

ELHOR

Watts *n*

MARK II

PRECISION ENERGY METER

METER USER MANUAL



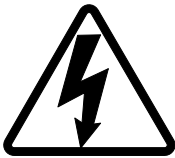
Installation Considerations

Installation and maintenance of the WattsOn device must only be performed by qualified, competent personnel who have appropriate training and experience with electrical high voltage and current installations. The WattsOn device must be installed in accordance with all Local and National Electrical Safety Codes.

WARNING

Failure to observe the following may result in severe injury or death:

- During normal operation of this device, hazardous voltages are present on the input terminals of the device and throughout the connected power lines, including any potential transformers (PTs). With their primary circuit energized, current transformers (CTs) may generate high voltage when their secondary windings are open. Follow standard safety precautions while performing any installation or service work (i.e. remove line fuses, short CT secondaries, etc).
- This device is not intended for protection applications.
- Do not HIPOT and/or dielectric test any of the digital outputs. Refer to this manual for the maximum voltage level the meter can withstand.
- Do not exceed rated input signals as it may permanently damage the device.
- The power supply input should be connected via a rated 12-35 VDC / 24VAC power supply and properly isolated from the line voltage.



Danger

Line voltages up to 600 VRMS may be present on the input terminals of the device and throughout the connected line circuits during normal operation. These voltages may cause severe injury or death. **Installation and servicing must be performed only by qualified, properly trained personnel.**

Limitation of Liability

Elkor Technologies Inc. ("Elkor") reserves the right to make changes to its products and/or their specifications without notice. Elkor strongly recommends obtaining the latest version of the device specifications to assure the most current information is available to the customer. Specifications and manual are available at <http://www.elkor.net>

Elkor assumes no liability for applications assistance, customer's system design, or infringement of patents or copyrights of third parties by/or arising from the use of Elkor's devices.

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Although the information contained in this document is believed to be accurate, Elkor assumes no responsibility for any errors which may exist in this publication.

TABLE OF CONTENTS

Installation Considerations.....	3
WARNING.....	3
Limitation of Liability	3
Table of Contents.....	4
1. Introduction.....	6
1.1. Electrical Wiring	6
1.2. Disclosure.....	6
1.3. Revision History	6
1.4. Warranty	7
1.5. Product Description	7
1.6. Specifications.....	8
1.7. Indicators	9
2. Installation.....	10
2.1. Grounding Considerations	10
2.2. Power Supply	10
2.3. Line Circuits Wiring.....	10
2.4. Fusing of Voltage Sensing Inputs	10
2.5. Enclosure Mounting	10
3. Digital Communications.....	11
3.1. RS-485 Port (M1/M2 models)	11
3.2. Ethernet Port (E2/E3/E4 models).....	11
3.3. Wi-Fi (E4 model)	11
3.4. Network Discovery — E2 model.....	11
3.5. Network Discovery — E3/E4 model.....	11
3.6. Emergency Recovery — E4 model	12
4. The Display (For models with the –DL option).....	13
4.1. Using the Display	13
4.2. Monitoring	16
4.3. Configuration	18
4.4. Customizing the Display.....	25
5. Built-In Data Logging (For M1 or E3/E4 models with the –DL option).....	28
5.1. Features	28
5.2. Flash Memory	28
5.3. Battery-backed Real-time Clock.....	28
5.4. PC Interface.....	29
5.5. Modbus Interface	32
6. The Modbus Protocol (For M1 and E3/E4 models).....	34
6.1. Protocol Overview	34
6.2. Instantaneous Data Registers	36
6.3. Accumulated Data Registers.....	39
6.4. Configuration and Status Registers	44
6.5. System Registers.....	51
6.6. Relay Output Configuration Registers	54
6.7. Customizing the Register Map (Advanced)	55
7. The BACnet MS/TP Protocol (For M2 models).....	58
7.1. BACnet MS/TP Specifications.....	58
7.2. BACnet Protocol Implementation Conformance Statement (PICS).....	58
7.3. BACnet Object List	61
7.4. BACnet Configuration	64
8. The Web Interface (For E3/E4 models).....	67
8.1. Accessing the Web Interface.....	67
8.2. Posting Status.....	67
8.3. Information Page	67
8.4. Diagnostics Page.....	68
8.5. Filesystem Page	68

8.6. Network Page	70
8.7. System Page	71
8.8. Changing the Administrator Password.....	71
8.9. Advanced Web Interface Settings (E3 model only)	72
8.10. Viewing Real-Time Data	72
8.11. Viewing the Meter Configuration.....	73
8.12. Posting Data to the Elkor Cloud	73
8.13. Posting Data to your own Web Server (Advanced Feature)	73
8.14. Customizing the Web Posting Format (Advanced Feature).....	76
9. Firmware Updates and the Bootloader	80
10. Appendix A, Wiring Diagrams	81
10.1. Four-Wire (Wye) Wiring Diagram.....	81
10.2. Three-Wire (Delta) Wiring Diagram (Three CTs).....	82
10.3. Three-Wire (Delta) Wiring Diagram (Two CTs)	83
10.4. Split-Phase Wiring Diagram	84
10.5. CT Wiring Notes	85
11. Appendix B, Modbus Protocol Details	86
11.1. Modbus Frames on RS-485 Networks	86
11.2. Modbus Frames on Ethernet/Wi-Fi Networks	86
11.3. Cyclic Redundancy Checksum.....	86
11.4. Read Holding Registers	87
11.5. Read Input Registers	87
11.6. Write Single Register	87
11.7. Write Multiple Registers	87
11.8. Mask Write Register.....	88
11.9. Read/Write Multiple Registers	88
11.10. Diagnostic Functions.....	89
11.11. Get Comm Event Counter.....	91
11.12. Report Slave ID.....	91

1. INTRODUCTION



1.1. Electrical Wiring

Because of possible electrical shock or fire hazards, connection of this equipment should only be made by qualified personnel in compliance with the applicable electrical codes and standards.

1.2. Disclosure

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1.3. Revision History

Version	Date	Changes
Revision 1	October 2014	Original Version
Revision 2	December 2014	Clarified reserved registers in tables from section 5.4.1 through to 5.5.4. Corrected default threshold voltage in section 2.1 from 5V to 20V. Corrected frequency channel selection in section 5.6.15 to state that changes occur on voltages below 5V
Revision 3	February 2015	Corrected description of Report Slave ID in Appendix B to include the byte count
Revision 4	September 2015	Added Total Capacitive/Reactive Energy registers (Firmware version \geq v10.52)
Revision 5	February 2016	Corrected R/RW status of a few registers Added MRS-75 and MRS-125 to CT Turns table
Revision 6	January 2018	Adding "Billing" import and export energy registers and explanation (Firmware version \geq 11.00) Added minimum/maximum Voltage and Current registers (Firmware version \geq 10.74) Combined several separate guides (Display, Logging, Web Interface, BACnet) into one comprehensive manual
Revision 7	February 2019	Added E4 model
Revision 8	April 2019	Added the E4 factory reset procedure
Revision 9	July 2020	Added HTTP Posting Examples (E4 model)
Revision 10	November 2021	Updated Phase Compensation Setting via LCD (DL option) Fixed Energy Divider default

1.4. Warranty

The WattsOn-Mark II is warranted against defective material and workmanship. During the warranty period Elkor will repair or replace, at its option, all defective equipment that is returned freight prepaid. There will be no charge for repair provided there is no evidence that the equipment has been mishandled or abused. If the equipment is found to be in working order, a service fee will be billed to the customer. Warranty claims must be made via the original purchaser.

Standard Warranty duration is one (1) year from date of sale. Extended warranties are available to OEMs.

1.5. Product Description

The WattsOn-Mark II Precision Energy Meter utilizes advanced metering technology to implement a multi-functional power and energy meter into a small, cost-effective package. WattsOn-Mark II incorporates three meters into one to provide a unique solution for monitoring single phase, split phase and three phase loads.

The meter provides comprehensive per phase data, as well as cumulative data, including Volts, Amps, Real Power, Reactive Power, Apparent Power, Voltage Angle, Power Factor and Frequency, Quadrant, Import/Export/Net Wh/VAh and per Quadrant VARh.

WattsOn-Mark II features full four-quadrant metering, and all parameters are metered and accumulated on a per-phase basis. Additionally, the meter may be configured with per-phase CT ratios allowing for metering asymmetrical loads such as individual building branch circuits. Therefore, it is possible to use different CT sizes and ratios on each input.

The unit accepts up to 600V (line-to-line) directly without needing potential transformers. It may be configured for use with 333mV output CTs, mA output CTs (such as Elkor's "safe" mA split and solid core CTs) or industry standard 5A CTs.

The WattsOn-Mark II meter features a proven high performance metering architecture, which allows for accurate and extremely high resolution measurements over a very wide dynamic range input. The data is updated up to two times per second. The true-RMS inputs may be used even with distorted waveforms such as those generated by variable frequency drives and SCR loads.

Information is available via a digital communication port depending on the model – RS-485, Ethernet, and Wi-Fi are available depending on the model, using either the Modbus (models M1 or E3/E4) or BACNET (models M2 or E2) protocols. In addition, two solid-state relay outputs are available and may be software configured for pulse outputs, or alarm triggers, as well as direction of power. An on-board graphic LCD display, real-time clock and data logging is optionally available.

1.6. Specifications

Inputs		
Control Power Input Rating	12-35V VDC / 24VAC, 100 mA max	
System Types Supported	120/208V Delta, Wye 277/480V Delta, Wye 347/600V Delta, Wye Single-phase installations up to 347V RMS Split-phase (two phase) installations	
Frequency	40-70 Hz	
Voltage Input Rating	5 to 347V L-N (600 V L-L)	
Voltage Continued Overload Rating	20%	
Voltage Absolute Maximum Rating	450V L-N, 780V L-L	
Voltage Input Impedance	1.5M Ω (line-to-neutral) minimum, 3.0M Ω (line-to-line) minimum	
Voltage Wire Size	AWG 30-12, solid / stranded (AWG 16-22 recommended)	
Current Input Rating	Up to 200 mA RMS (-mA model) Up to 333 mV RMS (-mV model) Up to 10A RMS (-5A model)	
Current Continued Overload Rating	+20%	
Current Absolute Maximum Rating	400 mA RMS (-mA model) 666 mV RMS (-mV model) 20A RMS (-5A model)	
Current Burden/Input Impedance	1.5 Ω total maximum(-mA model) 800k Ω minimum, 1.2M Ω typical (-mV model) 0.05 Ω total maximum (-5A model)	
Current Wire Size	AWG 24-12, solid / stranded (AWG12-16 recommended for 5A CTs)	
Tightening Torque	7.0 Lb-In (Voltage), 4.4 Lb-In (Other)	
Outputs		
Serial	RS-485 2-wire Modbus RTU, 9600 (default) to 230400 baud Elkor Expansion Bus Port	
Relay	2x Solid-State Relay Outputs (100 mA @ 50V max)	
Indicators	3x Current Bi-color LEDs 3x Voltage LEDs 2x Relay State LEDs 1x Status Bi-color LED 2x Communication Bi-color LEDs	
Display	Back-lit Graphic LCD Display 128x32 (-DL models only)	
Accuracy		
Current (A)	0.05% typical	0.1% max
Voltage, Line-to-Neutral (V)	0.1% typical	0.2% max
Voltage, Line-to-Line (V)	0.2% typical	0.3% max
Real Power (W)	0.1% typical	0.2% max
Apparent Power (VA)	0.1% typical	0.2% max
Reactive Power (VAR)	0.1% typical	0.2% max
Energy	0.1% typical	0.2% max
Power Factor	0.2% max	
Frequency	0.01% max	
Sampling Rate	2 KHz	
Data Update Time	2 Hz	
Environmental		
Operating Temperature	-40°C to +70°C	
Storage Temperature	-65°C to +85°C	
Humidity	10 to 90% non-condensing	
Mechanical		
Mass	0.15 kg (-mA and -mV models) - 0.23 kg (-5A-DL model)	
Mounting	DIN Rail mounting 2-point screw mounting	
Regulatory		
Electromagnetic Emissions	FCC part 15 Class B (residential and industrial)	
Safety	UL 508 listed	
Accuracy	ANSI C12.20 Class 0.2	



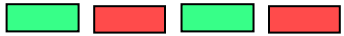


1.7. Indicators

A number of indicator LEDs are present on the WattsOn. They are described in the table below.

Label	Color	Description
STATUS	Green/Red	Indicates the status of the device. See the Status Indicator Codes, below.
MB	Green/Red	Indicates Modbus RS-485 communication. Green indicates transmission, red indicates reception. Solid red indicates that Modbus is wired backwards (+ and – terminals are reversed).
XB	Green/Red	Indicates Elkor Expansion Bus communication. Green indicates transmission, red indicates reception. Solid red indicates that the Expansion bus is wired backwards (+ and – terminals are reversed).
K1	Yellow	Indicates the state of the first relay output. Off indicates open, on indicates closed.
K2	Yellow	Indicates the state of the second relay output. Off indicates open, on indicates closed.
V	3x Green	Voltage indicators. By default, the LED is on when the voltage is greater than 20V.
I	3x Green/Red	Current & power indicators. See Current & Power Indicators, below.


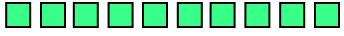


1.7.1. Status Indicator Codes

The status indicator uses a variety of patterns to indicate the device's status, as described by the following table.

Code	Description
	Solid green indicates that the device is operating normally.
	Two periodic green blinks indicates that the meter has started in bootloader mode. See section 9, Firmware Updates and the Bootloader (p. 80) for details.
	Alternating green and red indicates that the Modbus address is set to 0, which is used only for debugging purposes.
	Two periodic red blinks indicates that corrupt firmware has been detected on the device, halting the device in bootloader mode.
	Flashing red indicates a product malfunction that prevents it from reading correctly.

1.7.2. Current & Power Indicators

The WattsOn features three current indicator LEDs which display the status of metering inputs. The table below summarizes the LED states. The LEDs will not turn on (in any state) if the input current is less than 0.1% (by default) of the full scale input.

Code	Description
	Solid green indicates that current is present. When voltage is present, solid green indicates that active power (kW) is being <i>imported</i> .
	When voltage is present, blinking green indicates that active power is being <i>exported</i> .
	When voltage is present, solid red indicates that active power is being <i>imported</i> , but absolute reactive power (kVAR) exceeds absolute active power.
	When voltage is present, blinking red indicates that active power is being <i>exported</i> , but absolute reactive power (kVAR) exceeds absolute active power (kW).
	By default, the LED is off when the current is less than 0.1% of the full scale input.

2. INSTALLATION

2.1. Grounding Considerations

Output signal ground is usually provided by the controller (RTU, DDC, PLC etc). The output common (GND) **IS ISOLATED** (3500VAC minimum) from the input reference (N terminal), however the "-" terminal of the input power supply and the output common (GND) are tied together internally.

2.2. Power Supply

The power supply must be properly isolated from the measurement line to maintain the required isolation voltage. A small dedicated transformer or DIN mount switching power supply is recommended to ensure the best isolation between system components. Contact Elkor to purchase recommended accessories.

For DC power supplies, the polarity must be observed. For AC power supplies, it must be noted that the RS-485 output common (G) and "-" power supply terminal are tied together. Care must be taken if multiple devices are powered using one AC supply to prevent shorting the supply.

The power supply may be shared by multiple devices.

2.3. Line Circuits Wiring

The WattsOn meter is a true 'three element' meter that can be used in any electrical system. For four-wire systems ('wye', with distributed neutral) the meter requires current and voltage information from each phase, therefore three current transformers (CTs) and three line voltages plus neutral must be wired to the unit.

WattsOn may be used in three wire systems ('delta', without a distributed neutral) as a 'three element' meter (three CTs required). The 5A meter version may be wired as a 'two element' meter utilizing only two CTs (and two PTs). When no neutral is present, the neutral connection should be omitted.

Standard wiring principles for electricity meters apply to the WattsOn meter, as for any other '3 element' electricity meter. The polarity of interfacing transformers must be observed. The left terminal of each current input connector is always associated with the 'X1' wire of the responding CT. Please refer to Appendix A for details on CT wiring.

All mV and mA CTs must be wired independently to the corresponding current inputs (two wires from each CT without shunts or jumpers). **mA and mV CTs must NOT be grounded, or interconnected with each other (or any other components) in any way.**

The use of a metering test switch containing fuses for voltage lines and shorting terminals for 5A CTs is recommended. A pre-assembled Elkor *i-Block™* may be used as a convenient and economical solution.

A CT shorting mechanism is not required for mV and Elkor mA style CTs, since these are voltage clamped, however appropriate protection (fuse or breaker) for input line voltages is required.

See **Section 10, Appendix A, Wiring Diagrams** (p. 81) for details on wiring the meter for various system configurations.

2.4. Fusing of Voltage Sensing Inputs

The input voltage lines should be protected as per electrical code requirements. This is also good practice to facilitate an easy disconnect means for servicing the meter. In some cases, the voltage may be tapped off of existing fuses or breakers. If this is not possible, Elkor recommends a 1A or lower fuse (fast acting) for protection of the installation wiring. The WattsOn voltage inputs are high impedance (> 1.5MΩ) and draw negligible current (less than 0.3mA max).

2.5. Enclosure Mounting

The WattsOn is housed in a UL 94V-0 plastic enclosure intended for either DIN mount installation or wall mounted installation. All of the input (bottom) and output (top) signals are available on the exterior of the enclosure. The unit does not contain any user serviceable parts and thus should not be accessed by the user.

3. DIGITAL COMMUNICATIONS

The WattsOn has a communications port which can be used to connect with computers, PLCs, web servers, and other devices. Different models have different kinds of ports.

3.1. RS-485 Port (M1/M2 models)

The M1 and M2 models contain an RS-485 serial port, which (for the M1 model) uses the Modbus RTU protocol, or (for the M2 model) the BACNET MS/TP protocol.

The RS-485 port comes factory-programmed with the indicated settings below, depending on its model. The baud rate, parity, and stop bit settings can be changed via the display, if available, or via the communications port; see **Section 6, The Modbus Protocol** (p. 34) the M1 model, or **Section 7, The BACnet Protocol** (p. 58) for the M2 model.

Parameter	Default Setting	
	M1 Model	M2 Model
Device Address	Modbus Address 1	MAC Address 1
Baud rate	9600 bps	76,800 bps
Parity	None	None
Data bits	8	8
Stop bits	1	1

Using the rotary switch, addresses from 1-15 can be set, which represent the Modbus address for M1 models and the MAC address for M2 models. The switch indicates numbers as hexadecimal values, with 1-9 being shown as normal, "A" representing 10, "B" representing 11, and so on. When the rotary switch is set to F (15) the device will instead use an address programmed into the unit. The internally programmed address defaults to 15, to match the rotary switch setting. See the appropriate section listed above for details on configuring the meter to use higher addresses.

Address 0 is not a valid address; it is used for troubleshooting purposes only.

3.2. Ethernet Port (E2/E3/E4 models)

The E2, E3 and E4 models contain an Ethernet port, which (for the E2 model) uses the BACNET TCP protocol, or (for the E3/E4 model) uses the Modbus TCP protocol in addition to web server and web posting functionality.

3.3. Wi-Fi (E4 model)

The E4 model supports Wi-Fi networks, using the Modbus TCP protocol in addition to web server and web posting functionality. Wi-Fi mode is **only enabled when the Ethernet port is disconnected**.

3.4. Network Discovery — E2 model

For the E2 model, see the ETBAC Installation Guide at http://elkor.net/pdfs/ETBAC_Installation_Guide.pdf.

