unused
-kVARh

16. 000.00 VA hours (Most significant half)
000.00 VA hours (Least significant half)
□□□□□ Unused
kVAh

17. 00000 Watt hours Net (Most significant half)
00000 Watt hours Net (Least significant half)
□□□□□ Unused
kWh NET

18. 00000 Total Watts
00000 3Φ PF
0000 Frequency
xW·PF·Hz

[1] - Screen available on WYE meters only
x - indicates blank, (k)ilo, (M)ega, or (G)iga

DEMAND DISPLAY SCREENS

| | Format | Quantity |
|---|---|---|
| 19. | 000.00 | Phase A Amps Demand |
| | 000.00 | Phase B Amps Demand |
| | 000.00 | Phase C Amps Demand |
| | Amps Dmd | |
| 20. | 00000 | Phase A Maximum Amperes Demand |
| | 00000 | Phase B Maximum Amperes Demand |
| | 00000 | Phase C Maximum Amperes Demand |
| | Amps MAX | |
| 21. | 000.00 | Residual Amps Demand Maximum |
| | 000.00 | Residual Amps Demand |
| | □□□□□ | Unused |
| | AmpsDmdR | |
| 22. | 000.00 | Phase A Average Voltage |
| | 000.00 | Phase B Average Voltage |
| | 000.00 | Phase C Average Voltage |
| | xV Avg | |
| 23. | 00000 | Phase A Maximum Volts Demand [1] |
| | 00000 | Phase B Maximum Volts Demand |
| | 00000 | Phase C Maximum Volts Demand |
| | xV MAX | |
| 24. | 00000 | Phase A Minimum Volts Demand [1] |
| | 00000 | Phase B Minimum Volts Demand |
| | 00000 | Phase C Minimum Volts Demand |
| | xV MIN | |
| 25. | 000.00 | Phase A-B Average Voltage |
| | 000.00 | Phase B-C Average Voltage |
| | 000.00 | Phase C-A Average Voltage |
| | xV Avg | |
| 26. | 00000 | Phase A-B Maximum Volts Demand |
| | 00000 | Phase B-C Maximum Volts Demand |
| | 00000 | Phase C-A Maximum Volts Demand |
| | xV MAX | |

27. 00000 Phase A-B Minimum Volts Demand
00000 Phase B-C Minimum Volts Demand
00000 Phase C-A Minimum Volts Demand
xV MIN

28. 00000 Total Maximum Watt Demand
00000 Total Watts (Also on Screen 7)
00000 Total Minimum Watt Demand
xW · ↑ · ↓

29. 00000 Total Maximum VAR Demand
00000 Total VARs (Also on Screen 7)
00000 Total Minimum VAR Demand
xVAR · ↑ · ↓

30. 00000 Total Maximum VAs
00000 Total VAs (Also on Screen 10)
00000 Total Minimum VAs
xVA · ↑ · ↓

[1] - Screen available on WYE meters only
x - indicates blank, (k)ilo, (M)ega, or (G)iga

## HARMONIC SUMMARY DISPLAY SCREENS

| | Format | Quantity |
|---|---|---|
| 31. | 00000 | Phase A Fundamental Amperes |
| | 00000 | Phase B Fundamental Amperes |
| | 00000 | Phase C Fundamental Amperes |
| | Fnd Amps | |
| 32. | 00000 | Fundamental Residual Amperes [1] |
| | □□□□□ | Unused |
| | □□□□□ | Unused |
| | FndN · Amps | |
| 33. | 00000 | Phase A Fundamental Volts |
| | 00000 | Phase B Fundamental Volts |
| | 00000 | Phase C Fundamental Volts |
| | Fnd xV | |
| 34. | 000.00 | Phase A-B Fundamental Voltage |
| | 000.00 | Phase B-C Fundamental Voltage |
| | 000.0 | Phase C-A Fundamental Voltage |
| | Fnd xV | |
| 35. | 000.00 | Phase A Current %Total Demand Distortion (%TDD) |
| | 000.00 | Phase B Current %Total Demand Distortion (%TDD) |
| | 000.00 | Phase C Current %Total Demand Distortion (%TDD) |
| | %TDD I | |
| 36. | 000.00 | Phase A Voltage %Total Harmonic Distortion (%THD)[1] |
| | 000.00 | Phase B Voltage %Total Harmonic Distortion (%THD) |
| | 000.00 | Phase C Voltage %Total Harmonic Distortion (%THD) |
| | %THD V | |
| 37. | 000.00 | Phase A-B Voltage %Total Harmonic Distortion (%THD) |
| | 000.00 | Phase B-C Voltage %Total Harmonic Distortion (%THD) |
| | 000.00 | Phase C-A Voltage %Total Harmonic Distortion (%THD) |
| | %THD V | |

| | | |
|---|---|---|
| 38. | 00.000 | K-Factor Phase A (Current) |
| | 00.000 | K-Factor Phase B (Current) |
| | 00.000 | K-Factor Phase C (Current) |
| | K-Factor | |

[1] - WYE meters only
x - indicates blank, (k)ilo, (M)ega, or (G)iga

HARMONIC SUMMARY DISPLAY SCREENS (Cont'd)

| | Format | Quantity |
|---|---|---|
| 39. | 0.0000 | Phase A Displacement PF [1] |
| | 0.0000 | Phase B Displacement PF |
| | 0.0000 | Phase C Displacement PF |
| | DispPF Φ | |
| 40. | 00000 | 3Φ Displacement PF |
| | □□□□□ | Unused |
| | □□□□□ | Unused |
| | DispPF T | |
| 41. | 000.00 | Phase A Fundamental Demand Amps |
| | 000.00 | Phase B Fundamental Demand Amps |
| | 000.00 | Phase C Fundamental Demand Amps |
| | FndDmdIΦ | |
| 42. | 000.00 | Phase A Maximum Fundamental Demand Amps |
| | 000.00 | Phase B Maximum Fundamental Demand Amps |
| | 000.00 | Phase C Maximum Fundamental Demand Amps |
| | FndDmdIΦ | |
| 43. | 000.00 | Maximum Fundamental Demand Amps Residual |
| | 000.00 | Fundamental Demand Amps Residual |
| | □□□□□ | Unused |
| | FundDmdIR | |
| 44. | 000.00 | Phase A Average Watts |
| | 000.00 | Phase B Average Watts |
| | 000.00 | Phase C Average Watts |
| | xW Avg | |
| 45. | 000.00 | Phase A Maximum Average Watts |
| | 000.00 | Phase B Maximum Average Watts |
| | 000.00 | Phase C Maximum Average Watts |
| | xW Max | |

46. 000.00 Phase A Minimum Average Watts
000.00 Phase B Minimum Average Watts
000.00 Phase C Minimum Average Watts
xW Min

47. 000.00 Phase A Average VARs
000.00 Phase B Average VARs
000.00 Phase C Average VARs
xVAR Avg

48. 000.00 Phase A Maximum Average VARs
000.00 Phase B Maximum Average VARs
000.00 Phase C Maximum Average VARs
xVAr Max

49. 000.00 Phase A Minimum Average VARs
000.00 Phase B Minimum Average VARs
000.00 Phase C Minimum Average VARs
xVAR Min

50. 000.00 Phase A Average VAs
000.00 Phase B Average VAs
000.00 Phase C Average VAs
xVA Avg

51. 000.00 Phase A Maximum Average VAs
000.00 Phase B Maximum Average VAs
000.00 Phase C Maximum Average VAs
xVA Max

52. 000.00 Phase A Minimum Average VAs
000.00 Phase B Minimum Average VAs
000.00 Phase C Minimum Average VAs
xVA Min

53. 00000 Phase A Secondary Volts[1]
00000 Phase B Secondary Volts
00000 Phase C Secondary Volts

SecVolts

54. 00000 Phase A-B Secondary Volts
00000 Phase B-C Secondary Volts
00000 Phase C-A Secondary Volts
SecVolts

55. 000.00 Auxiliary Voltage
□□□□□ Unused
□□□□□ Unused
V aux

[1] - Screen available on WYE meters only
x - indicates blank, (k)ilo, (M)ega, or (G)iga

The screens that are displayed in the scrolling mode can be programmed (ENABLED/DISABLED) by the user. This programming can be done by using the front panel buttons of the device or through the web server.

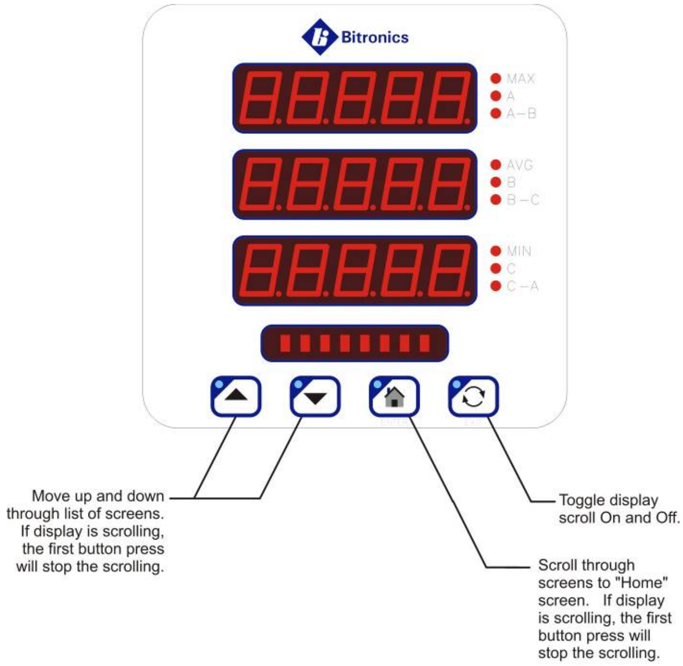
Enable/Disable Display Mode Screens via the front buttons on Display:
The Screens can be enabled or disabled (refer to Section 5.5) via the front display buttons by entering the setup mode section and going to the Screen Enable menu (1.6, Scrn Ena). This setup can also be accomplished via the web interface through the Ethernet service port by going to the appropriate setup page.

Enable/Disable Display Mode Screens via the Web Server:
The screens can be enabled or disabled via the web server (refer to section 5.6). From the web page, select the Settings tab then click on Screen Enable in the menu list.

For all the Watt, VAR and/or PF displays the "SIGN" of the quantity is indicated by the center segment of the left most digit, which will be illuminated to produce a "-" for negative quantities. Positive quantities will have no polarity indication. This restricts the display to 4 digits in the Watt and/or VAR display, however this is a restriction for the display only, internally the instrument still carries full precision.

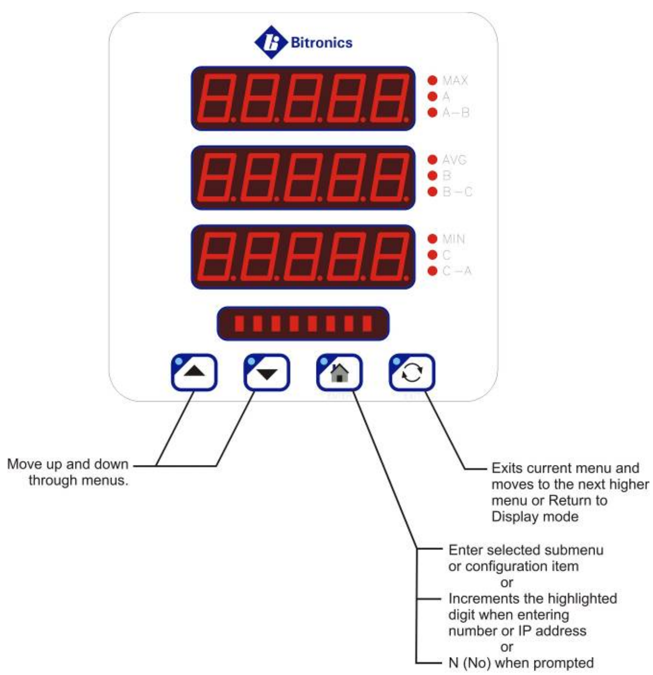
 

### 4.1.1 Overview – Buttons Functions




1. Pressing any button when the display is scrolling will end the scroll.

**Figure 5 – Button functions for Display Mode**




1. Setup mode is initiated upon pressing combination of Up Arrow and Exit

**Figure 6 – Button functions in Set-up Mode**

### 4.1.2 Keypad Functions for Display Mode

Measurements screens may be stepped through manually by pushing the up and down arrow keys. Pushing the Toggle (Exit) key turns the scroll function off and on. When the scroll function is activated, the measurement screens will automatically step through the user-defined screens. Auto scroll state (ON/OFF) is stored in non-volatile memory. Pressing the Home (Enter) key will bring up the home screen. The factory default home screen will be Amps A, B, C. If a user enables or disables screens via the front display buttons from Setup Mode - 1.6 Scrn Ena, then the home screen will automatically become the 1st enabled screen. The home screen can be setup as any one of the enabled screens by simultaneously pressing the Home (Enter) and Toggle (Exit) buttons when on the desired screen and can also be done through the web server Settings tab.

**Table 1 –Button Functions**

| Button | Display Mode Function | Setup Mode Function |
|---|---|---|
| Up Arrow | Next measurement/value | Next menu item |
| Down Arrow | Previous measurement/value | Previous menu item<br>or<br>Y (Yes) when prompted |
| Home (Enter)<br>Enter | Scroll to designated home screen | Enter selected submenu (or configuration item), or<br>Increments the hightlighted digit when entering number, or<br>IP address, or<br><br>N (No) when prompted |
| Toggle (Exit)<br>EXIT | Toggle Auto Scroll On/Off | Exits current menu selection and moves up to next higher menu level.<br><br>Returns to display mode on exit from main setup menu |
| Combination Up and Exit keys | Enter Setup Mode<br><br>(Resets and configuration setting are done in the setup menu) | |
| Combination Up and Down Keys | Resets Demand Values | |

| Button | Display Mode Function | Setup Mode Function |
|---|---|---|
| Combination Home (Enter) and Toggle (Exit) keys | Designate the displayed screen as “Home Screen” | |

Resets are found in setup menu

### 4.1.3 Display Error Messages

Error messages from self test are shown on the display. The table below summarizes the errors and the messages displayed:

**SELF TEST RESULT SUMMARY FOR 50 SERIES DEVICES**

| Fault | Fault Indication | Effects of Fault | Corrective Action |
|---|---|---|---|
| Display Oveflow | Display flashes 9999 | Measured quantity is too large to be displayed. Communication option output may still be accurate, if overload does not exceed meter input ratings | Correct fault external to instrument. |
| Input gain calibration checksum error | G CAL | Calibration constants for the input gain are in error. The display and the communication option output are reduced in accuracy to approximately +/-3%. | Return to factory for repair |
| Input phase calibration checksum error | P CAL | Calibration constants for the phase are in error. The display and the communication option output are reduced in accuracy to approximately +/-3%. | Return to factory for repair |
| Analog outputs calibration checksum error | A CAL | Calibration constants for the analog outputs are in error. The analog output option is reduced in accuracy to approximately +/-3%. | Return to factory for repair |
| Input Over-Range | CLIP | Peak input quantity exceeds the range of the instrument. Both display and communication option output accuracy reduced by an amount depending upon the degree of over-range. | Verify input signals are within range. If within range, return to factory for repair. |
| Protocol Configuration Error | P CFG | Instrument protocol configuration may be corrupted and inaccurate. This may cause communication errors. | Reset configuration. |
| Firmware Download in Progress | FLASH | Will be displayed during download and will disappear shortly after user reboots meter | Reboot meter when prompted. |

## 4.2 Serial Port

This port when ordered can be set to RS-232 or RS-485, and support baud rates up to 115200. Set-up of the Serial Port can be accomplished by using a web browser connected to the Ethernet port, or via the front display buttons (Setup menu - 1.4 Serial). The default configuration for the serial ports is:

| Serial Port Default Setting | | | | | |
|---|---|---|---|---|---|
| Port | Protocol | Parity | Baud | IED | Physical Media |
| Serial | DNP 3 | None | 9600 | 1 | RS-232 |

Serial cable requirements for RS485 connection:
Tie RS-485 cable shields (pin 15) to earth ground at one point in system.

The recommended torque ratings for the terminal block wire fasteners are listed in the Physical Specifications table (section 1.3).

Transient Voltage Suppressor (TVS) clamp devices are used on the serial port as the method of protection. The serial port is clamped to a voltage of 16.7-18.5V nominal, 24.46V max. The clamps are rated for a peak pulse current of 24.6 max.

### 4.2.1 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 imperative 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. See figure 7 below for RS485 cable wiring diagrams.

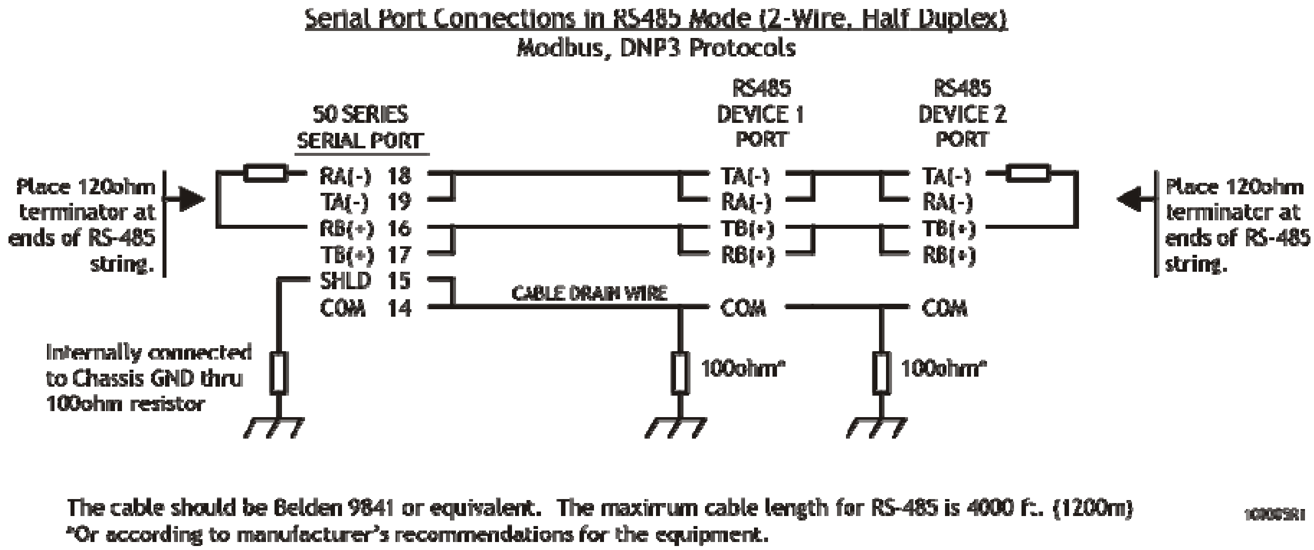



**Figure 7 - Typical RS-485 Cable Wiring**

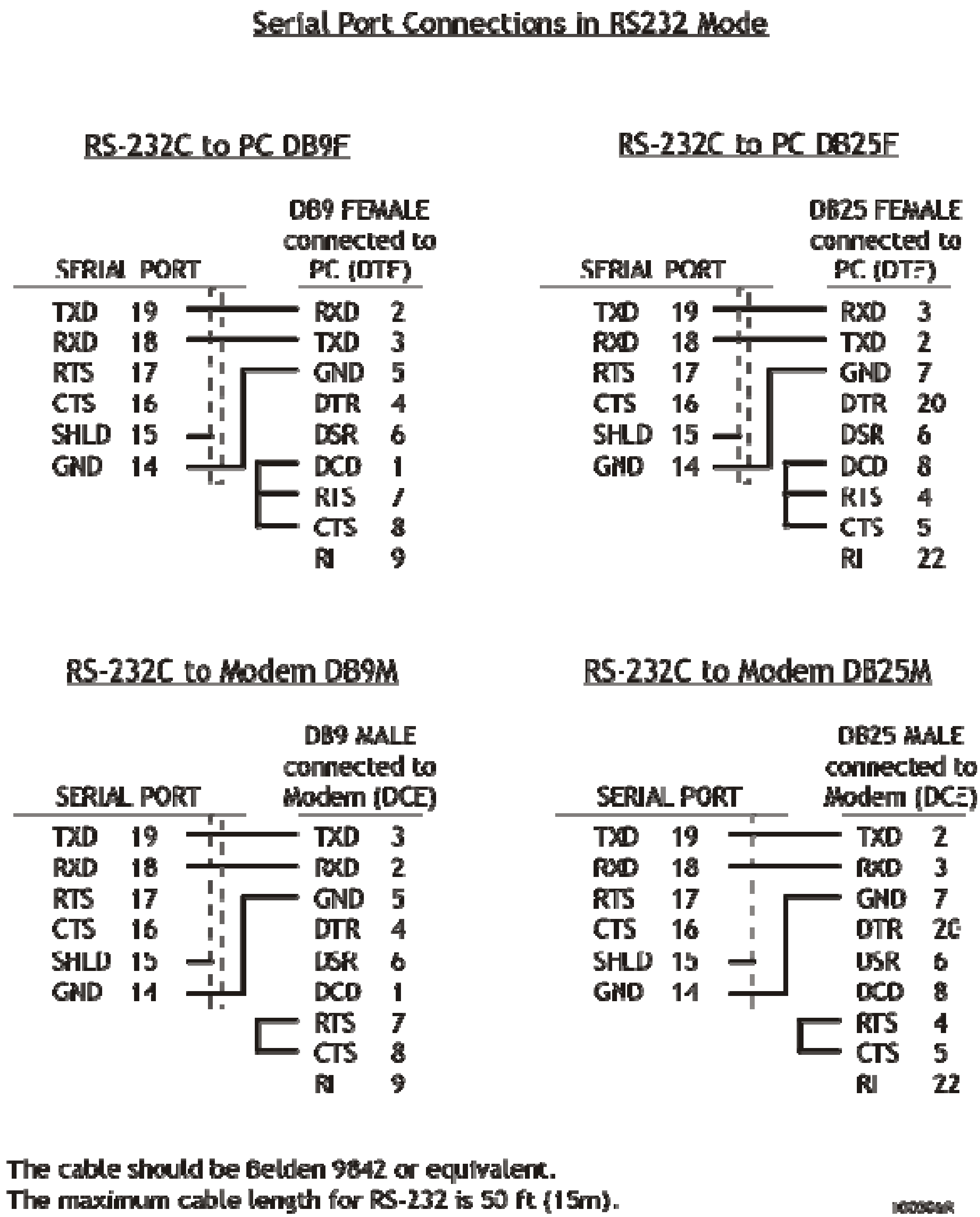



**Figure 8 – RS-232 Cable Wiring Diagram**

# 5.0 FUNCTIONAL DESCRIPTION

## 5.1 Configuration

Setup of the M650 meters is most easily performed using the web interface via the Ethernet service port. Basic configuration can also be handled from the front display by entering the setup mode.

## 5.2 HTML Web Server

The M650 incorporates an internet-compatible HTML web page.

## 5.3 Passwords

Passwords can be setup through the web interface in the 50 Series for use in controlling access to configuration and other functions available through the Ethernet port or the front panel display. Passwords may be comprised of the 95 printable ASCII characters as defined by http://en.wikipedia.org/wiki/ASCII#ASCII_printable_characters which includes 0-9, a-z, A-Z, and special characters with the exception of the tilde character (~). Passwords may have maximum length of 20 characters and a minimum of 1 character. Passwords prompts are disabled by leaving the new password field blank and clicking the 'Change Password' button. The default from the factory is to have no password set.

