Bitronics

PowerPlex II Synchronizing Ethernet Transducer

Modbus Manual



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ML0046 Document Revision B

NovaTech®
Bitronics ◆ D/3 ◆ Orion

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VERSION HISTORY (ABRIDGED)

V1.00.0	2014-07-29	Initial Release
V1.30.0	2014-10-22	Minor feature upgrades and bug fixes
V2.05.0	2015-05-08	Line-to-line volts in 2-element on Synchronization page
V2.06.0	2015-05-21	Minor feature upgrades
V2.12.0	2016-02-22	Support for IEC 61850, universal power supply, IRIG-B and display ports
V2.20.0	2016-10-04	Support for serial port and digital I/O
V2.21.0	2016-10-26	Minor feature upgrades and bug fixes
V2.22.0	2017-03-15	Added support for KYZ Energy Counter and Energy LED.
V2.23.0	2017-06-21	Energy resets did not work without an IO card; 2-Element mode enabled for 3-phase averages
V2.24.0	2017-08-15	Added Average L-L Volts, Average L-N Volts and Average Amps to protocols
V2.25.0	2017-12-11	Support for trend recording
V2.30.0	2018-05-14	Support for EtherNet/IP protocol
V2.31.0	2018-06-29	Support for EtherNet/IP protocol in 60 Series
V2.51.0	2019-10-11	Fix protocol session selector responsiveness
V2.52.0	2019-11-20	Add normalized voltages for M661P3

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SAFETY SECTION

Please refer to the PPX II User Manual (ML0044) for information regarding safety, installation, commissioning and decommissioning.

1.0 MODBUS INTERFACE

1.1 Description

The PowerPlex II (PPX II) supports the Modbus protocol on the Ethernet ports. Refer to the PPX II User Manual for hardware details.

The Modbus network is a "MASTER" to "SLAVE" network, that is to say, one node asks a question and a second node answers. A NODE is a Modbus device (PLC, Computer, PPX II, etc.) that is connected to the network. Each SLAVE NODE has an ADDRESS in the range of 1 to 247; it is this address that allows a MASTER to selectively request data from any other device. Address 0 is a BROADCAST ADDRESS that can be used with certain MODBUS functions to allow the MASTER to address all SLAVE NODES at one time. The PPX II does not respond to BROADCAST messages.

The Modbus implementation in the PPX II conforms to all standard Modbus specifications and capabilities, such as maximum nodes, distance, signal sensitivity, etc. The PPX II devices are classified as SLAVE DEVICES in the Modbus structure. The data items that are available from the instrument can be obtained via the Modbus Network by issuing a READ HOLDING REGISTERS command from the requesting node.

1.2 Modbus Address

Setting the address is done via a web browser.

1.3 Transaction Timing

The instrument completes a set of calculations approximately every 1 cycle. The HOST CPU processor services the Modbus port by interrupts received from the corresponding Ethernet port. Incoming messages are parsed and response initiated in approximately 5 ms.

1.4 Data Format

The PPX II contains a set of holding registers (4XXXX) into which the instrument places values that correspond to the measurements the instrument is making. These holding registers can be read by any other device on the network using a READ HOLDING REGISTER (Function Code 3).

When using HOLDING REGISTER DATA, the Health Check Register should always be read and checked before interpreting data, since some failure modes will cause erroneous data to be presented (See Section 1.7). Appendix A provides the Legacy or Bitronics Legacy Fixed (BiLF) register set for the 12-bit default. Appendix B provides the 16-bit BiLF version.

NOTE: Unless otherwise specified, all points are READ ONLY.

1.4.1 Modbus Calculation-Type Codes

The Modbus Type codes for Optimal Resolution that are applicable to the register assignments in the appendix tables are highlighted within the following Calculation Type table.

Type	Value / Bit Mask	Description
T1		Unsigned 16-Bit Integer $kWh\ (kVARh) = Value_{HIGH} \times 65536 + Value_{LOW}$
T2		Signed 16-Bit Integer - 2's Complement - Saturation 10
		Float Value = ((Integer Value) / 32768) * Scale * 10) $AMPERES_{(Inst,\ Fund,\ Demand,\ \mathrm{Max})} = \frac{Value}{32768} \times 10^{*} \times CT_{RATIO}$
		Example: 5.0 A stored as 16384 when Amp Scale = 1:1
T3		Signed 16-Bit Integer - 2's Complement - Saturation 15
		Float Value = ((Integer Value) / 32768) * Scale * 15) $AMPERES_{N\ (Inst,\ Fund,\ Demand,\ \mathrm{Max})} = \frac{Value}{32768} \times 15^{*} \times CT_{RATIO}$
		Example: 150 A stored as 16384 when Amp Scale = 20:1
T4		Signed 16-Bit Integer - 2's Complement - Saturation 150
		Float Value = ((Integer Value) / 32768) * Scale * 150) $VOLTS_{L\text{-}N\ (Inst,\ Fund,\ Demand,\ \mathrm{Min},\ \mathrm{Max})} = \frac{Value}{32768} \times 150 \times PT_{RATIO}$
		Example: 119.998 V stored as 26214 when Volt Scale = 1:1
T5		Signed 16-Bit Integer - 2's Complement - Saturation 1500
		Float Value = ((Integer Value) / 32768) * Scale * 1500) $WATTs\ (VARs)\ (VAs)_{PER\ PHASE\ (Inst)} = \frac{Value}{32768} \times 1500^{*} \times PT_{RATIO} \times CT_{RATIO}$
		Example: -750.0 W stored as -16384 when Volt Scale = 1:1, Amp Scale 1:1
T6		Signed 16-Bit Integer - 2's Complement - Saturation 4500
		Float Value = ((Integer Value) / 32768) * Scale * 4500) $WATTs\ (VARs)\ (VAs)_{TOTAL\ (Inst,\ Demand,\ \mathrm{Min},\ \mathrm{Max})} = \frac{Value}{32768} \times 4500^{*} \times PT_{RATIO} \times CT_{RATIO}$
		Example: -90.0 kW stored as -8192 when Volt Scale = 20:1, Amp Scale 4:1
T7		Signed 16-Bit Integer - 2's Complement - 3 Decimal Places $POWER\ FACTOR_{(True,\ Displacement)} = \frac{Value}{1000}$
		Example: -12.345 stored as -12345