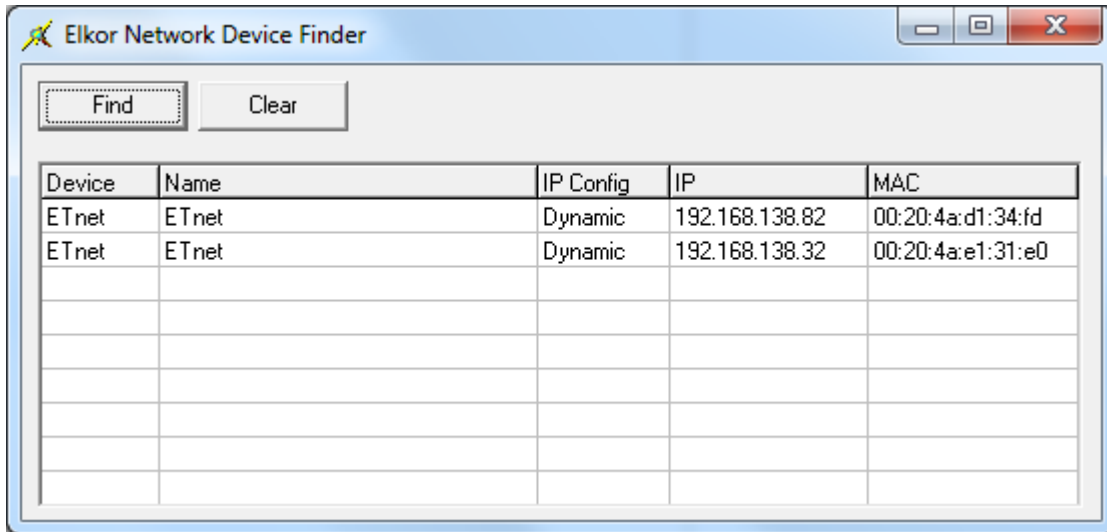
3.5. Network Discovery — E3/E4 model

The E3/E4 model is configured, by default, to automatically obtain its IP address via DHCP if available, and with AutoIP otherwise. If you are the network administrator, you may be able to determine the device's IP address by consulting your router's user interface. Otherwise, you can use the Elkor Network Device Finder utility available for the Windows operating system.

The Elkor Network Device Finder is a stand-alone program that runs on Microsoft Windows operating systems to assist in discovering any devices on the local area network when their IP addresses are not known. You can download the utility from Elkor's website, at <http://www.elkor.net/bin/finder.exe>.

To run the utility, simply double-click on the downloaded executable. The executable is "portable" – it does not require an installer, making it easy to take with you on a USB key or similar device if it must be used in a field location that does not have full internet access.

The utility will automatically search for any Elkor devices present on the network. If the device does not show up within a few seconds, you can have the program send subsequent broadcasts by clicking the *Find* button.



If you can access the device's web interface, it is recommended that you configure its IP address by using a web browser (see section 3, Configuration). If you cannot access the device using its default IP address settings (for example, because you do not have a DHCP server on your network), you will first need to change it using the Elkor Network Device Finder utility.

Once you have found the device with the Elkor Network Device Finder (see the previous subsection), you can double-click on it to enter the IP address configuration dialog box.

You can choose to either use a static IP configuration (i.e. one that you provide manually), or the Dynamic Host Configuration Protocol (DHCP, a router or other device on the network automatically assigns the device an IP configuration when it starts up). By default, the device uses DHCP. If it has been configured to use a static IP configuration, you can set it back to DHCP by clicking the *DHCP* radio button and clicking *Apply*.

To enter a static IP configuration, click the *Static* radio button, and the other fields will be available for editing. You can enter an IP address, subnet mask, default gateway, primary and secondary DNS servers. If you are unsure as to how to configure IP address settings, consult your network administrator.

The default gateway, primary and secondary DNS server IP addresses are either supplied by your internet service provider, or the same as the address of the device you use to connect to the network (i.e. your router). The secondary DNS server is optional, and may be left blank.

3.6. Emergency Recovery — E4 model

On the E4 model, the rotary switch can be used for emergency device recovery in case of an unexpected problem or unknown misconfiguration.

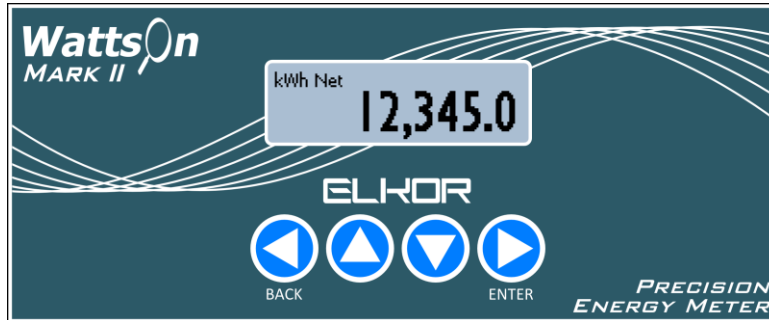
To reset the device's Ethernet and Wi-Fi configuration to factory default settings, perform the following procedure:

1. Set the rotary switch to position "C"
2. Power cycle the device
3. Wait approximately 15 seconds
4. Set the rotary switch back to position "1"
5. Power cycle the device again

4. THE DISPLAY (For models with the -DL option)

4.1. Using the Display

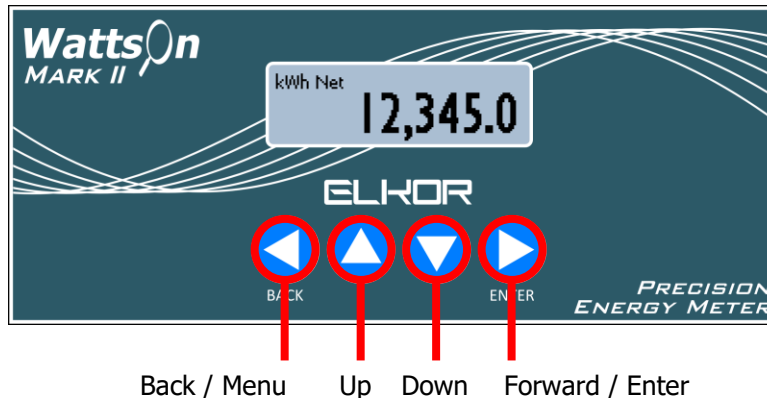
The WattsOn-Mark II "DL" model contains a 128x32 pixel backlit display and four control buttons. In its default configuration, the display shows the name and value of one or more parameters of the electrical system that the device is monitoring.



4.1.1. General Controls

From left to right, the four buttons correspond to the following general functions:

- Back/Menu
- Up
- Down
- Forward/Enter



By default, pressing any of the buttons turns on the backlight for 90 seconds.

The Back/Menu button performs the following functions:

- Shows the main menu, when used from the default monitor screen
- Shows the monitor screen, when used from the main menu
- Leaves the current sub-menu, when used from within a sub-menu
- Moves the cursor to the left, when editing numerical values

The Up button performs the following functions:

- Shows the previous parameter page, when used from the default monitor screen
- Moves the cursor up, when used from a menu
- Increases a digit by 1, when editing numerical values

The Down button performs the following functions:

- Shows the next parameter page, when used from the default monitor screen
- Moves the cursor down, when used from a menu
- Decreases a digit by 1, when editing numerical values

The Forward/Enter button performs the following functions:

- Shows the main menu, when used from the default monitor screen
- Selects an item from the menu
- Moves the cursor to the right, when editing numerical values

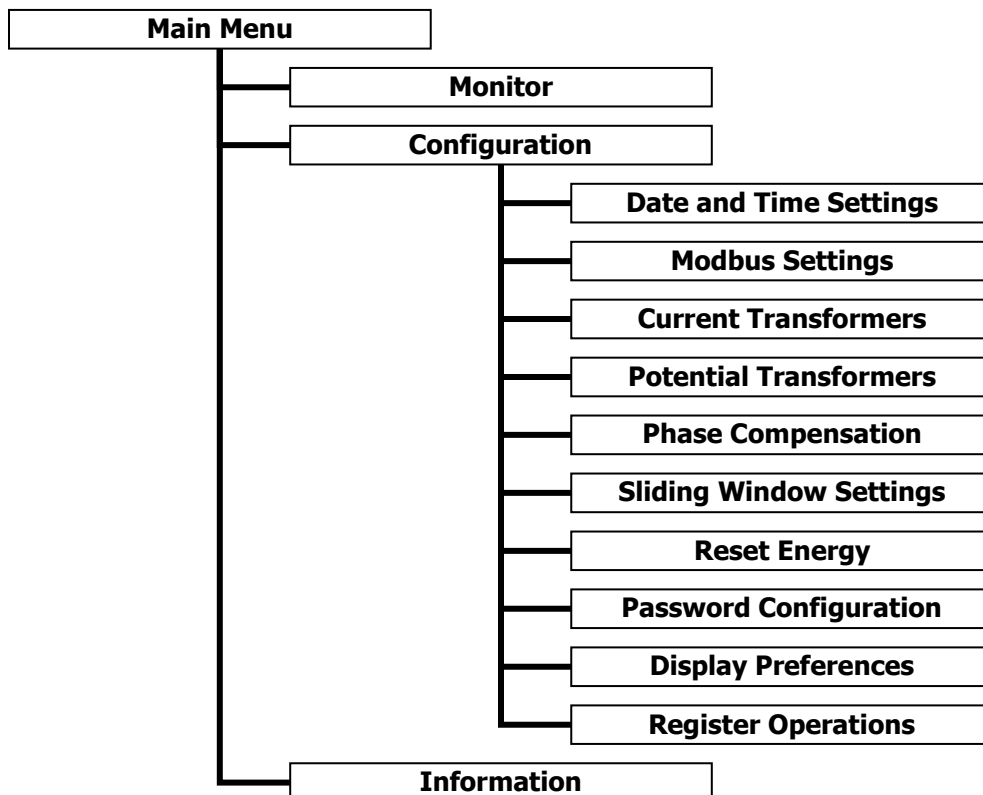
4.1.2. Navigating Menus

Pressing the Back/Menu button from the default monitoring screen shows the main menu. While in a menu, a triangular cursor is shown on the left-hand side of the screen, indicating which menu item is currently selected. If more than three menu items are available, a scroll bar is shown on the right-hand side of the screen, indicating the position within the larger menu.



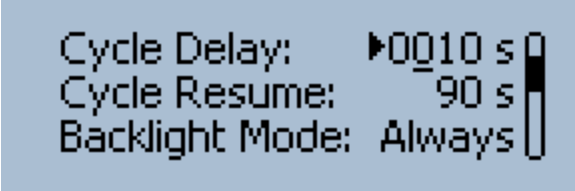
Pressing the Up / Down buttons moves the cursor to the next and previous menu items, respectively, and pressing the Forward / Enter button confirms the selection. Some menu items bring up sub-menus; pressing the Back/Menu button, leaves a sub-menu to go back to the previous menu.

A hierarchy of the menus on the device is shown below:



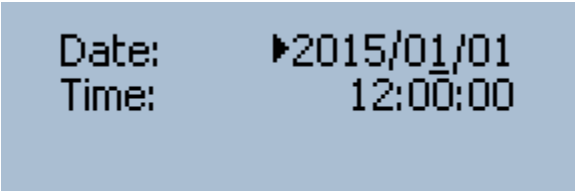
4.1.3. *Editing Numbers*

On several configuration screens, there are numerical parameters that can be changed. Pressing the Forward/Enter button will begin editing a numerical value. Use the Back/Menu and Forward/Enter button to move left and right, respectively, to select which digit to change. The currently selected digit is indicated with a line underneath the digit. Use the Up and Down buttons to change that digit to a higher or lower value, respectively.



Cycle Delay: ▶0010 s
Cycle Resume: 90 s
Backlight Mode: Always

When the number shows the desired value, press the Forward/Enter button from the right-most digit to finish editing the number. In the case of numbers with multiple parts, such as the date, time, or CT/PT ratios, this will instead move to the next part of the number (such as from the year to the month, etc.). Press Forward/Enter from the right-most part to finish editing.



Date: ▶2015/01/01
Time: 12:00:00

HINT: individual digits which form larger numbers interact with each other. Changing a specific digit will increment or decrement the entire formed number by the appropriate digit placeholder (ie: thousands, hundreds, tens, ones). That is: decrementing an individual digit, enacts the change on the entire number group.

Example 1: Suppose that the "Cycle Delay" parameter is being edited as in the above image. If the initial value is "0010", selecting the "ones" digit and decrementing by one, will change the entire number to "0009". Subsequently, sequentially incrementing "0009" in the ones place, will display "0010", "0011", "0012", and so on.

Example 2: If a "CT Ratio" is being set, and a target value of "7498" is desired, it is possible to set the "thousands" digit to "7", the "hundreds" digit to "5". At this point, "7500" will be entered. By scrolling to the "ones" digit and pressing down twice, the value will be set to "7498".

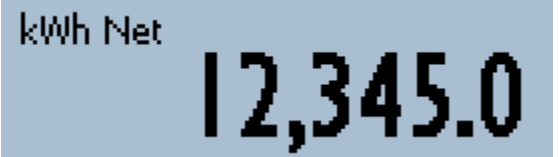
4.2. Monitoring

4.2.1. Cycling Mode (Default)

By default, the display will cycle through various parameter pages. The pages show the name and value of several electrical quantities which the WattsOn-Mark II is monitoring. The default configuration of parameter pages is as follows:

- kWh Net
- Real Power (kW)
- Power Factor Average
- Frequency (Hz)
- Amps A, B, C
- Volts A, B, C
- Volts AB, BC, AC
- kW A, B, C
- kVAR A, B, C
- kVA A, B, C
- Power Factor A, B, C

Pages showing a single parameter, such as the kWh Net parameter, show the parameter's name (and units, if applicable) at the top of the screen and the numerical value at the bottom. Some parameters also display additional information in the lower-left hand corner of the screen; see **1.1.1(ii), Supplemental Information** (p. 16), below.



Pages showing multiple parameters, such as the per-phase current parameter, display them in a short list, with the parameter names on the left and the values on the right.



(i) Controls

By default, the display shows each of the above parameter pages for 10 seconds before cycling to the next one. The user can also cycle through pages by using the Up and Down buttons. If either button is pressed, the display will not return to automatically cycling for 90 seconds (by default). This behaviour can be changed if desired from the Display Preferences screen, described in section **4.3.10, Display Preferences** (p. 23).

Pages can be added or removed from the list using from a PC via Modbus; See **Chapter 4.4, Customizing the Display** (p. 25).




Pressing either the Back/Menu button or the Forward/Enter button from this screen brings up the main menu.

(ii) Supplemental Information

Several parameters show additional supplemental information in the lower-left corner of the screen when in cycling mode. These parameters and the supplemental information they display is described below. Some of these parameters are not shown in the default cycling list, but may be added by the user if desired; see **Chapter 4.4, Customizing the Display** (p. 25) for information on adding parameters to the list.

(iii) Power Factor, A, B, C and Average

Three icons are displayed in the lower-left hand corner of the power factor pages. Their meanings are as follows:

- | | |
|--|---|
|  | Quadrant 1, Quadrant 2, Quadrant 3, Quadrant 4 (respectively) |
|  | Inductive, Capacitive (respectively) |
|  | Lagging, Leading (respectively) |

(iv) Frequency

An icon is displayed in the lower-left hand corner of Frequency pages indicating which voltage phase the frequency is being measured on. V_A indicates the first voltage line from the left, V_B indicates the second, and V_C indicates the third.

(v) *Line-to-Line Voltage AB, BC, AC and Average*

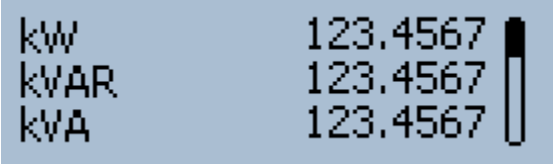
The phase angle between the two voltage lines is displayed in the lower-left hand corner of the line-to-line. For the line-to-line voltage average parameter, the average of the phase angles between phases AB, BC, and AC is displayed.

4.2.2. *List Mode*

If a more complete list of electrical parameters is desired, the display can be configured to show all parameters in a list according to categories.

In list mode, all electrical parameters are available across 4 lists. The lists are as follows:

- Real-Time Summary Parameters
- Accumulated Summary Parameters
- Real-Time Per-Phase Parameters
- Accumulated Per-Phase Parameters



kW	123.4567
kVAR	123.4567
kVA	123.4567

To enable list mode, do the following:

1. From the default screen, press the Back/Menu button to enter the main menu.
2. Press Down to select Configuration, then press Forward/Enter to enter the sub-menu.
3. Press Down until the cursor reaches Display Preferences, then press Forward/Enter to enter the sub-menu.
4. Monitor Mode is the first field. Press Forward/Enter to toggle the field from Cycling to List mode.


A list can be scrolled by using the Up and Down buttons. The next list can be selected by using the Forward/Enter button, and the previous list can be selected by using the Back/Menu button. To go to the main menu, press the Back/Menu button from the first list, or the Forward/Enter button from the last list.

List mode always displays all electrical parameters – they can not be added or removed.

4.3. Configuration

4.3.1. Configuration Menu

Various aspects of the meter or the display itself can be configured through the display's menu interface. The main menu can be accessed from the default screen by pressing the Back/Menu button. From the main menu, press Down to select Configuration, and then press Forward/Enter to enter the configuration menu. The following items can be configured from the configuration menu:



Monitor
▶ Configuration
Information

- Date and Time Settings - For setting the time and date
- Modbus Settings - For changing serial port settings such as Modbus address, baud rate, etc.
- Current Transformers - For entering the ratios of the current transformers used with the meter
- Potential Transformers - For entering the ratios of the potential transformers used with the meter (if any)
- Phase Compensation - For compensating for inherent phase shift errors present in transformers
- Sliding Window Settings - For configuring the sliding window demand power parameter
- Reset Energy - For resetting the resettable energy registers to zero
- Password Configuration - For locking the meter against unwanted access with a passcode
- Display Preferences - For customizing the appearance and behaviour of the display screen
- Register Operations - For directly accessing the underlying Modbus registers of the meter

Use the Up and Down buttons to move the cursor to any of the menu items listed above, and use the Forward/Enter button to confirm your selection. This will open up a sub-menu as described in the sections below.

4.3.2. Date and Time Settings

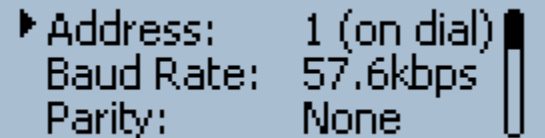
The date and time are used for data logging, and can also be displayed on screen. The date is displayed in the international *yyyy/mm/dd* format (four digit year, two digit month, two digit day) format. The time is displayed in 24-hour format, with hours, minutes, and seconds. The date and time can be editing as described in section **4.1.3, Editing Numbers** (p. 15).



Date ▶ 2015/01/01
Time 12:34:56

4.3.3. Modbus Settings

The WattsOn-Mark II communicates using the Modbus protocol over an RS-485 serial line. The settings used by this device to communicate over the serial line can be configured on the Modbus Settings screen. The settings chosen on this screen must match the settings used by the master device that is reading the meter over Modbus, and any other devices also present on the Modbus line. The following settings can be configured on this screen:



▶ Address: 1 (on dial)
Baud Rate: 57.6kbps
Parity: None

- Modbus Address - Each device on the Modbus line must have a unique address
- Baud Rate - The speed at which the serial port communicates, in bits per second (bps)
- Parity Mode - An extra data bit can be added to each data byte to help ensure integrity
- Stop Bits - The amount of space in between each byte transmitted and received
- Delay - Minimum wait time in between receiving a message and transmitting a response

The WattsOn-Mark II defaults to the following settings:

Parameter	Value
Modbus Address	1
Baud Rate	9600 bps
Parity Mode	None
Stop Bits	1
Delay	0 ms

(i) Modbus Address

By default, the number shown on the WattsOn-Mark II's physical rotary switch is used as the Modbus Address, and it can not be changed using the display. However, when the rotary switch is set to "F" (15), any address (including addresses up to 247) may be configured using this display (or using Modbus). To change the Modbus address using the display, use the following procedure:

1. Use a screwdriver to turn the physical rotary switch on top of the WattsOn-Mark II to the "F" position
2. From the Modbus Settings screen, select Address with the cursor using the Up and Down buttons, and press the Forward/Enter button.
3. Edit the number as desired as described in section **4.1.3, Editing Numbers** (p. 15).