The password is used to authenticate a session when prompted. The session authentication will last until the user clicks the 'Log Out' link on the upper right corner of the Web Interface or after five minutes elapses. Authentication will be required when attempting the following actions:

- Resetting demand and energy values on the Web Interface Resets page
- Applying changes to any settings on the Web Interface Settings tab
- Uploading new firmware on the Firmware Upload page
- Changing the password on the Password Security page
- Rebooting the IED

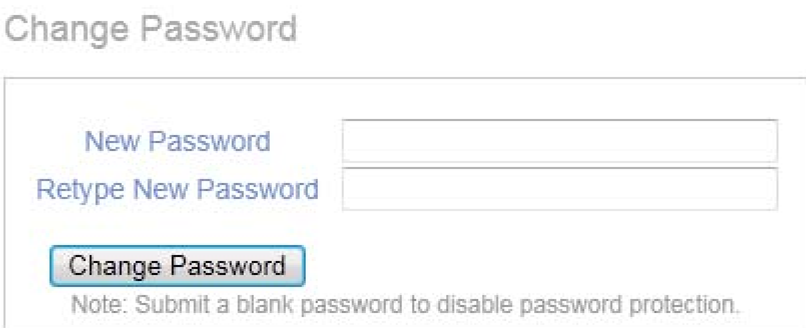
The Password Security page includes the Front Panel Configuration Lock, which may be used to prevent access to the following actions:

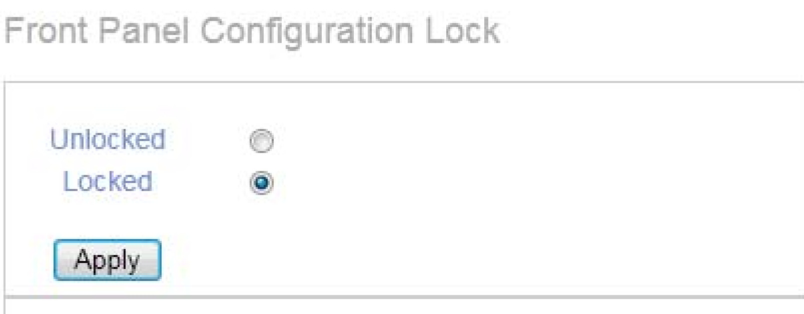
- Setup Mode on the Front Panel (see section 5.5)
- Demand Resets from the Front Panel (section 6.9.4).
- Home Screen selection from the Front Panel (section 4.1.2)

If these options are attempted while the lock is enabled, the message 'Locked' will be briefly displayed on the front panel alphanumeric display for M65x.

A user has five attempts to enter the correct password. If unsuccessful, the unit will be locked out for 5 minutes before another attempt can be made.



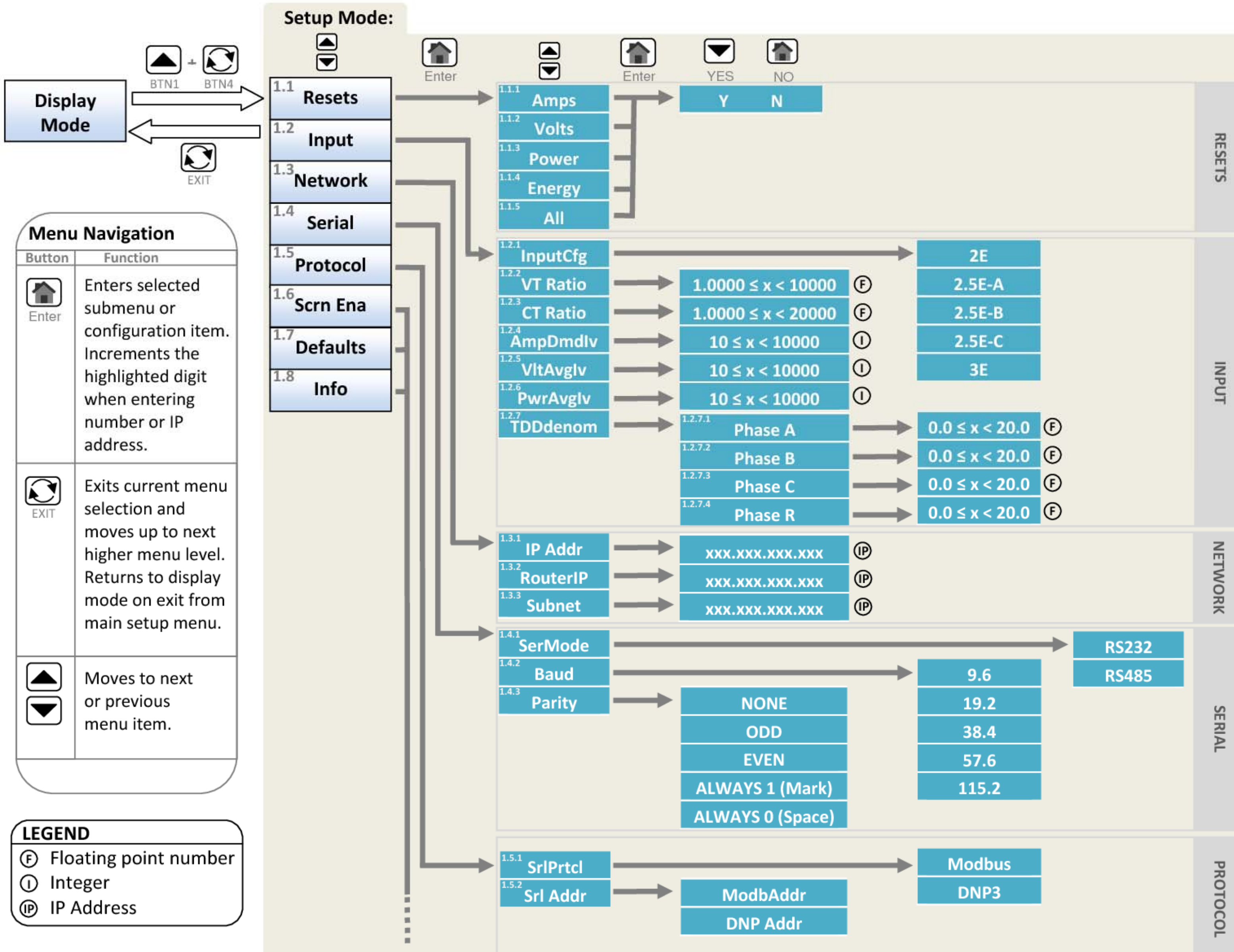

## 5.4 Using the M650 with a Bitronics Analog Output Converter

The M650 may be used with any of the Bitronics AOC units (NAO8101, NAO8102, NAO8103, or NAO8104). The AOC may be connected to the serial port. The serial port must be configured for the appropriate protocol and register set for the AOC that will be connected. Setting up the serial ports is accomplished by using the web interface or front buttons. AOC units will only function with the M650 configured for Optimal Resolution and the Bitronics Legacy register set. When using AOCs that communicate via Modbus (NAO8101 and NAO8102), the M650 serial port must be set for an RxD to TxD Delay of 10ms for proper operation. Serial port and connection information is shown below. Refer to Figure 7 for interconnection. As stated previously, the AOC address must match the protocol address assigned to the M650 communications port.

| Protocol | Baud | Parity | Media |
|---|---|---|---|
| DNP | 9600 | NONE | RS485 |
| Modbus | 9600 | EVEN | RS485 |

## 5.5 Navigating the M650's setup menu from the front panel



SCRN ENA

| | |
|---|---|
| [Amps Φ] | Amps A, B C |
| Amps R] | Amps Reidual |
| [kVolts Φ] | Volts AN, BN, CN |
| [kVolts] | Volts AB, BC, C |
| [Watts Φ] | WattsA, B,C |
| [kVARΦ] | VARs A, B, C |
| [kW·kVAR] | Total Watts· Total VARs |
| [kVAΦ] | VAs A, B, C |
| [PFΦ] | Power Factor A, , C |
| [kVA·PF] | Total VAs · 3Φ PF |
| [Hz] | Frequeny |
| [kWh] | kWatt-Hour Normal(+) |
| [-kWh] | kWatt-Hours Reverse(-) |
| [+kVARh] | kVAR-Hous Laggin(+) |
| [-kARh] | kVA-Hours Leading(-) |
| [kVAh] | kVA-Hours |
| [kWhNE] | kWatt-Hours Net |
| [kW·PF·Hz] | Total Watts · 3Φ PF · Frequency |
| [AmpsDmd] | Demand Amps A,B,C |
| [AmpsDmd | axDmand Amps A,B,C |
| [AmpsDmdR] | Demand Amps Residual |
| [VAvg] | Average Volts AN, B, CN |
| [Vax] | Max verage Vlts AN, BN, CN |
| [VMin] | Min Average Volts AN BN, CN |
| [VAvg] | Average Volts AB, BC, CA |
| [VMax] | Max Aveage Volts AB, BC, CA |
| [VMin] | Min Average Volts AB, BC, CA |

. . .

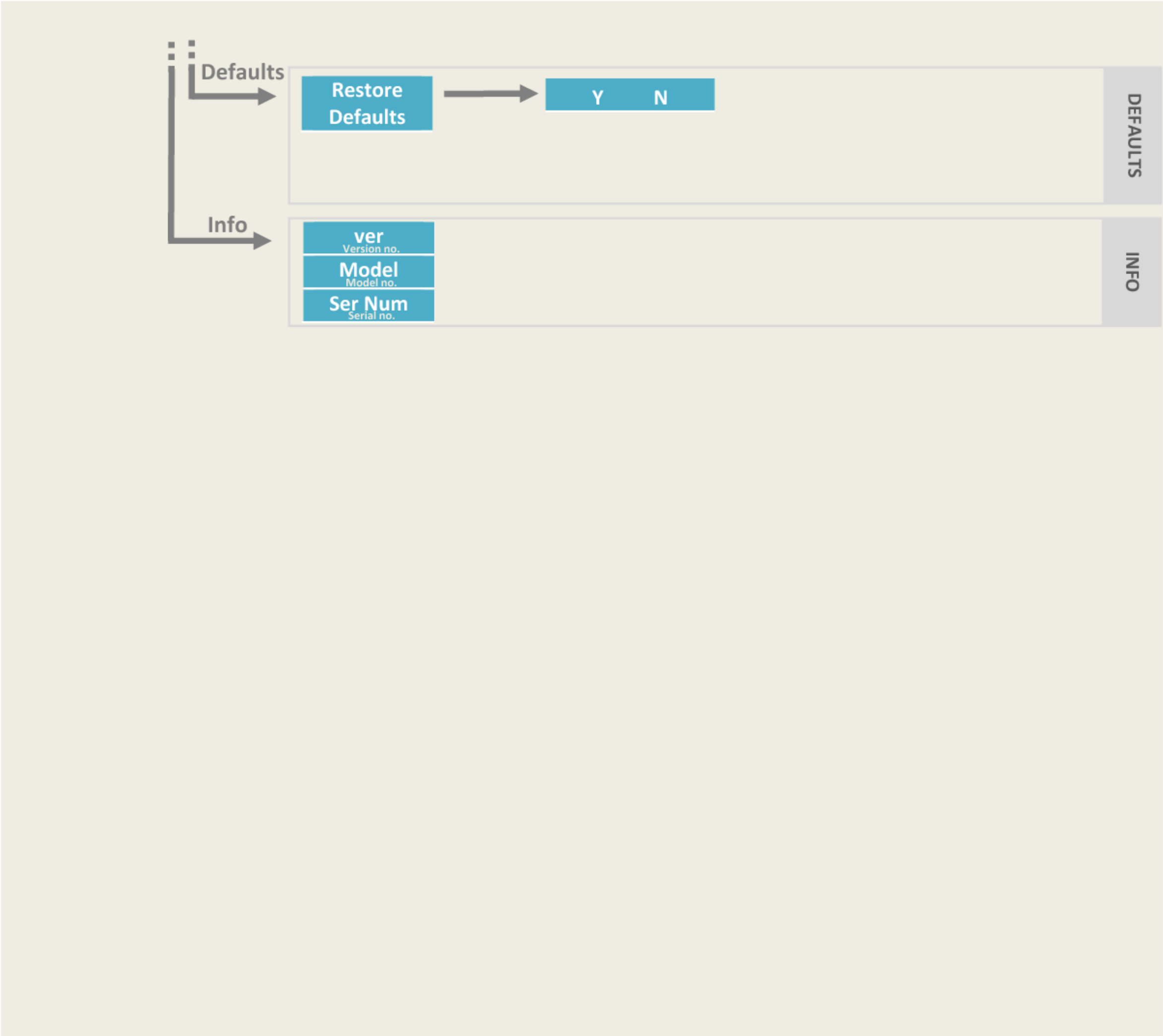
SCREEN ENABLE

...contd.

| | |
|---|---|
| [kWTot] | Average Watts Max · Total · Min |
| [kVARTot] | Average VARs Max · Total · Min |
| [kVATot] | Average VAs Max · Total · Min |
| [FndAmps] | Fund Amps A, B, C |
| [FndAmpsR] | Fund Amps Residual |
| [FndV] | Fund Volts AN, BN, CN |
| [FndV] | Fund Volts AB, BC, CA |
| [%TDDI] | TDD Amps A,B,C |
| [%THDV] | THD Volts AN, BN, CN |
| [%THDV] | THD Volts AB, BC, CA |
| [K-Factor] | K-Factor Amps A,B,C |
| [DispPFΦ] | Displacement Power Factor A,B,C |
| [DispPFT] | Displacement Power Factor Total |
| [FndDmdIΦ] | Fund Demand Amps A,B,C |
| [FndDmdIR] | Max Fund Demand Amps Residual |
| [FndDmdIΦ] | Max Fund Demand Amps A,B,C |
| [kWAvg] | Average Watts A, B, C |
| [kWMax] | Max Average Watts A, B, C |
| [kWMin] | Min Average Watts A, B, C |
| [kVARAvg] | Average VARs A. B, C |
| [kVARMax] | Max Average VARs A. B, C |
| [kVARMin] | Min Average VARs A. B, C |
| [kVAAvg] | Average VAs A, B, C |
| [kVAMax] | Max Average VAs A, B, C |
| [kVAMin] | Min Average VAs A, B, C |
| [VAux] | Volts Aux |
| [SecVolts] | Secondary Volts AN, BN, CN |
| [SecVolts] | Secondary Volts AB, BC, CA |
| [All] | All on/off |

SCREEN ENABLE

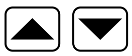
 


Defaults
Restore Defaults
Y N
DEFAULTS
Info
ver
Version no.
Model
Model no.
Ser Num
Serial no.
INFO

**How to Enter an Integer:**



Increment highlighted digit by 1.



Highlight Previous/Next digit.


Exit to menu

**How to Enter a Floating Point Number:**



Increment highlighted digit by 1.

Shifts decimal point one place to right. Decimal moves to left-most digit when right-most digit is passed.

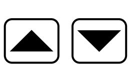
Highlight Next digit. Highlights left-most digit when right-most digit is passed.


Exit to menu

**How to Enter an IP address:**



Increment highlighted digit by 1.



Highlight Previous/Next digit. Numbers scroll left and right to follow highlighted digit.


Exit to Network menu

## 5.6 Performing set-up through the web page interface

This section will assume you are able to use the factory default IP address of 192.168.0.171 to connect to the web page using an HTML web server. If this is not the case you may need to refer to section 3.5.1 (Network settings) and the previous section (Navigating the M650's setup menu from the Front panel) to change your network configuration settings.

Enter the M650's IP address into your internet browser to connect with the M650 web page interface. Internet browsers supported are Firefox, Internet Explorer, Safari and Google Chrome. The Home page screen should appear as shown below.

**Home page:**


From the home screen you can select from the following tabs:

- Data – This page displays current data measurements
- Resets – This page allows certain quantities to be reset
- Settings – This page allows the user to change the configuration settings. Making M650 configuration changes require the unit to be rebooted. Configuration settings for the M650 are stored in flash memory.
- Contact – This page indicates how to contact Bitronics

NOTE: Some screen shots shown below may not exactly match the appearance of those from your actual meter.

## Data page: Two views – Instantaneous and Demands

Live Data View

**Instantaneous** | Demands

| | Amps | Volts | | Volts |
|---|---|---|---|---|
| Phase A | 0.000 | 123.29 | A-B | 0.08 |
| Phase B | 0.000 | 123.29 | B-C | 0.11 |
| Phase C | 0.000 | 123.33 | C-A | 0.09 |
| Residual | 0.000 | | | |

| | Watts | VARs | VAs | PF |
|---|---|---|---|---|
| Phase A | 0.0 | 0.0 | 0.0 | 0.000 |
| Phase B | 0.0 | 0.0 | 0.0 | 0.000 |
| Phase C | 0.0 | 0.0 | 0.0 | 0.000 |
| Total | 0. | 0. | 0. | 0.000 |

| | |
|---|---|
| Energy Used (+kWh) | 101 |
| Energy Produced (-kWh) | 121 |
| Energy Lag (+kVARh) | 154 |
| Energy Lead (-kVARh) | 76 |

| | |
|---|---|
| VT Scaling | 1.0000 : 1. |
| CT Scaling | 5.0000 : 5. |

| | | | |
|---|---|---|---|
| Frequency | 60.013 | Health | 0000 0000 |
| Time Between Polls | 1.004 sec | Heartbeat | 12 |

Live Data View

Instantaneous | **Demands**

Amps

| | Maximum | Present Demand | |
|---|---|---|---|
| Phase A | 0.000 | 0.000 | Amps |
| Phase B | 0.000 | 0.000 | Amps |
| Phase C | 0.000 | 0.000 | Amps |

Volts

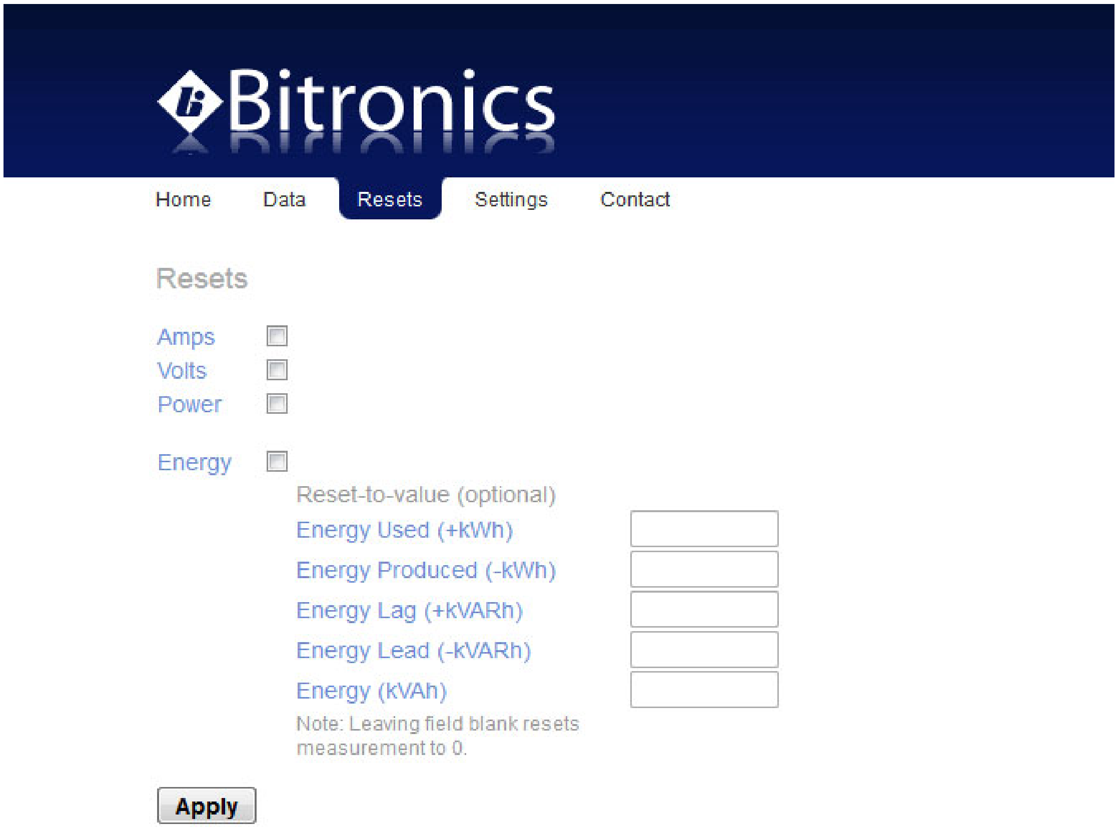
| | Maximum | Present Demand | Minimum | |
|---|---|---|---|---|
| Phase A | 123.70 | 123.57 | 0.00 | Volts |
| Phase B | 123.71 | 123.57 | 0.00 | Volts |
| Phase C | 123.74 | 123.61 | 0.00 | Volts |

Total Power

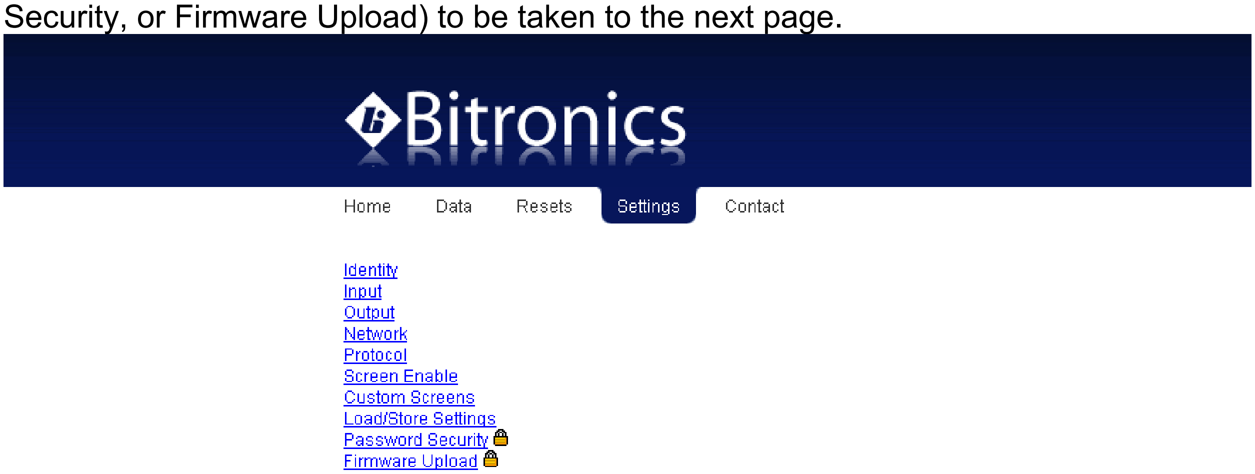
| | Maximum | Present Demand | Minimum | |
|---|---|---|---|---|
| Watts | 0. | 0. | 0. | Watts |
| VARs | 0. | 0. | 0. | VARs |
| VAs | 0. | 0. | 0. | VAs |

**Resets page:** From this page select the quantity to be reset and click apply. Optionally, Energy values can be reset to specific non-zero values by entering the desired reset value in the appropriate field as a whole number and clicking Apply. Any fields that are left blank will be reset to zero.




**Settings page:** Click on one of the settings categories (Identity, Input, Network, Serial Port, Protocol, Screen Enable, Custom Screens, Load/Store Settings, Password Security, or Firmware Upload) to be taken to the next page.



**Contact Page:**

**Settings Page Selections:**
From the Settings page screen you can select one of the following selections:

Identity– This page allows the user to enter information that is necessary to identify the meter. It gives an identity to a particular M650. Each M650 should have different information entered for its identity.

Input – This page allows for the selection of wiring configuration, setup of CT and PT ratios, demand intervals, and TDD denominator.

Network – This page allows the user to change the network configuration settings for IP address, gateway and router address.

Serial Port – This page allows user configuration for the serial port settings. Note that if no serial port is ordered this setting won't appear and if the transducer output option is selected then that setting will replace serial.

Protocol – This page allows user configuration of the protocols – DNP or Modbus

Screen Enable - Allows the screens shown on the M650 display (front panel) to be enabled or disabled by the user.

Custom Screens – Allows the user to set up custom display screens if the standard screens don't meet their needs.