Type	Value / Bit Mask	Description
T8		Signed 16-Bit Integer - 2's Complement - 2 Decimal Places $FREQUENCY = \frac{Value}{100}$
		Example: 123.45 stored as 12345
T9		Signed 16-Bit Integer - 2's Complement -1 Decimal Place
		Example: -1234.5 stored as -12345
T10		Unsigned 16-Bit Integer - Normalized Ratio
		ratio = (Normalized Ratio / Ratio Divisor)
		Example : 1.234, 12.34, 123.4, and 1234 are all stored as 1234
T11		Unsigned 16-Bit Integer - Ratio Divisor
		ratio = (Normalized Ratio / Ratio Divisor); valid Ratio Divisors are 1,10,100,1000
		Example: X.XXX stored as 1000, XX.XX stored as 100, XXX.X stored as 10
T12		Signed 16-Bit - 2's Complement - Saturation 2
		Gain Value = Integer Value /16384)
		Example: -0.250 stored as -4096
T13		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 10
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 10 $AMPERES_{(Inst,\ Fund,\ Demand,\ \mathrm{Max})} = \frac{Value - 2047}{2048}\ x\ 10^{*}\ x\ CT_{RATIO}$
		Example: 5.0 A stored as 3071 when Amp Scale 1:1
T14		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 150
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 150 $VOLTS_{L\text{-}N\ (Inst,\ Fund,\ Demand,\ \mathrm{Min},\ \mathrm{Max})} = \frac{Value - 2047}{2048}\ x\ 150\ x\ PT_{RATIO}$
		Example: 119.97 V stored as 3685 when Volt Scale 1:1
T15		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 1000
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 1000 $WATTs\ (VARs)\ (VAs)_{PER\ PHASE\ (Inst)} = \frac{Value - 2047}{2048}\ x\ 1000^{*}\ x\ PT_{RATIO}\ x\ CT_{RATIO}$
		Example: -500 W stored as 1023 when Volt Scale = 1:1, Amp Scale = 1:1
T16		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 3000
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 3000 $WATTs\ (VARs)\ (VAs)_{TOTAL\ (Inst,\ Demand,\ \mathrm{Min},\ \mathrm{Max})} = \frac{Value - 2047}{2048}\ x\ 3000^{*}\ x\ PT_{RATIO}\ x\ CT_{RATIO}$
		Example: 349.10 kW stored as 3040 when Volt Scale = 6:1, Amp Scale = 40:1

Type	Value / Bit Mask	Description
T17		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 15
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 15 $AMPERES_{N\ (Inst,\ Fund,\ Demand,\ \mathrm{Max})} = \frac{Value - 2047}{2048}\ x\ 15^{*}\ x\ CT_{RATIO}$
		Example: 11.79 A stored as 2369 when Amp Scale 5:1
T18		Unsigned 16-Bit Integer - 12 Bit Offset Binary -1 Decimal Place
		Float Value = ((Integer Value - 2047) / (10))
		Example: 121.4 degrees stored as 3261
T19		Unsigned 16-Bit Integer - 12 Bit Offset Binary -3 Decimal Place
		Float Value = ((Integer Value - 2047) / (1000)) $PF_{(True,\ Displacement)} = \frac{Value - 2047}{1000}$
		Example: 0.978 Power Factor stored as 3025
T20		Unsigned 16-Bit Integer - Bit Control/Status
		0' - stored as zero; '1' - stored as 65536
T21		Unsigned 16-Bit Integer - 3 Decimal Places
		Example: 54.321 stored as 54321
T22		Bit
		Example: 1-bit is set, 0-bit is clear
T23		Signed 16-Bit Integer – 2's complement – Saturation 300
		Float Value = ((Integer Value)/32768) * Scale * 300)
		Example: 207.846 V stored as 22702 when Volt Scale = 1:1
T24		Signed 16-Bit Integer – 2's Complement – 3 Decimal Places, offset by 60
		Float Value = (Integer Value)/1000) + 60.0)
		Example: 60.005Hz stored as 5
T25		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 750
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 750 $VOLTS_{L\text{-}N\ (Inst,\ Fund,\ Demand,\ \mathrm{Min},\ \mathrm{Max})} = \frac{Value - 2047}{2048}\ x\ 150\ x\ PT_{RATIO}$
		Example: 649.67 V stored as 3821 when Volt Scale 1:1
T26		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 10000
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 10000 $WATTs\ (VARs)\ (VAs)_{PER\ PHASE\ (Inst)} = \frac{Value - 2047}{2048}\ x\ 1000^{*}\ x\ PT_{RATIO}\ x\ CT_{RATIO}$
		Example: -5000 W stored as 1023 when Volt Scale = 1:1, Amp Scale = 1:1

The above equations provide answers in basic units (VOLTs, AMPs, WATTs, VARs, VAs and Hz). If the user desires other units such as KILOVOLTS, KILOWATTS or KILOVARS, the answers given by the equations should be divided by 1,000. If the user desires MEGAWATTS or MEGAVARS, the answers given by the equations should be divided by 1,000,000. Energy values are in units of kWh or kVARh.

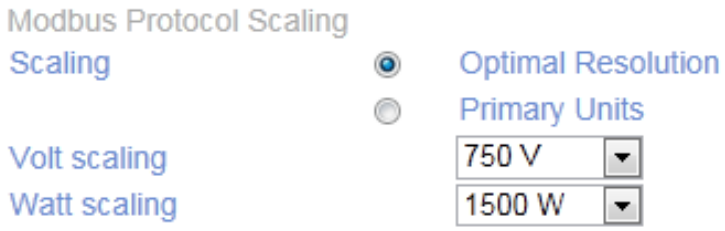
The **Value** referred to in the equations would be the value stored in the register that you wished to convert to engineering units. For example if you wanted to convert Phase A Amperes into engineering units, Value would be the value in 40003.

ENERGY is stored as 32-BIT values in static COUNTER registers. Energy values are in units of PRIMARY kWh or kVARh.

When using Optimal Resolution mode, the user may choose the Full Scale values for Voltage and Power measurements. As with Primary Unit mode (see section 1.7 below), the selection causes a substitution of calculation types. As an example, using TUC (totally user configurable) to select bus two voltages, when 150V is used as the Full Scale value the calculation type T14 above applies resulting in the following:

40001	RMS Volts A 2	B16_2S_150_M150
40002	RMS Volts B 2	B16_2S_150_M150
40003	RMS Volts C 2	B16_2S_150_M150

If 750V is chosen as the full scale value instead from the drop down in the web page (see screen shot below), then the calculation type T25 applies and the results are shown below:



40001	RMS Volts A 2	B16_2S_750_M750
40002	RMS Volts B 2	B16_2S_750_M750
40003	RMS Volts C 2	B16_2S_750_M750

The table below summarizes the changes in calculation type that result when either the 750V or the 10000W full scale options are selected:

Default	Replaced by	Replaced by

Optimal Resolution Calculation Type	750V Full Scale Calculation Type	10000W Full Scale Calculation Type
B16_2S_150_M150	B16_2S_750_M750	
B16_2S_300_M300	B16_2S_750_M750	
B16_2S_600_M600	B16_2S_750_M750	
B16_2S_1500_M1500		B16_2S_10000_M10000
B16_2S_4500_M4500		B16_2S_10000_M10000

1.5 Configuration

1.5.1 Setting CT and VT Ratios

The PPX II is capable of internally storing and recalling CT and VT ratios. The CT and VT ratios are set using the web configuration interface, and are stored in non-volatile memory on the CT/VT section of the power supply board. Ratios can be read from registers 40041 through 40044. Each ratio is stored in two registers, one for the Normalized Ratio and the other for the Ratio Divisor. Allowable constants for the normalized ratios are 1000 to 9999. The Ratio Divisors may be 1, 10, 100, or 1000 only. The number stored will be the high side rating of the CT Ratio or VT Ratio. Both a 500:5 ratio CT and a 100:1 CT will have a value of 100 stored. For example, to calculate a CT and VT ratio for Phase A from the data stored in the PPX II, use the following equation:

$$Phase\ A\ CT_{RATIO} = \frac{Phase\ A\ CT\ Value\ (40041)}{Phase\ A\ CT\ Ratio\ Divisor\ (40042)}$$

$$Phase\ A\ PT_{RATIO} = \frac{Phase\ A\ PT\ Value\ (40043)}{Phase\ A\ PT\ Ratio\ Divisor\ (40044)}$$

The PPX II calculates all measured quantities in **SECONDARY UNITS (except energy)**, like other Bitronics instruments (such as MultiComm and PowerPlex). The CT and VT ratio information is used to calculate the primary values.