(ii) Baud Rate

The baud rate can be set to any baud rate from the following list of supported baud rates: 9600 bps (the default), 19.2 kbps, 28.8 kbps, 38.4 kbps, 48.0 kbps, 57.6 kbps, 115.2 kbps, and 230.4 kbps. The baud rate can be changed from the Modbus Settings screen by selecting Baud Rate with the cursor using the Up and Down buttons, and pressing the Forward/Enter button to scroll through the available baud rates until the desired baud rate is shown.

(iii) Parity Mode

Normally, the use of parity is unnecessary on a Modbus line, because data integrity is accomplished using a checksum as part of the Modbus protocol. However, if the use of a parity bit is desired or required for compatibility with other devices on the line, the parity mode can be set to none (default), even, or odd. To change the parity mode from the Modbus Settings screen, select Parity with the cursor using the Up and Down buttons, and press the Forward/Enter button to cycle through the available parity modes until the desired parity mode is shown.

(iv) Stop Bits

The number of stop bits can be set to 1 or 2. To change the number of stop bits from the Modbus Settings screen, select Stop Bits with the cursor using the Up and Down buttons, and press the Forward/Enter button to toggle the number of stop bits between 1 and 2.

(v) Delay

Some older Modbus master devices may have trouble receiving responses from the WattsOn-Mark II if they are sent too soon after the transmission was sent. To troubleshoot connectivity issues with such older devices, a delay from 0 to 1000 milliseconds can be set. To set the delay from the Modbus Settings screen, select Delay with the cursor using the Up and Down buttons, and press the Forward/Enter button. The number can be editing as described in **4.1.3, Editing Numbers** (p. 15).

4.3.4. Current Transformers

The WattsOn-Mark II is designed to be used with current transformers (CTs) to scale large current values down to proportionally smaller current values which can be safely measured by the meter. The turns ratio of the current transformers being used must be programmed into the meter in order for the meter to report real-world current, power, and energy values.

Current transformer turns ratios can be programmed either identically or individually per channel. This enables the use of different CTs (of the same output type) per phase, or the ability to compensate for CT part-to-part differences to achieve higher accuracy (see below).

Select the Phases menu item and use the Forward/Enter button to toggle "Identical CTs" or "Different CTs" as desired.

Refer to the CT documentation for the turns ratio. Common mA output CT Ratios are listed below.

Phases: Identical CTs
 ▶ CT Turns: 2500:1
(mA Input Version)

Phases: Identical CTs
 ▶ CT Turns: 600A:333mV
(mV Input Version)

Phases: Identical CTs
 ▶ CT Turns: 800:5
(5A Input Version)

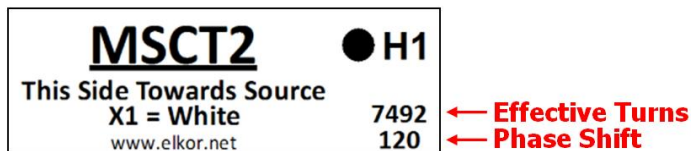
mV Current Transformer	Number of Turns
MCTA	2500:1
MCTB	4000:1
MS160	3000:1
MS240, MS360	2000:1
MRA/MRS-75, 125, 2x3	7500:1
MRA/MRS-3x5	10000:1
MSCT1, 2, 3	7500:1
MSCT5	11000
MS160	3000
MS360	2000

mV input (model -mA) meters require a conversion factor from Amps to millivolts, for example 200A:333mV. This indicates that 200A of current through the CT will create a 333 mV voltage on the output of the CT.

CT ratios can be edited as described in section **4.1.3, Editing Numbers** (p. 15).

Elkor CTs (such as the MS, MSCT and MRA Series) have their effective turns ratio and phase shift performance quantified and labelled at the factory. This data can be used to further enhance the metering accuracy by compensating for the CT performance.

A typical CT label is shown below. The values on the lower right of the CT represent the Effective Turns ratio (top), and the effective phase shift (bottom). The phase shift value is measured in 1/100th of a degree (therefore "120" represents 1.20° of phase shift).



NOTE: Older Display versions of the -mA meter model only showed one number for the CT ratio (ie: 2500 vs 2500:1)

HINT: If entering different CT ratios in each channel, it is permissible to enter the ratio using the "Identical CTs" settings first, and then changing the "Phases" setting to "Different CTs". By doing this the initial starting ratio will be set identically in all three phases, and it is thereby quicker to fine tune each ratio if required.

4.3.5. *Potential Transformers*

Potential Transformer (PT) ratios allow the device to scale the data to report the real-world voltage values on the input of the potential transformers. Because the WattsOn can accept up to 600V line-to-line voltage directly, potential transformers are often not required. In this case, PT ratios may be left at their default values of 1:1.

```
Phases:      Identical PTs
▶ PTs:       1:1
```

Potential transformer ratios can be programmed in either globally for all three channels or individually with different values for each channel. Select the Phases menu item and use the Forward/Enter button to toggle Identical CTs or Different CTs as desired. Setting Different CTs allows different values to be entered for each of the three phases, while using Identical CTs will use the same value for all three phases.

PT ratios can be edited as described in section **4.1.3, Editing Numbers** (p. 15).

4.3.6. *Phase Compensation*

Most current transformers have an inherent phase shift. This causes inaccuracies in power measurements as the power factor decreases. If the phase shift of a particular type of CT is known, the WattsOn can compensate for this phase shift either globally or per-phase.

```
Phase Shifts:  Identical
Phase Shift:   ▶ +063
```

The Phase Compensation values are entered into the LCD as they are displayed on the CT label. Refer to **4.1.3, Editing Numbers** (p. 15).

Phase compensation values are measured and labelled as an integer value representing 1/100th of a degree. Therefore, a value of "63" represents an effective phase shift of "0.63°".

NOTE: Older LCD firmware versions used a degree representation (ie: 0.63°), while newer versions use an integer representation as per the CT label (ie: 63). If the displayed number shows a degree symbol ("°"), then you must divide the CT label number by 100 and enter it as a decimal number.

4.3.7. *Sliding Window Settings*

The WattsOn can measure the average power over an arbitrary interval of time, called demand power. The interval length can be programmed in seconds to any value between 1 and 65,535 seconds. Typical values are 1 minute (60 seconds), 5 minutes (300 seconds), 10 minutes (600 seconds), 15 minutes (900 seconds), 30 minutes (1800 seconds), 1 hour (3600 seconds), or any arbitrary value expressed in seconds.

```
Sub-Intervals
▶ Length:      60s
Count:        1
```

In addition, the WattsOn can be configured to measure sliding window (also called rolling demand) power. In this case, the time interval is divided into several sub-intervals. The average power over the full interval is updated each sub-interval. This device can be configured for up to 60 sub-intervals. The interval length is equal to the sub-interval length times the number of sub-intervals. If sub-intervals are not needed, set the sub-interval count to 1.

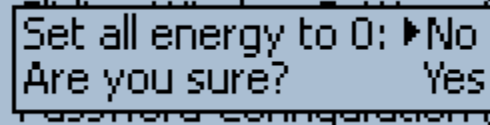
Example 1: To configure the device to record the average power over 15 minute intervals, set the Length field to 900 (15 minutes × 60 seconds) and the Count field to 1. Every 15 minutes, the *Sliding Window Power* registers will update with the average power over the previous 15 minutes.

Example 2: To configure the device to record the average power over 15 minute intervals, updating every 5 minutes, set the Length field to 300 (5 minutes × 60 seconds) and the Count field to 3 (15 minute intervals ÷ 5 minute sub-intervals). Every five minutes, the *Sliding Window Power* registers will update with the average power over the previous 15 minutes.

4.3.8. Reset Energy

To reset the resettable accumulated data registers to 0, perform the following procedure:

1. Select the Reset Energy menu item with the cursor using the Up and Down buttons, and press the Forward/Enter button to confirm your selection.
2. The display will prompt you to confirm. Press the Down button to move the cursor to "Yes", and press the Forward/Enter button the reset the energy.



Set all energy to 0: No
Are you sure? Yes

Note that the meter keeps a permanent record of all energy accumulated even if the meter is reset. By default, the energy displayed on the meter incorporates any resets. If desired, the display can be configured to display total accumulated energy despite any resets; see **Chapter 4.4, Customizing the Display** (p. 25) for details on this procedure.

4.3.9. Password Configuration


The WattsOn-Mark II features a password protection system. The device can be locked to prevent energy from being reset or any settings from being changed (with the exception of settings in the Display Preferences menu).



Set/Change Password
Status: Unlocked

(i) Editing Passwords

A password is a number from 1 to 99,999,999, entered one digit at a time. To change a digit, use the Up or Down buttons to increase or decrease it by 1, respectively. To add a digit, press the Forward/Enter button to move to the next position, and use Up and Down to select a digit. To move back to a previous digit, use the Back/Menu button. To finish, select the ↵ symbol on the right-most digit. To cancel, press Back/Menu on the left-most digit.



Enter new password:
123456

(ii) Setting a Password

1. From the main menu, select Configuration, and then Password Configuration.
2. Select Set/Change Password with the cursor, and use the Forward/Enter button to confirm your selection.
3. Enter a password as described above in section 3.9.1.
4. Re-enter the same password, as above, to confirm the password.
5. Confirm that the Status field now reads "Locked."

Once a password is set, attempting to change any setting will present a prompt to enter the password. After the correct password has been entered, the device has been unlocked, and will remain unlocked until 10 minutes of inactivity has passed, or until the device is either manually locked again or rebooted, whichever comes first. To permanently unlock the device, see *(v) Removing Password Protection*.

(iii) Manually Locking the Device (if a password has previously been set)

1. From the main menu, select Configuration, and then Password Configuration.
2. Select Status with the cursor, and use the Forward/Enter button to change "Unlocked" to "Locked."

(iv) Changing the Password

1. From the main menu, select Configuration, and then Password Configuration.
2. Select Set/Change Password with the cursor, and use the Forward/Enter button to confirm your selection.
3. The display will present a prompt for the password. Enter the correct password to unlock the device.
4. Now that the device is unlocked, select Set/Change Password once again.
5. Enter a password as described above in section 3.9.1.
6. Re-enter the same password, as above, to confirm the new password.
7. Confirm that the Status field now reads "Locked."

(v) Removing Password Protection

Perform the procedure described in (iii) Changing the Password, above, but enter "0" as the new password.

4.3.10. Display Preferences

A number of preferences related to the screen itself can be configured from this page. Some settings are not shown if they are not applicable for the given configuration. The following is a list of parameters that can be changed from this page:

- Monitoring Mode - Which screen style to use when displaying electrical parameters, either Cycling or List
- Auto-cycling - When in Cycling mode (above), automatically move to the next parameter after some time
- Cycle Delay - When in Cycling mode (above), how long to wait before moving to the next parameter
- Cycle Resume - When in Cycling mode (above), how long to wait after a button is pressed to resume cycling
- Backlight Mode - Determines if the backlight should be always on, only after button presses, or never on.
- Backlight Time - When Backlight Mode is set to "Button," how long the backlight is on after a button is pressed
- Contrast - Higher values show darker text, lower values show lighter text
- Digit Grouping - Symbol used to group sets of three digits, for various American, European, and SI styles
- Decimal Symbol - Symbol used as the decimal point, either a period or comma

(i) Monitoring Mode

The monitoring mode determines how the electrical parameters are displayed on the screen when the meter powers on or when "Monitor" is selected from the main menu. There are two modes available:

- Cycling (default): Displays single parameters or groups of three parameters on a single page, and cycles between different pages showing different parameters.
- List: Displays all electrical parameters in lists grouped according to categories.

Pressing the Forward/Enter button while Monitoring Mode is selected toggles between the two modes. For details on the two modes, see **Chapter 4.2, Monitoring** (p. 16).

(ii) Auto-cycling

This field is only displayed when the monitoring mode, described above, is set to Cycling. When the box is checked, the parameter pages will automatically cycle from one to the next without any user interaction. If the box is unchecked, the parameter pages will only cycle when with the Up and Down buttons are pressed. The default value is checked. Press the Forward/Enter button while this field is selected to toggle auto-cycling on and off.

(iii) Cycle Delay

This field is only displayed when Auto-cycling, described above, is checked. This field determines the number of seconds each parameter page is displayed before automatically cycling to the next one. Any value from 1 to 3600 (one hour) can be set. The default value is 10 seconds. This field can be edited as described in section **4.1.3, Editing Numbers (p. 15)**.

(iv) Cycle Resume

This field is only displayed when Auto-cycling, described above, is checked. This field determines the number of seconds each parameter page is displayed after the pages have been manually cycled by the user. Any value from 1 to 3600 (one hour) can be set. The default value is 90 seconds. This field can be edited as described in section **4.1.3, Editing Numbers (p. 15)**.

(v) Backlight Mode

This field determines when the backlight turns on. There are three backlight modes available:

- Button (default): The backlight turns on whenever a button is pressed, and remains on for an amount of time determined by the Backlight Time parameter, described below.
- Always: The backlight is always on.
- Off: The backlight is always off.

Pressing the Forward/Enter button while Backlight Mode is selected cycles between the three modes.

(vi) Backlight Time

This field is only displayed when Backlight Mode, described above, is set to "Buttor". This field determines the number of seconds that the backlight remains on after a button has been pressed. Any value from 1 to 3600 (one hour) can be set. The default value is 90 seconds. This field can be edited as described in section **4.1.3, Editing Numbers (p. 15)**.

(vii) Contrast

This field determines the display's contrast setting. Any value from 0 to 9 can be set. Changes take effect immediately. The default value is 6. This field can be edited as described in section **4.1.3, Editing Numbers (p. 15)**.

(viii) Digit Grouping

This field determines how numbers are grouped into sets of three digits on the electrical parameter pages. Different parts of the world use different conventions when displaying numbers. Press the Forward/Enter button while Digit Grouping is selected to cycle through the available styles. The following table describes the supported styles:

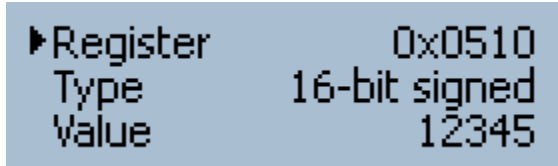
Grouping Style	Symbol	Example
None		1234567
Space		1 234 567
Comma	,	1,234,567
Period	.	1.234.567
Apostrophe	'	1'234'567

(ix) Decimal Symbol

This field determines which symbol is used as a decimal separator to distinguish the integer part from the fractional part of a number on the electrical parameter pages. Either a period (.) or a comma (,) may be used. Press the Forward/Enter button while Decimal Symbol is selected to toggle between a period and a comma.

4.3.11. Register Operations (advanced)

This page allows direct access to the WattsOn-Mark II's Modbus registers. These registers are described in detail in **Section 6, The Modbus Protocol** (p. 34). This page can be used to read or configure aspects of the WattsOn-Mark II that does not have a built-in graphical user interface available in the display. There is not normally any need to use this page, but it may be useful in certain specific situations.



The register address (as found in **Section 6, The Modbus Protocol**, on page 34) can be entered in hexadecimal format in the first field, as described in section **4.1.3, Editing Numbers (p. 15)**. Note that hexadecimal digits A to F, representing 10 to 15, are available in this field. Pressing Forward/Enter while Type is selected will cycle through the available data types. The data type should match the type described for the register you are accessing as described **Section 6, The Modbus Protocol** (p. 34). The following types are supported:

- 16-bit Signed
- 16-bit Positive (unsigned)
- 32-bit Signed
- 32-bit Positive (unsigned)
- 32-bit Decimal (floating-point)

Once the register address and type are chosen, the register's value is displayed in the third field. If there is no register at this address, a 0 is displayed. If the value is writable, it can be edited as described in **4.1.3, Editing Numbers (p. 15)**. If not, any writes to the register will be ignored and the field will return to its previous value when leaving the field.

4.4. Customizing the Display

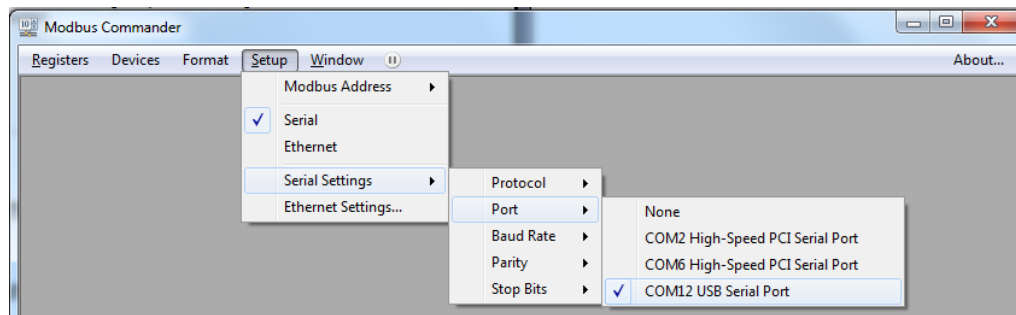
4.4.1. Introduction

The electrical parameters shown on the display's main screen can be customized to suit a particular application with a Windows PC connected to the WattsOn-Mark II, either via a USB-to-RS485 cable or an Ethernet/Wi-Fi gateway device. Display configuration files can be created with the free version of the Modbus Commander application, available from Elkor's website at <http://www.elkor.net>.

4.4.2. Getting Started

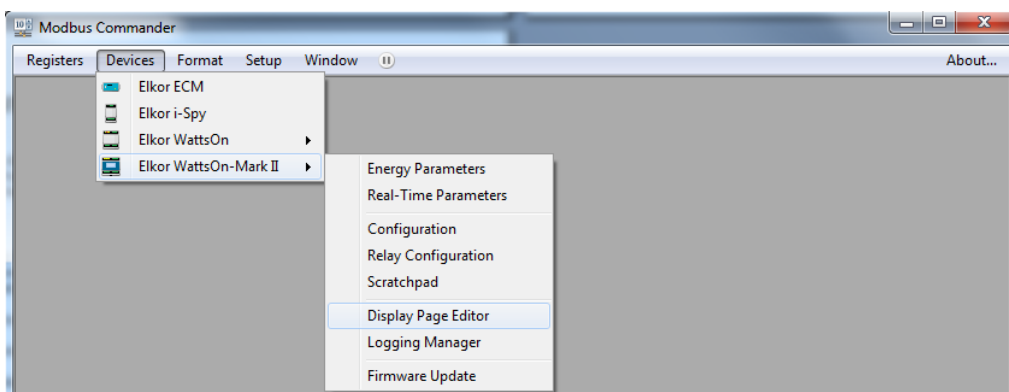
To connect to the WattsOn-Mark II via Modbus Commander, follow the procedure outlined below. The procedure assumes that the WattsOn-Mark II is connected to a PC via a USB-to-RS485 converter using default settings, but it is possible to connect using serial, Ethernet, or Wi-Fi with a variety of settings.

2. Download Modbus Commander from Elkor's website, <http://www.elkor.net>.
3. Run the installer for Modbus Commander to install the program onto your computer.
4. Run the application from the desktop shortcut created by the installer.
5. Select the serial port on which the WattsOn is connected by selecting Setup → Serial Settings → Port, and clicking on the appropriate port (see screenshot below).