Load/Store Settings – This page allows you to save and retrieve settings for the M650 meter

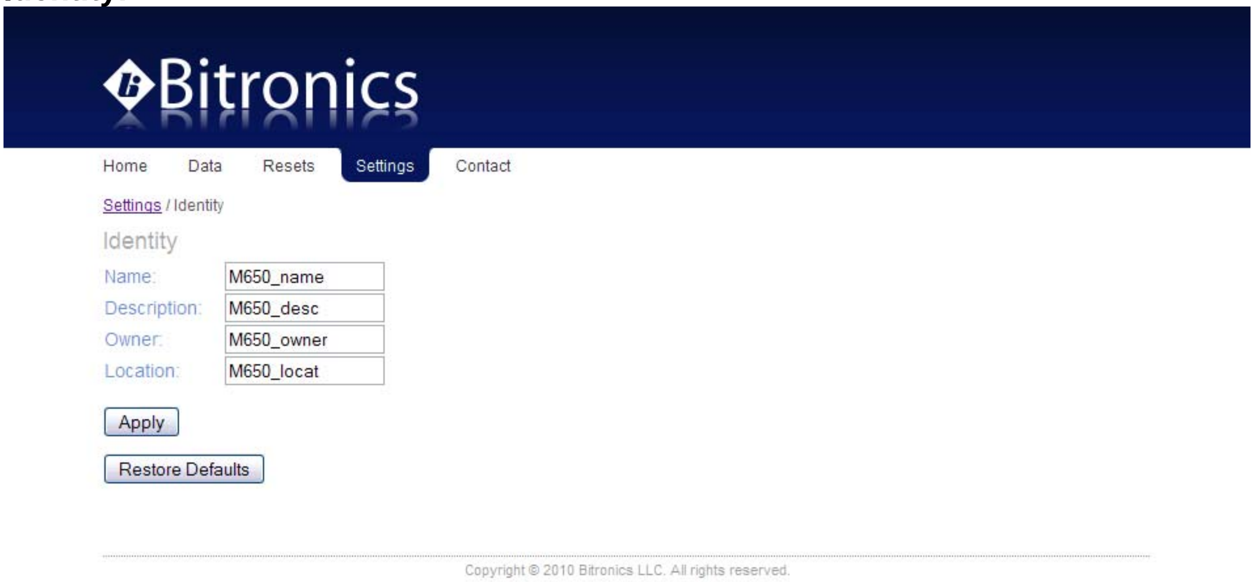
Password Security – This page allows the user to set a password and to enable or disable access to front display configuration (M650 and M653)

Firmware Upload – This page allows the user an interface to browse for or type in the location on their PC of new firmware for purposes of uploading to the unit.

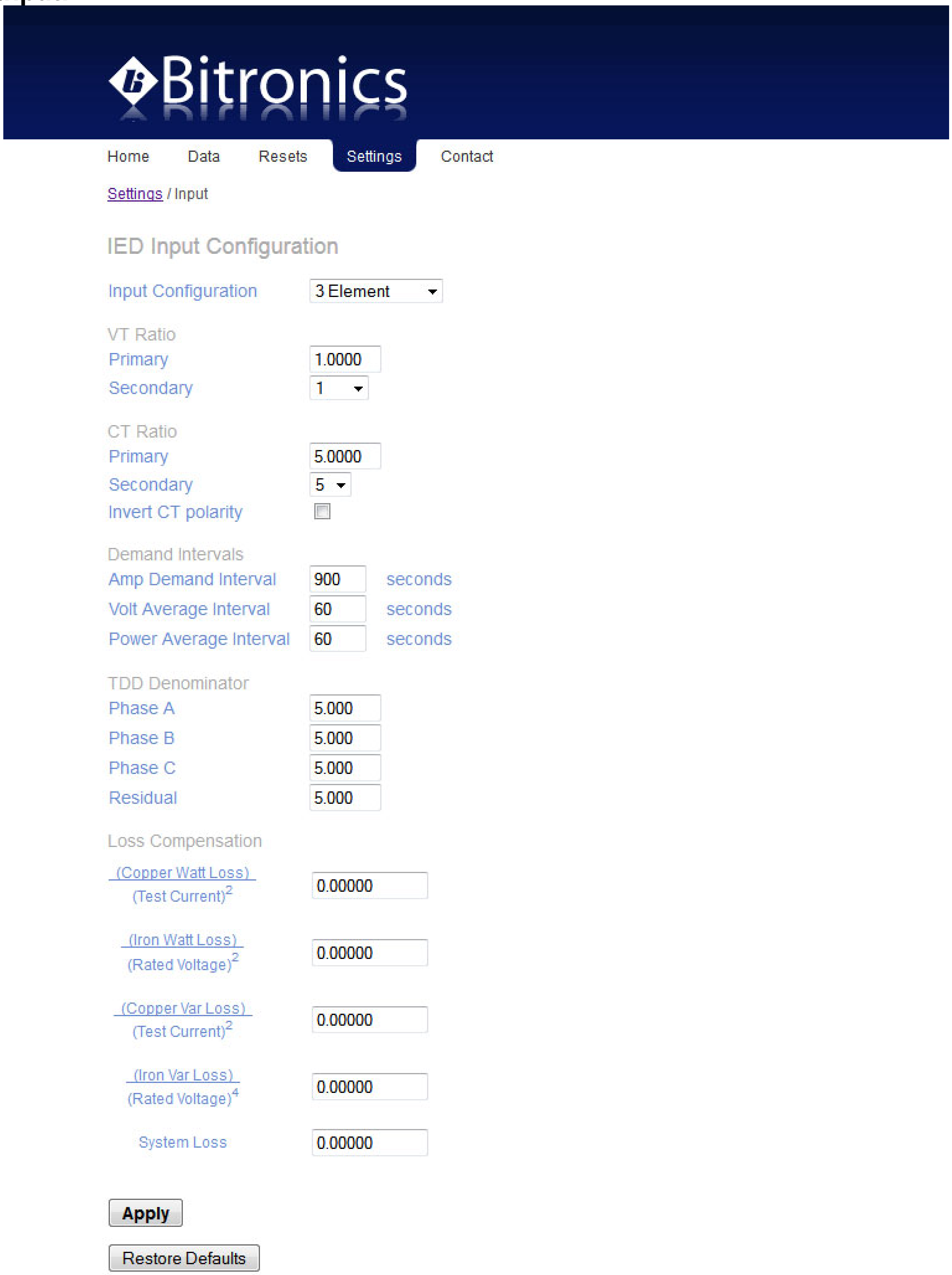
Screen shots showing the selections to be made for each of the above selections follow on the next few pages. Default values are shown where applicable.

M650 configuration changes require the unit to be rebooted. Configuration settings for the M650 are stored in flash memory.

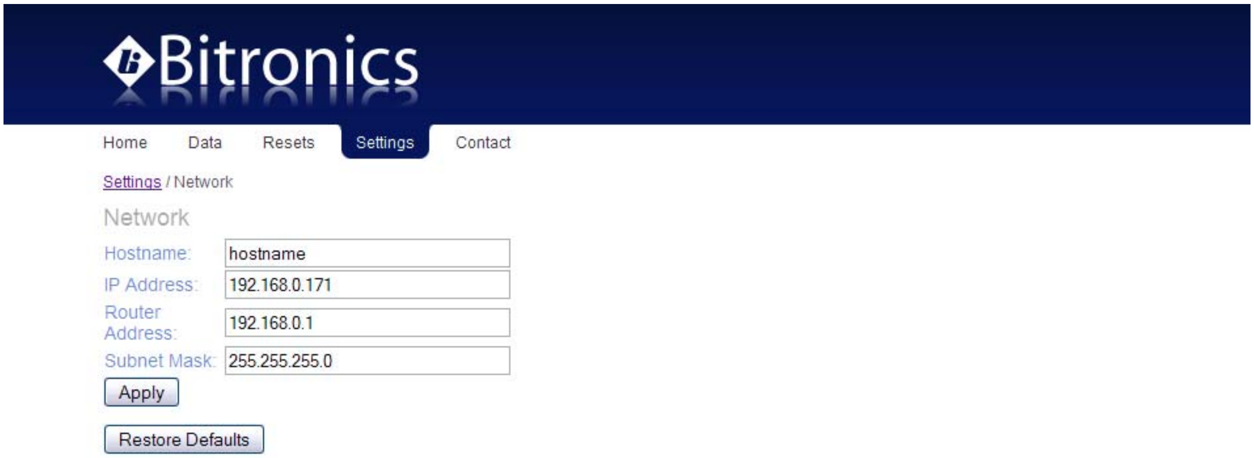
## Identity:


Bitronics
Home
Data
Resets
Settings
Contact
Settings / Identity
Identity
Name:
M650_name
Description:
M650_desc
Owner:
M650_owner
Location:
M650_locat
Apply
Restore Defaults
Copyright © 2010 Bitronics LLC. All rights reserved.

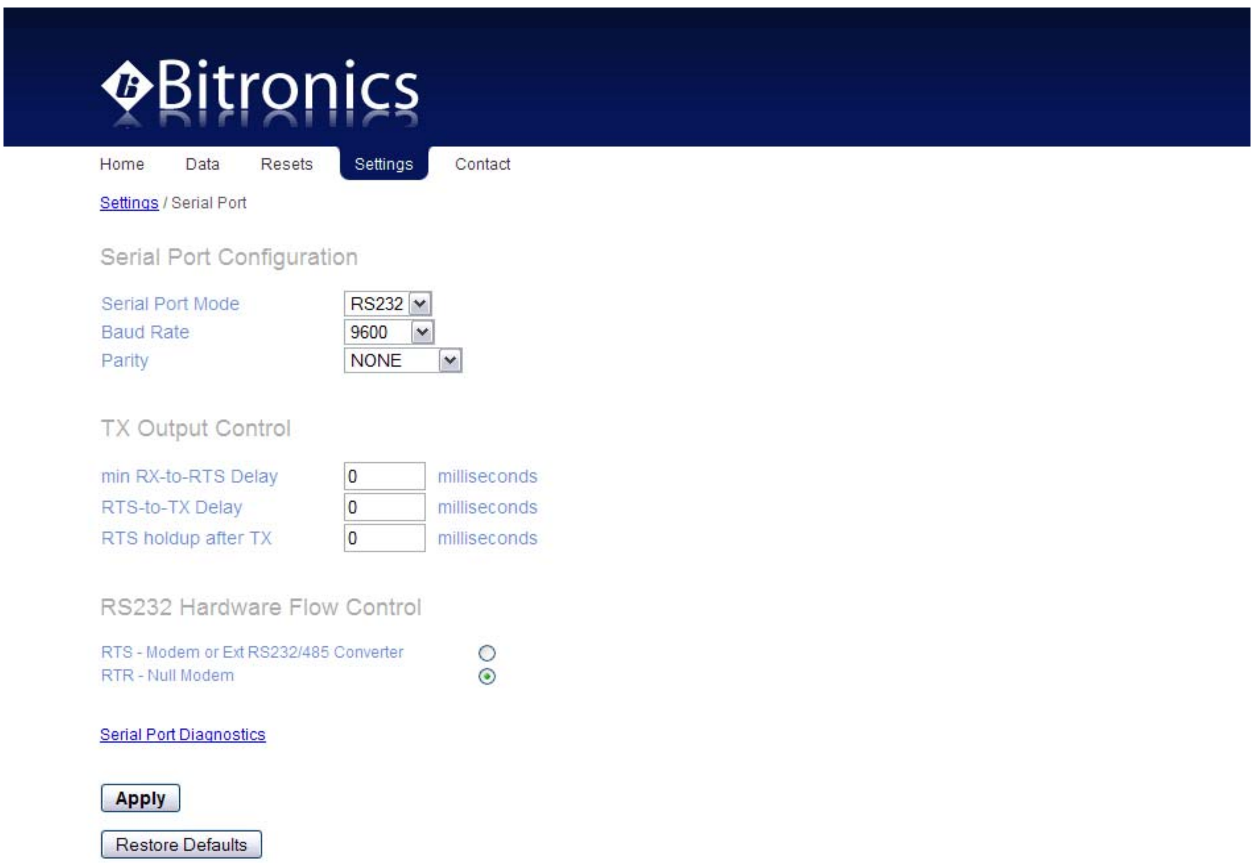
## Input:


Bitronics
Home
Data
Resets
Settings
Contact
Settings / Input
IED Input Configuration
Input Configuration
3 Element
VT Ratio
Primary
1.0000
Secondary
1
CT Ratio
Primary
5.0000
Secondary
5
Invert CT polarity
Demand Intervals
Amp Demand Interval
900
seconds
Volt Average Interval
60
seconds
Power Average Interval
60
seconds
TDD Denominator
Phase A
5.000
Phase B
5.000
Phase C
5.000
Residual
5.000
Loss Compensation
(Copper Watt Loss) / (Test Current)^2
0.00000
(Iron Watt Loss) / (Rated Voltage)^2
0.00000
(Copper Var Loss) / (Test Current)^2
0.00000
(Iron Var Loss) / (Rated Voltage)^4
0.00000
System Loss
0.00000
Apply
Restore Defaults

## Network:

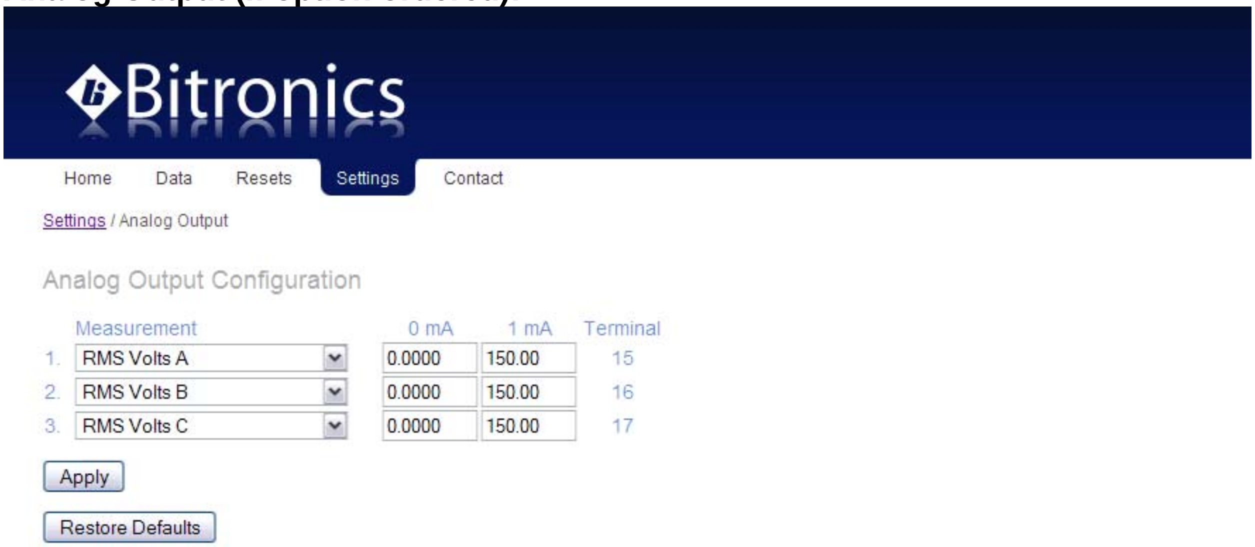



## Serial Port (if option ordered):



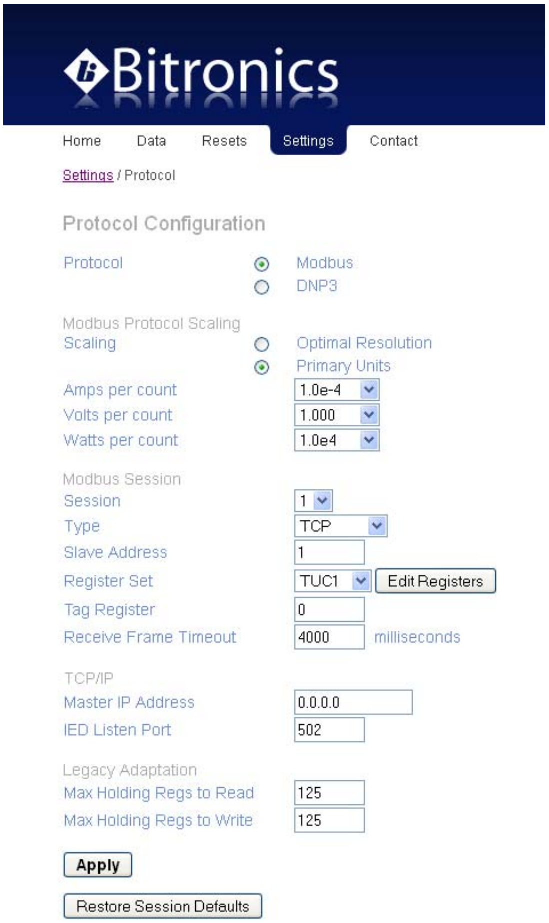
**Analog Output (if option ordered):**



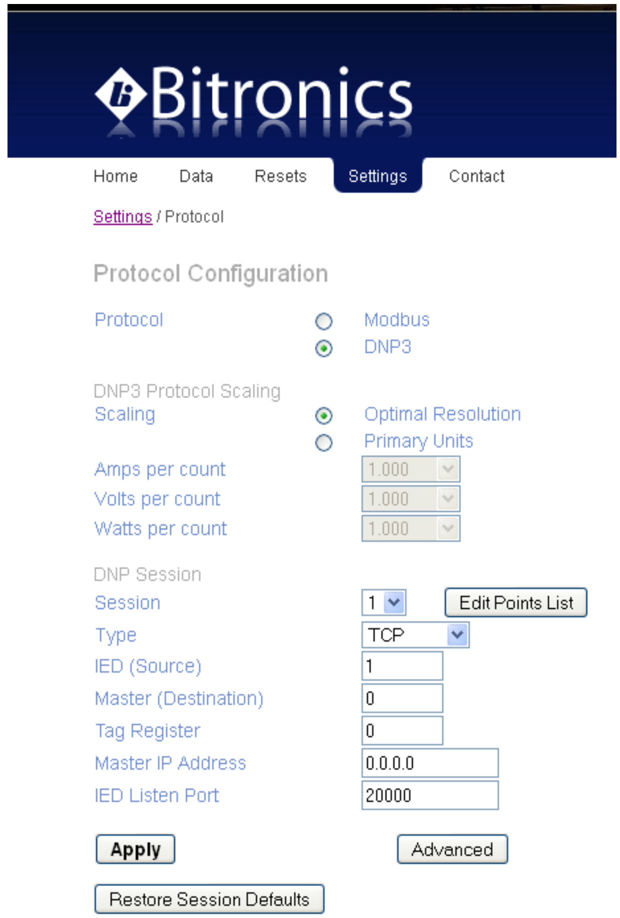

**Protocol Selection (if Option ordered):**

First select between Modbus or DNP3. You will then select Optimal Resolution (default) or Primary Units. Next you will choose a session. Under Type, there will be 4 different selections for Modbus and 3 for DNP3. Under Modbus the options are Disabled, TCP, ASCII, or RTU. For DNP3 the selections are Disabled, Serial, or TCP. Under DNP3, clicking on the Advanced button reveals more advanced functions that may or may not need to be changed. Clicking on the Basic button hides the advanced functions. A detailed description of the setup parameters for Modbus and DNP3 can be found in the Appendix of the respective protocol manuals.

There are both fixed and configurable register/point lists. Please refer to the appropriate protocol manual for more information regarding how to view or edit the register/point list.

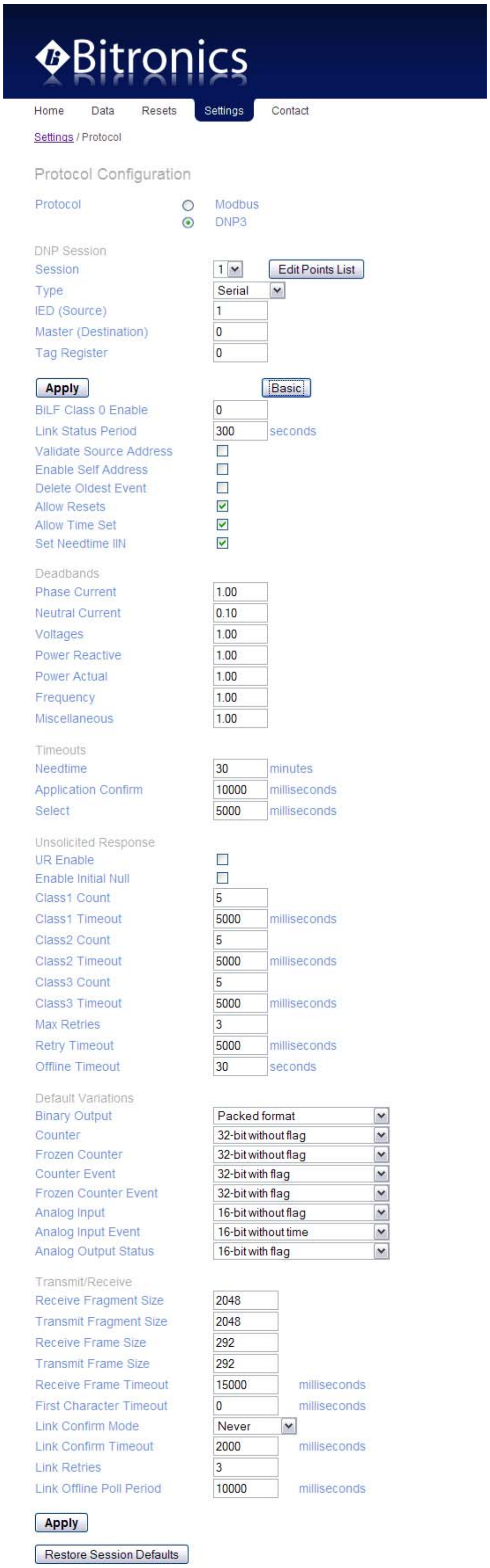

Bitronics
Home
Data
Resets
Settings
Contact
Settings / Protocol
Protocol Configuration
Protocol
Modbus
DNP3
Modbus Protocol Scaling
Scaling
Optimal Resolution
Primary Units
Amps per count
1.0e-4
Volts per count
1.000
Watts per count
1.0e4
Modbus Session
Session
1
Type
TCP
Slave Address
1
Register Set
TUC1
Edit Registers
Tag Register
0
Receive Frame Timeout
4000
milliseconds
TCP/IP
Master IP Address
0.0.0.0
IED Listen Port
502
Legacy Adaptation
Max Holding Regs to Read
125
Max Holding Regs to Write
125
Apply
Restore Session Defaults