In the event of a CT/VT Ratio Checksum Failure, the value in the Normalized CT Ratio and Normalized VT Ratio registers default to 1000, and the value in the CT Ratio Divisor and VT Ratio Divisor default to 1000. This results in a 1:1 CT Ratio and 1:1 VT Ratio.

> WARNING – TO PRESERVE SYSTEM PERFORMANCE, ONLY WRITE TO RATIO REGISTERS WHEN THE RATIOS NEED TO BE CHANGED.

1.5.2 Resetting Energy and Demands

The Energy and Demand registers can be RESET by writing a non-zero value to the appropriate Holding Registers.

Reset Functions
Reset Energy
Reset Demand Amps
Reset Demand Volts
Reset Demand Power

1.5.3 Tag Register

The PPX II provides a "TAG" register for user identification purposes. This register is a READ/WRITE register that allows the user to write a number from 0 to 65,535 in the tag register. The tag register is stored in non-volatile memory and can also be read/written through the web interface.

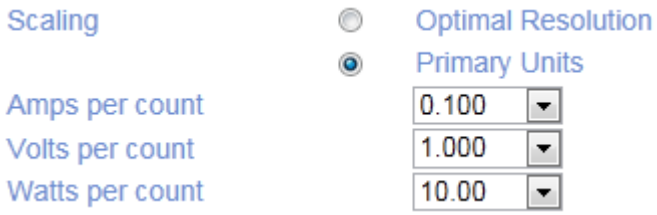
1.6 Register Sets and Register Types

The PPX II is shipped with a pre-defined set of registers and data types. These fixed registers do not change. The List of Available Measurements may be found in the User Manuals. It is possible to create a custom register list from the available measurements. The Ethernet port and web browser are required to create the custom register list. See section 1.10 for more detail.

For users who wish to use the PPX II on systems configured for other Bitronics products, a legacy register list may be selected. This legacy register list cannot be modified and will cause the PPX II to emulate the response of a Bitronics MultiComm or PowerPlex product. The Bitronics Legacy register list BiLF12 can be found in appendix A. There is also a BiLF 16 register set shown in Appendix B that provides better resolution.

1.7 Primary Units

An option exists to choose Primary Units instead of the pre-existing scaling mode, 'Optimal Resolution' adding the concept of 'scaling modes' to PPX II. The pre-existing scaling mode is called 'Optimal Resolution' on the basis that resolution of the protocols are optimized based on secondary full scale and therefore independent of CT and VT settings. The 'Primary Units' mode creates protocol values that include CT and VT settings, which requires the user to choose a scaling factor (in multiples of 10). The scaling factor must be selected such that it achieves the desired resolution and does not cause an overflow in the protocol value. The Scaling mode selection and the scaling factors are maintained separately for both Modbus and DNP and are configured on the Settings/Protocol webpage. Below is a screen shot and explanation of the Primary Units mode:



There are three new configurable parameters:

- Amps per count – APC
- Volts per count – VPC
- Watts per count - WPC

There are three new calculation types:

- Currents - B16_2S_PRIMARY_I
  $Measurement = Protocol\ Value * APC$
- Voltages - B16_2S_PRIMARY_V
  $Measurement = Protocol\ Value * VPC$
- Powers - B16_2S_PRIMARY_P
  $Measurement = Protocol\ Value * WPC$

When Primary Unit mode is selected, appropriate calculation types are substituted per the following table. This substitution occurs across all pre-defined and user configured register sets. Note, other calculation types are unaffected as they represent their values (such as Frequency, Power factor) in primary units even in Optimal Resolution mode. Also, since the 12-bit calculation types are not included in the substitution this means that the Modbus BiLF12 register set is not affected.

Modbus Manual	DNP Manual	Optimal Resolution Calculation Type	Replaced by Calculation Type	Note
T2	T2	B16_2S_10_M10	B16_2S_PRIMARY_I	
T3	T3	B16_2S_15_M15	B16_2S_PRIMARY_I	
T4	T4	B16_2S_150_M150	B16_2S_PRIMARY_V	
T23	T23	B16_2S_300_M300	B16_2S_PRIMARY_V	
na	na	B16_2S_600_M600	B16_2S_MULT_10	Power supply voltage
T5	T5	B16_2S_1500_M1500	B16_2S_PRIMARY_P	
T6	T6	B16_2S_4500_M4500	B16_2S_PRIMARY_P	

1.8 Health Check

The PPX II has 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 (40001), 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. Contact the factory for further instructions.

Health Check Error Codes	
Bit	Description
0	N/A (related to transducer output options not available in PPX II)
2	Checksum error on gain calibration of inputs
4	Checksum error on phase calibration of inputs
12	Indicates firmware download in progress and measurements are offline

1.9 Heartbeat State Counter

PPX II devices 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 16-bit counter that rolls over at 65535 (65.535 seconds). The counter starts at zero on power-up, and is NOT stored in non-volatile memory.

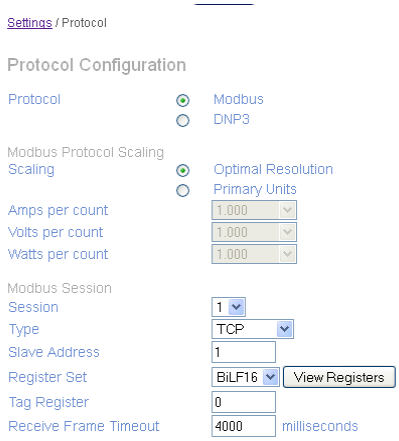
1.10 Meter ID Register

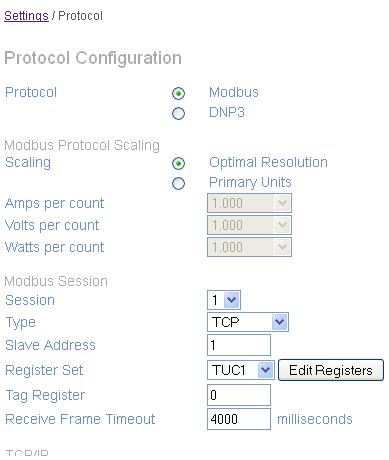
PPX II devices provide a "Meter Type ID" register for model identification purposes (40055 for PPX II default register set) which returns a value of 600 (BiLF12 Modbus, BiLF DNP), 601 (BiLF16 Modbus), or 602 (TUC DNP/ Modbus).