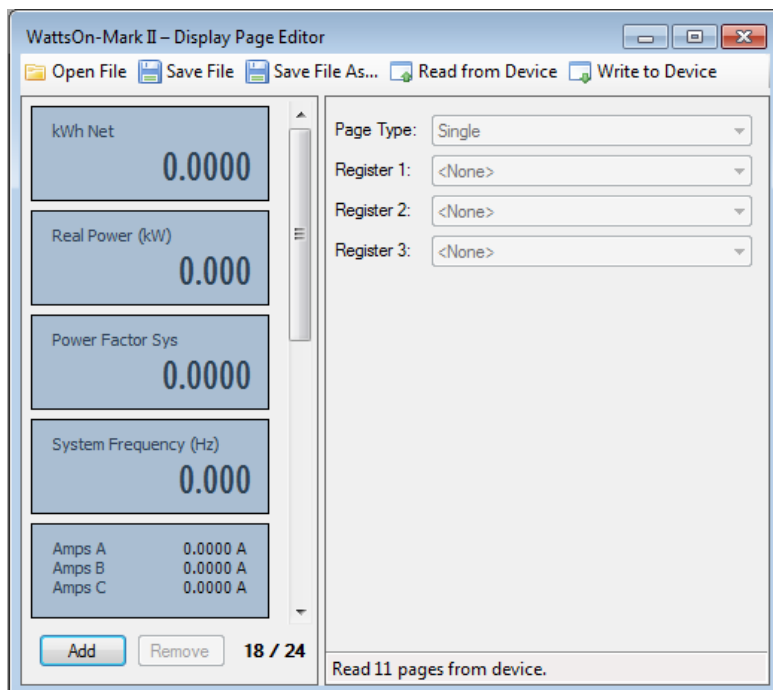
If the appropriate serial port is not obvious from its name, the Windows Device Manager can be used to determine the correct port. Otherwise, simply try each port in sequence.

6. Open the WattsOn-Mark II Display Page Editor by clicking on Devices → Elkor WattsOn-Mark II → Display Page Editor (see screenshot below).



4.4.3. *Editing Pages*

If the WattsOn-Mark II is connected correctly, the Display Page Editor will read the pages stored in the meter and display them in the interface. See the screenshot to the right.



(i) *Editing an Existing Page*

To edit an existing page, click on the desired page in the left-hand pane. From the selection boxes on the right-hand pane, it is possible to change the page type and the register(s) shown on the page. Available page types are as follows:

- Single Shows one register on a page using a large font.
- Triple Shows three registers on a single page using the standard font.
- Pixel Test Turns on all pixels of the display, useful for ensuring that no pixels are damaged before reading.

Single-type pages may have only one register. The register being displayed can be selected from the Register 1 selection box. Triple-type pages may have three registers, which can be selected from the Register 1, Register 2, and Register 3 selection boxes.

(ii) *Moving a Page*

To move a page, drag it to a new location in the list to move a page. While dragging, a thick blue line will show the new position the page will occupy when the mouse button is released.

(iii) *Adding a New Page*

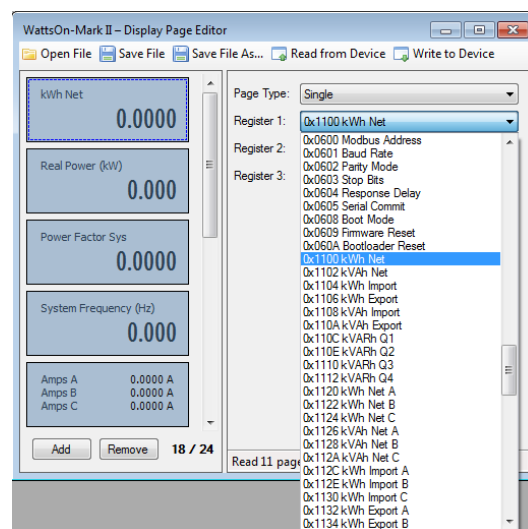
To add a new page, click the Add button in the lower-left hand corner of the window. The page can then be edited or moved as described above. A new page will be added to the bottom of the list. Up to 24 single pages or 12 triple pages can be added.

(iv) *Removing a Page*

Click on the desired page and click on the Remove button in the lower-left hand corner of the window to remove it.

(v) *Updating the Meter*

Once the desired changes are complete, click the Write to Device button in the upper-right hand corner of the screen to write the configuration to the WattsOn-Mark II. If the main monitor screen is currently shown on the meter's display, the monitor screen must be exited in order for the changes to take effect. To do this, press the Back/Menu button to enter the main menu, then press Back/Menu again to return to the main monitor screen.



4.4.4. Display Register Map

WattsOn-Mark II models with the display module add the following additional registers to the device register map. See Chapter 6, The Modbus Protocol (*FOR M1 AND E3/E4 MODELS*) (p. 34) for details on the Modbus protocol.

Name	Offset	Size	Type	R/W	Default	Description
Module ID	0x4000	128	S	R	"IDLM"	A string indicating the name of this module – the integrated display and logging module.
Backlight Mode	0x4016	32	U	RW	0	"0" for "On button press", "1" for "Always", and "2" for "Off".
Backlight Time	0x4017	32	U	RW	-	When the Backlight Mode is set to 0, the number of seconds the backlight stays on for.
Monitor Mode	0x401A	16	U	RW	0	"0" for "Cycling Mode", "1" for "List Mode"
Auto-cycling	0x401B	32	U	RW	1	When Monitor Mode is set to "0" (cycling mode), the display will automatically cycle through each page after a given amount of seconds (see Cycle Delay, below).
Cycle Delay	0x401C	32	U	RW	10	When Monitor Mode is set to "0" (cycling mode), and Auto-cycling is set to "1", the number of seconds to wait on each monitor page before moving to the next one.
Cycle Resume	0x401D	16	U	RW	90	When Monitor Mode is set to "0" (cycling mode). and Auto-cycling is set to "1", the number of seconds to wait after a button has been pressed before resuming automatic cycling.
Contrast	0x401E	16	U	RW	4	The number of "pages" in the log
Digit group separators	0x401F	16	U	RW	0	<p>Indicates the characters to use as a thousands separator, and as a decimal separator.</p> <p>"0" — No thousands separator, "." = decimal separator "1" — No thousands separator, "," = decimal separator "2" — Space = thousands separator, "." = decimal separator "3" — Space = thousands separator, "," = decimal separator "4" — "," = thousands separator, "." = decimal separator "5" — "," = thousands separator, "," = decimal separator (not recommended) "6" — "." = thousands separator, "." = decimal separator (not recommended) "7" — "." = thousands separator, "," = decimal separator "8" — "," = thousands separator, "." = decimal separator "8" — "." = thousands separator, "," = decimal separator</p> <p>This setting will not take effect until after the monitor page is exited and re-entered, or the device reboots. Optionally, "0xAA55" can be written to Modbus register 0x609 for a software reboot (see page 51 for details).</p>

5. BUILT-IN DATA LOGGING *(For M1 or E3/E4 models with the –DL option)*

5.1. Features

Some WattsOn-Mark II models contain an integrated logging module that can record historical data from any of its registers onto built-in Flash memory. The logging module features:

- Programmable battery-backed real-time clock for timestamps
- Freely configurable parameter selection for logging
- Logging frequency from 1 second to 18 hours
- Log downloadable via Modbus
- 2MB of storage space available for storing log entries

Data logging is supported on the M1 and E3/E4 models of the WattsOn-Mark II that have the display option (–DL is included in the part number). Built-in logging is not supported on the M2 or E2 models; an external third-party system would be required to read the meter and log data for such models.

5.2. Flash Memory

The logging module contains two megabytes of flash memory used for storing log entries. Flash memory has inherently limited write endurance; the memory used in the WattsOn-Mark II is guaranteed to sustain 100,000 complete writes (from beginning to end) before failing. Each time the log is erased, the flash memory is reset to its starting position. If frequent logging is expected, it is best to allow the log to stay in “continuous” mode, thereby overwriting old entries, and writing in a circular fashion to incorporate a simple “wear-leveling” mechanism.

5.3. Battery-backed Real-time Clock

The logging module contains a battery-backed real-time clock. The battery is rechargeable and should not need replacement. The clock must be set by the user before starting logging to obtain accurate timestamps. It can be set with the LCD display (if present), over Modbus (for M1 or E3/E4 models), or using the free version of Modbus Commander (also for M1 or E3/E4 models).

The clock contains a battery to allow the time to be retained despite power failures. The WattsOn-Mark II will retain the current time during a power failure of at least one month in duration. If the device is unpowered for longer than one month, check the device’s clock to see if it requires setting before starting a log. Note: the WattsOn-Mark II may require up to 48-hours to fully charge the battery if it has not been charged for a long time.

(vi) Setting the clock using the built-in display (if present)

If the WattsOn-Mark II model includes a display, it can be used to quickly set the time.

1. From the main screen, press the Back/Menu button to enter the main menu.
2. Use the Down button to select Configuration with the cursor, and press the Forward/Select button to confirm.
3. Press the Forward/Select button again to enter the Date and Time Settings screen.
4. Press the Forward/Select button to enter the date editor. Use the Up and Down buttons to increase or decrease a digit, and use the Back/Menu and Forward/Select buttons to move left and right between digits.
5. When finished editing the date, press the Forward/Select button until the cursor leaves the field.

See the WattsOn-Mark II Display Guide for details about using the display, editing numbers, and setting the time.

(vii) Setting the clock via Modbus Commander

1. Open the Logging Manager page, as described in section Error! Reference source not found., Error! Reference source not found. (p. **Error! Bookmark not defined.**).
2. Click the “Sync” button to use the program the current PC date/time into the unit. A date/time can also be manually entered into the Clock field, if a date/time different from the PC’s date/time is desired.

(i) Setting the clock via Modbus

The clock can be accessed as an unsigned 32-bit register at offset **0x4008** containing a standard UNIX timestamp; that is, it records the number of seconds that have elapsed since January 1st, 1970, at midnight. 32-bit registers are accessed as two 16-bit Modbus registers, in this case, **0x4008** containing the most significant two bytes, and **0x4009** containing the least significant two bytes.

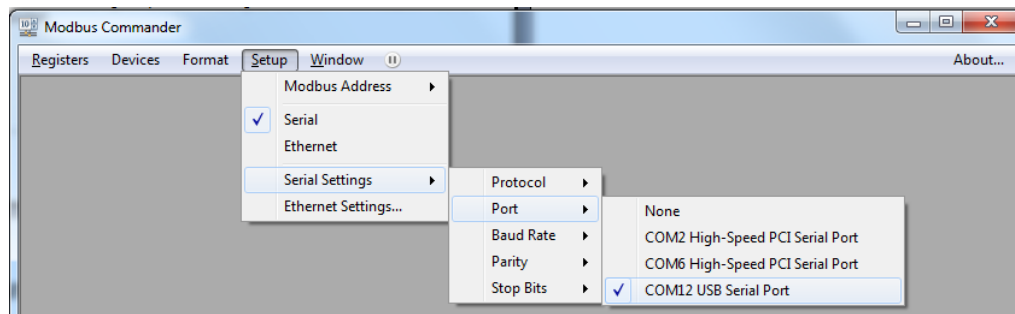
It is recommended that both registers be written with the same command, using Modbus Function *0x16 Write Multiple Registers*; otherwise, the most significant register should be written first, followed by the least significant register, to avoid any anomalies.

5.4. PC Interface

Logging features of the WattsOn-Mark II may be configured either using the Modbus protocol (for M1 models, see **Section 6, The Modbus Protocol**, on page 34), or with a Windows PC connected to the WattsOn-Mark II. A Windows PC can be connected to the WattsOn-Mark II in various ways, including a USB-to-RS-485 cable (for M1 and M2 models), over a local area network (for E3/E4 models), or through a gateway device such as the ETnet. Logging configuration can be done using the free version of the Modbus Commander application, available from Elkor's website at <http://www.elkor.net>.

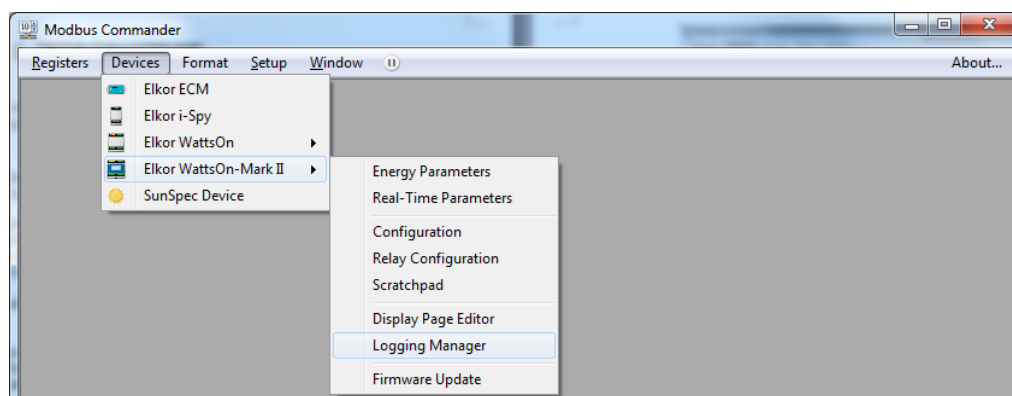
To connect to the WattsOn-Mark II via Modbus Commander, follow the procedure outlined below. The procedure assumes that the WattsOn-Mark II is connected to a PC via a USB-to-RS485 converter using default settings, but it is possible to connect using serial, Ethernet or Wi-Fi with a variety of settings.

1. Download Modbus Commander from Elkor's website, <http://www.elkor.net>.
2. Run the installer for Modbus Commander to install the program onto your computer.
3. Run the application from the desktop shortcut created by the installer.
4. Select the serial port on which the WattsOn is connected by selecting Setup → Serial Settings → Port, and clicking on the appropriate port (see screenshot below).



If the appropriate serial port is not obvious from its name, the Windows Device Manager should be used to determine the correct port.

5. Open the WattsOn-Mark II Display Page Editor by clicking on Devices → Elkor WattsOn-Mark II → Logging Manager (see screenshot below).



5.4.1. Configuring the Log

The WattsOn-Mark II can be configured to save any number of its registers at configurable intervals into a downloadable log file. The device can be configured to log until the Flash memory is full, or to log continuously, deleting the oldest entries as new ones are added. The procedure is described below.

(i) *Changing Logging Settings*

The majority of logging settings can only be changed while logging is disabled and there is no log saved on the device. If logging has not been used before, the settings can be changed immediately (proceed to section **5(i), Changing Logging Settings**).

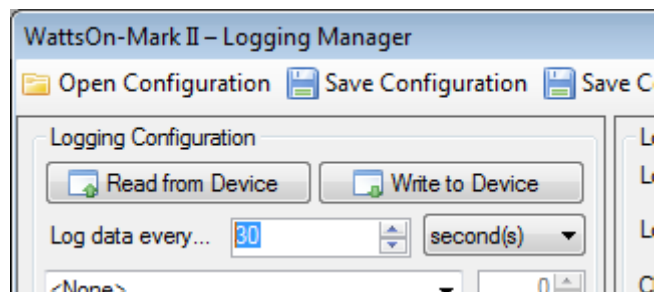
If logging is currently enabled, it must first be disabled before proceeding. Set the Logging Mode drop-down box to "Logging Disabled." The logging frequency can be changed whenever the log is disabled, regardless of whether there is a pre-existing log file saved on the device or not.

If a log has been saved on the device (i.e., the Log Size field reports something other than "No log on device"), it must be erased before the list of logged registers can be changed. If necessary, download the log first (see section **5.4.2, Downloading the Log**), and then click the "Erase" button to remove the log from the device. The other settings can now be edited as desired.

(ii) *Selecting Logging Frequency*

Choose the frequency at which to add entries to the log. The frequency can be set between once every second, up to once every 18 hours (64800 seconds). For a single register block, these times are accurate to ± 1 second.

To choose the logging frequency, enter a number into the field labeled "Log data every..." and select the appropriate units (seconds, minutes, hours) from the drop-down box to the right. In the example on the right, the logging frequency is set to once every 30 seconds.



The more frequently data is logged, the faster the space available to will be consumed.

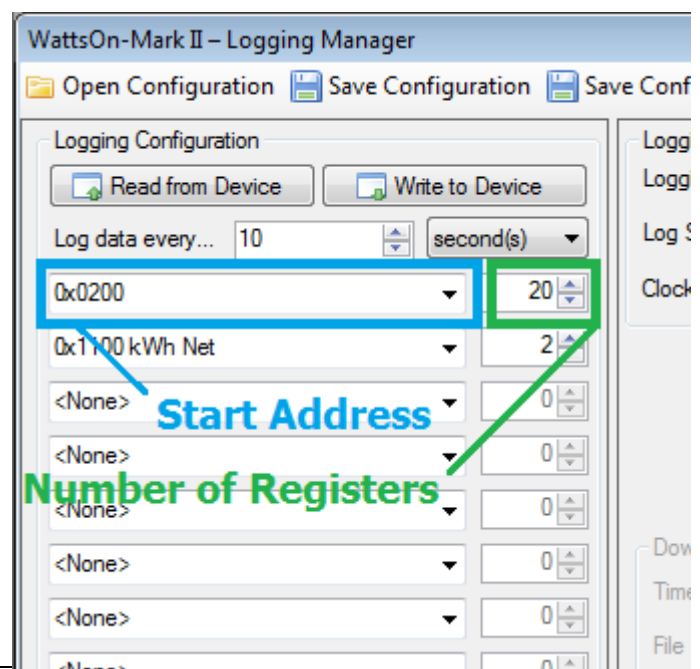
(iii) *Selecting Registers*

Any register on the WattsOn-Mark II can be logged. For a complete list of registers, see **Section 6, The Modbus Protocol** (p. 34).

Registers are grouped together into blocks for efficient reading. Up to sixteen blocks of registers may be configured for logging. Each register block may contain up to 125 registers each. A register block consists of a starting address and a number of registers in that block. Note that many of the WattsOn-Mark II parameters are 32-bits, meaning they occupy two registers in the register map.

Example 1: Suppose logging only the total active power is required. Total active power is a 32-bit register at offset **0x200**. Enter the starting address as **0x200** and the register count as **2**. The count is 2 because the register is a 32-bit register.

Example 2: Suppose logging all of the following parameters is required: Total active, reactive, and apparent power, voltage average, line-to-line voltage average, current average, system



power factor and frequency. All of these registers are in the same block and contiguous. Enter the lowest address of all of the registers in the block, which is **0x200** for total active power, and enter **16** for the register count. There are 8 registers in the list, and they are all 32-bit registers, so a count of 16 is required.

Example 3: Suppose logging both real power and net energy consumption is required. These registers are in different register blocks. For the first block, enter **0x200** and **2**, as in example 1. For the second block, enter **0x1100** for the starting address and **2** for the register count.

Register addresses can be entered manually, or selected from the drop-down list for convenience. The more registers selected for logging, the faster the space available will be consumed.

Once all of the desired register blocks are configured, click on the "Write to Device" button to send the log configuration to the WattsOn-Mark II device.

(iv) Selecting Logging Mode

To begin logging, a logging mode must be selected. The logging mode determines what to do when the log space is full. The two available modes are described in the table below:

Mode	Description
Overwrite Old Entries	Logging continues indefinitely. Once the flash memory used to store the log is full, old entries are overwritten.
Until Full	Logging stops when flash memory is full.

Select the desired Logging Mode drop-down box on the top-right hand side of the window. Once selected, logging begins.

If "Logging (unit log is full)" was selected, the drop-down box will automatically revert to "Logging Disabled" once the space has been completely filled. At that point, the log can be downloaded, erased, or the mode can be changed to "Overwrite Old Entries."