Modbus

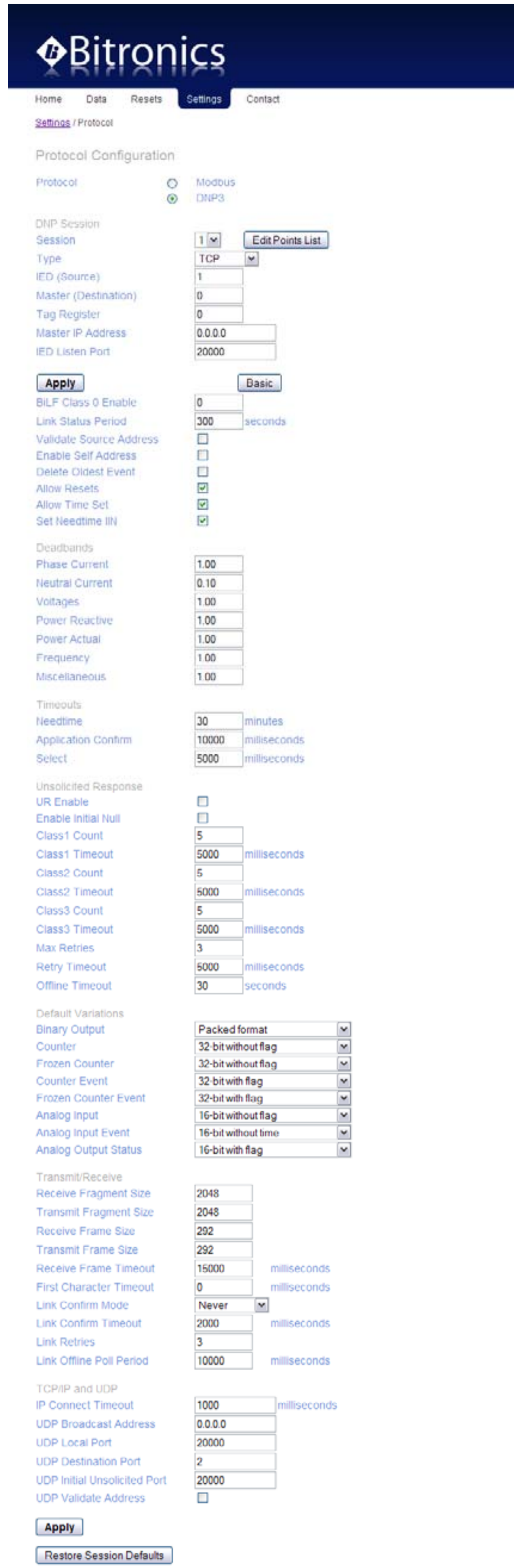

Bitronics
Home
Data
Resets
Settings
Contact
Settings / Protocol
Protocol Configuration
Protocol
Modbus
DNP3
DNP3 Protocol Scaling
Scaling
Optimal Resolution
Primary Units
Amps per count
1.000
Volts per count
1.000
Watts per count
1.000
DNP Session
Session
1
Edit Points List
Type
TCP
IED (Source)
1
Master (Destination)
0
Tag Register
0
Master IP Address
0.0.0.0
IED Listen Port
20000
Apply
Advanced
Restore Session Defaults

DNP3

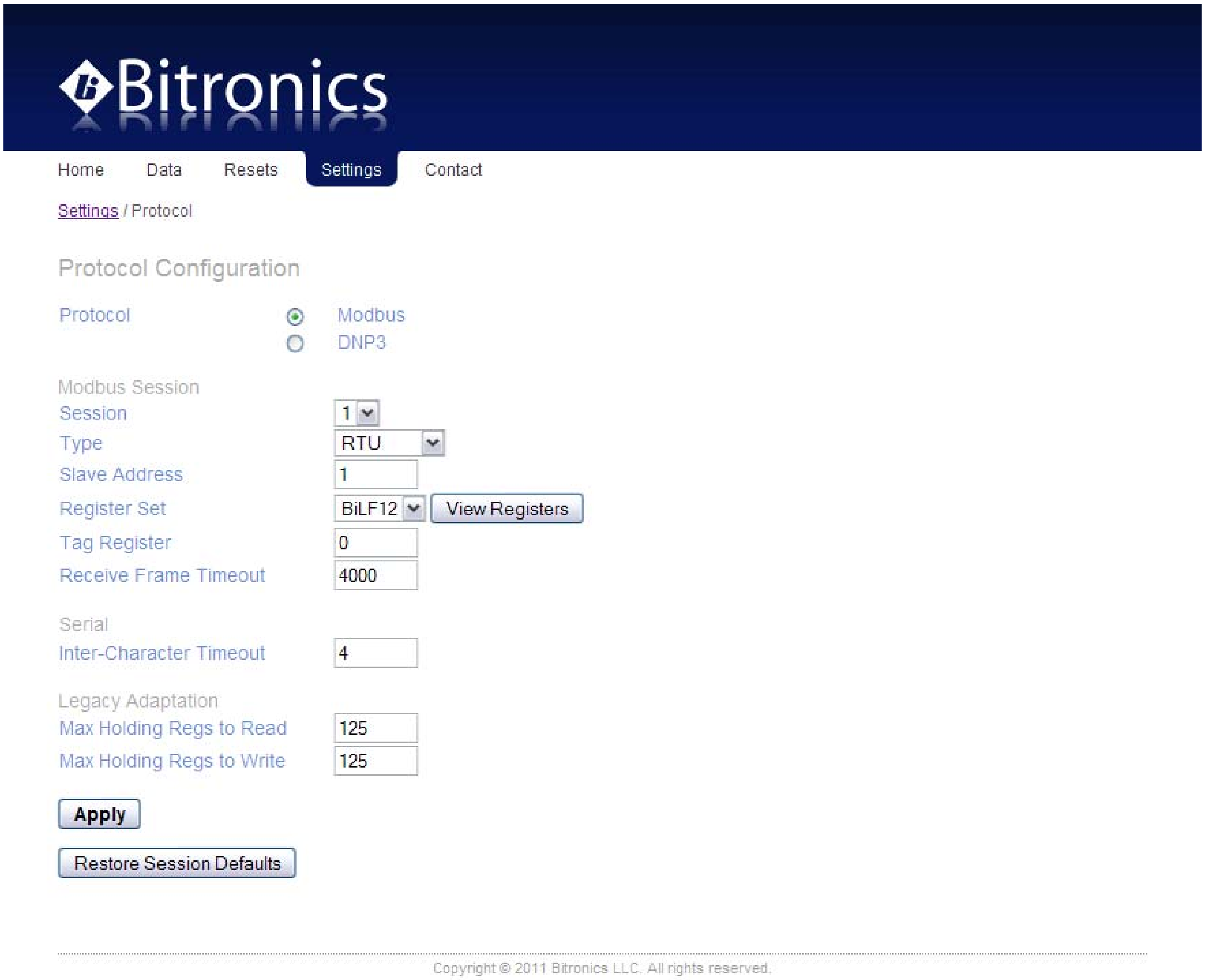
 



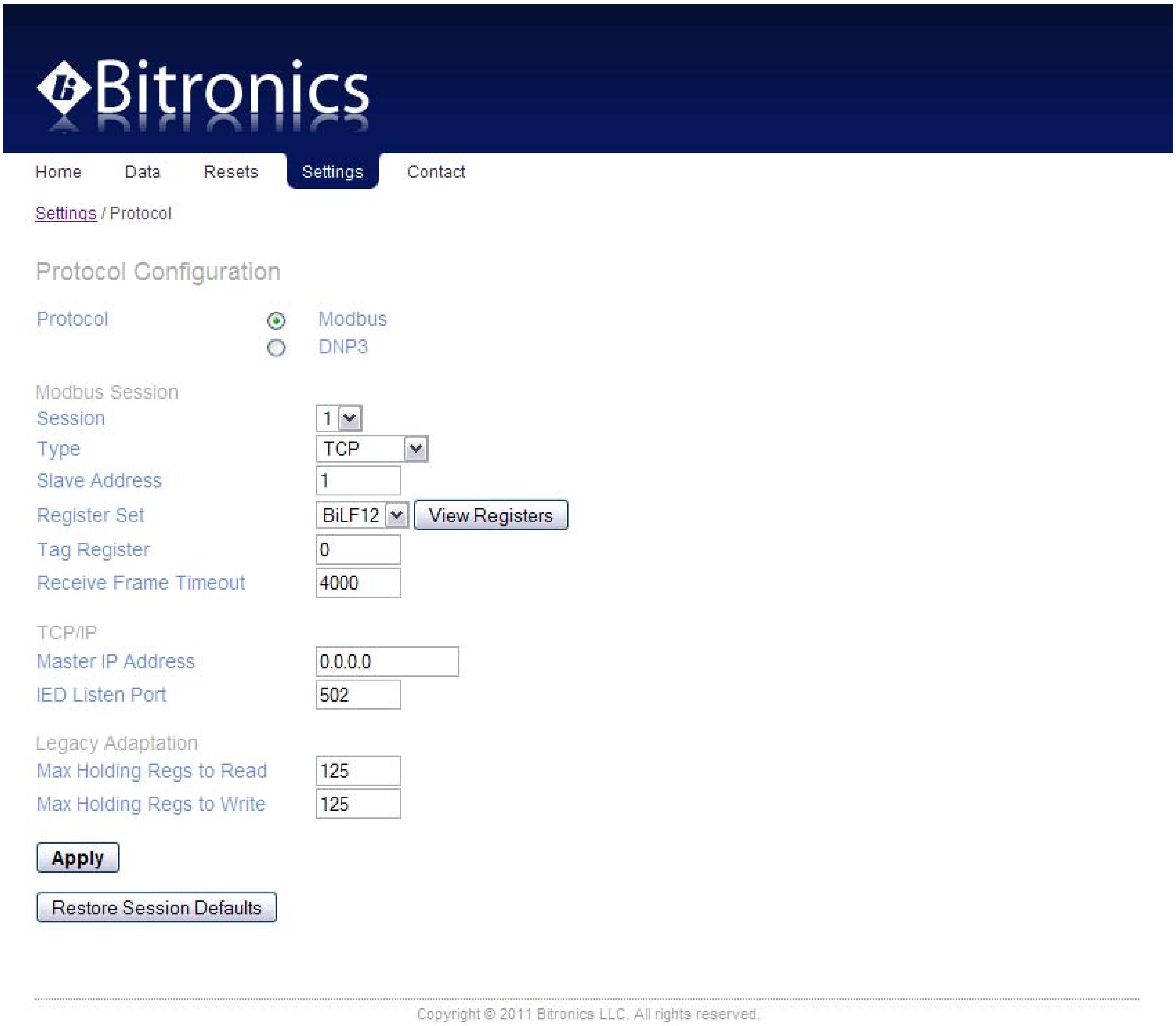

DNP Serial




DNP TCP

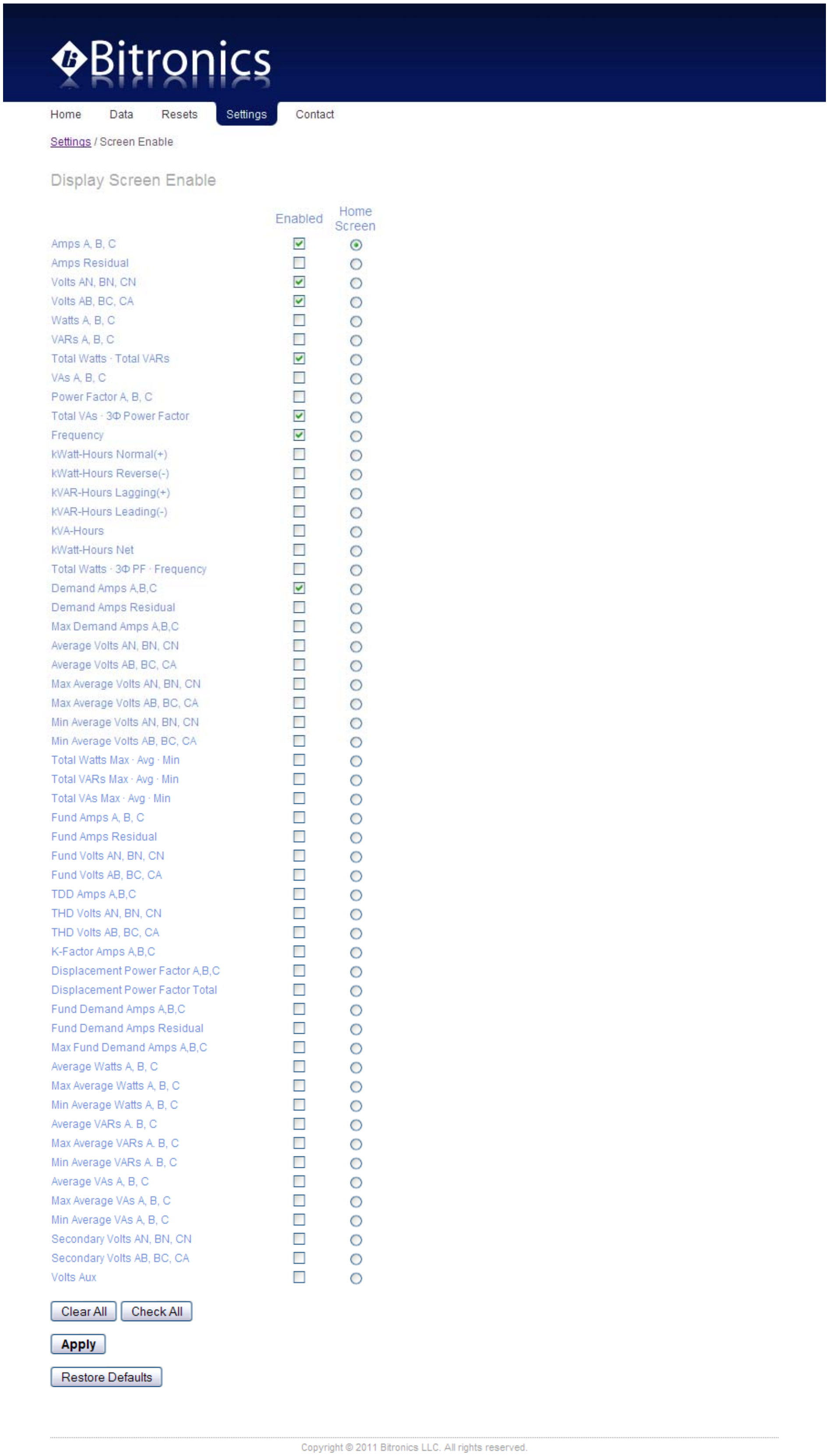

Bitronics
Home
Data
Resets
Settings
Contact
Settings / Protocol
Protocol Configuration
Protocol
Modbus
DNP3
Modbus Session
Session
1
Type
RTU
Slave Address
1
Register Set
BiLF12
View Registers
Tag Register
0
Receive Frame Timeout
4000
Serial
Inter-Character Timeout
4
Legacy Adaptation
Max Holding Regs to Read
125
Max Holding Regs to Write
125
Apply
Restore Session Defaults
Copyright © 2011 Bitronics LLC. All rights reserved.

Modbus RTU


Bitronics
Home
Data
Resets
Settings
Contact
Settings / Protocol
Protocol Configuration
Protocol
Modbus
DNP3
Modbus Session
Session
1
Type
TCP
Slave Address
1
Register Set
BiLF12
View Registers
Tag Register
0
Receive Frame Timeout
4000
TCP/IP
Master IP Address
0.0.0.0
IED Listen Port
502
Legacy Adaptation
Max Holding Regs to Read
125
Max Holding Regs to Write
125
Apply
Restore Session Defaults
Copyright © 2011 Bitronics LLC. All rights reserved.

Modbus TCP

## Screen Enable:



## Custom Display Screen Settings: Two Sections – Build/Edit and Summary

The Custom Display Screen Configuration page contains two sections: the Build/Edit panel and the Summary panel. One custom display screen is built at a time in the Build/Edit panel and is then added to the Summary panel, which presents a list of all the custom screens that have been built.  The Build/Edit panel is presented if there are no custom screens stored on the IED when the page is loaded; otherwise, the Summary panel is presented. Only one panel is visible at a time.

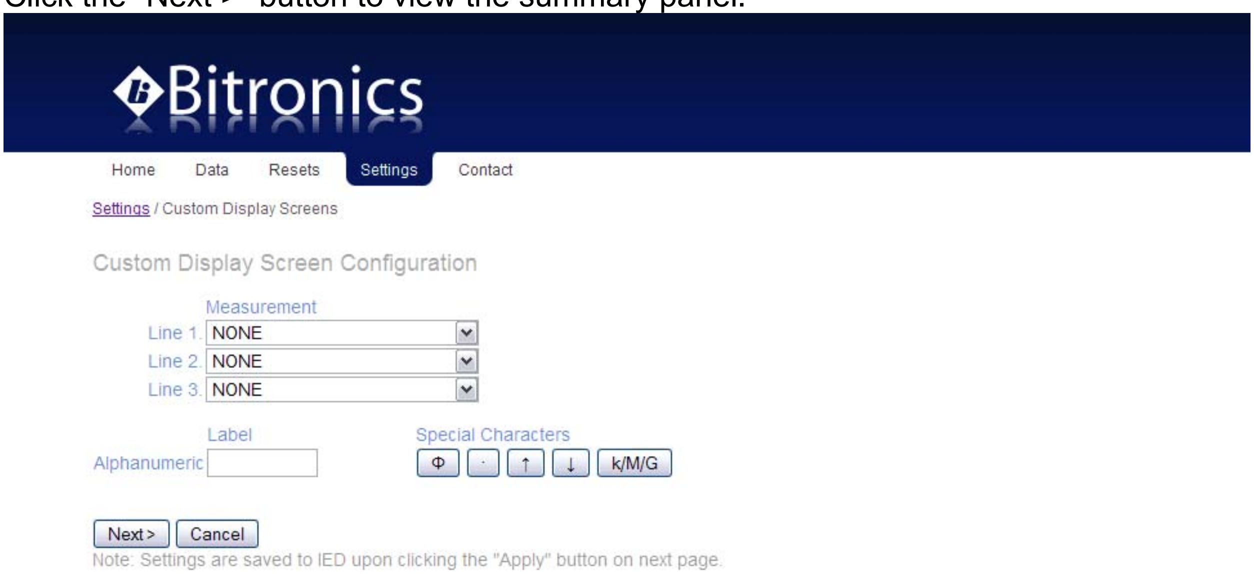
### Build/Edit panel

Select a measurement to be displayed on each display line from the dropdown lists and enter an alphanumeric label that describes the display screen.

Special character buttons insert the characters shown on the buttons into the “Label” field.  The “k/M/G” (kilo/Mega/Giga) button inserts an underscore character into the “Label” field, which is automatically replaced with the appropriate unit prefix when displayed on the IED’s front panel.  The dot character is used to separate parts of a single label into multiple labels that apply to the different display lines. It is necessary to place dots between underscore that apply to different display lines.

The MIN, MAX, AVG, line and phase LEDs are automatically lit by the IED, based on the selected measurements.

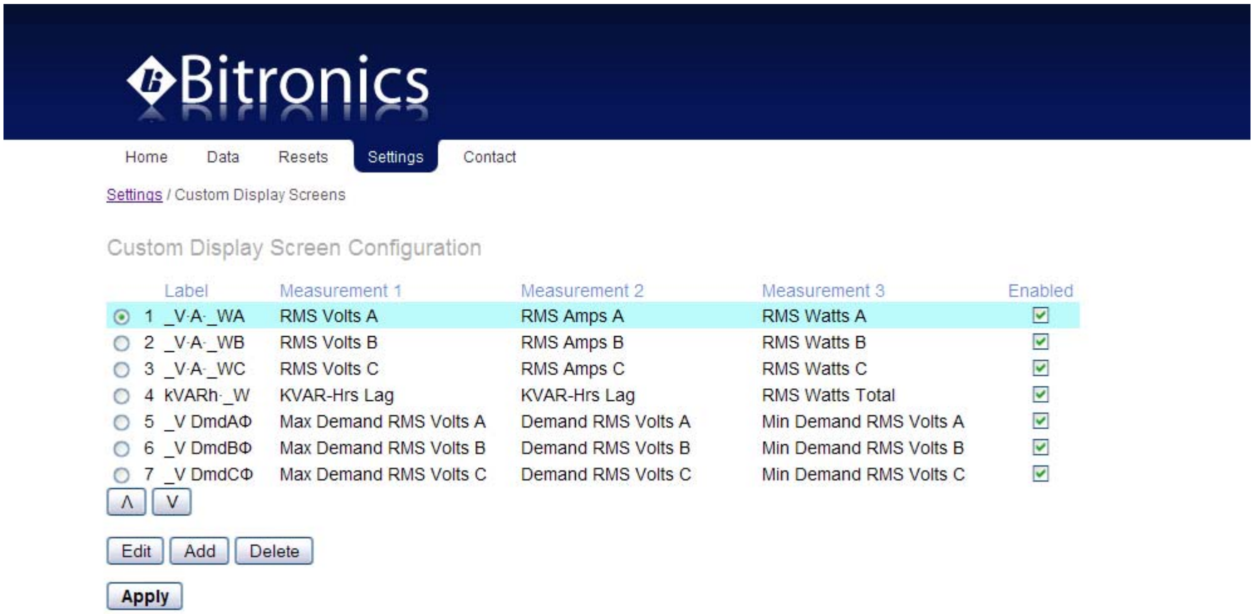
Click the “Next >” button to view the summary panel.



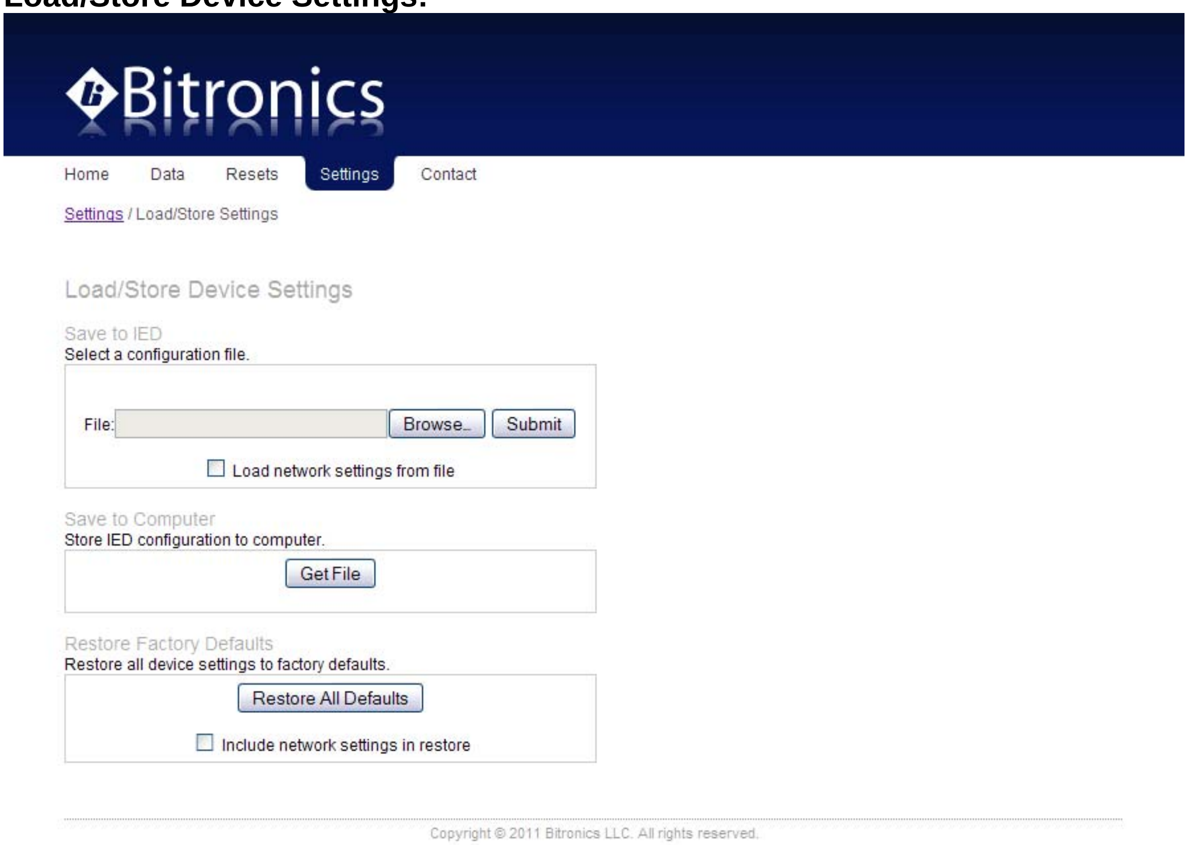

### Summary panel

Screens are saved to IED once the “Apply” button has been clicked.  A row (screen) from the summary table can be selected for viewing, editing or deleting by clicking its radio button.