1.11 Custom Register Lists

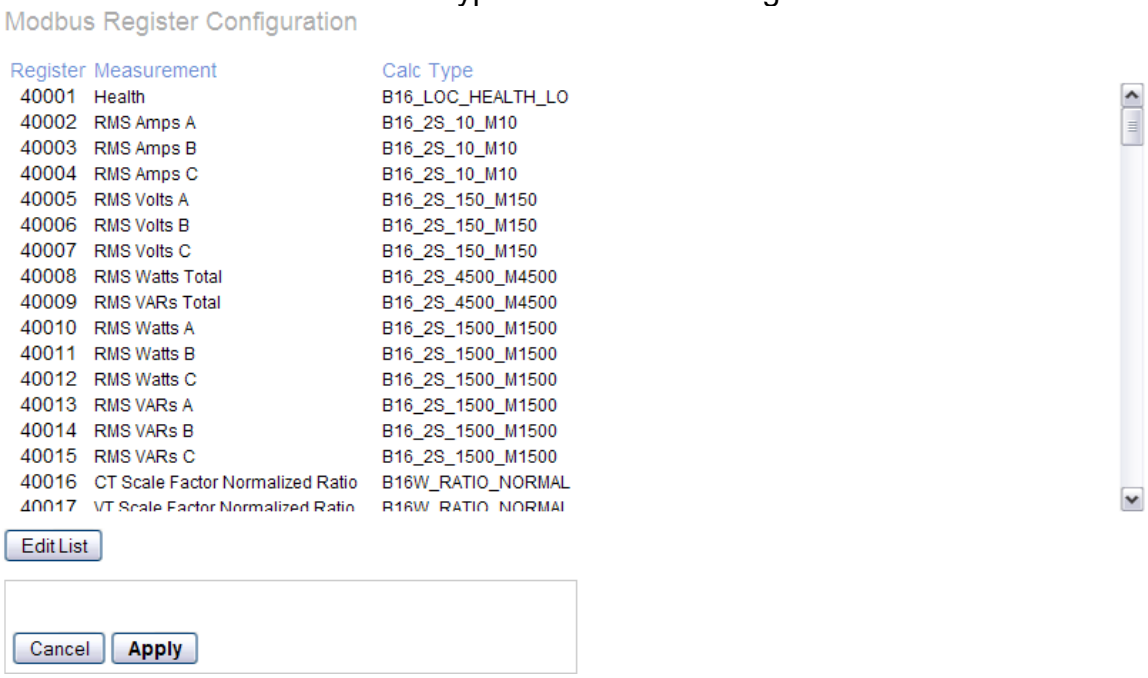
From the Protocol Configuration page, there are four Modbus register set choices in the “Register Set” dropdown box: BiLF16, BiLF12, TUC1 and TUC2. The BiLF12 and BiLF16 (Bitronics Legacy Fixed) register set definitions can be viewed by clicking on the “View Registers” button, located next to the “Register Set” dropdown box. These standard register sets cannot be edited.

The “TUC” or “Totally User Configurable” register sets are intended to allow you to define your own custom register sets. There are two, independent custom register sets, TUC1 and TUC2. The button next to the Register set dropdown list changes from “View Registers” to “Edit Registers” when one of these editable register sets is selected. Click on “Edit Registers” to begin configuring a register set.

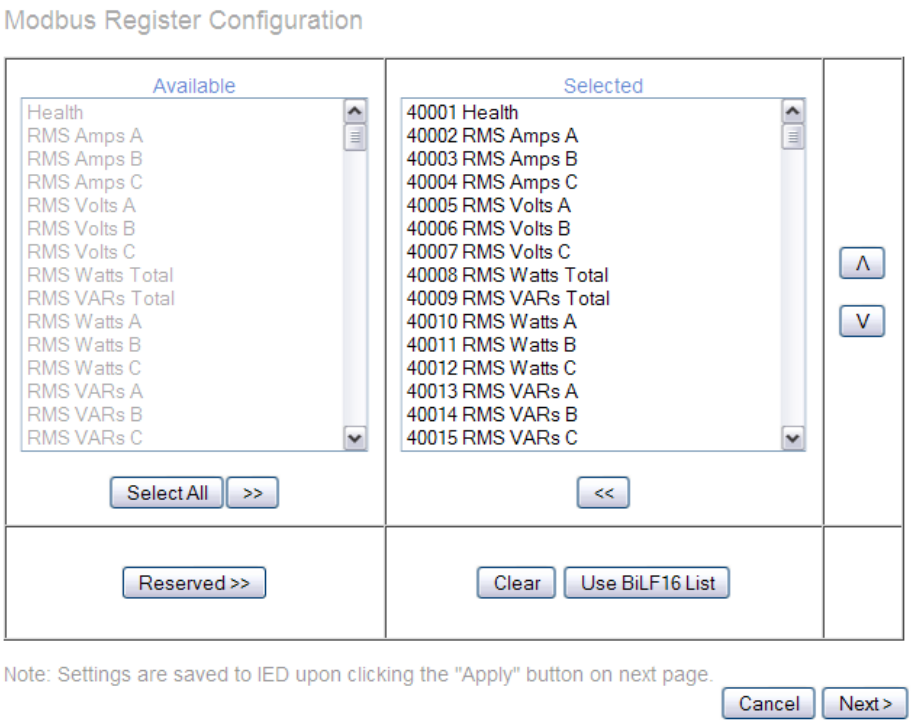




The “View Registers”/“Edit Registers” button brings you to the Modbus Register Configuration page. A register summary list is shown, which includes the register number, measurement name and calculation type of the selected register set.



Click the “Edit List” button to modify the register list. This button is disabled for the standard (non-editable) register sets.



All available measurements and data are displayed in the “Available” list in the left-hand pane. The present register configuration is shown in the “Selected” list in the right-hand pane. Measurement and data items can be added to and removed from the “Selected” list using the buttons on the page:

Select All – Highlights all measurement/data items in “Available” list

>> – Places highlighted measurement/data items from “Available” list into the “Selected” list.

Reserved >> – Places a “Reserved” placeholder item in the “Selected” list.

<< – Removes highlighted items from the “Selected” list.

Λ – Shifts highlighted items in the “Selected” list up by one point position.

V – Shifts highlighted items in the “Selected” list down by one point position.

Clear – Clears the “Selected” list for selected DNP Type.

Use BiLF16 List – Replaces the entire “Selected” list with the standard BiLF points list. A “Class 0 Enable” can be entered to programmatically configure Class 0 for all items in the list.

NOTES

- Multiple items can be selected at once using the shift or control keys.
- Any item that appears in the “Selected” list appears gray in the “Available” list.
- The same data item can be used in multiple different registers.
- Items added to the “Selected” list will be placed *above* the first highlighted item.
- If no items are highlighted in the “Selected” list, items are added to the end of the list.

2.0 MODBUS PROTOCOL

2.1 Introduction

The MODBUS protocol is an open standard which defines a command-response method of communicating digital information between a master and slave device. The electrical connection between devices is known as a bus. In MODBUS, two types of devices attach to the bus, master and slave devices. A master device issues commands to slaves. A slave device, such as a PPX II, issues responses to master commands that are addressed to them. Each bus must contain exactly one master and may contain as many slaves as the electrical standards permit. *NOTE: Much of the following information is general in nature and does not apply to the PPX II since it does not have a serial port. It has been left in as general information.*

All devices on a bus must operate according to the same electrical standards (i.e. all must be RS-232C or all must be RS-485). RS-232C standards specify that only two devices may be connected to a bus (i.e. only one slave is allowed). RS-485 specifications allow up to 32 devices (31 slaves) on a bus.

The MODBUS protocol specifications define two types of transmission modes: ASCII and RTU. This manual describes only the more common RTU mode. For more information, the manual "MODICON MODBUS PROTOCOL REFERENCE GUIDE" (PI-MBUS-300) may be purchased for a nominal fee directly from Modicon Inc.