5.4.2. Downloading the Log

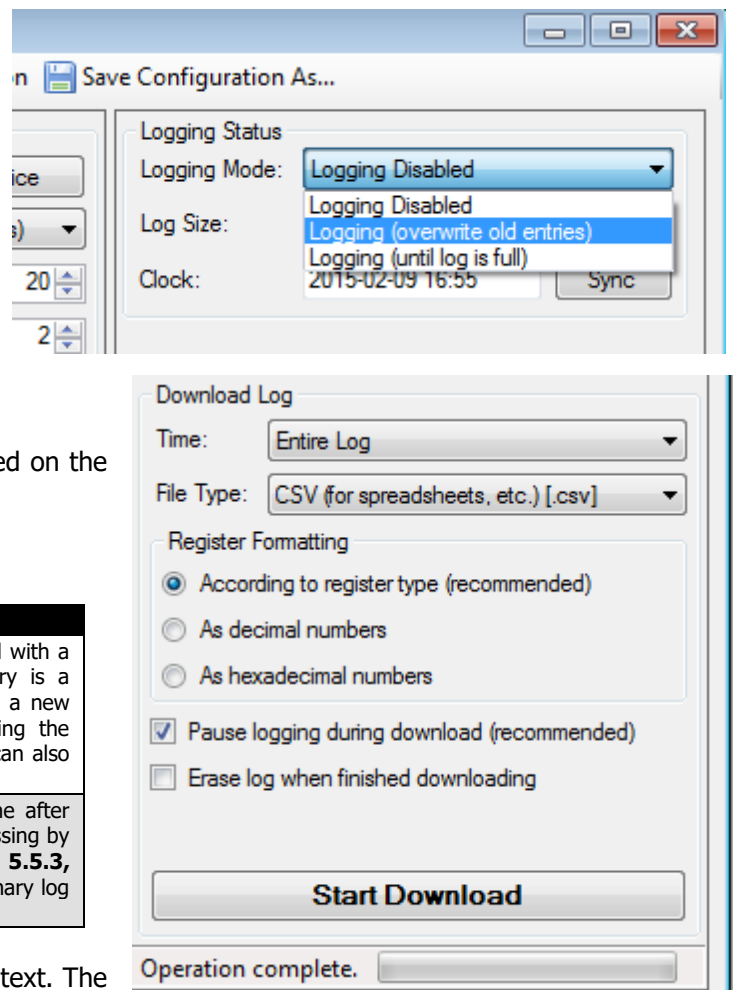
Once data has been logged, it can be easily downloaded to a PC using Modbus Commander (see screenshot on the right).

The Time field allows the log to be partially downloaded based on the timestamps of the log entries, and the current system time.

The log can be saved in two formats, described below:

File Type	Description
Comma-Separated Values (.csv)	Each value in the log entry is separated with a delimiter. The first value in each entry is a timestamp. Each entry is separated by a new line. This format is useful for importing the data into a spreadsheet program, and can also be easily read in a text editor.
Binary (.bin)	Each value is represented in binary one after another. This format is useful for processing by simple computer programs. See section 5.5.3, Log Format for a description of the binary log format.

When using CSV format, the register values are converted to text. The Register Formatting options determine how that process occurs. The three options are described as follows:



Register Formatting Option	Description
According to register type	The software will format each register value according to what kind of value the register represents. For example, both floating-point values and integer values will be converted appropriately. This is recommended.
As decimal numbers	All registers will be converted based on their raw values, represented as integers in decimal format.
As hexadecimal numbers	All registers will be converted based on their raw values, represented as integers in hexadecimal format.

When the settings have been configured as desired, click the Start Download button to begin downloading. Modbus Commander will ask for a directory to save the resulting file into, and then the log will be downloaded. This can take some time if the log is large.

5.5. Modbus Interface

The features of the logging module can also be accessed over the Modbus protocol on M1 models using the device's RS-485 port, or on E3/E4 models using the device's Ethernet port, or on the E4 model over Wi-Fi. See the **Section 6, The Modbus Protocol** (p. 34) for details on communicating using the Modbus protocol.

5.5.1. Logging Register Map

WattsOn-Mark II models with the logging module add the following additional registers to the device register map.

Name	Offset	Size	Type	R/W	Default	Description
Module ID	0x4000	128	S	R	"IDLM"	A string indicating the name of this module – the integrated display and logging module.
Clock	0x4008	32	U	RW	-	The battery-backed real-time clock value, expressed as the number of seconds since January 1 st , 1970, at midnight (a standard UNIX timestamp).
Entry Count	0x400A	32	U	R	-	The number of entries in the log.
Entry Length	0x400C	16	U	R	-	The number of registers occupied by a single entry in the log.
Log Space Used	0x400D	32	U	R	-	A percentage indicating how much space in the log is used. A value of 10000 represents 100.00% full.
Logging Frequency	0x400E	32	U	RW	-	How often to create a new log entry, expressed in seconds
Log Page	0x4010	16	U	RW	0	The "page" of the log currently available at register 0x4010.
Log Page Count	0x4011	16	U	R	-	The number of "pages" in the log
Approximate Entries per Page	0x4012	16	U	R	-	An approximate count of the number of entries per page. If 250 is not a multiple of the entry length, a page may also contain a partial entry.
Logging Mode	0x4013	16	U	RW	0	"0" for "Disabled," "1" for "Log Continuously," and "2" for "Log Until Full."
Log Full	0x4014	16	B	R	-	Indicates whether the log is completely full.
Wipe Log	0x4015	16				When 0xA5A5 (42,405) is written to this register, the log is completely erased.
Reserved	0x4016	-	-	R	-	Reserved for future use. These registers output "0" when read. To ensure compatibility with future versions, these registers should not be written to.
...						
Reserved	0x401F	-	-	R	-	
1st Block Offset	0x4020	16	U	RW	0	Register offset of the first register in the first block to be logged.
1st Block Length	0x4021	16	U	RW	0	Length of the first block to be logged.
2nd Block Offset	0x4022	16	U	RW	0	Register offset of the first register in the second block to be logged.
2nd Block Length	0x4023	16	U	RW	0	Length of the second block to be logged.
16th Block Offset	0x403E	16	U	RW	0	Register offset of the first register in the last block to be logged.
16th Block Length	0x403F	16	U	RW	0	Length of the last block to be logged.

5.5.2. Downloading the Log

The log is broken up into "pages" of 250 registers each. The raw binary data in the currently selected page is available in registers 0x4100 to 41FA. The page can be selected by writing to the *Log Page* register at address 0x4010. The algorithm for reading the entire log is outlined below:


```

page ← 0
entries ← read 2 Modbus registers at 0x400A
size ← read 1 Modbus register at 0x400C
remaining ← entries × size
file ← open binary file

loop while remaining > 0
  write page to Modbus register at 0x4010

  count = min(remaining, 125)
  remaining = remaining - count
  data = read count Modbus registers at 0x4100
  append file with data

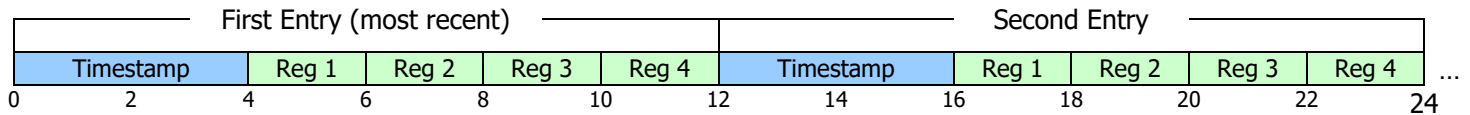
  count = min(remaining, 125)
  remaining = remaining - count
  data = read count Modbus registers at 0x417D
  append file with data

page = page + 1

```

5.5.3. Log Format

The log is composed of a sequence of entries, with the most recent entry first. Each entry is a series of bytes. The first four bytes represents the timestamp of the entry, and the remaining bytes represent each register that was chosen to be logged, in order. Each register requires at least 2 bytes, though many of the registers available in the WattsOn-Mark II require 4 bytes (such as all of the electrical parameters). Below is an example in which 4 registers have been logged.

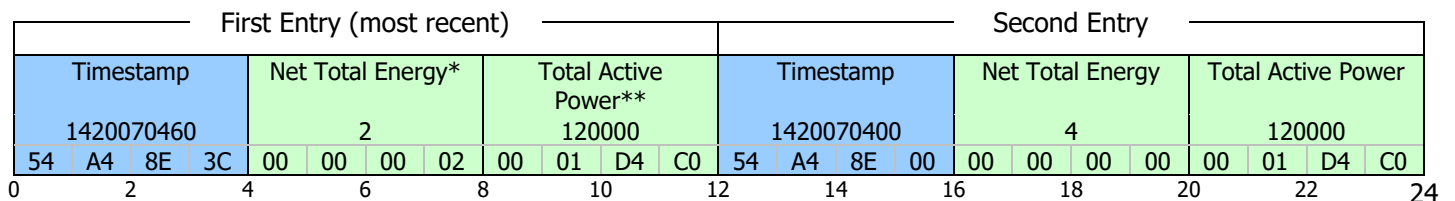


5.5.4. Example Configuration

For example, suppose the device is configured to log two parameters, the *Net Total Energy* (register **0x1000**) and the *Total Active Power* (register **0x100**), every 1 minute. To do this, the following registers are set to the values indicated in the table below. For this example, the 32-bit integer versions of the registers are used.

Register	Offset	Value	Notes
Logging Frequency	0x400E	60	Represented in seconds.
1 st Block Offset	0x4020	0x1000	Address of the first (and only) register in the block, <i>Net Total Energy</i> .
1 st Block Length	0x4021	2	Length of the block. Because <i>Net Total Energy</i> is 32 bits long, 2 registers are required.
2 nd Block Offset	0x4022	0x100	Address of the first (and only) register in the block, <i>Total Active Power</i> . This register is not continuous with the previous register, 0x1000, so two separate blocks are required.
2 nd Block Length	0x4023	2	Length of the block. Because <i>Net Total Energy</i> is 32 bits long, 2 registers are required.

Suppose that logging is started at January 1st, 2015, at midnight. At this time, the total active power is a constant 12 kW, and no energy has accumulated previously. The log is started by writing a "1" to the *Logging Mode* register at address **0x4013**. After one minute has passed and the log is downloaded, it will be in the format illustrated below. For each parameter, its name is given, followed by the decimal value of the parameter on the next line, followed by the value of each individual byte (shown in hexadecimal) on the last line.



* In this example, Net Total Energy assumes an energy divider setting of 100, thereby the integer energy registers have a resolution of 100Wh. When Net Total Energy shows "2" in this case, it represents an accumulation of 200 Wh (12 kW after 1 minute)

** Total Active Power has a resolution of 0.1W, therefore when Total Active Power shows 120,000, it represents a value of 12,000.0 W

6. THE MODBUS PROTOCOL (For M1 and E3/E4 models)

6.1. Protocol Overview

The WattsOn M1 and E3/E4 models communicate using Modbus, a communication protocol over either an RS-485 port, an Ethernet network, or a Wi-Fi network. When using RS-485, the protocol is called Modbus RTU; over Ethernet or Wi-Fi, it is called Modbus TCP. These protocols are used by various PC applications, PLCs, data logging devices, and other Modbus "master" devices, which can read data from the WattsOn. The WattsOn is defined as a Modbus "slave" device (sometimes called a "server" in Modbus TCP), meaning that it responds to queries sent by the Modbus "master" device (or "client" in Modbus TCP).

A Modbus slave device defines blocks of "registers" that contain information, each with a particular address. Each register contains a 16-byte field of data which can be read by the master device. The registers defined by the WattsOn are described in section **7.3, BACnet Object List** (p. 61).

For technical details on the Modbus protocol, see **Appendix B, Modbus Protocol Details** (p. 86), or see the official Modbus Application Specification available for free from <http://www.modbus.org/specs.php>.

6.1.1. Modbus Functions

The WattsOn supports a number of different Modbus functions used to query the device or issue commands. Some Modbus software/devices require the user specify specific Modbus functions. Others are more sophisticated, and will automatically use the appropriate functions as needed, without requiring detailed knowledge of the Modbus protocol.

(i) Supported Functions

The WattsOn supports the following Modbus functions:

Function Name	Function Code	Description
Read Holding Registers	03 (0x03)	Reads the data contained in one or more registers (identical to function 04 on this device).
Read Input Registers	04 (0x04)	Reads the data contained in one or more registers (identical to function 03 on this device).
Write Register	06 (0x06)	Writes data to a single register.
Diagnostics	08 (0x08)	Return Query Data 00 (0x00)
		Clear Counters 10 (0x0A)
		Bus Message Count 11 (0x0B)
		Bus Comm Error Count 12 (0x0C)
		Bus Exception Count 13 (0x0D)
Slave Message Count 14 (0x0E)	The Diagnostics function is a series of sub-functions that assist in diagnosing communication problems. See Diagnostic Functions (below) for details on each one.	
Get Event Counter	11 (0x0B)	Reads a count of successful messages since power-on, excluding function 11 messages.
Write Multiple Registers	16 (0x10)	Writes data to one or more registers.
Report Slave ID	17 (0x11)	Returns various information used to identify this device. See Slave ID (below).
Write Mask Register	22 (0x16)	Modifies data in a single register based on an OR mask and an AND mask.
Read/Write Registers	23 (0x17)	Writes data to one or more registers, and then reads data from one or more registers.
Read Device ID	43 (0x2B)/14 (0x0E)	Reads various text strings giving device parameters. See Device ID (next page).

(ii) Diagnostic Functions

The WattsOn implements various diagnostic functions to assist in verifying and diagnosing communication problems. The Diagnostic function is divided into a number of sub-functions each identified by a sub-function code. The following table summarizes the diagnostic sub-functions implemented by this device.

Description	Sub-Function	Description
Return Query Data	00 (0x00)	Sends dummy data to the device, which is then returned as-is. Used for testing communication.
Clear Counters	10 (0x0A)	Clears all counters associated with the communication system, including the Bus Message Counter, the Bus Comm Error Counter, the Bus Exception Counter, the Slave Message Counter, and the Event Counter (also used in function 11).
Bus Message Count	11 (0x0B)	Returns the number of messages that the device has detected since power-up. These messages were not necessarily valid or addressed to this device.
Bus Comm Error Count	12 (0x0C)	Returns the number of CRC errors detected by the device since power-up. The messages containing these CRC errors were not necessarily addressed to this device.
Bus Exception Count	13 (0x0D)	Returns the number of exception responses returned by this device since power-up.

Slave Message Count	14 (0x0E)	Returns the count of messages addressed to this device that were received since power-up.
---------------------	-----------	---

(iii) Slave ID

The WattsOn implements function 17, Report Slave ID, which returns three separate pieces of information. It returns an ID code identifying this particular device, a status code indicating if the device is running or not, and a null-terminated text string identifying this particular device.

Field	Data
ID Code	130
Status	0xFF (ON) when running normally, 0x00 (OFF) when in bootloader mode.
Text String	An ASCII text string containing the name of the product, its input configuration (mA, mV, or 5A), and its hardware and software version. The string is null-terminated, meaning a 0 is transmitted after the last character. For example, "Elkor Technologies W2-M1-mA Hardware 1.00 Firmware 1.00". While in bootloader mode, the string returned contains the bootloader version, for example, "Elkor Technologies Bootloader 1.00".

(iv) Device ID

The WattsOn implements the Read Device ID function, which provides access to various strings that identify various device properties. This is sub-function 14 (0x0E) of function 43 (0x2B), Encapsulated Interface Transport. The WattsOn implements this function at the highest Conformity Level of 0x83 (basic, regular, and extended identification, stream or individual access).

Each string, called an "object", is accessed with a number, called the object ID. The WattsOn defines the following objects, which can be read using this function.

Object	Object ID	Category	Value
VendorName	0 (0x00)	Standard (Basic)	"Elkor Technologies"
ProductCode	1 (0x01)	Standard (Basic)	"W2"
MajorMinorRevision	2 (0x02)	Standard (Basic)	The firmware version of the device, such as "1.00"
VendorUrl	3 (0x03)	Standard (Regular)	"http://www.elkor.net"
ProductName	4 (0x04)	Standard (Regular)	"WattsOn-Mark II"
ModelName	5 (0x05)	Standard (Regular)	The device's model name, for example, "W2-M1-mA"
UserApplicationName	6 (0x06)	Standard (Regular)	"Elkor Firmware"
HardwareRevision	128 (0x80)	Extended	The hardware version on the device, such as "1.00"
BootloaderRevision	129 (0x81)	Extended	The bootloader version on the device, such as "1.00"
SerialNumber	130 (0x82)	Extended	The serial number of the device, such as "12345"
DeviceID	131 (0x83)	Extended	130

6.1.2. Register Addressing Conventions

There are several different conventions for specifying the address of a particular register. Various conventions are used in different software programs, PLCs, and other devices. Three common conventions are described below.

- **Offsets:** Addresses are presented as hexadecimal numbers (shown with the "0x" prefix) with the first address starting at address 0. This is how addresses are transmitted digitally over the serial cable, and many software packages describe Modbus addresses.
- **PLC-style addresses:** Addresses are presented as 5-digit decimal numbers, starting with a "3" or a "4" indicating whether they are considered "input registers" which are read-only, or "holding registers" which are read-write (respectively). The first input register is defined as 30001, and the first holding register is defined as 40001. For ease of integration, this device treats both Holding Registers and Input Registers as identical; therefore, either 30000-based addresses or 40000-based addresses will work with the WattsOn, though only 40000-based addresses can be written to. Many PLCs and some other devices describe Modbus addresses in this manner.
- **Register numbers:** Addresses are presented as decimal numbers, with the first register defined as register 1. These are similar to the PLC-style addresses described above, without "3" or "4" prefix. Some software packages describe Modbus addresses in this manner.

Examples	
Offset:	0x0
PLC-style:	40001
Register No:	1
Offset:	0x10
PLC-style:	40017
Register No:	17
Offset:	0x200
PLC-style:	40513
Register No:	513

The address of each register is presented in the first two styles in this manual. The required convention that is used depends on the Modbus master software or device.

6.1.3. Register Size

Modbus registers are defined as each containing 16 bits of information. In this document, some registers are described as being 32-bits wide, rather than 16. In these cases, two consecutive registers are concatenated together in order to obtain the 32-bit value. Most modern Modbus software and hardware devices understand the notion of 32-bit registers, and will do this processing, provided the data is configured as a 32-bit register.

Example: Register **0x100** is a 32-bit register. Suppose a read of register **0x100** returns 0x0003, and a read of register **0x101** returns 0x0D40. Concatenate these two registers together to get a hexadecimal value of 0x00030D40, or a decimal value of 200,000.

By default, the higher-order 16-bit word of a 32-bit register is the register with the lower address, and the lower-order word is at the higher address. Most Modbus software and devices will interpret 32-bit registers this way. Alternatively, the WattsOn can be configured to reverse the byte ordering, so that the higher-order word is at the higher address, and the lower-order word is at the lower address. See **6.4.6, Setting 32-bit Endianness** (p. 46) for details on how to configure this setting.

6.1.4. Data Types

Registers contain data in one of four different types. Data types are given in the register tables with a single letter code in the "Type" column to indicate the type. The types are as follows.

Type	Code	Description
Unsigned Integer	U	Positive whole numbers (no sign). Can range from 0 to 65,535 for 16-bit registers, and 0 to 4,294,967,295 for 32-bit registers.
Signed Integer	S	Positive or negative whole numbers. Represented in 2's complement format. Can range from -32,768 to +32,767 for 16-bit registers and -2,147,483,648 to +2,147,483,647 for 32-bit registers.
Floating-Point	F	Positive or negative decimal numbers. Represented in IEEE 754 format. Can represent values from negative infinity to positive infinity, at decreasing levels of resolution as the number because larger.
Boolean	B	True or false. False is represented by the value 0, true is represented by the value 1.

6.2. Instantaneous Data Registers

Instantaneous data registers contain the real-time measurements from the input channels on the device, including current, voltage, power, power factor, and frequency. For energy registers, see **6.3, Accumulated Data Registers** (p. 39). The instantaneous registers are presented in two different formats, each in a separate block of registers – as floating-point data (for modern systems), and as integer data (for systems which do not support floating-point data). It is recommended to read the floating-point data if possible, as there is then no need to scale the registers manually.

Both integer and floating-point registers incorporate the CT and PT ratios entered into the configuration registers described in section **6.4, Configuration and Status Registers** (p. 44).