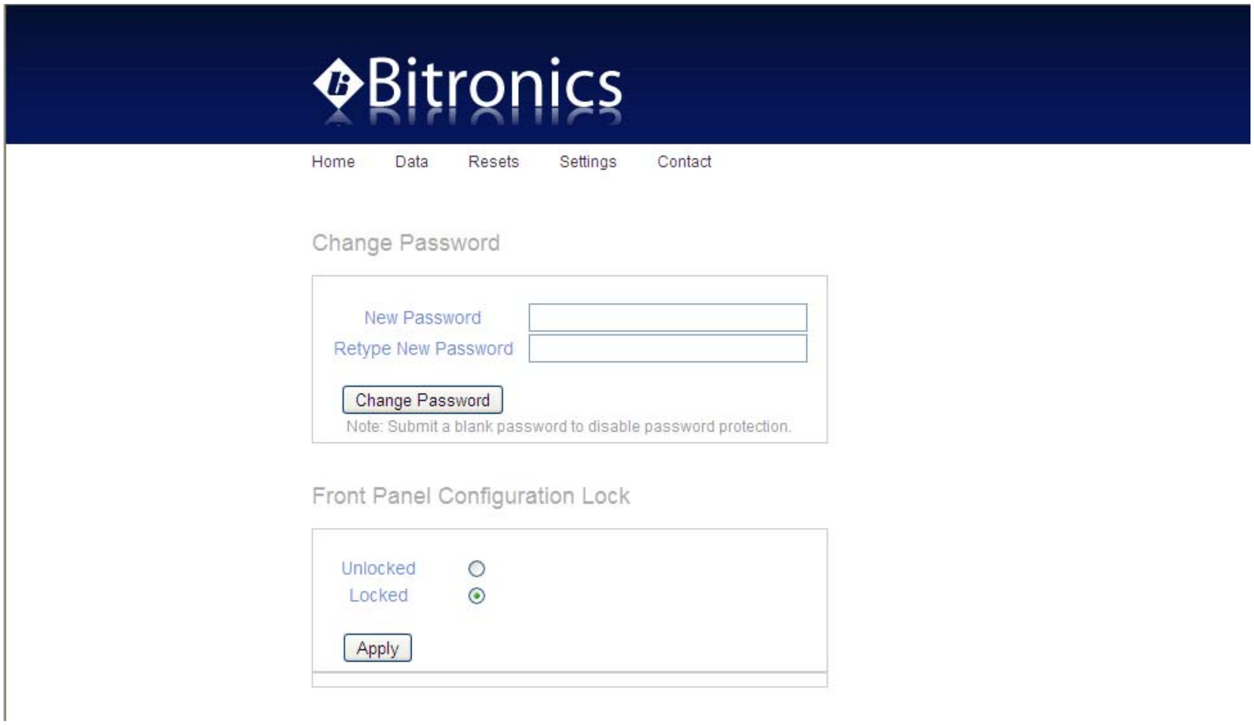
The order of the screens can be changed by selecting a screen from the list and clicking on the up or down arrows.




## Load/Store Device Settings:



## Password Security Settings:




## Firmware Upload:

# 6.0 MEASUREMENTS

Basic measurement quantities are calculated and updated every 100 ms. These quantities include RMS Amperes and RMS Volts, Watts, VARs, VAs, Power Factor, all harmonic-based measurements (such as fundamental-only quantities), Energy, and Frequency, and Phase Angle.

Note: For all of the following measurements, it is important to keep in mind that the specific protocol used to access the data may affect the data that is available, or the format of that data. No attempt is made here to describe the method of accessing measurements - always check the appropriate protocol manual for details.

## 6.1 Changing Transformer Ratios

The M650 has the capability to store values for Current Transformer (CT) and Potential Transformer (VT) turns ratios. The VT and CT values are factory set to 1:1 CT and 1:1 VT. These values can be entered into the M650 over the network or via front display buttons or web page, and will be stored in internal non-volatile memory. All measurements are presented in primary units, based on these ratios. Please note that the value entered via the front display should be the result of the division of the primary value by 5. For example for a ratio of 6000:5, you would enter a value of 1200 through the front display. The web interface allows you to choose either 1A or 5A for the denominator, and the primary value is entered directly. The PT ratio is to 1 when entering through the front display. The web allows other denominators (110, 115, or 120) to be used. Refer to the appropriate protocol manual for more information on changing transformer ratios.

## 6.2 Current

The M650 has three current inputs, with an internal CT on each channel except in the case where external split-core CTs are used. These inputs can read to 2x nominal ($2A_{RMS}$ for 1A input, $10A_{RMS}$ for 5A input (symmetrical)) under all temperature and input frequency conditions. No range switching is used, allowing a high dynamic range.

The current signals are transformer coupled, providing a true differential current signal. Additionally, a continuous DC removal is performed on all current inputs. Instrument Transformer Ratios can be entered for each current input, as described above.

The average of the 3 current phases ((Ia + Ib + Ic)/3) is also available.

### 6.2.1 Residual Current

The M650 calculates the vector sum of the three phase currents, which is known as the Residual Current. The Residual Current is equivalent to routing the common current return wire through the neutral current input on systems without separate current returns for each phase.

## 6.3 Voltage Channels

All voltage inputs are measured relative to a common reference level (essentially panel ground). See Appendix 1 for input connection information. Common mode signals can be removed by signal processing algorithms, instead of the more traditional difference amplifier approach. This greatly simplifies the external analog circuitry, increases the accuracy, and allows measurement of the Neutral-to-Ground voltage at the panel. The 7kV input divider resistors are accurate to within +/-25ppm/DegC, and have a range of $400V_{PEAK}$, from any input to panel ground. Each sample is corrected for gain using factory calibration values stored in non-volatile memory on the board. Additionally, a continuous DC removal is performed on all inputs.

The advantages of this method of voltage measurement are apparent when the M650 is used on the common 2, 2½, and 3 element systems (refer to Section 6.5). The M650 is always calculating Line-to-Neutral, and Line-to-Line voltages with equal accuracy. On 2 element connections, any phase can serve as the reference phase.

On 2½ element systems, one of the phase-to-neutral voltages is missing, and the M650 must create it from the vector sum of the other two phase-to-neutral voltages. In order to configure the M650 for 2½ element mode and which phase voltage is missing, select one of the following: 2.5 element - A, 2.5 element - B, or 2.5 element – C.

The average of the 3 voltage phases ((Va + Vb + Vc)/3) is also available.

## 6.4 Voltage Aux

The M650 M3 provides a measurement for the voltage connected to the power supply terminals. This is a differential voltage. The value can be AC or DC depending upon the power supply voltage source.

## 6.5 Power Factor

The per-phase Power Factor measurement is calculated using the "Power Triangle", or the per-phase WATTS divided by the per-phase VAs. The Total PF is similar, but uses the Total WATTS and Total VAs instead. The sign convention for Power Factor is shown in Figure 9.

## 6.6 Watts / Volt-Amperes (VAs) / VARs (Uncompensated)

On any power connection type (2, 2½, and 3 element), the M650 calculates per-element Watts by multiplying the voltage and current samples of that element together. This represents the dot product of the voltage and current vectors, or the true Watts. The per-element VAs are calculated from the product of the per-element Volts and Amps. The per-element VARs are calculated from fundamental VARs.

In any connection type, the Total Watts and Total VARs is the arithmetic sum of the per-element Watts and VARs. The sign conventions are shown in Figure 9.

When used on 2-element systems, the reference phase voltage (typically phase B) input, is connected to the Neutral voltage input, and effectively causes one of the elements to be zero. ***It is not required to use any particular voltage phase as the reference on 2-element systems. When used on 2-element systems the per-element Watts, VARs, and VAs have no direct physical meaning***, as they would on 2½ and 3 element systems where they represent the per-phase Watts, VARs, and VAs.

When used on 2½ element systems, one of the phase-to-neutral voltages is fabricated, as described in Section 6.3. In all other respects, the 2½ element connection is identical to the 3 element connection.

### 6.6.1 Geometric VA Calculations

$$GEOMETRIC\ VA_{TOTAL} = \sqrt{Watts_{TOTAL}{}^2 + VARs_{TOTAL}{}^2}$$

This is the traditional definition of Total VAs for WYE or DELTA systems, and is the default method for Total VAs calculation. The value of Total VAs calculated using this method does not change on systems with amplitude imbalance, relative to a balanced system.

There is also a relationship to the Total Power Factor, which is described in Section 6.4. Total Power Factor calculations using the Geometric VA method will still indicate a "1" on a system with phase amplitude imbalance, or canceling leading and lagging loads.

For example, on a system with a lagging load on one phase and an equal leading load on another phase, the Geometric VA result will be reduced relative to a balanced system but the Total Power Factor will still be "1".

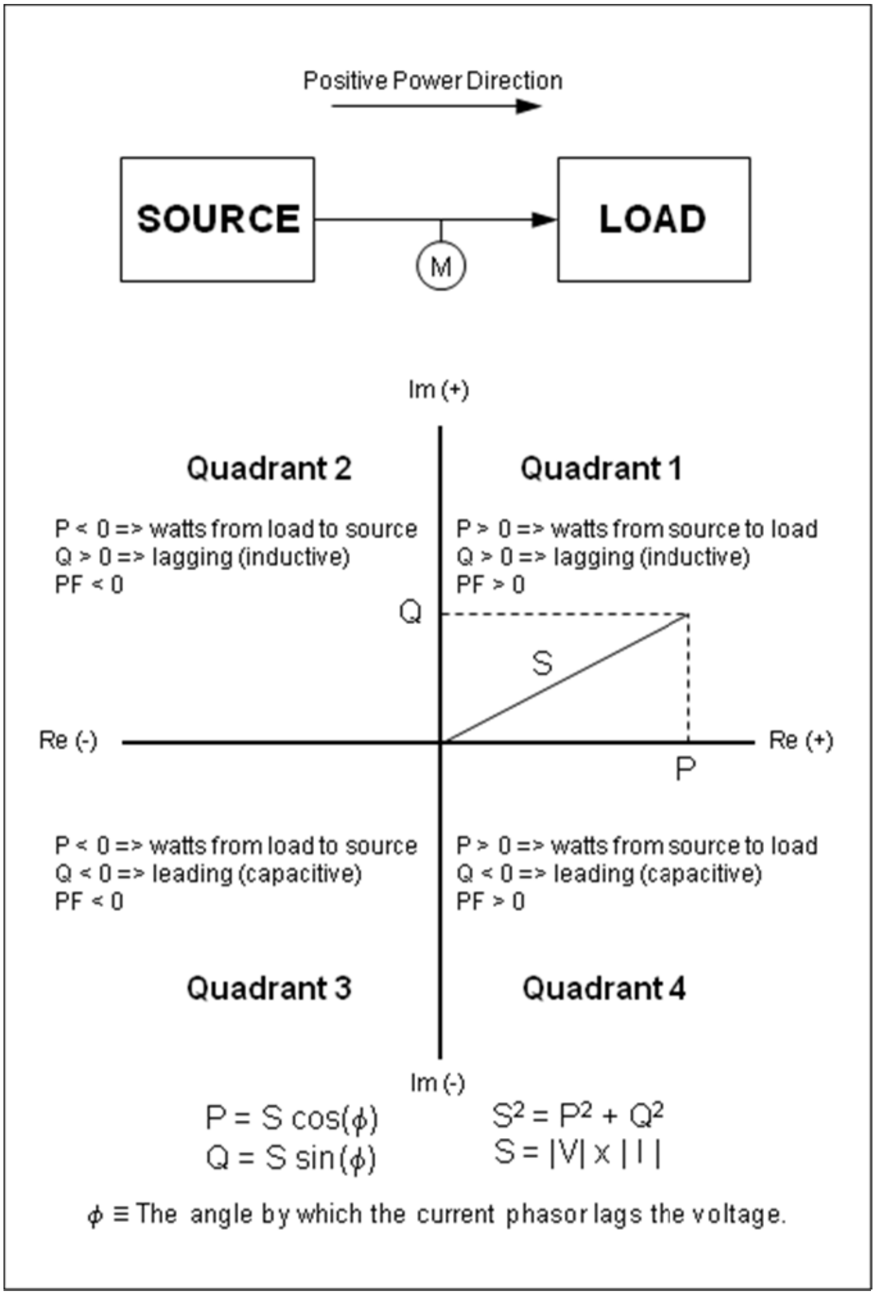



**Figure 9 - Sign Conventions for Power Measurements**
**(P is Power, Q is VARS and S is VA)**

### 6.7 Compensated Watts and VARs (Line and Transformer Loss Compensation)

The total Watt and Var losses can be calculated using five user entered parameters and measured current and voltage values. These losses are added or subtracted to/from the measured Total Watts and Total Vars when accumulating Energy.

Loss compensation on the M650 takes the following general form:

$$P_{COM} = P_{UNC} + A \cdot I^2 + B \cdot V^2 + E \cdot P_{UNC}$$
$$Q_{COM} = Q_{UNC} + C \cdot I^2 + D \cdot V^4 + E \cdot Q_{UNC}$$

Where:

- $P_{COM}$ Compensated three-phase total watts. Note the accumulators for +kWh and –kWh in the M650 are calculated by integrating the $P_{COM}$ measurement over time.
- $P_{UNC}$ Uncompensated three-phase total watts measured at the point where the meter is connected.
- $Q_{COM}$ Compensated three-phase total VARs. Note the accumulators for +kVARh and –kVARh in the M650 are calculated by integrating the $Q_{COM}$ measurement over time.
- $Q_{UNC}$ Uncompensated three-phase total VARs measured at the point where the meter is connected.
- $I$ RMS line current measured at the point where the meter is connected.
- $V$ RMS *line-line* voltage measured at the point where the meter is connected.
- *A* **Meter setting** that accounts for the sum of the full-load-watt-losses from all sources.
- *B* **Meter setting** that accounts for the transformer’s no-load-watt-losses.
- *C* **Meter setting** that accounts for the sum of the full-load-VAR-losses from all sources.
- *D* **Meter setting** that accounts for the transformer’s no-load-VAR-losses.
- *E* **Meter setting** that accounts for any “system” losses, proportional to the uncompensated power.

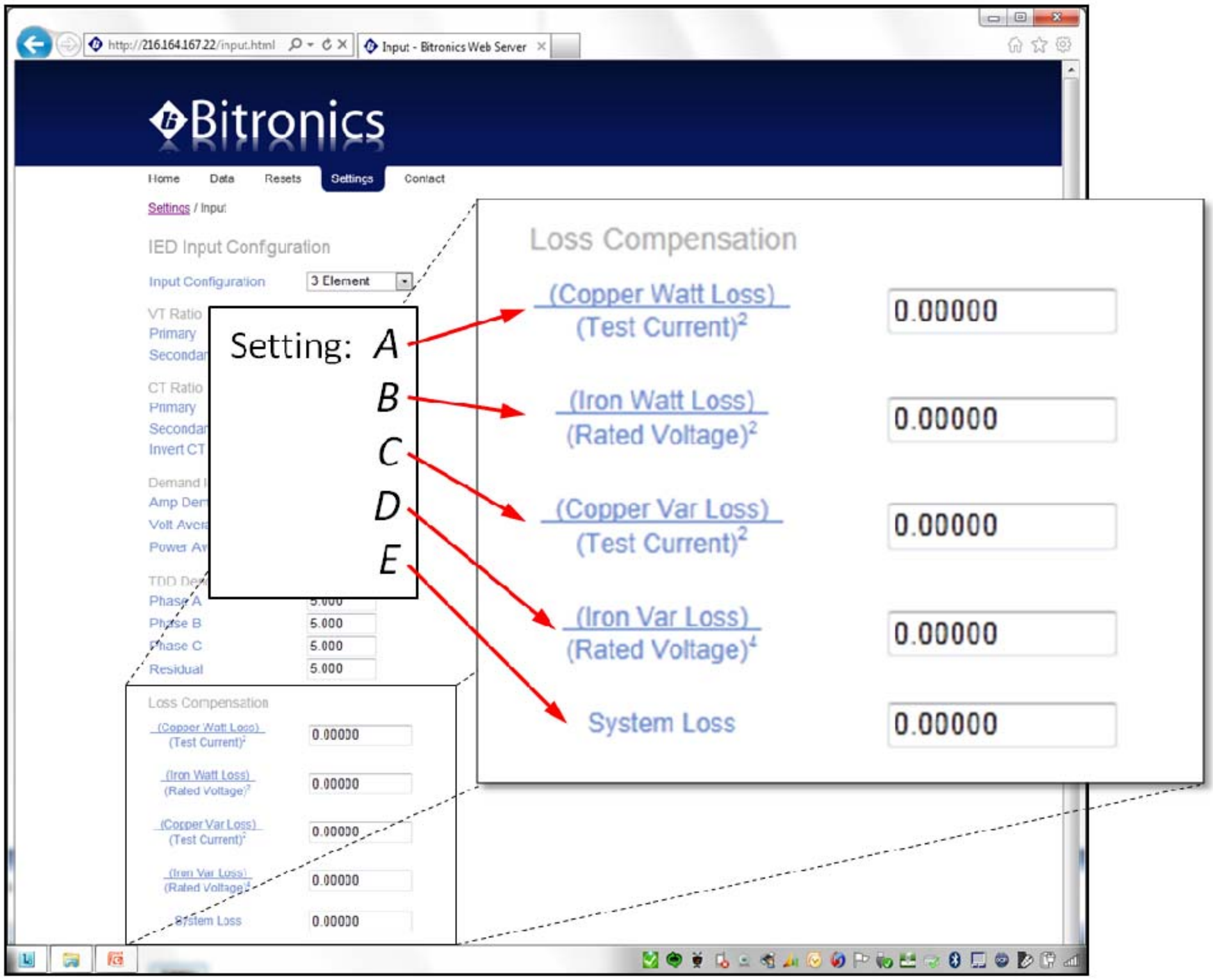
Configuring the meter to perform loss compensation simply requires the user to calculate the coefficients *A, B, C, D,* and *E* defined above, and enter them in the appropriate fields in the M650’s webserver interface on the Settings/Input page as shown in the screen shot below

The *sign* of the settings *A*, *B*, C, *D*, and *E* determines whether losses will be added to or subtracted from the uncompensated measurements in order to determine the compensated power and energy. To add losses, be sure the settings are all positive. To subtract losses, be sure the settings are all negative. Settings should always have the same sign.

Making all of the settings equal to zero *turns off* loss compensation.
System losses (*E*) are a fixed percentage, mutually agreed upon between two electric utilities, about an interchange point that lies on a branched line. As such, *E* is not a physical property of any particular line, transformer or the meter, so no further

guidance on how best to calculate the coefficient *E* can be provided here. All instructions following will be concerned only with the calculation of the coefficients *A, B, C,* and *D*. Users who do not intend to use system losses should simply set *E* equal to zero.




A detailed application note on loss compensation in the 50 Series can be found in the documentation library of the Novatech website, www.novatechweb.com.

## 6.8 Energy

Separate values are maintained for both positive and negative Watt-hours, positive and negative VAR-hours, and VA-hours, for each feeder. These energy quantities are calculated every cycle from the Total Watts, Total VARs, and Total VAs, and the values are stored into non-volatile memory every 15 seconds. Energy values may be reset. All values are reset simultaneously. Refer to the appropriate protocol manual for details.

## 6.9 Frequency

The M650 monitors the change in Phase Angle per unit time using the Phase Angle measurement for the fundamental generated by the FFT. The System Frequency is the frequency of the input used for synchronizing the sampling rate.

## 6.10 Demand Measurements

The traditional thermal demand meter displays a value that represents the logarithmic response of a heating element in the instrument driven by the applied signal. The most positive value since the last instrument reset is known as the maximum demand (or peak demand) and the lowest value since the last instrument reset is known as the minimum demand. Since thermal demand is a heating and cooling phenomenon, the demand value has a response time T, defined as the time for the demand function to change 90% of the difference between the applied signal and the initial demand value. For utility applications, the traditional value of T is 15 minutes, although the M650 can accommodate other demand intervals (Section 6.10.5).

The M650 generates a demand value using modern microprocessor technology in place of heating and cooling circuits, it is therefore much more accurate and repeatable over a wide range of input values. In operation, the M650 continuously samples the basic measured quantities, and digitally integrates the samples with a time constant T to obtain the demand value. The calculated demand value is continuously checked against the previous maximum and minimum demand values. This process continues indefinitely, until the demand is reset or until the meter is reset (or power removed and reapplied). The demand reset and power-up algorithms are different for each measurement. These routines are further described in following paragraphs. The maximum and minimum demand values are stored in non-volatile memory on the Host Processor module.

**NOTE:** Changing VT or CT ratios does NOT reset demand measurements to zero.

| Demand Quantity | Phase Reference | Function |
| --- | --- | --- |
| Amperes | Phase, Residual | Present, Max |
| Fundamental Amperes | Phase, Residual | Present, Max |
| Volts | Phase - Neutral, Phase - Phase | Present, Max, Min |
| Total Watts (A, B, C, Total) | Phase, Total | Present, Max, Min |

| Demand Quantity | Phase Reference | Function |
|---|---|---|
| Total VARs (A, B, C, Total) | Phase, Total | Present, Max, Min |
| Total VAs (A, B, C, Total) | Phase, Total | Present, Max, Min |

### 6.10.1 Ampere and Fundamental Ampere Demand

Present Ampere Demands are calculated via the instantaneous measurement data used to calculate the per-phase Amperes.

Upon power-up, all Present Ampere Demands are reset to zero. Maximum Ampere Demands are initialized to the maximum values recalled from non-volatile memory. Upon Ampere Demand Reset, all per-phase Present and Maximum Ampere Demands are set to zero. When Ampere Demands are reset, Fundamental Current Demands are also reset.

### 6.10.2 Volt Demand

Present Volt Demands are calculated via the instantaneous measurement data used to calculate the per-phase Volts. Upon power-up all Present Volt Demands are reset to zero. The Maximum Volt Demands and Minimum Volt Demands are initialized to the minimum and maximum values recalled from non-volatile memory. In order to prevent the recording of false minimums a new Minimum Volt Demand will not be stored unless two criteria are met. First, the instantaneous voltage for that particular phase must be greater than $20V_{rms}$ (secondary). Second, the Present Demand for that particular phase must have dipped (Present Demand value must be less than previous Present Demand value). Upon Voltage Demand Reset, all per-phase Maximum Voltage Demands are set to zero. Minimum Voltage Demands are set to full-scale.

### 6.10.3 Power Demands (Total Watts, VARs, and VAs)

Present Total Watt, VAR, and VA Demands are calculated via the instantaneous measurement data. The Total VA Demand calculation type is based on the instantaneous Total VA calculation type (Section 6.6)

Upon power-up, all Present Total Watt, VAR, and VA Demands are reset to the average of the stored Maximum and Minimum values. The Maximum and Minimum Demands are initialized to the minimum and maximum values recalled from non-volatile memory. Upon a demand reset, the Maximum and Minimum Demands are set equal to the Present Total Watt, VAR, and VA Demand values. A demand reset does not change the value of the Present Total Watt, VAR, and VA Demands.

### 6.10.4 Demand Resets

The demand values are reset in 3 groups: current, voltage, and power. This can be accomplished via the front display or from a web browser.

### 6.10.5 Demand Interval

The M650 uses 900 seconds (15 minutes) as the default demand interval for current. The default for average volts and average power measurements is 60 seconds. Three separate, independent demand intervals may be set for current, voltage, and power. The range of demand intervals is 10 to 9999 seconds. These settings can be accomplished by using the front display or web server setup.

## 6.11 Harmonic Measurements

All harmonic and harmonic related measurements are calculated every 100 ms. In the following sections, Harmonic 0 indicates DC, Harmonic 1 indicates the fundamental, and Harmonic N is the nth multiple of the fundamental.