2.2 MODBUS RTU Message Framing

Each message from either a master or slave consists of a continuous stream of characters. A silent interval of 3.5 character times (3.5 * 11 bits / 9600 baud = 3.5 millisecond), or more, separates these streams. PPX II devices implement this requirement by waiting for a 4 millisecond (configurable) gap between characters. If the stream is valid and is addressed to this instrument, then the instrument responds as follows:

Enable the output interface drivers (RS-485 option only)
Wait TX Delay time (if configured)
Send the response as a continuous stream
Disable the output interface drivers (RS-485 option only)

2.3 MODBUS RTU Message Content

The MODBUS RTU message stream consists of an address byte, a function code byte, a number of message bytes, and two check bytes. The address byte, which is in the range 1... 247, specifies the identity of the slave device. The function code byte in a master command indicates the operation that the slave is to perform. The function code byte in a slave response is the same value as the master command function code if no error occurs, otherwise it has 128 added to it. The message bytes in a command contain additional information needed to perform the command. Message bytes in a response contain the data requested if no error has occurred or a one-byte exception code upon errors. The check bytes are generated using the CRC-16 polynomial generator sequence (x16 + x15 + x2 + 1) with the remainder pre-initialized to all 1's. The most significant byte of the CRC is transmitted first.

2.4 MODBUS Function Codes

Bitronics instruments currently support the function codes shown in the following table. Note that the values are shown in hexadecimal (base 16). This table also shows the value that a slave would return upon an error.

MODBUS Function Codes			
Master Function	Slave Error	Name	Meaning
03_{16}	83_{16}	Read Holding Registers	Read values from transducer
06_{16}	86_{16}	Preset Single Register	Write ratio or reset energy/demand
10_{16}	90_{16}	Preset Multiple Registers	Write ratio or reset energy/demand

2.5 MODBUS Exception Codes

Bitronics instruments return exception codes back to the master upon certain conditions. All functions codes greater than 127 decimal ($7F_{16}$ or 0x7F) indicate a slave error response. The message byte indicates the exception code according to the following table:

MODBUS Exception Codes		
Code	Name	Meaning
1	Illegal Function	Master command contained an unrecognized function code.
2	Illegal Data Address	Starting address is illegal. Note that some registers are read-only and some are read/write.
3	Illegal Data Value	Either the register count is invalid or an attempt to write an illegal register value was found. Note that this code can be caused by attempting to read beyond the last instrument register.
4	Slave Device Failure	Instrument has failed. If problem persists, please consult customer service.

2.6 Supported MODBUS Commands

Bitronics instruments support one read and two write commands. All commands require a register address to be specified in the command. The first register, named 40001 is at hexadecimal address 0x0000. The energy/demand reset register, named 40100 is at hex address 0x0063. In commands and responses, the most significant byte of a two-byte value is transmitted first. All examples that follow use the hexadecimal values and an instrument address of 1.

2.6.1 Read Holding Registers (Function Code 03)

This function reads from 1 to 125 registers from the Bitronics instrument. The command requires a starting register and the number of registers to read. Attempting to read non-existent registers will cause an exception. Modbus read commands are limited to 125 registers maximum per read request, and some Modicon PLC Master Blocks (MSTR) are limited to 100 registers maximum per read request. The following example (PPX II standard register set) shows two registers being read: Watts Total (register 40008) and VARs Total (40009).

COMMAND - Function Code 03 (Read Holding Registers)			
Byte	**Name**	**Example**	**Notes**
1	Slave Address	1	
2	Function code	3	
3	Start address high	0	Watts Total at register 40008
4	Start address low	7	(40008-40001=07)
5	Register count high	0	
6	Register count low	2	Read 2 registers total
7	CRC-16 low	75	
8	CRC-16 high	CA	

RESPONSE - Function Code 03 (Read Holding Registers)			
Byte	**Name**	**Example**	**Notes**
1	Slave Address	1	
2	Function code	3	
3	Byte count	4	2 registers, 2 bytes each
4	Data high (40008)	66	Watts Total = 6670 hex = 26224 decimal
5	Data low (40008)	70	
6	Data high (40009)	66	VARs Total = 6650 hex = 26192 decimal
7	Data low (40009)	50	
8	CRC-16 low	CE	
9	CRC-16 high	FC	

2.6.2 Preset Single Register (Function Code 06)

This function writes to a single register. An attempt to write to a READ-ONLY register results in an exception response. The response to a valid (writeable) register command is an echo of the command. The following example shows reset Energy command by writing 1 to register 40100.

COMMAND and RESPONSE - Function Code 06 (Preset Single Register)			
Byte	**Name**	**Example**	**Notes**
1	Slave Address	1	
2	Function code	6	
3	Start address high	0	0063 hex = 99 to specify register 40100
4	Start address low	63	
5	Data high	00	
6	Data low	01	1
7	CRC-16 low	B8	
8	CRC-16 high	14	

2.6.3 Preset Multiple Registers (Function Code 16)

This function writes one or more contiguous registers. An attempt to write to a READ-ONLY register results in an exception. The following example shows writing the Reset registers (40100 - 40103).

COMMAND - Function Code 16 (Preset Multiple Registers)			
Byte	**Name**	**Example**	**Notes**
1	Slave Address	01	
2	Function code	10	10 hex = 16 decimal
3	Start address high	00	63 hex = 99 decimal = 40100 (reset energy)
4	Start address low	63	
5	Register count high	00	We write 4 registers (40100 - 40103)
6	Register count low	04	
7	Byte count	08	Four register = 8 bytes
8	Data high	00	Write 1 to register 40100 (Reset energy)
9	Data low	01	
10	Data high	00	Write 1 to register 40101 (Reset demand amps)
11	Data low	01	
12	Data high	00	Write 1 to register 40102 (Reset demand volts)
13	Data low	01	
14	Data high	00	Write 1 to register 40103 (Reset demand power)
15	Data low	01	
16	CRC-16 low	8F	
17	CRC-16 high	FE	

3.0 MODBUS OVER ETHERNET (TCP)

The PPX II will respond to Modbus commands via TCP. It can communicate with any device certified by Schneider Automation, Inc. for Modbus over Ethernet, as well as other devices. The PPX devices can support either Modbus or DNP3 and HTML protocols over the Ethernet link, but must be set the same as the serial port if the device is equipped with one. The table below lists default port assignments for all Ethernet based protocols supported by the PPX II.

Protocol	Port number
DNP3	20000 (TCP, UDP)
Modbus	502 (TCP)
HTML	80 (TCP)

The Modbus/TCP interface allows up to 8 simultaneous connections to PPX II devices. The configuration parameters are described in Appendix C. Any Unit_Id (including zero) will be accepted since there is only one device per IP address.

3.0.1 IP Addressing

The TCP/IP stack needs to be configured with an IP address, a SUBNET mask, and a ROUTER (GATEWAY) address. It is very important that the network have no duplicate IP addresses. Configuration of the address may be accomplished by a web browser, or via the front panel menu buttons.