6.2.1. Integer Instantaneous Data Registers

The following registers are 32-bit integer representations of the measured parameters. To allow integer registers to represent decimal numbers, the integer registers are scaled according to a scaling factor. Divide the value read from these registers by the scaling factor in the *Scale* column to get a decimal value in the units specified by the *Units* column.

Example: If you read the value "4501" from the Current A register, divide 4501 by the scaling factor of 1000, to get a value of 4.501 Amps on channel A.

Name	Offset	Address	Size	Type	R/W	Units	Scale
Active Power Total	0x100	40257	32	S	R	W	10
Reactive Power Total	0x102	40259	32	S	R	VAR	10
Apparent Power Total	0x104	40261	32	S	R	VA	10
Voltage Average	0x106	40263	32	S	R	V	100
Voltage L-L Average	0x108	40265	32	S	R	V	100
Current Average	0x10A	40267	32	S	R	A	1000
System Power Factor	0x10C	40269	32	S	R	-	10000
System Frequency	0x10E	40271	32	S	R	Hz	1000
Voltage Phase Angle Average	0x110	40273	32	S	R	°	10
System Quadrant	0x112	40275	32	U	R	-	-
<i>Reserved</i>	<i>0x114</i>	<i>40277</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>	<i>-</i>
		...					
<i>Reserved</i>	<i>0x11E</i>	<i>40287</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>	<i>-</i>
Voltage A	0x120	40289	32	S	R	V	100
Voltage B	0x122	40291	32	S	R	V	100
Voltage C	0x124	40293	32	S	R	V	100
Voltage AB	0x126	40295	32	S	R	V	100
Voltage BC	0x128	40297	32	S	R	V	100
Voltage AC	0x12A	40299	32	S	R	V	100
Current A	0x12C	40301	32	S	R	A	1000
Current B	0x12E	40303	32	S	R	A	1000
Current C	0x130	40305	32	S	R	A	1000
Active Power A	0x132	40307	32	S	R	W	10
Active Power B	0x134	40309	32	S	R	W	10
Active Power C	0x136	40311	32	S	R	W	10
Reactive Power A	0x138	40313	32	S	R	VAR	10
Reactive Power B	0x13A	40315	32	S	R	VAR	10
Reactive Power C	0x13C	40317	32	S	R	VAR	10
Apparent Power A	0x13E	40319	32	S	R	VA	10
Apparent Power B	0x140	40321	32	S	R	VA	10
Apparent Power C	0x142	40323	32	S	R	VA	10
Power Factor A	0x144	40325	32	S	R	-	10000
Power Factor B	0x146	40327	32	S	R	-	10000
Power Factor C	0x148	40329	32	S	R	-	10000
Voltage Phase Angle AB	0x14A	40331	32	S	R	°	10
Voltage Phase Angle BC	0x14C	40333	32	S	R	°	10
Voltage Phase Angle AC	0x14E	40335	32	S	R	°	10
Quadrant A	0x150	40337	32	U	R	-	-
Quadrant B	0x152	40339	32	U	R	-	-
Quadrant C	0x154	40341	32	U	R	-	-
Sliding Window Power	0x156	40343	32	S	R	W	10
Voltage L-N Minimum [v. ≥ 10.74]	0x158	40345	32	S	R	V	100
Voltage L-N Maximum [v. ≥ 10.74]	0x15A	40347	32	S	R	V	100
Voltage L-L Minimum [v. ≥ 10.74]	0x15C	40349	32	S	R	V	100
Voltage L-L Maximum [v. ≥ 10.74]	0x15E	40351	32	S	R	V	100
Current Minimum [v. ≥ 10.74]	0x160	40353	32	S	R	A	1000
Current Maximum [v. ≥ 10.74]	0x162	40355	32	S	R	A	1000

6.2.2. Floating-Point Instantaneous Data Registers

The following registers are 32-bit floating-point representations of the measured parameters, expressed in IEEE 754 format. Unlike the integer registers described above, these registers are capable of representing decimal numbers and therefore do not require any scaling.

Name	Offset	Address	Size	Type	R/W	Units
Active Power Total	0x200	40513	32	F	R	KW
Reactive Power Total	0x202	40515	32	F	R	KVAR
Apparent Power Total	0x204	40517	32	F	R	KVA
Voltage Average	0x206	40519	32	F	R	V
Voltage L-L Average	0x208	40521	32	F	R	V
Current Average	0x20A	40523	32	F	R	A
System Power Factor	0x20C	40525	32	F	R	-
System Frequency	0x20E	40527	32	F	R	Hz
Voltage Average Angle	0x210	40529	32	F	R	°
System Quadrant	0x212	40531	32	F	R	-
Reserved	0x214	40533	32	-	R	-
		...				
Reserved	0x21E	40543	32	-	R	-
Voltage A	0x220	40545	32	F	R	V
Voltage B	0x222	40547	32	F	R	V
Voltage C	0x224	40549	32	F	R	V
Voltage AB	0x226	40551	32	F	R	V
Voltage BC	0x228	40553	32	F	R	V
Voltage AC	0x22A	40555	32	F	R	V
Current A	0x22C	40557	32	F	R	A
Current B	0x22E	40559	32	F	R	A
Current C	0x230	40561	32	F	R	A
Active Power A	0x232	40563	32	F	R	KW
Active Power B	0x234	40565	32	F	R	KW
Active Power C	0x236	40567	32	F	R	KW
Reactive Power A	0x238	40569	32	F	R	KVAR
Reactive Power B	0x23A	40571	32	F	R	KVAR
Reactive Power C	0x23C	40573	32	F	R	KVAR
Apparent Power A	0x23E	40575	32	F	R	KVA
Apparent Power B	0x240	40577	32	F	R	KVA
Apparent Power C	0x242	40579	32	F	R	KVA
Power Factor A	0x244	40581	32	F	R	-
Power Factor B	0x246	40583	32	F	R	-
Power Factor C	0x248	40585	32	F	R	-
Voltage Angle AB	0x24A	40587	32	F	R	°
Voltage Angle BC	0x24C	40589	32	F	R	°
Voltage Angle AC	0x24E	40591	32	F	R	°
Quadrant A	0x250	40593	32	F	R	-
Quadrant B	0x252	40595	32	F	R	-
Quadrant C	0x254	40597	32	F	R	-
Sliding Window Power	0x256	40599	32	F	R	KW

6.3. Accumulated Data Registers

Accumulated data registers contain energy data accumulated over time from the input channels on the device, including real energy, apparent energy, and reactive energy. For instantaneous registers such as power and current, see **6.2, Instantaneous Data Registers** (p. 36).

There are four blocks of accumulated data registers in total. Two blocks reflect resets – they can be reset to 0 at any time. The remaining two blocks do not reflect resets, and retain their total accumulated value despite any number of resets issued by the user. Revenue-grade metering applications, or applications that do not require the ability to reset the meter, should always read the non-resettable registers.

Resettable and non-resettable registers each have a floating-point block (for modern systems) and an integer block (for systems that do not support floating-point data). It is recommended to read the floating-point data if possible, as there is then no need to multiply the results by any scaling factors in that case.

6.3.1. Integer Energy Divider

The WattsOn's internal accumulated energy will never overflow; however, when reading 32-bit integer representations of the energy registers in combination with large CT or PT ratios, 32-bit integers may not be large enough to contain the information. To address this problem, the WattsOn has an *Energy Integer Divider Register*, **0x52E** which is applied to the energy values as they are read. By default, this is set to 100. This sets the resolution of the energy registers to 100 Wh/VAh/VARh by default. The maximum resolution is 1 Wh/VAh/VARh (including CT/PT scaling) with the divider set to 1.

This divider can be adjusted if desired, either to accommodate larger CT/PT ratios, or if greater resolution is desired. Multiply the value read from the registers by the value of the *Energy Integer Divider* register to obtain the units expressed in the *Units* column of the following tables. See **6.4.13, Energy Integer Divider** (p. 49) for details on the *Energy Integer Divider* register.

Example: If you read the value "45" from the *Net Energy A* register, and "1000" from the *Energy Integer Divisor* register. Multiply 45 by 1000 to get a value of 45000 Wh (or 45.0 kW) on channel A.

The floating-point representations of the energy registers do not use the *Energy Integer Divider Register*, as they can represent arbitrarily large values. For this reason, reading the floating-point registers is recommended. However, their resolution will decrease for very large values.

6.3.2. Import and Export Energy Computation

Each block contains registers which accumulate import and export energy. Energy is accumulated into the per-phase Import Energy and Export Energy registers according to the direction of power **in each phase** when the energy is measured. In other words, each phase is considered independently. The Total Import Energy and Total Export Energy registers are computed by summing the per-phase registers.

The Billing Import Energy and Billing Export Energy registers (version 11.00+) use an alternative method of computation. Instead of considering the direction of power in each phase independently, the direction of total power for the three-phase system is considered when determining whether power is accumulated in the import or export energy registers.

Example: Consider a system in which phase A and phase B are each importing 100 W of power, while phase C is exporting 50W of power. After one hour, the Total Import Energy register would read 200 Wh, while the Total Export Energy register would read 50 Wh. The Billing Import Energy register would read 150 Wh, and the Billing Export Energy register would be 0 (since the system as a whole was never exporting more energy than it was importing). This example is summarized in the table below:

Power (constant)		Energy (after one hour)	
Active Power A	100 W	Total Import Energy	200 Wh
Active Power B	100 W	Total Export Energy	50 Wh
Active Power C	-50 W	Billing Import Energy	150 Wh
Total Active Power	150 W	Billing Export Energy	0 Wh

6.3.3. Resettable Integer Accumulated Data Registers

These registers reflect resets made using the *Energy Reset* register **0x524**; see **6.4.8, Resetting Accumulated Energy** (p. 47) for details.

Name	Offset	Address	Size	Type	R/W	Units
Net Total Energy (Resettable)	0x1000	44097	32	S	R	Wh
Total Net Apparent Energy (Resettable)	0x1002	44099	32	S	R	VAh
Total Import Energy (Resettable)	0x1004	44101	32	S	R	Wh
Total Export Energy (Resettable)	0x1006	44103	32	S	R	Wh
Total Import Apparent Energy (Resettable)	0x1008	44105	32	S	R	VAh
Total Export Apparent Energy (Resettable)	0x100A	44107	32	S	R	VAh
Q1 Total Reactive Energy (Resettable)	0x100C	44109	32	S	R	VARh
Q2 Total Reactive Energy (Resettable)	0x100E	44111	32	S	R	VARh
Q3 Total Reactive Energy (Resettable)	0x1010	44113	32	S	R	VARh
Q4 Total Reactive Energy (Resettable)	0x1012	44115	32	S	R	VARh
Q1+Q2 Total Inductive Reactive Energy (Resettable) [v. ≥ 10.52]	0x1014	44117	32	S	R	VARh
Q3+Q4 Total Capacitive Reactive Energy (Resettable) [v. ≥ 10.52]	0x1016	44119	32	S	R	VARh
Billing Import Energy (Resettable) [v. ≥ 11.00]	0x1018	44121	32	S	R	Wh
Billing Export Energy (Resettable) [v. ≥ 11.00]	0x101A	44123	32	S	R	Wh
<i>Reserved</i>	<i>0x101C</i>	<i>44125</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>
<i>Reserved</i>	<i>0x101E</i>	<i>44127</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>
Net Energy (Resettable) A	0x1020	44129	32	S	R	Wh
Net Energy (Resettable) B	0x1022	44131	32	S	R	Wh
Net Energy (Resettable) C	0x1024	44133	32	S	R	Wh
Net Apparent Energy (Resettable) A	0x1026	44135	32	S	R	VAh
Net Apparent Energy (Resettable) B	0x1028	44137	32	S	R	VAh
Net Apparent Energy (Resettable) C	0x102A	44139	32	S	R	VAh
Import Energy (Resettable) A	0x102C	44141	32	S	R	Wh
Import Energy (Resettable) B	0x102E	44143	32	S	R	Wh
Import Energy (Resettable) C	0x1030	44145	32	S	R	Wh
Export Energy (Resettable) A	0x1032	44147	32	S	R	Wh
Export Energy (Resettable) B	0x1034	44149	32	S	R	Wh
Export Energy (Resettable) C	0x1036	44151	32	S	R	Wh
Import Apparent Energy (Resettable) A	0x1038	44153	32	S	R	VAh
Import Apparent Energy (Resettable) B	0x103A	44155	32	S	R	VAh
Import Apparent Energy (Resettable) C	0x103C	44157	32	S	R	VAh
Export Apparent Energy (Resettable) A	0x103E	44159	32	S	R	VAh
Export Apparent Energy (Resettable) B	0x1040	44161	32	S	R	VAh
Export Apparent Energy (Resettable) C	0x1042	44163	32	S	R	VAh
Q1 Reactive Energy (Resettable) A	0x1044	44165	32	S	R	VARh
Q1 Reactive Energy (Resettable) B	0x1046	44167	32	S	R	VARh
Q1 Reactive Energy (Resettable) C	0x1048	44169	32	S	R	VARh
Q2 Reactive Energy (Resettable) A	0x104A	44171	32	S	R	VARh
Q2 Reactive Energy (Resettable) B	0x104C	44173	32	S	R	VARh
Q2 Reactive Energy (Resettable) C	0x104E	44175	32	S	R	VARh
Q3 Reactive Energy (Resettable) A	0x1050	44177	32	S	R	VARh
Q3 Reactive Energy (Resettable) B	0x1052	44179	32	S	R	VARh
Q3 Reactive Energy (Resettable) C	0x1054	44181	32	S	R	VARh
Q4 Reactive Energy (Resettable) A	0x1056	44183	32	S	R	VARh
Q4 Reactive Energy (Resettable) B	0x1058	44185	32	S	R	VARh
Q4 Reactive Energy (Resettable) C	0x105A	44187	32	S	R	VARh

6.3.4. *Resettable Floating-Point Accumulated Data Registers*

The following registers are 32-bit floating-point representations of the accumulated energy parameters, expressed in IEEE 754 format. These registers reflect resets made using the *Energy Reset* register **0x524**; see **6.4.8, Resetting Accumulated Energy** (p. 47) for details.

Name	Offset	Address	Size	Type	R/W	Units
Net Total Energy (Resettable)	0x1100	44353	32	F	R	kWh
Total Net Apparent Energy (Resettable)	0x1102	44355	32	F	R	kVAh
Total Import Energy (Resettable)	0x1104	44357	32	F	R	kWh
Total Export Energy (Resettable)	0x1106	44359	32	F	R	kWh
Total Import Apparent Energy (Resettable)	0x1108	44361	32	F	R	kVAh
Total Export Apparent Energy (Resettable)	0x110A	44363	32	F	R	kVAh
Q1 Total Reactive Energy (Resettable)	0x110C	44365	32	F	R	kVARh
Q2 Total Reactive Energy (Resettable)	0x110E	44367	32	F	R	kVARh
Q3 Total Reactive Energy (Resettable)	0x1110	44369	32	F	R	kVARh
Q4 Total Reactive Energy (Resettable)	0x1112	44371	32	F	R	kVARh
Q1+Q2 Total Inductive Reactive Energy (Resettable) [v. ≥ 10.52]	0x1114	44373	32	F	R	kVARh
Q3+Q4 Total Capacitive Reactive Energy (Resettable) [v. ≥ 10.52]	0x1116	44375	32	F	R	kVARh
Billing Import Energy (Resettable) [v. ≥ 11.00]	0x1118	44377	32	F	R	kWh
Billing Export Energy (Resettable) [v. ≥ 11.00]	0x111A	44379	32	F	R	kWh
<i>Reserved</i>	<i>0x111C</i>	<i>44381</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>
<i>Reserved</i>	<i>0x111E</i>	<i>44383</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>
Net Energy (Resettable) A	0x1120	44385	32	F	R	kWh
Net Energy (Resettable) B	0x1122	44387	32	F	R	kWh
Net Energy (Resettable) C	0x1124	44389	32	F	R	kWh
Net Apparent Energy (Resettable) A	0x1126	44391	32	F	R	kVAh
Net Apparent Energy (Resettable) B	0x1128	44393	32	F	R	kVAh
Net Apparent Energy (Resettable) C	0x112A	44395	32	F	R	kVAh
Import Energy (Resettable) A	0x112C	44397	32	F	R	kWh
Import Energy (Resettable) B	0x112E	44399	32	F	R	kWh
Import Energy (Resettable) C	0x1130	44401	32	F	R	kWh
Export Energy (Resettable) A	0x1132	44403	32	F	R	kWh
Export Energy (Resettable) B	0x1134	44405	32	F	R	kWh
Export Energy (Resettable) C	0x1136	44407	32	F	R	kWh
Import Apparent Energy (Resettable) A	0x1138	44409	32	F	R	kVAh
Import Apparent Energy (Resettable) B	0x113A	44411	32	F	R	kVAh
Import Apparent Energy (Resettable) C	0x113C	44413	32	F	R	kVAh
Export Apparent Energy (Resettable) A	0x113E	44415	32	F	R	kVAh
Export Apparent Energy (Resettable) B	0x1140	44417	32	F	R	kVAh
Export Apparent Energy (Resettable) C	0x1142	44419	32	F	R	kVAh
Q1 Reactive Energy (Resettable) A	0x1144	44421	32	F	R	kVARh
Q1 Reactive Energy (Resettable) B	0x1146	44423	32	F	R	kVARh
Q1 Reactive Energy (Resettable) C	0x1148	44425	32	F	R	kVARh
Q2 Reactive Energy (Resettable) A	0x114A	44427	32	F	R	kVARh
Q2 Reactive Energy (Resettable) B	0x114C	44429	32	F	R	kVARh
Q2 Reactive Energy (Resettable) C	0x114E	44431	32	F	R	kVARh
Q3 Reactive Energy (Resettable) A	0x1150	44433	32	F	R	kVARh
Q3 Reactive Energy (Resettable) B	0x1152	44435	32	F	R	kVARh
Q3 Reactive Energy (Resettable) C	0x1154	44437	32	F	R	kVARh
Q4 Reactive Energy (Resettable) A	0x1156	44439	32	F	R	kVARh
Q4 Reactive Energy (Resettable) B	0x1158	44441	32	F	R	kVARh
Q4 Reactive Energy (Resettable) C	0x115A	44443	32	F	R	kVARh

6.3.5. Revenue (Non-Resettable) Integer Accumulated Data Registers

These registers **do not** reflect resets made using the *Energy Reset* register.