### 6.11.1 Voltage Distortion (THD)

Voltage Harmonic Distortion is measured by phase in several different ways. The equation for Total Harmonic Distortion (THD) is given in Equation 1. Note the denominator is the fundamental magnitude.

$$= \frac{\sqrt{\sum_{=}}}{} \times$$

Equation 1 – Voltage THD

### 6.11.2 Current Distortion (THD and TDD)

Current Harmonic Distortion is measured by phase in several different ways. The first method is Total Harmonic Distortion (THD). The equation for THD is given in Equation 2. Note the denominator is the fundamental magnitude.

$$= \frac{\sqrt{\sum_{=}}}{} \times$$

Equation 2 – Current THD

Alternatively, Current Harmonic Distortion can be measured as Demand Distortion, as defined by IEEE-519/519A. Demand Distortion differs from traditional Harmonic Distortion in that the denominator of the distortion equation is a fixed value. This fixed denominator value is defined as the average monthly peak demand. By creating a measurement that is based on a fixed value, TDD is a "better" measure of distortion problems. Traditional THD is determined on the ratio of harmonics to the fundamental. While this is acceptable for voltage measurements, where the fundamental only varies slightly, it is ineffective for current measurements since the fundamental varies over a wide range. Using traditional THD, 30% THD may mean a 1 Amp load with 30% Distortion, or a 100 Amp load with 30% Distortion. By using TDD, these same two loads would exhibit 0.3% TDD for the 1 Amp load and 30% TDD for the 100 Amp load (if the Denominator was set at 100 Amps). In the M650, Current Demand Distortion is implemented using Equation 3. The TDD equation is similar to Harmonic Distortion (Equation 2), except that the denominator in the equation is a user-defined number. This number, $I_L$, is meant to represent the average load on the system. The denominator $I_L$ is different for each phase and neutral, and is set by changing the denominator values within the M650.

$$= \frac{\sqrt{\sum_{=}}}{} \times$$

**Equation 3 – Current TDD**

Note that in Equation 3, if $I_L$ equals the fundamental, this Equation becomes Equation 2 - Harmonic Distortion. In the instrument this can be achieved by setting the denominator to zero amps, in which case the instrument will substitute the fundamental, and calculate Current THD.

Note that there is a separate, writeable denominator for each current input channel. The TDD Denominator Registers are set by the factory to 5 Amps (secondary), which is the nominal full load of the CT input with a 1:1 CT. These writeable denominators can be used in conjunction with the distortion measurements to obtain the magnitudes of harmonics, in other words, convert from percent to amps. This is simply done by multiplying the percent TDD by the TDD Denominator for that phase, and the result will be the actual RMS magnitude of the selected harmonic(s). This technique can also be used if the THD mode (denominator set to zero) is used, by multiplying the percent THD by the Fundamental Amps for that phase.

### 6.11.3 Fundamental Current

Fundamental Amps are the nominal component (50/60 Hz) of the waveform. The M650 measures the magnitude of the fundamental amps for each phase. These measurements can be used in conjunction with the distortion measurements to obtain the magnitudes of harmonics, in other words, convert from percent to amps. As was mentioned previously, this is simply done by multiplying the percent THD by the Fundamental Amps for that phase (which is the denominator), and the result will be the actual RMS magnitude of the selected harmonic.

### 6.11.4 Fundamental Voltage

Fundamental Volts are the nominal component (50/60Hz) of the waveform. The M650 measures the magnitude of the fundamental phase-to-neutral and phase-to-phase volts. These measurements can be used in conjunction with the distortion measurements to obtain the magnitudes of harmonics, in other words, convert from percent to volts. This is simply done by multiplying the percent THD by the Fundamental Volts for that phase (which is the denominator), and the result will be the actual RMS magnitude of the selected harmonic.

Fundamental Volts and Amps can be used in conjunction to obtain Fundamental VAs, and when used with Displacement Power Factor can yield Fundamental Watts and Fundamental VARs.

### 6.11.5 K-Factor

K-Factor is a measure of the heating effects on transformers, and it is defined in ANSI/IEEE C57.110-1986. Equation 4 is used by the M650 to determine K-Factor, where "h" is the harmonic number and "$I_h$" is the magnitude of the $h^{th}$ harmonic. K-Factor is measured on each of the three phases of amps, however there is no "Total" K-Factor. K-Factor, like THD and PF, does not indicate the actual load on a device, since all three of these measurements are ratios. Given the same harmonic ratio, the calculated K-Factor for a lightly loaded transformer will be the same as the calculated K-Factor for a heavily loaded transformer, although the actual heating on the transformer will be significantly different.

$$K - Factor = \frac{\sum_{h=1}^{63} I_h^2 \times h^2}{\sum_{h=1}^{63} I_h^2}$$

**Equation 4 - K-Factor**

### 6.11.6 Displacement Power Factor

Displacement Power Factor is defined as the cosine of the angle (phi) between the Fundamental Voltage Vector and the Fundamental Current Vector. The sign convention for Displacement Power Factor is the same as for Power Factor, shown in Figure 9.

The Total Displacement Power Factor measurement is calculated using the "Power Triangle", or the three-phase Fundamental WATTS divided by the three-phase Fundamental VAs. The per-phase Fundamental VA measurement is calculated from the product of the per-phase Fundamental Amp and Fundamental Volts values. The three-phase Fundamental VA measurement is the sum of the per-phase Fundamental VA values (Arithmetic VAs).

### 6.11.7 Phase Angles

The M65x measures the Fundamental Phase Angles for all Currents, Line-to-Neutral Voltages, and Line-to-Line Voltages. The Phase Angles are in degrees, and all are referenced to the $V_{A-N}$ Voltage, which places all Phase Angles in a common reference system. Values are from -180 to +180 Degrees. Note that the phase angles are only available in the TUC register set and use calculation type T8 (see Modbus and DNP3 Protocol manuals for more detail). As with other measurements, the Phase angles can be mapped to analog outputs or used in custom display screens.

## 6.12 Heartbeat and Health Check

M65x meters provide a Heartbeat State Counter Register that allows the user to determine the time between successive polls. This counter will increment by the number of milliseconds that have elapsed since the last time the data was updated. Another use of this register is as a visual indicator that the data is changing; it allows users of certain MMIs to identify disruption in the polling of the instrument. The Heartbeat State Counter is a full 32-bit counter that rolls over at 4,294,967,295 (4,294,967 seconds). The counter starts at zero on power-up, and is NOT stored in non-volatile memory.

M65x meters have several self-tests built in to ensure that the instrument is performing accurately. The results of these self-tests are available in the Health Check register which is a simple 16-bit binary value. Each bit represents the results of a particular self-test, with "0" indicating the test was passed, and "1" indicating the test was failed. If Health status failures occur, the meter may have experienced an operational failure. The table below provides a reference of error codes. The Health Check value shown in the M650 web live data page is a hexadecimal representation of the binary value. For example, a Health Check value of 0000 0014 is the equivalent of the binary value 000000000010100. The “1” shown in bit 2 and bit 4 represents a failed test in those bits which indicates a checksum error for both the gain and phase on the calibration. Contact the factory for further instructions.

| Health Check Error Codes | |
|---|---|
| Bit | Description |
| 0 | Checksum error on analog output (either 0-1mA or 4-20mA) calibration constants |
| 2 | Checksum error on gain calibration of inputs |
| 4 | Checksum error on phase calibration of inputs |
| 5 | Clip - Input Over-Range |
| 12 | Indicates firmware download in progress and measurements are offline |

### 6.13 List of Available Measurements & Settings

Please note that not all measurements are available in every M65x model (demand and harmonic values only in M3).

| Available Measurements | |
|---|---|
| Amps A, B, C, Residual | Heartbeat |
| Average 3-phase Amps[1] | K-factor Amps A[1] |
| Average 3-Phase Volts (L-L, L-N)[1] | K-factor Amps B[1] |
| Average Volts AN, BN, CN, AB, BC, CA[1] | K-factor Amps C[1] |
| Average (Max.) Volts AN, BN, CN, AB, BC, CA[1] | K-factor Amps Residual[1] |
| Average (Min.) Volts AN, BN, CN, AB, BC, CA[1] | Meter Type |
| Average Watts A, B, C, Total[1] | Phase Angle Amps A, B, C[1] |
| Average (Max.) Watts A, B, C, Total[1] | Phase Angle Volts A, B, C[1] |
| Average (Min.) Watts A, B, C, Total[1] | Phase Angle Volts AB, BC, CA[1] |
| Average VARs A, B, C, Total[1] | Power Factor A, B, C, Total |
| Average (Max.) VARs A, B, C, Total[1] | Protocol Version |
| Average (Min.) VARs A, B, C, Total[1] | PT Scale Factor |
| Average VAs A, B, C, Total[1] | PT Scale Factor Divisor |
| Average (Max.) VAs A, B, C, Total[1] | TDD Amps A, B, C, Residual[1] |
| Average (Min.) VAs A, B, C, Total[1] | TDD Denominator A, B, C, [1] |
| Class 0 Response Setup[1] | THD Volts AN, BN, CN, AB, BC, CA[1] |
| CT Scale Factor | Uncompensated VARs, Total |
| CT Scale Factor Divisor | Uncompensated Watts, Total |
| Demand (Max.) Amps A, B, C, Residual | VA-Hrs |
| Demand (Max.) Fund. Amps A, B, C, Residual[1] | VAR-Hrs Lag |
| Demand Amps A, B, C, Residual | VAR-Hrs Lead |
| Demand Fundamental Amps A, B, C, Residual[1] | VARs A, B, C, Total |
| Displacement Power Factor A, B, C[1] | VAs A, B, C, Total |
| Displacement Power Factor Total[1] | Volts AN, BN, CN, AB, BC, CA |
| Factory Version Hardware | Volts Aux |
| Factory Version Software | Watt-Hrs Net |
| Frequency | Watt-Hrs Normal |
| Fund. Amps A, B, C, Residual[1] | Watt-Hrs Reverse |
| Fund. Volts AN, BN, CN, AB, BC, CA[1] | Watts A, B, C, Total |
| Health | |

[1]Available in M3 only

### 6.14 Calibration

Routine re-calibration is not recommended or required. A field calibration check every few years is a good assurance of proper operation.

## 6.15 Instantaneous Measurement Principles

The M650 measures all signals at an effective rate of 64 samples/cycle, accommodating fundamental signal frequencies from 45 to 65Hz depending on model. Samples of all bus signals are taken using a 16-Bit A/D converter, effectively creating 64 "snapshots" of the system voltage and current per cycle.

### 6.15.1 Sampling Rate and System Frequency

The sampling rate is synchronized to the frequency of any of the bus voltages prioritized as follows: $V1_{A\text{-}N}$, $V1_{B\text{-}N}$, $V1_{C\text{-}N}$. This is the frequency reported as the "System Frequency". The sampling rate is the same for all channels.

## 7.0 ANALOG TRANSDUCER OUTPUT OPTION

### 7.1 Introduction

The Transducer Output options (0 -1 mA or 4-20 mA) feature 3 separate outputs each with two terminals, one of which is common to all three outputs and one which provides a unique return path for each output.

### 7.2 Specifications

Outputs: 3 bi-directional, 0-1mA (active) or 4-20mA (loop powered, passive)

0 – 1mA Current Range

| | |
|---|---|
| Output Range: | 0 to +/-1mA into 10K ohms or less; Overload to +/-2.1mA into 5K ohms or less. |
| Resolution: | 0.22uA |
| Output Resistance: | 500 ohm |

4 – 20mA Current Range

| | |
|---|---|
| Output Range: | 4 to 20mA |
| Resolution: | 1.1uA |
| Max Loop Voltage: | 40Vdc |
| Max Voltage Drop: | 2.3V @ 20mA |

4 – 20mA Internal Loop Supply

| | |
|---|---|
| Max Output Voltage: | 6V @ 60mA, |

Accuracy: 0.25% of Full Scale Input

Data Update Rate (poll rate): 100ms minimum

Input Capacitance, any Terminal to Case: 470pF

### 7.3 Connections

The connections for the 0-1 mA output option are shown in figure 10 while the connections for the 4-20 mA with external and internal loop are shown in figure 11.

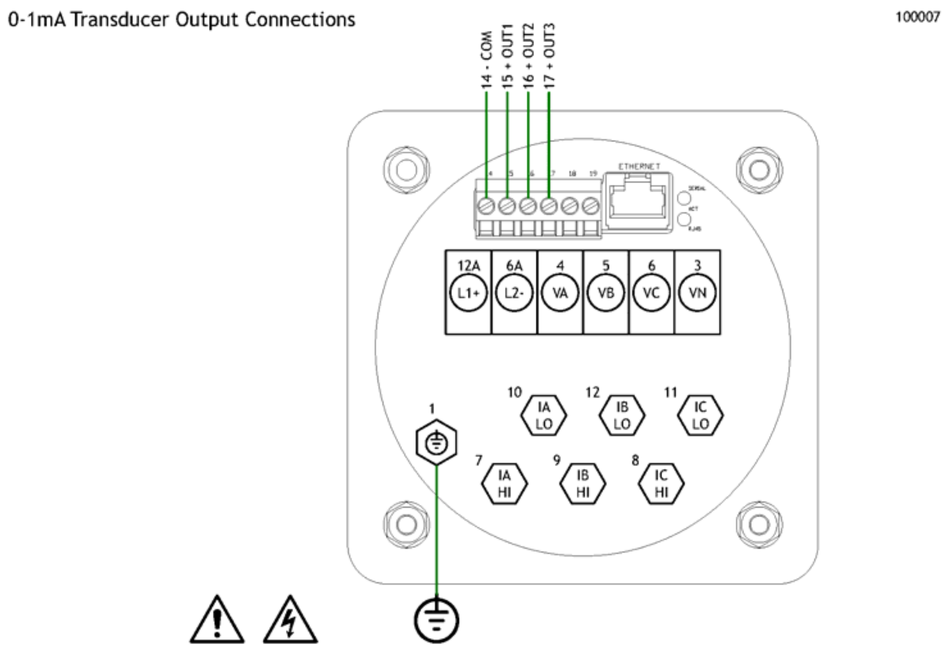
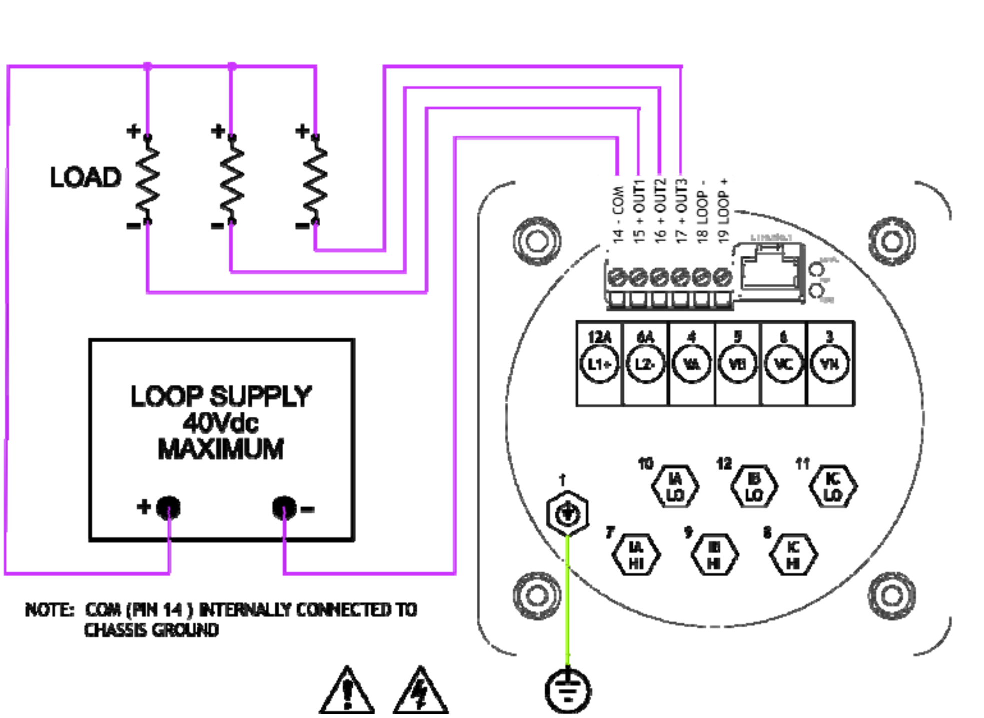



**Figure 10 – 0-1mA Transducer Output Connections**

4-20mA Transducer Output Connections - External Loop Supply




4-20mA Transducer Output Connections - Internal Loop Supply

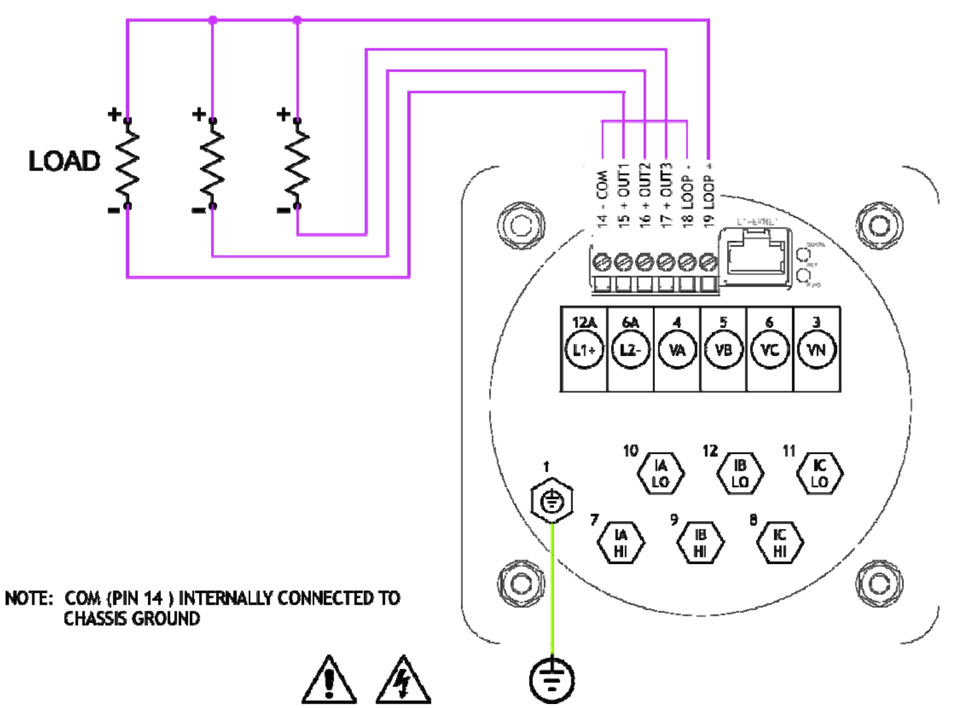
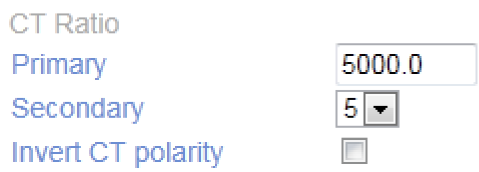



**Figure 11 – 4-20mA Transducer Output Connections**

## APPENDIX

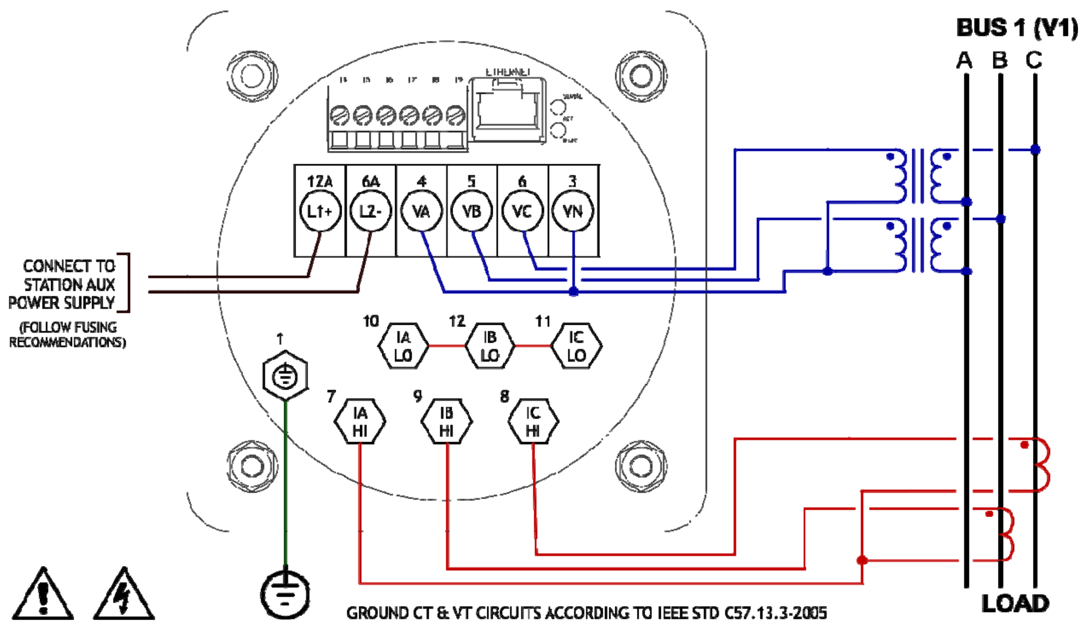
### A1 CT/VT Connection Diagrams

Please note that there is an option on the Settings/Input page to invert the CT Polarity (see screen shot clip below). This option is the equivalent of swapping the connections in the connection diagrams below at the HI and LO terminals for each CT input, that is, swapping 7 and 10, 8 and 11, 9 and 12. The effect is a 180 degree phase shift in the current signals.