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

192.168.0.171 / 255.255.255.0 / 192.168.0.1

APPENDIX A BITRONICS LEGACY MODBUS REGISTER ASSIGNMENTS – BILF12 (DEFAULT – 12 BIT)

Bitronics Legacy Modbus Register Assignments - BiLF12 (Default – 12 Bit)										
Code	**Modbus Address**	**Contents**	**Data**	**Scale**	**Ind**	**Values/Dependencies**	**Type**	**Min**	**Max**	**Step**
3	40001	Health 0	T1		Bit-0	Non zero = Error	Data	0-Norm	1-Fail	1
					Bit-1	Non zero = Error				
					Bit-2	Non zero = Error				
					Bit-3	Non zero = Error				
					Bit-4	Non zero = Error				
					Bit-5	Non zero = Error				
					Bit-6	Non zero = Error				
					Bit-7	Non zero = Error				
					Bit-8	Non zero = Error				
					Bit-9	Non zero = Error				
					Bit-10	Non zero = Error				
					Bit-11	Non zero = Error				
					Bit-12	Non zero = Error				
					Bit-13	Non zero = Error				
					Bit-14	Non zero = Error				
					Bit-15	Non zero = Error				
3	40002	Amps A	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40003	Amps B	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40004	Amps C	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40005	Volts A	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40006	Volts B	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40007	Volts C	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40008	Watts Total	T16	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) W
3	40009	VARs Total	T16	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) vars
3	40010	Watts A	T15	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) W
3	40011	Watts B	T15	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) W
3	40012	Watts C	T15	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) W
3	40013	VARs A	T15	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) vars

Bitronics Legacy Modbus Register Assignments - BiLF12 (Default – 12 Bit)										
Code	Modbus Address	Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40014	VARs B	T15	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) vars
3	40015	VARs C	T15	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) vars
3	40016	Amp Scale Factor	T10				Data	1000	9999	1
3	40017	Volt Scale Factor	T10				Data	1000	9999	1
3	40018	Amps Residual	T17	Amp Scale			Data	2047	4095	((1/2048) * 15 * Amp Scale) A
3	40019	Watt-Hrs Normal (High Word)	T1				Data	0	65536	65536 Kilowatt-Hours
3	40020	Watt-Hrs Normal (Low Word)	T1				Data	0	65536	1 Kilowatt-Hour
3	40021	Watt-Hrs Reverse (High Word)	T1				Data	0	65536	65536 Kilowatt-Hours
3	40022	Watt-Hrs Reverse (Low Word)	T1				Data	0	65536	1 Kilowatt-Hour
3	40023	VAR-Hrs Lag (High Word)	T1				Data	0	65536	65536 KilovarHours
3	40024	VAR-Hrs Lag (Low Word)	T1				Data	0	65536	1 KilovarHour
3	40025	VAR-Hrs Lead (High Word)	T1				Data	0	65536	65536 KilovarHours
3	40026	VAR-Hrs Lead (Low Word)	T1				Data	0	65536	1 KilovarHour
3	40027	System Frequency	T8				Data	2000	8000	0.01 Hz
3	40028	Unused	T1		0	spare unused register	Data	0	0	0
3	40029	Unused	T1		0	spare unused register	Data	0	0	0
3	40030	Unused	T1		0	spare unused register	Data	0	0	0
3	40031	Heart Beat	T1				Data	0	65536	1 msec
3	40032	Unused	T1		0	spare unused register	Data	0	0	0
3	40033	VAs A	T15	Amp Scale * Volt Scale			Data	2047	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) VAs
3	40034	VAs B	T15	Amp Scale * Volt Scale			Data	2047	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) VAs
3	40035	VAs C	T15	Amp Scale * Volt Scale			Data	2047	4095	((1/2048) * 1000 * Amp Scale * Volt Scale) VAs
3	40036	VAs Total Geometric	T16	Amp Scale * Volt Scale			Data	2047	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) VAs
3	40037	Power Factor A	T19				Data	1047	3047	0.001
3	40038	Power Factor B	T19				Data	1047	3047	0.001
3	40039	Power Factor C	T19				Data	1047	3047	0.001
3	40040	Power Factor Total Geometric	T19				Data	1047	3047	0.001
3	40041	Amp Scale Factor	T10				Setting	1000	9999	1
3	40042	Amp Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)
3	40043	Volt Scale Factor	T10				Setting	1000	9999	1
3	40044	Volt Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)

Bitronics Legacy Modbus Register Assignments - BiLF12 (Default – 12 Bit)											
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40045		Demand Amps A	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40046		Demand Amps B	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40047		Demand Amps C	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40048		Demand (Max) Amps A	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40049		Demand (Max) Amps B	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40050		Demand (Max) Amps C	T13	Amp Scale			Data	2047	4095	((1/2048) * 10 * Amp Scale) A
3	40051		Demand Amps Residual	T17	Amp Scale			Data	2047	4095	((1/2048) * 15 * Amp Scale) A
3	40052		Demand (Max) Amps Residual	T17	Amp Scale			Data	2047	4095	((1/2048) * 15 * Amp Scale) A
3	40053		Demand Volts A	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40054		Demand Volts B	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40055		Demand Volts C	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40056		Demand (Max) Volts A	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40057		Demand (Max) Volts B	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40058		Demand (Max) Volts C	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40059		Demand (Min) Volts A	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40060		Demand (Min) Volts B	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40061		Demand (Min) Volts C	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40062		Demand Watts Total	T16	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) W
3	40063		Demand (Max) Watts Total	T16	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) W
3	40064		Demand (Min) Watts Total	T16	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) W
3	40065		Demand VARs Total	T16	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) vars
3	40066		Demand (Max) VARs Total	T16	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) vars
3	40067		Demand (Min) VARs Total	T16	Amp Scale * Volt Scale			Data	0	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) vars
3	40068		Demand VAs Total	T16	Amp Scale * Volt Scale			Data	2047	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) VAs
3	40069		Demand (Max) VAs Total	T16	Amp Scale * Volt Scale			Data	2047	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) VAs
3	40070		Demand (Min) VAs Total	T16	Amp Scale * Volt Scale			Data	2047	4095	((1/2048) * 3000 * Amp Scale * Volt Scale) VAs
3	40071		Meter Type	T1		600	Legacy Register Set	Data	600	602	0
3	40072		Protocol Version	T21				Data	0	65536	0.001
3	40073		Factory Version Software	T21				Data	0	65536	0.001

Bitronics Legacy Modbus Register Assignments - BiLF12 (Default – 12 Bit)										
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40074		DSP Version	T21				Data	0	65536	0.001
3	40075		Volts N-G	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40076		Volts A-B	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40077		Volts B-C	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40078		Volts C-A	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40079		Unused	T1		0	spare unused register	Data	0	0	0
3	40080		Unused	T1		0	spare unused register	Data	0	0	0
3	40081		Unused	T1		0	spare unused register	Data	0	0	0
3	40082		Unused	T1		0	spare unused register	Data	0	0	0
3	40083		Unused	T1		0	spare unused register	Data	0	0	0
3	40084		Unused	T1		0	spare unused register	Data	0	0	0
3	40085		Unused	T1		0	spare unused register	Data	0	0	0
3	40086		Unused	T1		0	spare unused register	Data	0	0	0
3	40087		Unused	T1		0	spare unused register	Data	0	0	0
3	40088		Unused	T1		0	spare unused register	Data	0	0	0
3	40089		Unused	T1		0	spare unused register	Data	0	0	0
3	40090		Unused	T1		0	spare unused register	Data	0	0	0
3	40091		Unused	T1		0	spare unused register	Data	0	0	0
3	40092		Unused	T1		0	spare unused register	Data	0	0	0
3	40093		Unused	T1		0	spare unused register	Data	0	0	0
3	40094		Unused	T1		0	spare unused register	Data	0	0	0
3	40095		Unused	T1		0	spare unused register	Data	0	0	0
3	40096		Unused	T1		0	spare unused register	Data	0	0	0
3	40097		Unused	T1		0	spare unused register	Data	0	0	0
3	40098		Unused	T1		0	spare unused register	Data	0	0	0
3,6,16	40099		Tag Register	T1				Setting	0	65536	1
3,6,16	40100		Reset Energy	T20		0	Normal	Setting	0	65536	65536
						65536	Reset				
3,6,16	40101		Reset Demand Amps	T20		0	Normal	Setting	0	65536	65536
						65536	Reset				
3,6,16	40102		Reset Demand Volts	T20		0	Normal	Setting	0	65536	65536
						65536	Reset				
3,6,16	40103		Reset Demand Power	T20		0	Normal	Setting	0	65536	65536
						65536	Reset				
3	40104		Unused	T1		0	spare unused register	Data	0	0	0
3	40105		Unused	T1		0	spare unused register	Data	0	0	0
3	40106		Demand Volts AB	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V