Name	Offset	Address	Size	Type	R/W	Units
Net Total Energy (Revenue)	0x1200	44609	32	S	R	Wh
Total Net Apparent Energy (Revenue)	0x1202	44611	32	S	R	VAh
Total Import Energy (Revenue)	0x1204	44613	32	S	R	Wh
Total Export Energy (Revenue)	0x1206	44615	32	S	R	Wh
Total Import Apparent Energy (Revenue)	0x1208	44617	32	S	R	VAh
Total Export Apparent Energy (Revenue)	0x120A	44619	32	S	R	VAh
Q1 Total Reactive Energy (Revenue)	0x120C	44621	32	S	R	VARh
Q2 Total Reactive Energy (Revenue)	0x120E	44623	32	S	R	VARh
Q3 Total Reactive Energy (Revenue)	0x1210	44625	32	S	R	VARh
Q4 Total Reactive Energy (Revenue)	0x1212	44627	32	S	R	VARh
Q1+Q2 Total Inductive Reactive Energy (Revenue) [v. ≥ 10.52]	0x1214	44629	32	S	R	VARh
Q3+Q4 Total Capacitive Reactive Energy (Revenue) [v. ≥ 10.52]	0x1216	44631	32	S	R	VARh
Billing Import Energy (Revenue) [v. ≥ 11.00]	0x1218	44633	32	S	R	Wh
Billing Export Energy (Revenue) [v. ≥ 11.00]	0x121A	44635	32	S	R	Wh
<i>Reserved</i>	<i>0x1218</i>	<i>44637</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>
<i>Reserved</i>	<i>0x121E</i>	<i>44639</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>
Net Energy (Revenue) A	0x1220	44641	32	S	R	Wh
Net Energy (Revenue) B	0x1222	44643	32	S	R	Wh
Net Energy (Revenue) C	0x1224	44645	32	S	R	Wh
Net Apparent Energy (Revenue) A	0x1226	44647	32	S	R	VAh
Net Apparent Energy (Revenue) B	0x1228	44649	32	S	R	VAh
Net Apparent Energy (Revenue) C	0x122A	44651	32	S	R	VAh
Import Energy (Revenue) A	0x122C	44653	32	S	R	Wh
Import Energy (Revenue) B	0x122E	44655	32	S	R	Wh
Import Energy (Revenue) C	0x1230	44657	32	S	R	Wh
Export Energy (Revenue) A	0x1232	44659	32	S	R	Wh
Export Energy (Revenue) B	0x1234	44661	32	S	R	Wh
Export Energy (Revenue) C	0x1236	44663	32	S	R	Wh
Import Apparent Energy (Revenue) A	0x1238	44665	32	S	R	VAh
Import Apparent Energy (Revenue) B	0x123A	44667	32	S	R	VAh
Import Apparent Energy (Revenue) C	0x123C	44669	32	S	R	VAh
Export Apparent Energy (Revenue) A	0x123E	44671	32	S	R	VAh
Export Apparent Energy (Revenue) B	0x1240	44673	32	S	R	VAh
Export Apparent Energy (Revenue) C	0x1242	44675	32	S	R	VAh
Q1 Reactive Energy (Revenue) A	0x1244	44677	32	S	R	VARh
Q1 Reactive Energy (Revenue) B	0x1246	44679	32	S	R	VARh
Q1 Reactive Energy (Revenue) C	0x1248	44681	32	S	R	VARh
Q2 Reactive Energy (Revenue) A	0x124A	44683	32	S	R	VARh
Q2 Reactive Energy (Revenue) B	0x124C	44685	32	S	R	VARh
Q2 Reactive Energy (Revenue) C	0x124E	44687	32	S	R	VARh
Q3 Reactive Energy (Revenue) A	0x1250	44689	32	S	R	VARh
Q3 Reactive Energy (Revenue) B	0x1252	44691	32	S	R	VARh
Q3 Reactive Energy (Revenue) C	0x1254	44693	32	S	R	VARh
Q4 Reactive Energy (Revenue) A	0x1256	44695	32	S	R	VARh
Q4 Reactive Energy (Revenue) B	0x1258	44697	32	S	R	VARh
Q4 Reactive Energy (Revenue) C	0x125A	44699	32	S	R	VARh

6.3.6. Revenue (Non-Resettable) Floating-Point Accumulated Data Registers

The following registers are 32-bit floating-point representations of the accumulated energy parameters, expressed in IEEE 754 format. These registers **do not** reflect resets made using the *Energy Reset* register.

Name	Offset	Address	Size	Type	R/W	Units
Net Total Energy (Revenue)	0x1300	44865	32	F	R	kWh
Total Net Apparent Energy (Revenue)	0x1302	44867	32	F	R	kVAh
Total Import Energy (Revenue)	0x1304	44869	32	F	R	kWh
Total Export Energy (Revenue)	0x1306	44871	32	F	R	kWh
Total Import Apparent Energy (Revenue)	0x1308	44873	32	F	R	kVAh
Total Export Apparent Energy (Revenue)	0x130A	44875	32	F	R	kVAh
Q1 Total Reactive Energy (Revenue)	0x130C	44877	32	F	R	kVARh
Q2 Total Reactive Energy (Revenue)	0x130E	44879	32	F	R	kVARh
Q3 Total Reactive Energy (Revenue)	0x1310	44881	32	F	R	kVARh
Q4 Total Reactive Energy (Revenue)	0x1312	44883	32	F	R	kVARh
Q1+Q2 Total Inductive Reactive Energy (Revenue) [v. ≥ 10.52]	0x1314	44885	32	F	R	kVARh
Q3+Q4 Total Capacitive Reactive Energy (Revenue) [v. ≥ 10.52]	0x1316	44887	32	F	R	kVARh
Billing Import Energy [v. ≥ 11.00]	0x1318	44889	32	F	R	kWh
Billing Export Energy [v. ≥ 11.00]	0x131A	44891	32	F	R	kWh
<i>Reserved</i>	<i>0x1318</i>	<i>44893</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>
<i>Reserved</i>	<i>0x131E</i>	<i>44895</i>	<i>32</i>	<i>-</i>	<i>R</i>	<i>-</i>
Net Energy (Revenue) A	0x1320	44897	32	F	R	kWh
Net Energy (Revenue) B	0x1322	44899	32	F	R	kWh
Net Energy (Revenue) C	0x1324	44901	32	F	R	kWh
Net Apparent Energy (Revenue) A	0x1326	44903	32	F	R	kVAh
Net Apparent Energy (Revenue) B	0x1328	44905	32	F	R	kVAh
Net Apparent Energy (Revenue) C	0x132A	44907	32	F	R	kVAh
Import Energy (Revenue) A	0x132C	44909	32	F	R	kWh
Import Energy (Revenue) B	0x132E	44911	32	F	R	kWh
Import Energy (Revenue) C	0x1330	44913	32	F	R	kWh
Export Energy (Revenue) A	0x1332	44915	32	F	R	kWh
Export Energy (Revenue) B	0x1334	44917	32	F	R	kWh
Export Energy (Revenue) C	0x1336	44919	32	F	R	kWh
Import Apparent Energy (Revenue) A	0x1338	44921	32	F	R	kVAh
Import Apparent Energy (Revenue) B	0x133A	44923	32	F	R	kVAh
Import Apparent Energy (Revenue) C	0x133C	44925	32	F	R	kVAh
Export Apparent Energy (Revenue) A	0x133E	44927	32	F	R	kVAh
Export Apparent Energy (Revenue) B	0x1340	44929	32	F	R	kVAh
Export Apparent Energy (Revenue) C	0x1342	44931	32	F	R	kVAh
Q1 Reactive Energy (Revenue) A	0x1344	44933	32	F	R	kVARh
Q1 Reactive Energy (Revenue) B	0x1346	44935	32	F	R	kVARh
Q1 Reactive Energy (Revenue) C	0x1348	44937	32	F	R	kVARh
Q2 Reactive Energy (Revenue) A	0x134A	44939	32	F	R	kVARh
Q2 Reactive Energy (Revenue) B	0x134C	44941	32	F	R	kVARh
Q2 Reactive Energy (Revenue) C	0x134E	44943	32	F	R	kVARh
Q3 Reactive Energy (Revenue) A	0x1350	44945	32	F	R	kVARh
Q3 Reactive Energy (Revenue) B	0x1352	44947	32	F	R	kVARh
Q3 Reactive Energy (Revenue) C	0x1354	44949	32	F	R	kVARh
Q4 Reactive Energy (Revenue) A	0x1356	44951	32	F	R	kVARh
Q4 Reactive Energy (Revenue) B	0x1358	44953	32	F	R	kVARh
Q4 Reactive Energy (Revenue) C	0x135A	44955	32	F	R	kVARh

6.4. Configuration and Status Registers

The following registers are used for configuring the WattsOn.

6.4.1. Setting CT Ratios

Current transformer (CT) ratios allow the device to scale the data to report the real-world current values on the input of the current transformers. Typically, the same type of CT is used on all three current channels. In this case, write the CT ratio primary (in the case of 5A or mV CTs) or the number of turns (in the case of mA CTs) into the *Primary CT Ratio (All)* register, at address **0x500**. Setting the secondary CT ratio, register **0x501** is not generally necessary, as it will default to the correct value depending on the meter input type (5 for 5A CTs, 333 for 333 millivolt CT, and 1 for milliamp CTs).

Example 1: If a 100A:5A CT is being used, write the value "100" to register 0x500. Leave register 0x501 at its default value of "5".

Example 2: If an Elkor MCTA is being used, which has a turns ratio of 2500, write the value "2500" to register 0x500. Leave register 0x501 at its default value of "1".

The turn counts of various Elkor Milliamp CTs are listed in the table below. Contact Elkor for further details if the CT ratio is unknown. A correct setting of the CT ratio is critical to obtaining accurate measurements.

Current Transformer	Number of Turns
MCTA	2500
MCTB	4000
MSCT1, MSCT2, MSCT3	7500
MSCT5	11000
MS160	3000
MS360	2000
MRS-75 125, 2x3	7500
MRS-3x5	10000

(i) Setting CT Ratios Per-Channel

It is permissible to use different CT ratios in each channel, provided the CTs are of the same output type (mA, 5A or 333mV). In this case, it is necessary to enter the CT ratio primary (in the case of 5A or mV CTs) or the number of turns (in the case of mA CTs) into three separate registers, one for each channel. Write the value for channels A, B, and C into registers **0x502**, **0x504**, and **0x506**, respectively. Setting secondary CT ratios (registers **0x503**, **0x505**, and **0x507**) is not generally necessary, as they will default to correct values (5 for 5A CTs, 333 for 333 mV CT, and 1 for mA CTs).

Example: Suppose 50A:5A CTs are connected to channels A and B, and a 250A:5A CT is connected to channel C. Write the value "50" to registers 0x502 and 0x504, and the value "250" to register 0x506. Leave registers 0x503, 0x505, and 0x507 at their default values of "5".

Note: While it is possible to use CTs with different full scale ratings or turns ratios together on the same unit, it is not possible to mix 5A CTs, millivolt CTs, or milliamp CTs together on the same unit.

(ii) Greater Accuracy

To maximize accuracy, many Elkor milliamp CTs are factory-tested to quantify the precise effective turns ratio. In this case, the number of turns is indicated on the CT itself. The values account for manufacturing variations, resulting in greater accuracy. For each channel, enter the precise number of turns for the CT connected to the corresponding input channel. Write the value for channels A, B, and C into registers **0x502**, **0x504**, and **0x506**, respectively.

Example: Suppose there are three MSCT1 CTs connected to the device. The CTs have the effective turn count indicated on each of them. The CT connected to channel A lists 7492, the CT connected to channel B lists 7490, and the CT connected to channel C lists 7493. Write the value "7492" to register 0x502, the value "7490" to register 0x504, and the value "7493" to register 0x506. Leave registers 0x503, 0x505, and 0x507 at their default values of "1".

Note: 5A and millivolt CTs are not generally factory-tested in this way.

Name	Offset	Address	Size	Type	R/W	Default	Description
Primary CT Ratio (All)	0x500	41281	16	U	RW	*	Used for setting the CT ratios of each phase. Writing to the "All" registers globally sets the CT ratios for all of the phases simultaneously. If the CT ratios are not identical in all three channels, the "All" values are read as "0". See p. 44.
Secondary CT Ratio (All)	0x501	41282	16	U	RW	*	
Primary CT Ratio A	0x502	41283	16	U	RW	*	
Secondary CT Ratio A	0x503	41284	16	U	RW	*	
Primary CT Ratio B	0x504	41285	16	U	RW	*	
Secondary CT Ratio B	0x505	41286	16	U	RW	*	
Primary CT Ratio C	0x506	41287	16	U	RW	*	
Secondary CT Ratio C	0x507	41288	16	U	RW	*	
Primary PT Ratio (All)	0x508	41289	16	U	RW	1	Used for setting the PT ratios for each phase. Writing to the "All" registers globally sets the PT ratios for all of the phases simultaneously. If the PT ratios are not identical in all three channels, the "All" values are read as "0". See p. 46.
Secondary PT Ratio (All)	0x509	41290	16	U	RW	1	
Primary PT Ratio A	0x50A	41291	16	U	RW	1	
Secondary PT Ratio A	0x50B	41292	16	U	RW	1	
Primary PT Ratio B	0x50C	41293	16	U	RW	1	
Secondary PT Ratio B	0x50D	41294	16	U	RW	1	
Primary PT Ratio C	0x50E	41295	16	U	RW	1	
Secondary PT Ratio C	0x50F	41296	16	U	RW	1	
Debug 16-bit	0x510	41297	16	S	R	12345	These registers always output their default values. They are useful for debugging communication with the device.
Debug 32-bit	0x511	41298	32	S	R	1234567	
Debug Floating-Point	0x513	41300	32	F	R	1234.567	
Uptime	0x515	41302	32	U	RW	-	Seconds since the device was last powered on or reset. See p. 46.
Masking Enabled	0x517	41304	16	B	RW	False	Indicates whether Modbus Masking is enabled. See p. 46.
Masking Override	0x518	41305	16	B	RW	False	Indicates whether masks can override existing registers. See p. 46.
Noise Filtering Enabled	0x519	41306	16	B	RW	True	Indicates whether low current noise filtering is enabled. See p. 46.
32-bit Little Endian Mode	0x51A	41307	16	B	RW	False	If enabled, 32-bit registers are sent least significant word first. See p. 46.
Current LED Threshold	0x51B	41308	16	S	RW	1 (0.1%)	Expressed in 10ths of a percent of the full scale (varies by model). See p. 47.
Voltage LED Threshold	0x51C	41309	16	S	RW	5 (5%)	Expressed as a percentage of 400V. See p. 47.
Serial Number	0x51D	41310	32	U	RW	-	Factory programmed serial number of the unit.
Hardware Version	0x51F	41312	16	U	R	-	Version numbers of different hardware and software components of this device. Divide by 100 to get the version number; for example, a value of "100" indicates version 1.00.
Firmware Version	0x520	41313	16	U	R	-	
Bootloader Version	0x521	41314	16	U	R	-	
Model Number	0x522	41315	16	U	R	-	The model number of the device. This is expressed as a two-byte ASCII string. 19761 indicates the "M1" model.
Input Configuration	0x523	41316	16	U	R	-	"1" for milliamp CTs, "2" for mV CTs, "3" for 5A CTs, "0" for a custom setup.
Energy Reset	0x524	41317	16	U	RW	-	Writing 0xA5A5 (42405) resets the accumulated energy to 0. See p. 47.
Compatibility Mode	0x525	41318	16	B	RW	False	Enables limited emulation of the WattsOn-1100's register map. See p. 47.
Power Factor Sign Mode	0x526	41319	16	U	RW	3 (Quad)	Indicates how the sign of the power factor is calculated. See page 47.
Passcode	0x527	41320	32	U	RW	-	Used for entering a passcode when locking or unlocking the device. See p. 48.
Lock	0x529	41322	16	U	RW	0	"0" indicates unlocked, "1" indicates locked. With a passcode entered above, write "0" to unlock, "1" to lock, or "2" to change the passcode. See p. 48.
Phase Compensation (All)	0x52A	41323	16	S	RW	0	Compensates for the inherent phase shift in current transformers for more accurate power measurements. Represented in units of 0.01 degrees. Writing to the "All" register sets the phase compensation values for all phases simultaneously. If the values are not identical in all three channels, the "All" register reads as "0". See p. 49.
Phase Compensation A	0x52B	41324	16	S	RW	0	
Phase Compensation B	0x52C	41325	16	S	RW	0	
Phase Compensation C	0x52D	41326	16	S	RW	0	
Energy Integer Divider	0x52E	41327	16	U	RW	1000	Divisor for integer energy values to allow fitting into 32 bits. See p. 49.
SW Sub-Interval Length	0x52F	41328	16	U	RW	60	The length in seconds of a sub-interval for sliding window power. See p. 49.
SW Sub-Interval Count	0x530	41329	16	U	RW	15	The number of sub-intervals for sliding window power. See p. 49.
SW Synchronize	0x531	41330	16	U	RW	-	Resets the timer of the sliding window power calculation. See p. 49.
Auto Frequency Channel	0x532	41331	16	B	RW	True	Auto-select a valid voltage channel for frequency measurement. See p. 50.
Frequency Active Channel	0x533	41332	16	U	RW	0 (A)	Voltage channel used to measure frequency. 0, 1, 2 for A, B, C. See p. 50.
<i>Reserved</i>	<i>0x534</i>	<i>41333</i>	<i>16</i>	<i>-</i>	<i>R</i>	<i>0</i>	Reserved for future use. These registers output "0" when read. To ensure compatibility with future versions, these registers should not be written to.
...							
<i>Reserved</i>	<i>0x53F</i>	<i>41344</i>	<i>16</i>	<i>-</i>	<i>R</i>	<i>0</i>	
Scratch Pad Register 1	0x540	41345	16	-	RW	0	32 registers available for user storage. Values written here are stored in non-volatile memory. They can be used to store room numbers, customer IDs, etc. They can be used as 32 16-bit registers, or 16 32-bit registers.
...							
Scratch Pad Register 32	0x55F	41376	16	-	RW	0	

* Default values depend on the input type of the device. Milliamp units default to "1", 333 mV units default to "333", and 5A units default to "5". Because the primary and secondary values are equal for all models, the ratios all reduce to 1:1 regardless of the input type, by default.

6.4.2. *Setting PT Ratios*

Potential Transformer (PT) ratios allow the device to scale the data to report the real-world voltage values on the input of the potential transformers.

Because the WattsOn can accept up to 600V line-to-line voltage directly, potential transformers are often not required. In this case, PT ratios may be left at their default values of 1:1. If potential transformers are being used for higher voltages, and the same type of transformer is used on all three voltage channels, write the PT ratio primary into the *Primary PT Ratio (All)* register, at address **0x508** and the PT ratio secondary into the *Secondary PT Ratio (All)* register, at address **0x509**.

Example: If a 600:120V PT is being used (that is, a PT that outputs 120V when the input voltage is 600V), write the value "600" to register 0x508, and the value "120" to register 0x509.

It is also permissible to use different PTs in each channel. In this case, it is necessary to enter the PT ratio primary into three separate registers, one for each channel. Write the value for channels A, B, and C into registers **0x50A**, **0x50C**, and **0x50E**, respectively. Enter the PT ratio secondary for channels A, B, and C into registers **0x50B**, **0x50D**, and **0x50F**, respectively.

6.4.3. *Uptime*

The uptime register reports the number of seconds that the device has been running. This counter is reset when the device is powered off, reset, or the bootloader is started. Writes to this register are permitted if desired to represent a date, time, or elapsed time counter.

6.4.4. *Masking*

Modbus Masking is a feature used to change the Modbus map of the device. It can be enabled or disabled by writing a "1" or "0", respectively, to the *Modbus Enabled* register, **0x517**. Custom Modbus blocks may be configured to exist in the same register address space as the native WattsOn registers; this functionality can be enabled by writing a "1" to the *Masking Override* register, **0x518**. Otherwise, the WattsOn native registers will always override custom register blocks. See **6.7, Customizing the Register Map** (p. 55) for details on this feature.

6.4.5. *Low Current Noise Filtering*

When reading very low current values (such as below 1% of the unit's full scale), noise may become noticeable. Due to the design of the analog-to-digital converters in the device, there are slight oscillations at low input values, which may appear as reading instability. A proprietary noise filtering algorithm is employed by default to filter out noise when reading low current values, improving accuracy and increasing the dynamic range of the device. However, this will result in slower response times for low fluctuating signals. The settling time for slowly changing signals is approximately 5 seconds, however the settling time is much lower (i.e., under 500 ms) for signals that change magnitude quickly.

Note: Energy accumulation accuracy is not affected by this setting.

Filtering may be disabled by writing a "0" to register **0x519** (41306).

6.4.6. *Setting 32-bit Endianness*

By default, the higher-order 16-bit word of a 32-bit register is the register with the lower Modbus address, and the lower-order word is at the higher address. Most Modbus software and devices will interpret 32-bit registers this way. Writing a "1" to the *32-bit Little Endian* register at address **0x51A** (41307) configures the WattsOn to reverse the 16-bit word ordering, so that the higher-order word is at the higher address, and the lower-order word is at the lower address. See the following table for an example.