2 Element, 3 Wire, DELTA Connection (Phase A Reference Shown)
Two Phase CTs Shown, Phase A Current Measured in CT Return

100003R1




2 Element, 3 Wire, DELTA Connection (Phase B Reference Shown)

100002

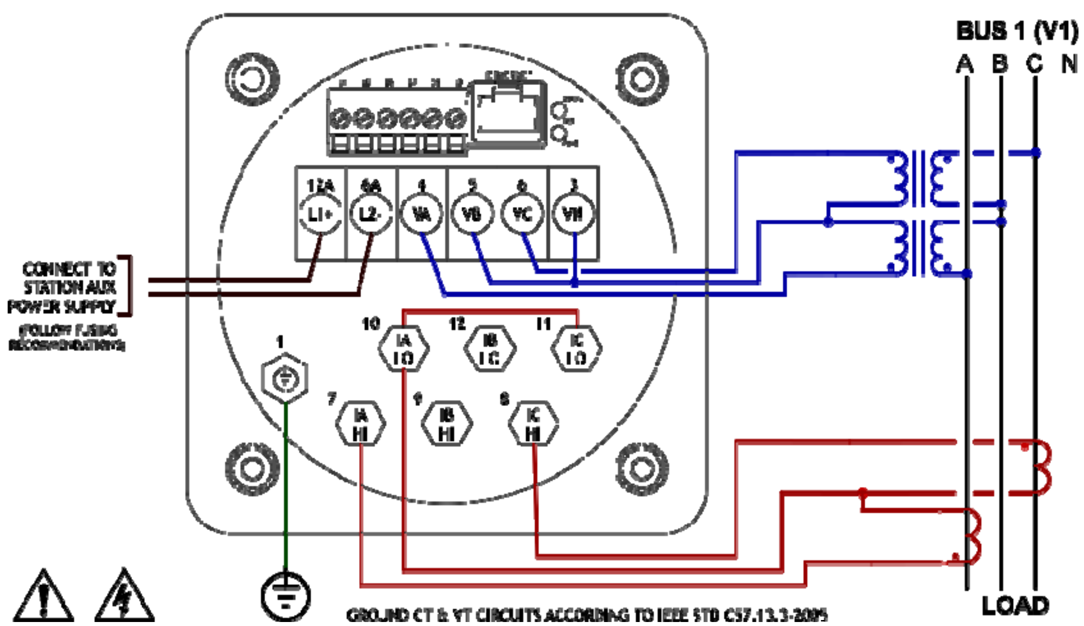
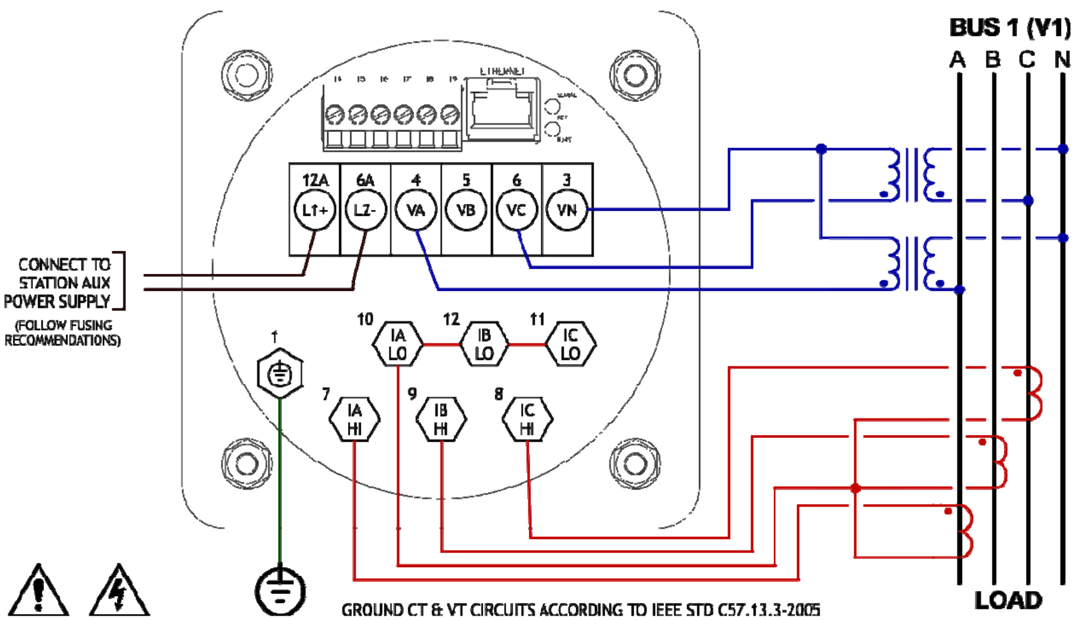



**Figure 12 - Signal Connections – M650**

2-1/2 Element, WYE Connection (Shown with Phase B Voltage Missing) 100004




3 Element, 4 Wire, WYE Connection 100001

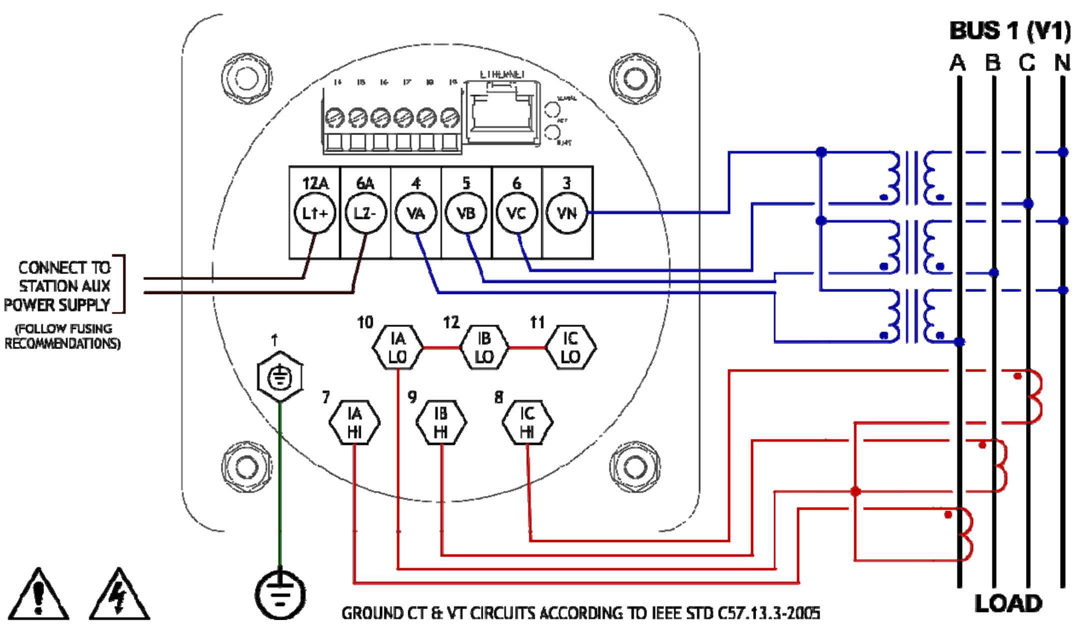
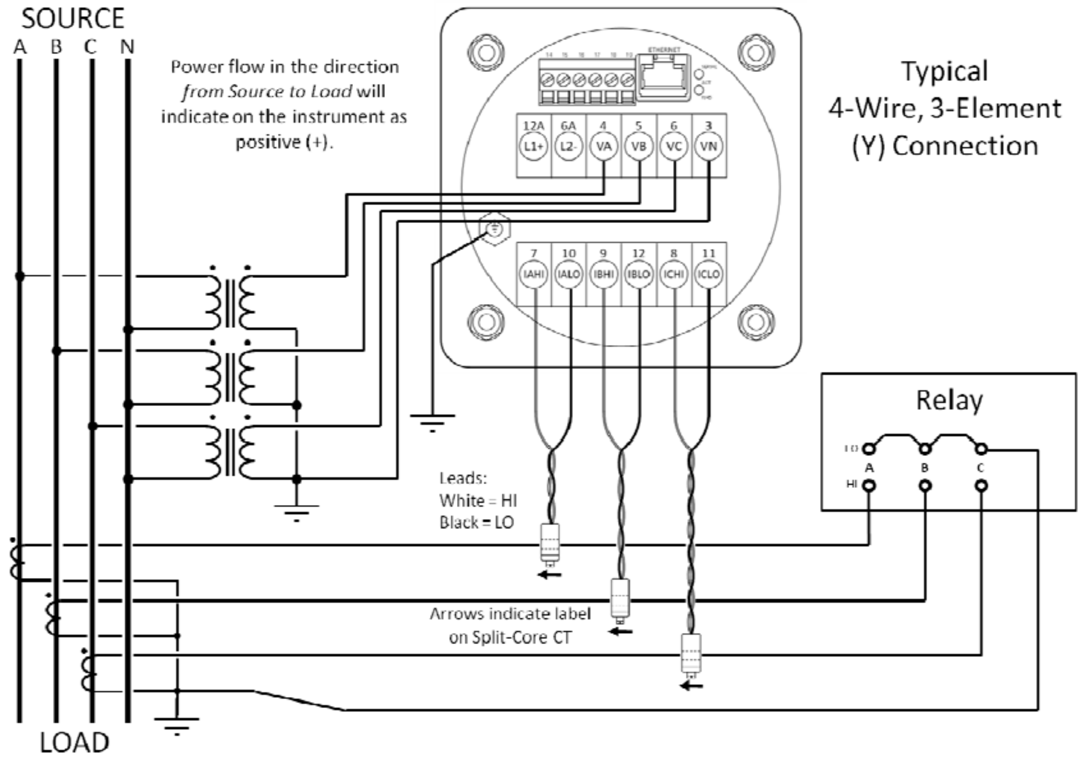



**Figure 12 - Signal Connections – M650**



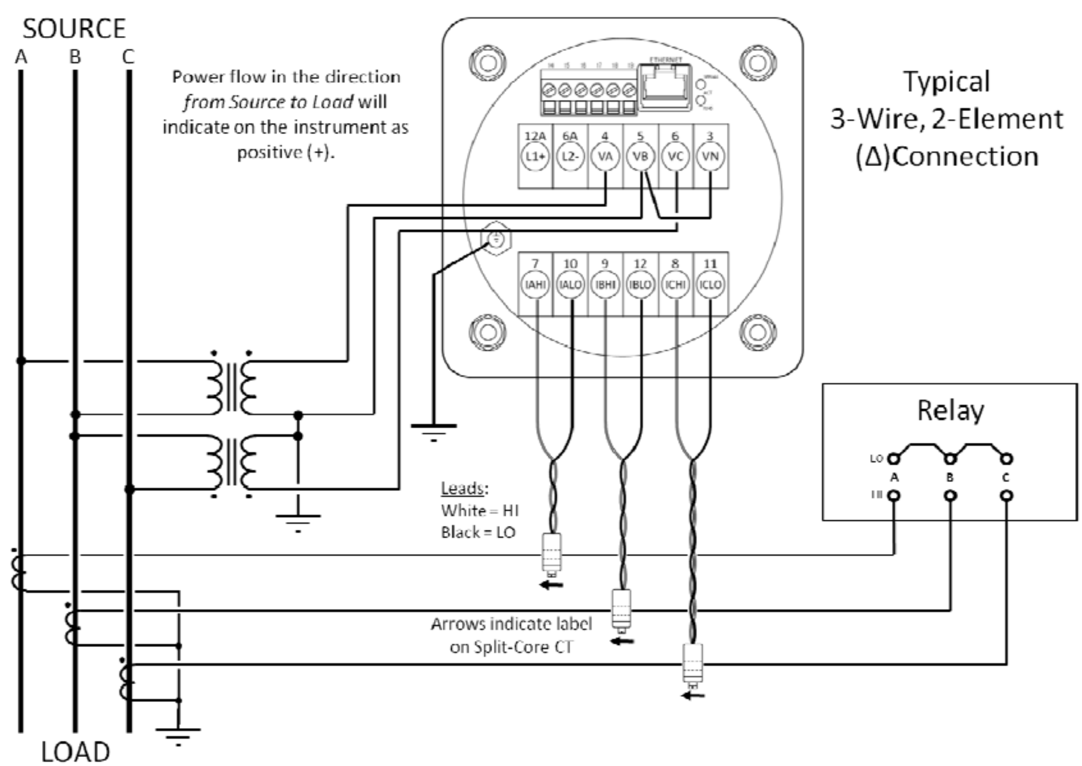




**Figure 13 - 50 Series External Split-Core Signal Connections**

## A2 Ethernet 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 M650 and the hub/switch, check the following items:

1. Verify that the connectors are fully engaged on each end.
2. 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).
3. Verify that both the M650 and hub/switch are powered.
4. Try another cable.
5. If a long CAT-5 cable is used, verify that is has never been kinked. Kinking can cause internal discontinuities in the cable.
6. If a copper connection is used to an external fiber converter:
7. 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.
8. 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 M650 to link. In this condition, no device completes the link.
9. Verify that the fiber converter(s) and/or fiber hub/switch are matched for the same type of fiber connections. A 100BASE-FX port will NEVER inter-operate with the 10BASE-FL port (fiber auto-negotiation does not exist).
10. On the fiber connection, try swapping the transmit and receive connector *on one end*.
11. Verify that the fiber converter(s) and/or fiber hub/switch use the proper optical wavelength (100BASE-FX should be 1300nm).

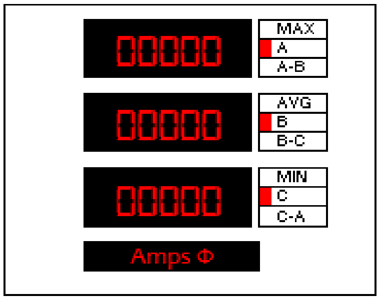
 

## A3 Display Screens – Visual Representations

Screen

Amps A, B, C

1



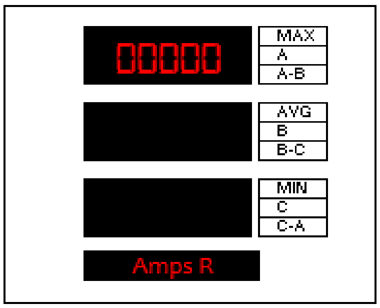

Phase A Amps

Phase B Amps

Phase C Amps

Amp Residual

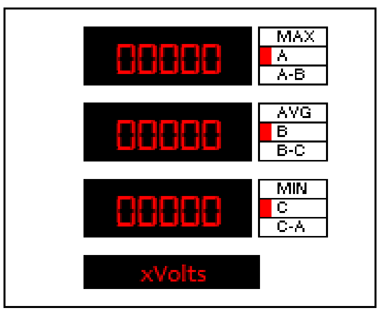
2




Amps Residual

Volts AN, BN, CN

3



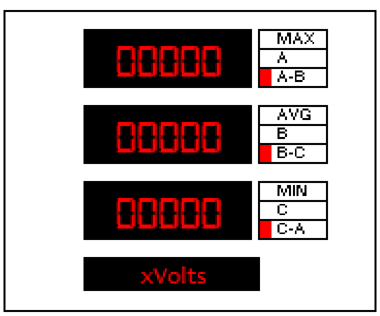

Volts A

Volts B

Volts C

Volts AB, BC, CA

4



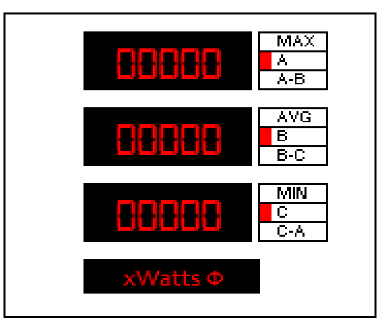

Volts AB

Volts BC

Volts CA

Watts A, B, C

5



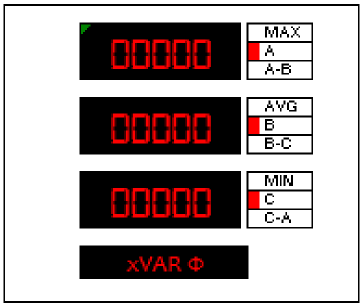

Watts A

Watts B

Watts C

VARs A, B, C

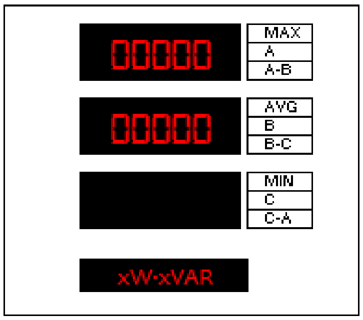
6 


VARs A

VARs B

VARs C

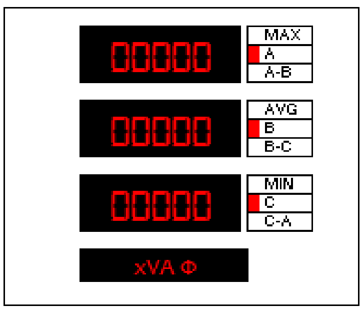
Total Watts · Total VARs

7 


Total Watts

Total Vars

VAs A, B, C

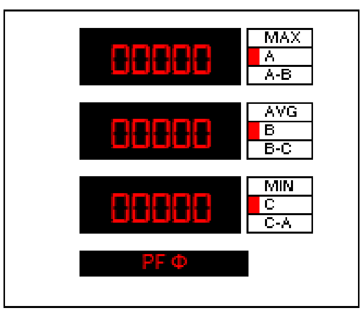
8 


VAs A

VAs B

VAs C

Power Factor A, B, C

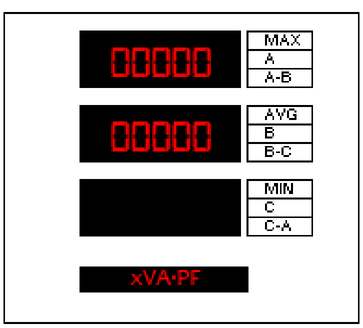
9 


PF A

PF B

PF C

Total VAs · 3Φ PF

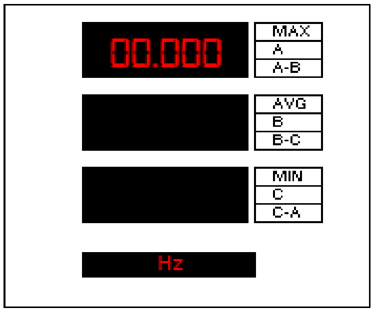
10 


VAs Total

3Φ PF

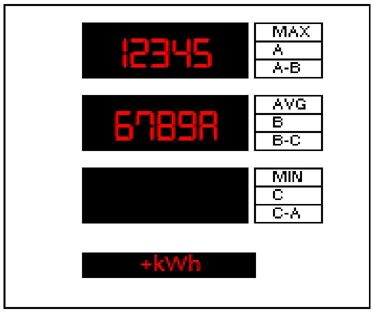
 

Frequency

11 


Frequency

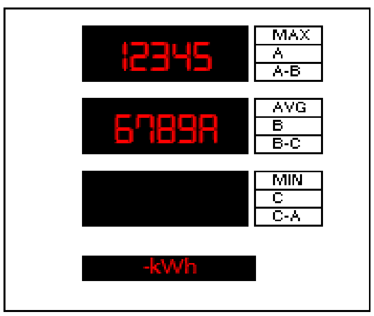
Watt Hrs Normal (+)

12 


Most significant half

Least significant half

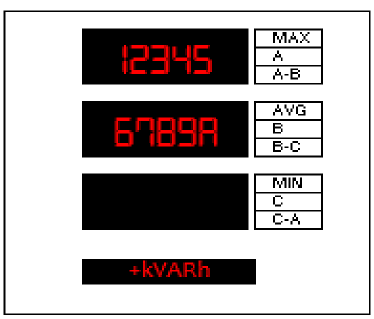
Watt Hrs Reverse (-)

13 


Most significant half

Least significant half

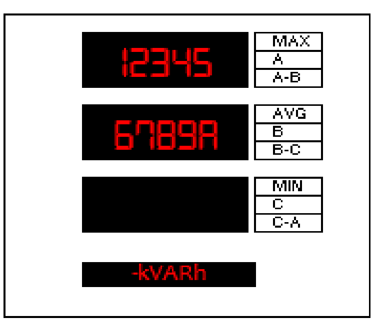
VAR Hrs Lagging (+)

14 


Most significant half

Least significant half

VAR Hrs Leading (-)