Bitronics Legacy Modbus Register Assignments - BiLF12 (Default – 12 Bit)										
Code	Modbus Address	Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40107	Demand Volts BC	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40108	Demand Volts CA	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40109	Demand (Max) Volts AB	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40110	Demand (Max) Volts BC	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40111	Demand (Max) Volts CA	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40112	Demand (Min) Volts AB	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40113	Demand (Min) Volts BC	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V
3	40114	Demand (Min) Volts CA	T14	Volt Scale			Data	2047	4095	((1/2048) * 150 * Volt Scale) V

- When connected to 2 Element (DELTA or 3-wire) systems, the Per-Element quantities may have no direct physical meaning.

APPENDIX B BITRONICS LEGACY MODBUS REGISTER ASSIGNMENTS – BILF16 (16 BIT)

Bitronics Legacy Modbus Register Assignments - BiLF16 (16 Bit)										
Code	**Modbus Address**	**Contents**	**Data**	**Scale**	**Ind**	**Values/Dependencies**	**Type**	**Min**	**Max**	**Step**
3	40001	Health 0	T1		Bit-0	Non zero = Error	Data	0-Norm	1-Fail	1
					Bit-1	Non zero = Error				
					Bit-2	Non zero = Error				
					Bit-3	Non zero = Error				
					Bit-4	Non zero = Error				
					Bit-5	Non zero = Error				
					Bit-6	Non zero = Error				
					Bit-7	Non zero = Error				
					Bit-8	Non zero = Error				
					Bit-9	Non zero = Error				
					Bit-10	Non zero = Error				
					Bit-11	Non zero = Error				
					Bit-12	Non zero = Error				
					Bit-13	Non zero = Error				
					Bit-14	Non zero = Error				
					Bit-15	Non zero = Error				
3	40002	Amps A	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40003	Amps B	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40004	Amps C	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40005	Volts A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40006	Volts B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40007	Volts C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40008	Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) W
3	40009	VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) vars
3	40010	Watts A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40011	Watts B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40012	Watts C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40013	VARs A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) vars

Bitronics Legacy Modbus Register Assignments - BiLF16 (16 Bit)										
Code	Modbus Address	Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40014	VARs B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) vars
3	40015	VARs C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) vars
3	40016	Amp Scale Factor					Data	1000	9999	1
3	40017	Volt Scale Factor					Data	1000	9999	1
3	40018	Amps Residual	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40019	Watt-Hrs Normal (High Word)	T1				Data	0	65536	65536 Kilowatt-Hours
3	40020	Watt-Hrs Normal (Low Word)	T1				Data	0	65536	1 Kilowatt-Hour
3	40021	Watt-Hrs Reverse (High Word)	T1				Data	0	65536	65536 Kilowatt-Hours
3	40022	Watt-Hrs Reverse (Low Word)	T1				Data	0	65536	1 Kilowatt-Hour
3	40023	VAR-Hrs Lag (High Word)	T1				Data	0	65536	65536 KilovarHours
3	40024	VAR-Hrs Lag (Low Word)	T1				Data	0	65536	1 KilovarHour
3	40025	VAR-Hrs Lead (High Word)	T1				Data	0	65536	65536 KilovarHours
3	40026	VAR-Hrs Lead (Low Word)	T1				Data	0	65536	1 KilovarHour
3	40027	Frequency Volts A	T8				Data	2000	8000	0.001 Hz
3	40028	Unused	T1		0	spare unused register	Data	0	0	0
3	40029	Unused	T1		0	spare unused register	Data	0	0	0
3	40030	Unused	T1		0	spare unused register	Data	0	0	0
3	40031	Heart Beat	T1				Data	0	65536	1 msec
3	40032	Unused	T1		0	spare unused register	Data	0	0	0
3	40033	VAs A	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40034	VAs B	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40035	VAs C	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40036	VAs Total Geometric	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) VAs
3	40037	Power Factor A	T7				Data	-1000	1000	0.001
3	40038	Power Factor B	T7				Data	-1000	1000	0.001
3	40039	Power Factor C	T7				Data	-1000	1000	0.001
3	40040	Power Factor Total Geometric	T7				Data	-1000	1000	0.001
3,6,16	40041	Amp Scale Factor	T10				Setting	1000	9999	1
3,6,16	40042	Amp Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)
3,6,16	40043	Volt Scale Factor	T10				Setting	1000	9999	1
3,6,16	40044	Volt Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)

Bitronics Legacy Modbus Register Assignments - BiLF16 (16 Bit)										
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40045		Demand Amps A	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40046		Demand Amps B	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40047		Demand Amps C	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40048		Demand (Max) Amps A	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40049		Demand (Max) Amps B	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40050		Demand (Max) Amps C	T2	Amp Scale			Data	0	32767	((1/32768) * 10 * Amp Scale) A
3	40051		Demand Amps Residual	T3	Amp Scale			Data	0	32767	((1/32768) * 15 * Amp Scale) A
3	40052		Demand (Max) Amps Residual	T3	Amp Scale			Data	0	32767	((1/32768) * 15 * Amp Scale) A
3	40053		Demand Volts A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40054		Demand Volts B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40055		Demand Volts C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40056		Demand (Max) Volts A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40057		Demand (Max) Volts B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40058		Demand (Max) Volts C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40059		Demand (Min) Volts A	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40060		Demand (Min) Volts B	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40061		Demand (Min) Volts C	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40062		Demand Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) W
3	40063		Demand (Max) Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) W
3	40064		Demand (Min) Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) vars
3	40065		Demand VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) vars
3	40066		Demand (Max) VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) vars
3	40067		Demand (Min) VARs Total	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) VAs
3	40068		Demand VAs Total	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) VAs
3	40069		Demand (Max) VAs Total	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) VAs
3	40070		Demand (Min) VAs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 4500 * Amp Scale * Volt Scale) W
3	40071		Meter Type	T1		601	Legacy Register Set	Data	600	602	0
3	40072		Protocol Version	T21				Data	0	65536	0.001
3	40073		Factory Version Software	T21				Data	0	65536	0.001

Bitronics Legacy Modbus Register Assignments - BiLF16 (16 Bit)

Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40074		DSP Version	T21				Data	0	65536	0.001
3	40075		Volts N-G	T4	Volt Scale			Data	0	32767	((1/32768) * 150 * Volt Scale) V
3	40076		Volts A-B	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40077		Volts B-C	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40078		Volts C-A	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40079		System Frequency (1mHz)	T24				Data	-32768	32767	0.001Hz
3	40080		Unused	T1		0	spare unused register	Data	0	0	0
3	40081		Unused	T1		0	spare unused register	Data	0	0	0
3	40082		Unused	T1		0	spare unused register	Data	0	0	0
3	40083		Unused	T1		0	spare unused register	Data	0	0	0
3	40084		Unused	T1		0	spare unused register	Data	0	0	0
3	40085		Unused	T1		0	spare unused register	Data	0	0	0
3	40086		Unused	T1		0	spare unused register	Data	0	0	0
3	40087		Unused	T1		0	spare unused register	Data	0	0	0
3	40088		Unused	T1		0	spare unused register	Data	0	0	0
3	40089		Unused	T1		0	spare unused register	Data	0	0	0
3	40090		Unused	T1		0	spare unused register	Data	0	0	0
3	40091		Unused	T1		0	spare unused register	Data	0	0	0
3	40092		Unused	T1		0	spare unused register	Data	0	0	0
3	40093		Unused	T1		0	spare unused register	Data	0	0	0
3	40094		Unused	T1		0	spare unused register	Data	0	0	0
3	40095		Unused	T1		0	spare unused register	Data	0	0	0
3	40096		Unused	T1		0	spare unused register	Data	0	0	0
3	40097		Unused	T1		0	spare unused register	Data	0	0	0
3	40098		Unused	T1		0	spare unused register	Data	0	0	0
3,6,16	40099		Tag Register	T1				Setting	0	65536	1
3,6,16	40100		Reset Energy	T22		0	Normal	Setting	0	1	1
						1	Reset				
3,6,16	40101		Reset Demand Amps	T22		0	Normal	Setting	0	1	1
						1	Reset				
3,6,16	40102		Reset Demand Volts	T22		0	Normal	Setting	0	1	1
						1	Reset				
3,6,16	40103		Reset Demand Power	T22		0	Normal	Setting	0	1	1
						1	Reset				
3	40104		Unused	T1		0	spare unused register	Data	0	0	0
3	40105		Unused	T1		0	spare unused register	Data	0	0	0
3	40106		Demand Volts AB	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V

Bitronics Legacy Modbus Register Assignments - BiLF16 (16 Bit)										
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40107		Demand Volts BC	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40108		Demand Volts CA	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40109		Demand (Max) Volts AB	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40110		Demand (Max) Volts BC	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40111		Demand (Max) Volts CA	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40112		Demand (Min) Volts AB	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40113		Demand (Min) Volts BC	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40114		Demand (Min) Volts CA	T4	Volt Scale			Data	0	32767	((1/32768) * 300 * Volt Scale) V
3	40115		Volts Aux	T4				Data	0	32767	((1/32768) * 600) V
3	40116		Watt-Hrs Net (High Signed)	T1				Data	0	65536	65536 Kilowatt-Hours
3	40117		Watt-Hrs Net (Low Signed)	T1				Data	0	65536	1 Kilowatt-Hour
3	40118		VA-Hrs (High)	T1				Data	0	65536	65536 KilovarHours
3	40119		VA-Hrs (Low)	T1				Data	0	65536	1 KilovarHour
3	40120		Max Average Watts A	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40121		Max Average Watts B	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40122		Max Average Watts C	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40123		Max Average VARs A	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs
3	40124		Max Average VARs B	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs
3	40125		Max Average VARs C	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs
3	40126		Max Average VAs A	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40127		Max Average VAs B	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40128		Max Average VAs C	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40129		Average Watts A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40130		Average Watts B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40131		Average Watts C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40132		Average VARs A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs
3	40133		Average VARs A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs

Bitronics Legacy Modbus Register Assignments - BiLF16 (16 Bit)										
Code	Modbus Address	Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step
3	40134	Average VARs A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs
3	40135	Average VAs A	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40136	Average VAs B	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40137	Average VAs C	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40138	Min Average Watts A	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40139	Min Average Watts B	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40140	Min Average Watts C	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) W
3	40141	Min Average VARs A	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs
3	40142	Min Average VARs B	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs
3	40143	Min Average VARs C	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VARs
3	40144	Min Average VAs A	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40145	Min Average VAs B	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40146	Min Average VAs C	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) * 1500 * Amp Scale * Volt Scale) VAs
3	40147	Unused	T1		0	spare unused register	Data	0	0	0
3	40148	Unused	T1		0	spare unused register	Data	0	0	0
3	40149	Unused	T1		0	spare unused register	Data	0	0	0
3	40150	Unused	T1		0	spare unused register	Data	0	0	0
3	40151	Unused	T1		0	spare unused register	Data	0	0	0
3	40152	Unused	T1		0	spare unused register	Data	0	0	0
3	40153	Unused	T1		0	spare unused register	Data	0	0	0
3	40154	Unused	T1		0	spare unused register	Data	0	0	0
3	40155	Unused	T1		0	spare unused register	Data	0	0	0
3	40156	Unused	T1		0	spare unused register	Data	0	0	0
3	40157	Unused	T1		0	spare unused register	Data	0	0	0
3	40158	Unused	T1		0	spare unused register	Data	0	0	0
3	40159	Unused	T1		0	spare unused register	Data	0	0	0

When connected to 2 Element (DELTA or 3-wire) systems, the Per-Element quantities may have no direct physical meaning.

APPENDIX C MODBUS CONFIGURATION PARAMETERS

Configuration Parameter	Description	Default or Options
Modbus Session		
Session	The number of the session you are configuring	Option of 1 – 8, default is 1
Type	The session type	Option RTU, TCP, default is RTU
Slave address	The source address for the selected session	Default is 1
Points List	The register set to be used for the meter. The options are the Bitronics Legacy Fixed (BiLF) 12-bit or 16-bit.	Default is BiLF12
Tag Register	Location of the tag register	Default is 0
Receive Frame Timeout (ms)	Maximum amount of time (ms) to wait for a complete frame after receiving valid frame sync characters	Default is 4000 ms
Serial		
Inter-Character Timeout (ms)	The amount of time (ms) of silence at the end of a frame before timeout. At 9600 baud, 4 ms is 4 character times.	Default is 4 ms.
Delimiter 1	Delimiter 1 and 2 are used only with Modbus ASCII for carriage return and line feed.	Default is 13
Delimiter 2	Delimiter 1 and 2 are used only with Modbus ASCII for carriage return and line feed.	Default is10
Legacy RTU Accommodation Factors	For this and all of the remaining items in this section, these are the maximum allowable values. Some older RTUs may not be able to accommodate the maximum and the settings can be reduced to work with those RTUs.	
Max Holding Regs to Read		Default is 125
Max Holding Regs to Write		Default is 125
TCP/IP		
IP Address	The IP address of the master (a value of 0 allows any IP address to connect)	Default is 0.0.0.0
IED Listen Port	The port that the 50 Series IED listens on.	Default is 502

Revision	Date	Changes	By
A	11/5/14	Original	E. DeMicco
B	5/21/20	Changed 40027 description to System Frequency in 16-Bit register list; corrected value in table in 1.4.1 Type T1 to 65536 from 10,000	E. DeMicco

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