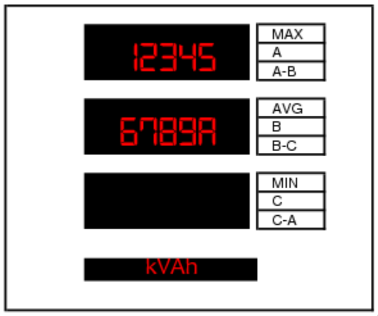
15 


Most significant half

Least significant half

kVA Hrs

16

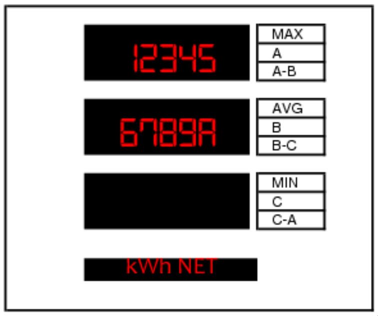



Most significant half

Least significant half

kWatt Hrs Net

17

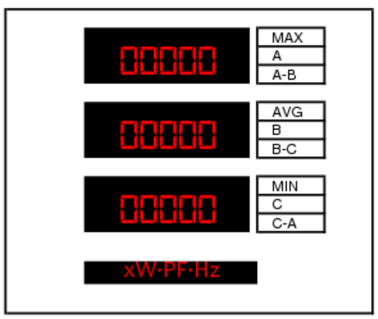



Most significant half

Least significant half

Total Watts · 3Φ PF · Frequency

18



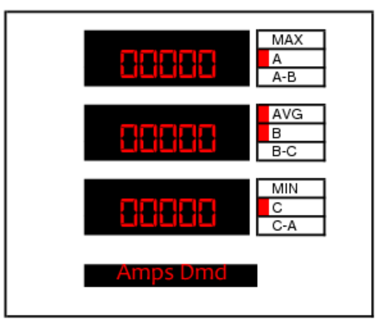

Total Watts

3Φ PF

Frequency

Demand Amps A, B, C

19



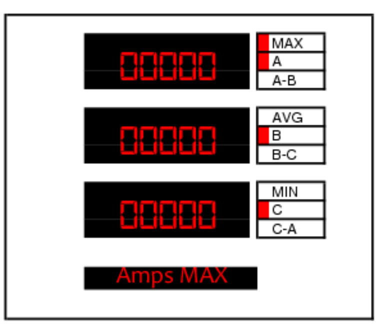

Demand Amps A

Demand Amps B

Demand Amps C

Max Dmd Amps A,B,C

20




Dmd Amps A Max

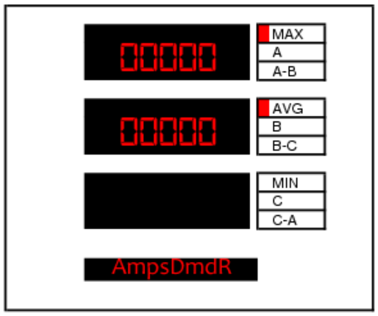
Dmd Amps B Max

Dmd Amps C Max

Demand Amps Residual

21

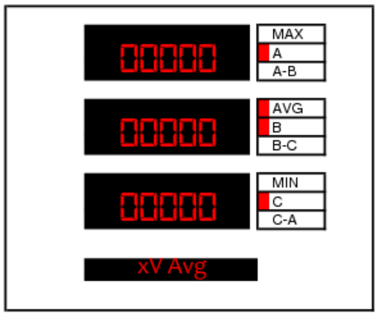



Demand Amps R MX

Dmd Amps R

Average Volts AN, BN, CN

22



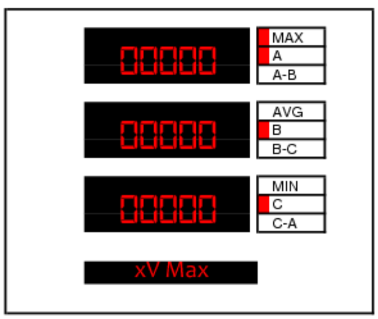

Volts A

Volts B

Volts C

Max Average Volts AN, BN, CN

23



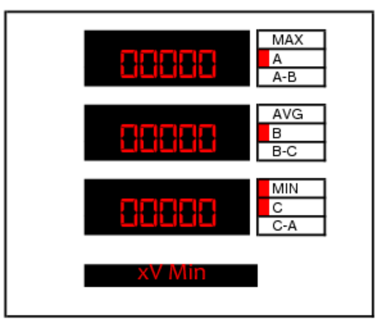

Volts A

Volts B

Volts C

Min Average Volts AN, BN, CN

24



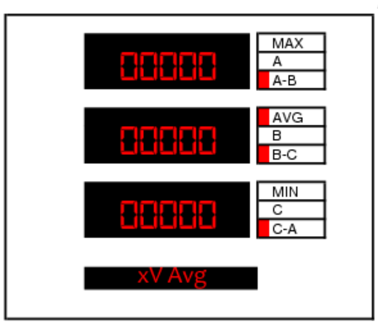

Volts A

Volts B

Volts C

Average Volts AB, BC, CA

25




Volts AB

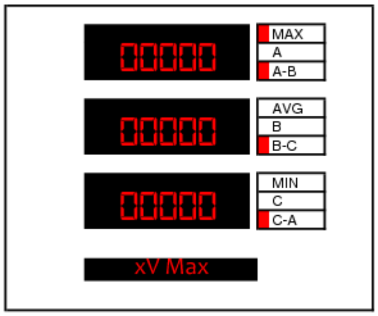
Volts BC

Volts CA

Max Average Volts AB, BC, CA

26



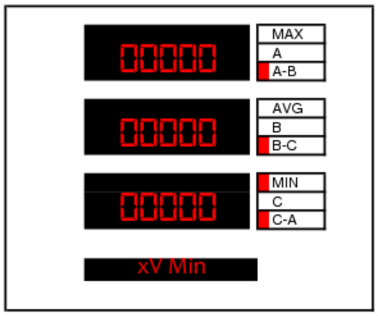

Volts AB

Volts BC

Volts CA

Min Average Volts AB, BC, CA

27



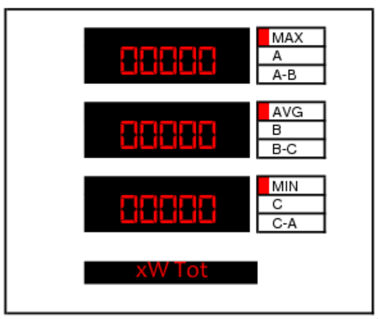

Volts AB

Volts BC

Volts CA

Total Watts Max · Avg · Min

28



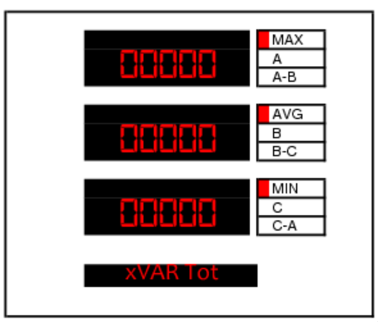

Average Watts Max

Average Watts Avg

Average Watts Min

Total VARs Maxl · Avg · Min

29



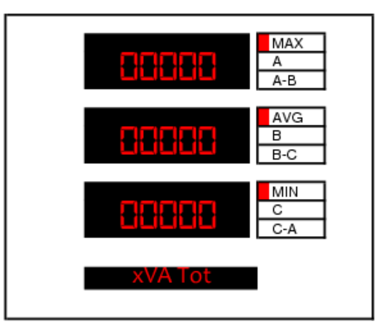

Average VARs Max

Average VARs Avg

Average VARs Min

Total VAs Max· Avg · Min

30




Average VAs Max

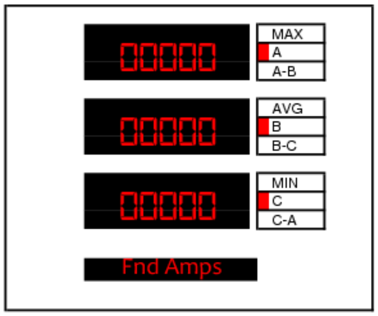
Average VAs Avg

Average VA Min

Fundamental Amps A, B. C

31



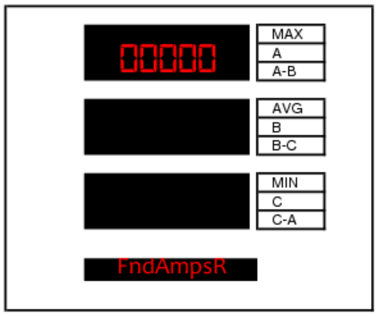

Fnd Amps A

Fnd Amps B

Fnd Amps C

Fundamental Amps Residual

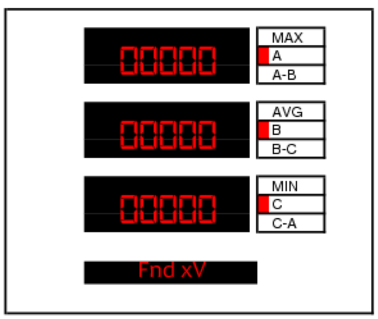
32




Fnd Amps Residual

Fund. Volts AN, BN, CN

33



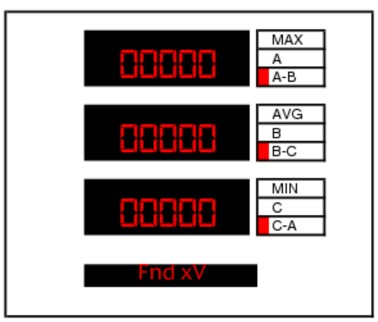

Fnd Volts A

Fnd Volts B

Fnd Volts C

Fund. Volts AB, BC, CA

34



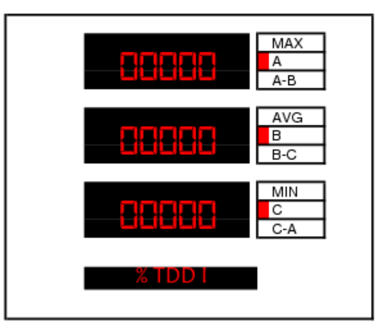

Fnd Volts AB

Fnd Volts BC

Fnd Volts CA

TDD Amps A, B, C

35



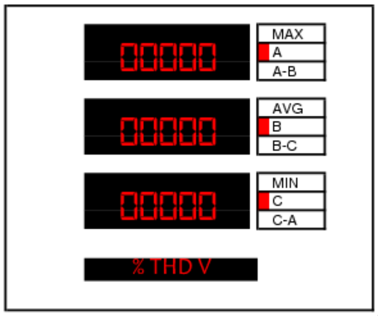

TDD Amps A

TDD Amps B

TDD Amps C

THD Volts AN, BN, CN

36



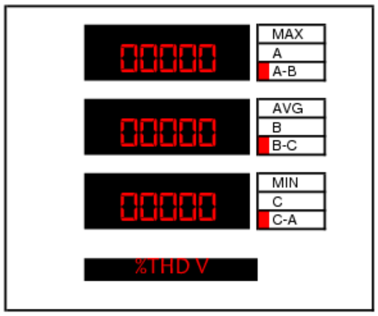

THD Volts AN

THD Volts BN

THD Volts CN

THD Volts AB, BC, CA

37



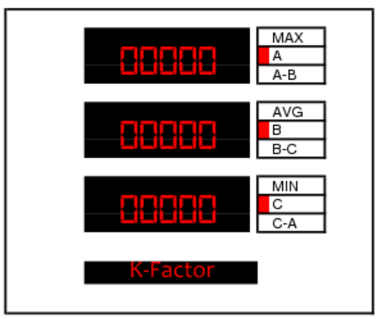

THD Volts AB

THD Volts BC

THD Volts CA

K-Factor Amps A, B, C

38



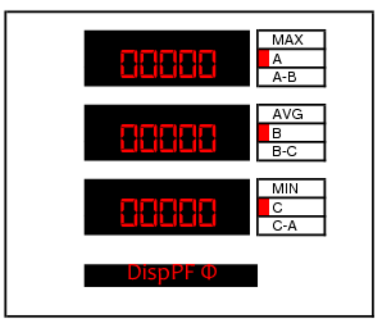

K-Factor A

K-Factor B

K-Factor C

Displacement Power Factor A, B, C

39



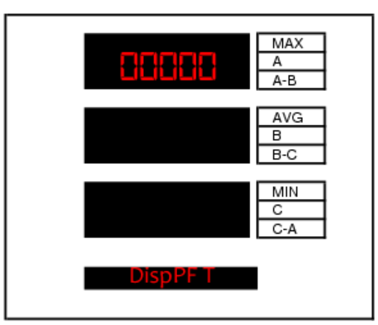

Displacement PF A

Displacement PF B

Displacement PF C

Displacement Power Factor Total

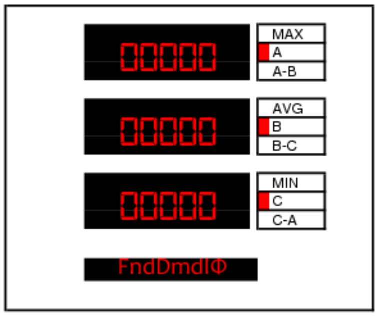
40




Displacement PF T

Fund. Demand Amps A, B, C

41



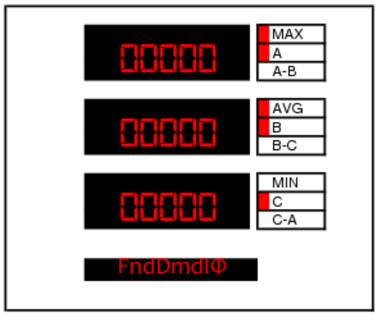

Fnd Dmd Amps A

Fnd Dmd Amps B

Fnd Dmd Amps C

Max Fund. Demand Amps A, B. C

42



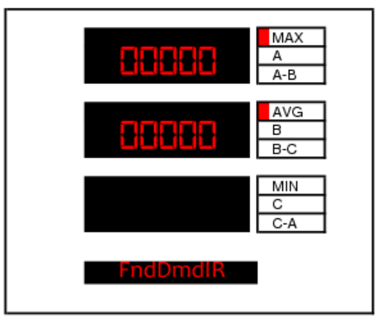

Fnd Dmd Amps A

Fnd Dmd Amps B

Fnd Dmd Amps C

Max Fund. Demand Amps Residual

43

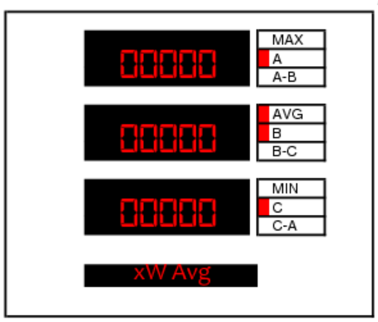



Fnd Dmd Amps R

Fnd Dmd Amps R

Average Watts A, B, C

44



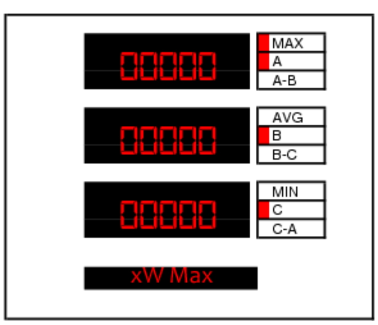

Watts A

Watts B

Watts C

Max Average Watts A, B, C

45




Watts A

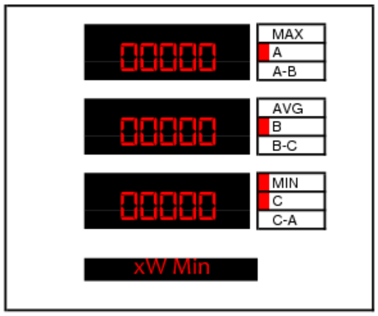
Watts B

Watts C

Min Average Watts A, B, C

46



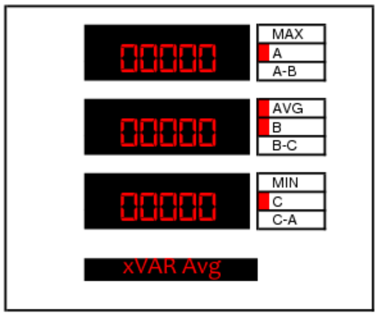

Watts A

Watts B

Watts C

Average VARs A. B, C

47



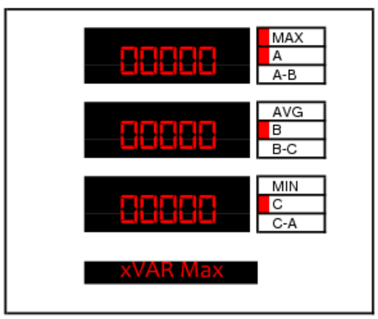

VARs A

VARs B

VARs C

Max Average VARs A. B, C

48



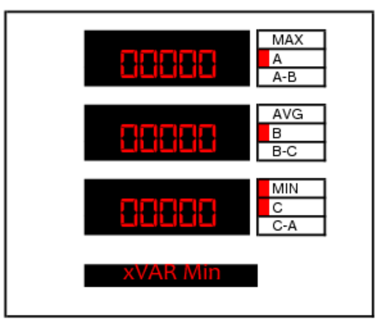

VARs A

VARs B

VARs C

Min Average VARs A. B, C

49



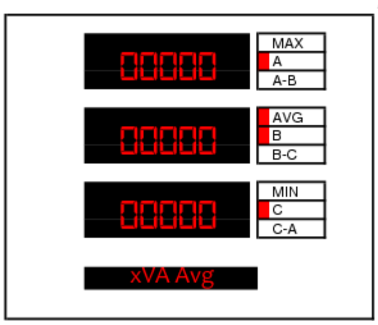

VARs A

VARs B

VARs C

Average VAs A, B, C

50




VAs A

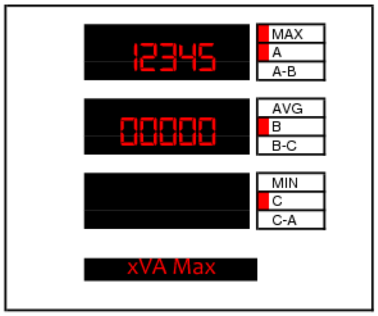
VAs B

VAs C

Max Average VAs A, B, C

51



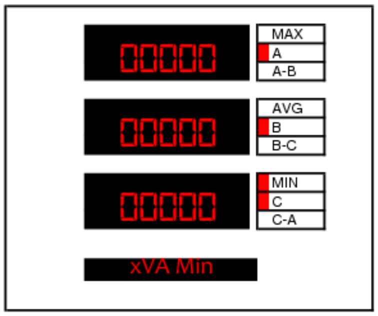

VAs A

VAs B

VAs C

Min Average VAs A, B, C

52



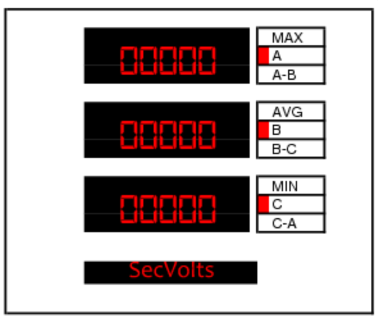

VAs A

VAs B

VAs C

Secondary Volts AN, BN, CN

53



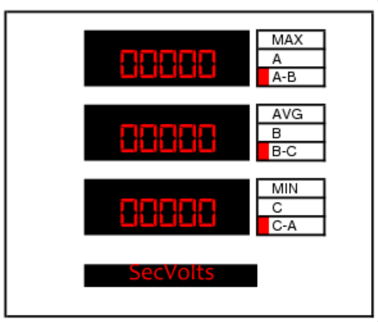

SecVolts A

SecVolts B

SecVolts C

Secondary Volts AB, BC, CA

54



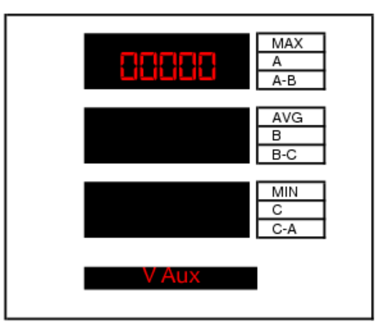

SecVolts AB

SecVolts BC

SecVolts CA

Volts Aux

55




V Aux

# EC Declaration of Conformity

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

**We, the undersigned:**

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

**hereby declare that the following product(s) :**

| | |
|---|---|
| **Product type :** | 50 Series & 60 Series |
| **Description :** | Multifunction 3-Phase Scada Meters, Multifunction 3-Phase Scada Transducers, 3-Phase Scada Ammeters and Voltmeters, Detached Display |
| **Models (50 Series):** | **M65xM3yzef, or M65xB3yzef, (where x=0,1,3) covering M650, M651, or M653, based on the following constructions:**<br>with Auxiliary voltage input monitoring (y = P, for models M3 only, but not B3), or without Auxiliary voltage input monitoring (y = U); including Measurement signal inputs for 3-Phase Voltages, and Current (CT) inputs rated for one of the following: Nominal input current of 1A ac or 5A ac (internal isolation for current input options, z = 1 or 5), or External Split Core CT rated 5A ac nominal (current input option z = C); including a 6-position option port selected as one of the following: without option port (e = 0), with serial port (e=1), with 4-20mA Analog Transducer Output port (e = 2) , with 0-1mA Analog Transducer Output port (e = 3), including standard copper RJ45 Ethernet port (f = 0 with service port only, or f = 1 with port enabled for protocols), or an optional fiber Ethernet port (f = 2),<br>**M350A3Uzef covering M350A3, based on the following constructions:**<br>Ammeters with Measurement signal inputs for 3-Phase Current Transformer (CT) inputs rated nominal input current of 1A ac or 5 A ac (internal isolation for current input options, z = 1 or 5); including a 6 -position option port selected as one of the following: without option port (e = 0), with serial port (e = 1), with 4-20mA Analog Transducer Output port (e = 2), with 0-1mA Analog Transducer Output port (e = 3); including standard copper RJ45 Ethernet port (f = 0 with service port only, or f = 1 with port enabled for protocols), or an optional fiber Ethernet port (f = 2).<br>**M350V3Uzef covering M350V3, based on the following constructions:**<br>Voltmeters with Measurement signal inputs for 3-Phase Voltage inputs (z = 0); including a 6-position option port selected as one of the following: without option port (e = 0), with serial port (e = 1), with 4-20mA Analog Transducer Output port (e = 2), with 0-1mA Analog Transducer Output port (e = 3); including standard copper RJ45 Ethernet port (f = 0 with service port only, or f = 1 with port enabled for protocols) or an optional fiber Ethernet port (f = 2).<br>**D650BXy0ef covering D650 based on the following construction:**<br>Detached Display without Auxiliary voltage input monitoring (y = U) ; with serial port (e = 1); including standard copper RJ45 Ethernet port (f = 0 with service port only). |

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| | |
|---|---|
| **Models**<br>**(60 Series):**<br><br>IEC 61850 protocol | **M66xM3yzef, (where x=0,1,3) covering**<br>**M660, M661, or M663, based on the following constructions:**<br>with Auxiliary voltage input monitoring (y = P), or without Auxiliary voltage input monitoring (y = U); including Measurement signal inputs for 3-Phase Voltages, and Current (CT) inputs rated for one of the following: Nominal input current of 1A ac or 5A ac (internal isolation for current input options, z = 1 or 5), or External Split Core CT rated 5A ac nominal (current input option z = C); including an Ethernet fiber option port selected as one of the following: without Ethernet fiber port (e = 0) or with Ethernet fiber port (e=5), including standard copper RJ45 Ethernet port ( f = 1 with port enabled for protocols). |

**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).

**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 B005 **Issue :** F

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

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

| | |
|---|---|
| **Technical File No. :** | TF B005 |
| **Date Issued or Revised :** | 5-Dec-2016 or later - New Legislative Framework & EMC Directive,<br>(Original issue: 13-Jul-2012, Reissued: 28-Oct-2013, 21-Mar-2016) |
| **Conformity Assessment Body :<br>(C.A.B.)** | Underwriters Laboratories, LLC, WiSE, Melville Division<br>1285 Walt Whitman Road, Melville, NY 11747-3081 USA |
| **Compliance Certificate / Test Report:** | 1001403534, 11ME06423, MC16183, 50 Series, EMC Assessment;<br>10059253, M66x, EMC Assessment;<br>D650 reliance on preceding reports is based on similar construction with a subset of inputs/parts removed. |

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 B005 |
| **Date Issued or Revised :** | 5-Dec-2016 or later - New Legislative Framework & LVD Directive,<br>(Original issue: 13-Jul-2012, Reissued :28-Oct-2013 - transition to IEC 61010-1, Ed. 3, & 21-Mar-2016) |
| **Conformity Assessment Body :<br>(C.A.B.)** | UL International (UK) Limited,<br>Wonersh House, The Guildway, Old Portsmouth Road, Guilford,<br>Surrey, GU3 1LR, United Kingdom |
| **Compliance Certificate / Test Report:<br>(Superceded)** | CB Certificate No. DK-27045-UL issued by National Certification Body:<br>UL (Demko), Borupvang 5A DK-2750 Ballerup, Denmark / CB Test Report<br>E164178-A1-CB-1, 50 Series/60 Series, Product Safety Assessment |
| **Conformity Assessment Body :<br>(C.A.B.)** | Underwriters Laboratories, LLC, Melville Division<br>1285 Walt Whitman Road, Melville, NY 11747-3081 USA |
| **Compliance Certificate / Test Report:** | CB Certificate No. US-22466-UL-A1 supercedes US-22466-UL &<br>US-19849-UL issued by National Certification Body:<br>UL (US), 333Pfingsten Rd., Northbrook, IL 60062, USA /<br>CB Test Reports, E164178-A4-CB-1, including Amendment 1,<br>Correction 2 & 1, supercedes E164178-A1-CB-2 & -1, 50 Series/60Series,<br>Product Safety Assessments |

**Reference Number :** DOC B005 **Issue :** F

**Date of issue :** 5-December-2016

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

| | |
|---|---|
| **IEC/EN 61010-1, Edition 3, 2010**<br>**UL 61010-1, Edition 3, 2012/05/11**<br>**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**<br>**UL 61010-2-030, Edition 1, 2012/05/11**<br>**CAN/CSA No. 22.2, No. 61010-2-030-12, Ed. 1, 2012/05/01** | 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 |
| **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,**<br>**EN 55011: 2016, Group 1 Class A** | Radiated Emissions Electric Field Strength,<br>AC Powerline Conducted Emissions |
| **EN 55022: 2010 + AC: 2011,**<br>**EN 55032: 2012 + AC: 2013,**<br>**EN 55032: 2015 + AC: 2016-07,**<br>**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**<br>**Class III** | Immunity to Radiated Electromagnetic Energy (Radio Frequency) |
| **EN 61000-4-4: 2012,**<br>**Severity Level 4 (AC Power)** | Electrical Fast Transient / Burst Immunity |
| **EN 61000-4-5: 2014,**<br>**Installation Class 3** | Surge Immunity |
| **EN 61000-4-6: 2014,**<br>**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 |
| **ANSI / IEEE C37.90.1: 2002** | Surge Withstand Capability Test for Protective Relays and Relay Systems |

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

CE Marking Year 2012, 2013, 2016

**Reference Number :** DOC B005 **Issue :** F

**Date of issue :** 5-December-2016

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| Revision | Date | Changes | By |
|---|---|---|---|
| A | 3/15/2010 | Original Issue | E. DeMicco |
| B | 4/15/2010 | New web screen shots, fiber Ethernet option, corrections | E. DeMicco |
| C | 6/21/2010 | Manual references, transducer output, new setup map, configurable display setup, demand screen in data view | E. DeMicco |
| D | 2/24/2011 | Secondary volts screens, default and identity setup via front, 4-20mA information, configurable registers/points, health check information | E. DeMicco |
| E | 9/27/11 | Split-core CTs, phase angle measurements, CT polarity invert, password, primary units | E. DeMicco |
| F | 11/15/11 | Correction to Display (4.1) Setup Menu (5.5) and Appendix A3 for screen order | E, DeMicco |
| G | 12/15/11 | New screen shot for serial port, added 4.1.3 Display Error Messages, new external CT drawing | E. DeMicco |
| H | 7/13/2012 | Format VT specification section, Clarified Split core in specification section, Added Protective Conductor terminal torque under physical specification; Sect. 1.3 various clarifications added to specifications; Sect. 1.5 revised with standards; Note added to Figure 2; Sect. 3.0 revised; Figure 3 became 3A; Figure3B added; Sect. 3.1 revised with monitoring option for L1(+)/L2(-) power input; Revise Sect. 3.1.1 information per Sect. 1.3; Sect. 3.2 Added references VA,VB, VC, VN; Sect. 3.3 Added references IA, IB, IC and current options for 1A(1), 5A(5), and external split core (C).<br>New dimension drawing to correct error with metric and added note on common return for transducer output. Updated fiber connector from MT-RJ to LC.<br>Added information for UL and CE certification and standards met. | R. Fisher<br>E. Demicco |
| I | 6/14/13 | Added support for loss compensation; updated information on firmware upgrade | E. DeMicco |
| J | 11/14/13 | Updated sections 1.3 – 1.5 for UL 61010 3rd edition changes | E. DeMicco |

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|---|---|---|---|
| K | 5/8/14 | Added new Declaration of Conformity document; updated firmware information Added information on password attempts and lockout. | E. DeMicco |
| L | 3/24/16 | Added information on password attempts/lockouts; updated Declaration of Conformance with addition of D650 display | E. DeMicco |
| M | 12/24/16 | Updated firmware revision history: added new DoC document | E. DeMicco |
| N | 5/22/17 | Updated standards information in section 1.5 | E. DeMicco<br>R. Fisher |
| O | 9/27/17 | Added information on 3-phase voltage and current averages; corrected information on allowable password character; updated revenue accuracy standard information | E. DeMicco |

 

NovaTech®
Bitronics ◆ D/3 ◆ Orion

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