For an total active power of 100,000 kW (hexadecimal 0x186A0)

32-bit Little Endian Mode register **0x51A** = 0 (default)

Register	Decimal	Hexadecimal
<i>Active Power Total</i> register 0x100	1	0x0001
<i>Active Power Total</i> register 0x101	34,464	0x86A0

32-bit Little Endian Mode register **0x51A** = 1

Register	Decimal	Hexadecimal
<i>Active Power Total</i> register 0x100	34,464	0x86A0
<i>Active Power Total</i> register 0x101	1	0x0001

6.4.7. Setting LED Thresholds

The WattsOn features an LED for each of the three current channels and each of the three voltage channels on the device. These LEDs are off when there is low current or voltage on the corresponding input channel. By default, these thresholds are less than 0.1% of the unit's maximum measurement current (200 mA, 333 mV, or 10A, depending on the meter type), or less than 5% of the unit's maximum voltage (400 V).

These percentages can be changed via Modbus. To change the threshold at which the current LED turns on, write to the *Current LED Threshold* register at address **0x51B** (41308). Valid values are between 0 and 1000, representing 0.0% to 100.0%, respectively. To change the threshold at which the voltage LED turns on, write to the *Voltage LED Threshold* register at address **0x51C** (41309). Valid values are between 0 and 100, representing 0% and 100%, respectively. These settings apply to all channels.

6.4.8. Resetting Accumulated Energy

To reset the resettable accumulated data registers to 0, write the hexadecimal value 0xA5A5 (decimal value 42405) into the *Energy Reset* register, **0x524**. Note that this will not affect that data in the revenue accumulated data registers; they will continue to hold their former values despite any resets.

6.4.9. WattsOn-1100 Compatibility Mode

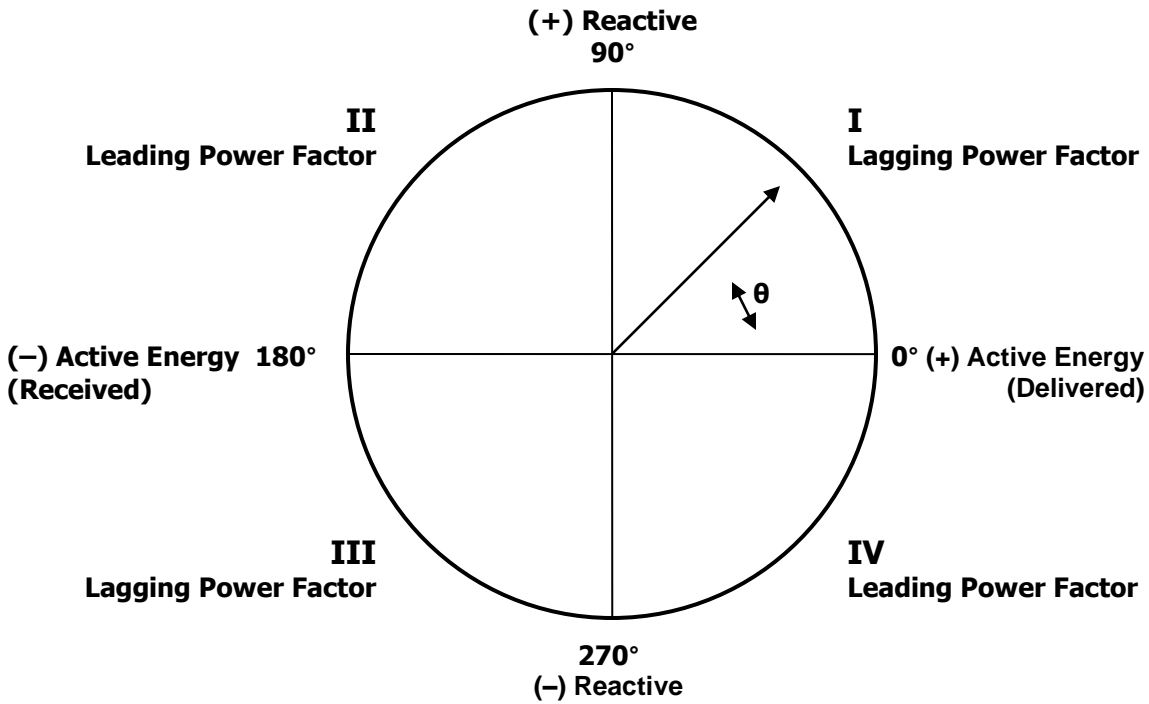
By writing a "1" to the *Compatibility Mode* register, **0x525**, the WattsOn-Mark II will emulate a partial register map of the legacy WattsOn-1100. The 32-bit floating-point registers from **0x300** to **0x376**, as well as the configuration registers from **0x080** to **0x09E** are emulated while in this mode. The 16-bit integer registers are not emulated. See the WattsOn-1100 manual for details on these registers. With the exception of the CT ratios, PT ratios, and scratch pad registers, the registers in the WattsOn-1100 configuration block are read-only; other settings must be configured using the WattsOn-Mark II configuration registers instead.

6.4.10. Power Factor Sign Mode

The sign of the power factor registers can be determined in several different ways. This is summarized in the table to the right.

Power quadrants (relevant in sign mode 3) are illustrated in the following diagram.

Sign Mode	Description
0	Absolute value Always positive.
1	Follows real power The power factor has the same sign as the real power.
2	Follows reactive power The power factor has the same sign as the reactive power.
3 (default)	Quadrant Positive when the power is in quadrants 1 or 3 Negative when the power is in quadrants 2 or 4



6.4.11. Password Protection

The WattsOn-Mark II features a password protection system. The device can be locked to prevent writes to **ALL** of its registers, preventing any settings from being changed or operations (resets, reboots, etc.) to be performed.

Lock Register Operation	Value
Unlock	0
Lock/Confirm Passcode	1
Change Passcode	2

(i) Setting a Password

1. Write any 32-bit number except 0 into the *Passcode* register, **0x527**. This number is the password. Whenever a password has been entered, this register will read "1".
2. Write "2" to the *Lock* register, **0x529**.
3. Write the same password into the *Passcode* register, **0x527**, a second time.
4. Write "1" to the *Lock* register. A password has now been set, and the device is now locked.
5. Read the *Lock* register to confirm that it now read "1", indicating that the device is now locked.

(ii) Unlocking the Device

1. Write the password into the *Passcode* register, **0x527**. This register will read "1".
2. Write "0" to the *Lock* register. If the password was correct, the device is now unlocked (the *Lock* register will read as 0) and the device can be written to normally. If the password was incorrect, the *Lock* register will continue to read "1", and the device will reject all password attempts for the next 5 seconds.

Once the device has been unlocked, it will remain unlocked for 10 minutes, or until the device is either manually locked again or rebooted, whichever comes first. To permanently unlock the device, see (v) *Removing Password Protection*.

(iii) Locking the Device (if a password has previously been set)

1. Write the password into the *Passcode* register, **0x527**. This register will read "1".
2. Write "1" to the *Lock* register. If the password was correct, the device is now locked (the *Lock* register will read as 1) and the device cannot be written to until unlocked again. If the password was incorrect, the *Lock* register will continue to read "0", and the device will remain unlocked.
3. Read the *Lock* register to confirm that it reads "1", indicating that the device is now locked.

(iv) Changing the Password

1. If the device is locked (the *Lock* register, **0x527** reads "1"), unlock the device; see (ii) *Unlocking the Device*.
2. Write a new password (any 32-bit number except 0) into the *Passcode* register, **0x527**. This register will now read "1".
3. Write "2" to the *Lock* register, **0x529**.
4. Write the same password into the *Passcode* register, **0x527**, a second time.
5. Write "1" to the *Lock* register. The password has now been changed, and the device is now locked.
6. Read the *Lock* register to confirm that it now reads "1", indicating that the device is now locked.

(v) Removing Password Protection

1. If the device is locked (the *Lock* register, **0x527** reads "1"), unlock the device; see (ii) *Unlocking the Device*.
2. Write "0" into the *Passcode* register, **0x527**. This register will now read "1".
3. Write "2" to the *Lock* register, **0x529**. The password protection has now been removed.

6.4.12. Phase Compensation

Most current transformers have an inherent phase shift. This causes inaccuracies in power measurements as the power factor decreases. If the phase shift of a particular type of CT is known, the WattsOn can compensate for this phase shift either globally or per-phase.

Phase compensation values are entered in hundreds of a degree, so a value of 1 represents a 0.01° compensation for lag. Some current transformers have the phase shift value printed on the label.

6.4.13. Energy Integer Divider

It is recommended to read the device using floating-point registers if possible, as floating-point registers can represent arbitrarily large energy values regardless of the scaling applied.

When using integer accumulated data registers, as described in section **6.3, Accumulated Data Registers** (p. 39), only values between -2,147,483,648 and +2,147,483,647 can be read. In order to permit reading larger energy values, they are first divided by the divider programmed into the *Energy Integer Divider* register, **0x52E** (by default, 1000) before they are returned in these registers. With the default setting, the base resolution of the integer registers is 1000 Wh/VAh/VARh.

Depending on the size of the system being monitored, it may be desirable to use a higher divider (if reaching values in excess of 2 billion is anticipated soon), or a lower divider (for greater resolution). Set this register to 1 to read individual Watt-hours (or VAh/VARh), or 1000 to read kWh (or kVAh/kVARh). Only multiples of 10 from 1 to 10000 may be used. Floating-point registers do not make use of this register.

Example 1: Suppose the system is consuming 10,000 kW. After 1 hour, the WattsOn will accumulate 10,000,000 Wh of energy. With a divider of 100, the energy register would read "100,000" at this time. Dividing the maximum value (2,147,483,647) by 100,000 yields about 21,475 hours (2.5 years) before the energy will no longer fit into a 32-bit register. The divider should be set to a higher value, such as 1,000 to extend to use of these registers, or floating-point may be read instead.

Example 2: Suppose the system is consuming 100 kW. After 1 hour, the WattsOn will accumulate 100,000 Wh of energy. With a divider of 100, the energy register would read "1,000" at this time. Dividing the maximum value (2,147,483,647) by 1,000 yields about 2,147,484 hours (250 years) before the energy will no longer fit into a 32-bit register. The divider may be set to a lower value, such as 10 to increase the resolution of the energy registers from 1000 Wh/VAh/VARh to 10 Wh/VAh/VARh.

6.4.14. Sliding Window Demand Power Measurement

The WattsOn can measure the average power over an arbitrary interval of time, called demand power. The interval length can be programmed in seconds to any value between 1 and 65,535 seconds. Typical values are 1 minute (60 seconds), 5 minutes (300 seconds), 10 minutes (600 seconds), 15 minutes (900 seconds), 30 minutes (1800 seconds), 1 hour (3600 seconds), or any arbitrary value expressed in seconds.

In addition, the WattsOn can be configured to measure sliding window (also called rolling demand) power. In this case, the time interval is divided into several sub-intervals. The average power over the full interval is updated each sub-interval. This device can be configured for up to 60 sub-intervals. The interval length is equal to the sub-interval length times the number of sub-intervals. If sub-intervals are not needed, set the sub-interval count to 1.

Example 1: To configure the device to record the average power over 15 minute intervals, set the *SW Sub-Interval Length* register, **0x52F**, to 900 (15 minutes × 60 seconds) and the *SW Sub-Interval Count* register, **0x530**, to 1. Every 15 minutes, the *Sliding Window Power* registers will update with the average power over the previous 15 minutes.

Example 2: To configure the device to record the average power over 15 minute intervals, updating every 5 minutes, set the *SW Sub-Interval Length* register, **0x52F**, to 300 (5 minutes × 60 seconds) and the *SW Sub-Interval Count* register, **0x530**, to 3 (15 minute intervals ÷ 5 minute sub-intervals). Every five minutes, the *Sliding Window Power* registers will update with the average power over the previous 15 minutes.

Writing any value to the *SW Sub-Interval Length* register, the *SW Sub-Interval Count* register, or writing a 1 to the *SW Synchronize* register restarts the demand interval.

6.4.15. Frequency Measurement Channel

Frequency is measured using one of the three voltage channels. By default, the device will automatically select a voltage channel with an RMS voltage greater than 5V on which to perform the frequency measurement. If the voltage in this channel falls to below 5V, a new channel will be automatically selected. If no channel contains a voltage above this threshold, the frequency will read "0". The channel currently being used is displayed in the *Frequency Active Channel* register, **0x533** (0, 1, and 2 represent channels A, B, and C, respectively).

The meter may instead be forced to use a specific voltage channel for frequency measurement. To do so, first disable automatic channel selection by writing "0" into the *Auto Frequency Channel* register, **0x532**. Then, write a value into the *Frequency Active Channel* register corresponding to the desired channel to be used for frequency measurement, with "0" representing channel A (the first channel from the left), "1" representing channel B, and "2" representing channel C.

6.4.16. Scratch Pad Registers

There are 32 scratch pad registers available, starting at register **0x540** and ending at **0x55F**. Any values can be written to these registers. Values written to these registers will be stored in non-volatile memory so that they are retained after the device has been powered off or rebooted. These can be used for room numbers, customer IDs, or any other purpose as desired. These registers are not used for any measurement purposes.

Note: Consideration should be given to the fact that these registers are written to flash memory, which has limited write cycle endurance. Writes should be limited to fewer than 10,000 operations. Writes in excess of 10,000 may cause the device to become permanently read-only in order to protect itself from a flash failure.

6.5. System Registers

These registers are used to configure the serial communication parameters, to reset the device, or to enter the device's bootloader mode for firmware updates.

Name	Offset	Address	Size	Type	R/W	Default	Description
Modbus Address	0x600	41537	16	U	RW	15	If the hardware address switch is in the "F" position, the value set here is used instead of the switch's address. This allows addressing more than 15 Modbus devices on the same line.
Serial Baud Rate	0x601	41538	16	U	RW	9600	Sets the device's serial parameters. These settings are not applied until a "1" is written to the Serial Commit register, and are not permanent until a valid Modbus query message is received using the new settings.
Serial Parity Mode	0x602	41539	16	U	RW	0	
Serial Stop Bits	0x603	41540	16	U	RW	1	
Serial Response Delay	0x604	41541	16	U	RW	0	
Serial Commit	0x605	41542	16	U	RW	0	
Reserved	0x606	41543	16	-	R	0	Reserved for future use. These registers output "0" when read. To ensure compatibility with future versions, these registers should not be written to.
Reserved	0x607	41544	16	-	R	0	
Device Mode	0x608	41545	16	U	R	1	"1" indicates the device firmware is running normally, "2" indicates the device is in bootloader mode.
Reset to Firmware	0x609	41546	16	U	W	0	Write the value 0xAA55 (43605) to reboot the unit. This register always reads as "0".
Reset to Bootloader	0x60A	41547	16	U	W	0	Write the value 0xB001 (45057) to reboot the unit. When reset in this way, the device will enter bootloader mode. This register always reads as "0".

6.5.1. Modbus Addresses above 15

Using the rotary switch, addresses from 1-15 can be set. The switch indicates numbers as hexadecimal values, with 1-9 being shown as normal, A representing 10, B representing 11, and so on. When the rotary switch is set to F (15), the device will instead use an address entered into the *Modbus Address* register, **0x600**, which defaults to 15. This allows addresses of 16 or greater to be assigned, or allows the address to be configurable conveniently over Modbus. Addresses up to 247 can be programmed into this register; higher addresses are not allowed under the Modbus specification.

Changes are not applied until a "1" is written to the *Serial Commit* register. Once the change is applied, a read of any register must be performed using the new Modbus address to confirm the change. See **6.5.3, Confirming Serial Settings Change** (p. 52) for details.

6.5.2. Configuring Serial Parameters

By default, the WattsOn ships pre-configured with the most common serial settings — 9600 baud, no parity, 8 data bits, 1 stop bit. In addition to the default settings, the WattsOn supports a variety of other baud rates, parity modes, and stop bit modes.

Supported serial settings are listed in the table below.

Parameter	Default Setting	Supported Values
Baud rate	9600	9600, 19200, 28800, 38400, 48000, 57600, 115200, 230400
Parity	No Parity (0)	No Parity (0), Odd Parity (1), Event Parity (2)
Stop bits	1	1, 2

Settings are changed by writing to the corresponding Modbus registers. To change the baud rate, write the new value to the *Serial Baud Rate* register **0x601**. For baud rates below 115200, write the value as-is into the register. For instance, to change the baud rate to 57600, write "57600" to register **0x601**. For baud rates equal to or greater than 115200, write only the first three digits into the register; this is done because such values are too large to fit into 16-bit registers. For instance, to change the baud rate to 115200, write "115" to register **0x601**. To change the parity mode, write a "0" for no parity, "1" for odd parity, or "2" for even parity into the *Serial Parity Mode* register **0x602**. To change the number of stop bits, enter "1" for 1 stop bit or "2" for 2 stop bits into the *Serial Stop Bits* register **0x603**.

In cases where legacy Modbus master devices cannot process responses fast enough, it may be necessary to enable a response delay within the WattsOn. If such problems exist, a delay may be introduced by using the Serial Response Delay register **0x604**. The WattsOn will wait at least as long as specified by this register (in milliseconds) before responding. Generally, small values between 0 to 100 milliseconds are sufficient. The default value is "0", meaning that the WattsOn will respond as soon as its data is ready to reply to the query.

Changes are not applied until a "1" is written to the *Serial Commit* register. This is to ensure that all serial settings are applied at once, in case that more than one serial parameter was changed. Once the changes are applied, the new settings must be confirmed by reading any register using the new settings, as described in the section below.

6.5.3. Confirming Serial Settings Change

In order to guard against accidental changes to the device's serial settings and to protect against incorrect or unknown values, there is a 3-minute period in which the Modbus master device must successfully communicate with the WattsOn before the new settings become permanent. This is to ensure that the Modbus master software or device is capable of correctly communicating at the new settings. Reading or writing any register, or using any other Modbus function, is sufficient for this purpose. If a successful query is not received within the 3-minute waiting period, or the WattsOn was rebooted before a successful communication, the previous settings will be restored.

As an additional failsafe, when the WattsOn's Modbus address is set to address 0 via the rotary switch on the unit, it will always communicate using default serial settings (9600 baud, no parity, 1 stop bit). While set to address 0, the device responds to Modbus queries addressed to **any** Modbus address. The device may then be reconfigured to the appropriate serial settings. Note that once the WattsOn's serial settings are changed, the Modbus address must be set to a non-zero value before it will begin using the new settings, so that the new settings can be confirmed as described in the paragraph above. New serial settings **cannot** be confirmed while in address 0.

6.5.4. Changing Settings from a Known Configuration

A step-by-step procedure for changing the serial configuration from a known configuration is described below. Use this procedure if communications with the device is established, but changes to the Modbus settings are required. *This procedure does not require physical access to the device (it can be done from a remote location).*

1. Change the desired serial parameters by writing to the corresponding Modbus registers.
2. Write a "1" to the *Serial Commit* register **0x605**
3. Change the Modbus master device's serial settings to match the settings applied to the WattsOn.
4. Read any register from the WattsOn using the new serial settings within 3 minutes to make the change permanent. Note that the WattsOn should remain powered during this time, or its settings will revert to their previous values.

Note: If the settings do not work with the Modbus master device, or if a mistake was made, wait 3 minutes or power cycle the device, and the previous settings will be restored.

6.5.5. Changing Settings from an Unknown Configuration

A step-by-step procedure for changing the serial settings from an unknown configuration is described below. Use this procedure if the device settings are not known, and communication is not possible. *This procedure requires physical access to the device.*

1. Set the device's Modbus address to 0 using the hardware rotary switch on the device. This sets the device's serial settings to their factory defaults.

Note 1: In address 0, the WattsOn responds to queries sent from any address. This may include queries intended for other devices on the Modbus line. It is therefore recommended that any other devices be removed from the Modbus line when performing this procedure.

Note 2: If the device is powered on while its address is already set to 0, it will enter bootloader mode. The serial settings can be changed in either mode, but the device must be rebooted with a non-zero address once the procedure is complete in order to read the data registers.

2. Set the Modbus master device's serial settings to 9600 baud, no parity, 8 data bits, and 1 stop bit.

3. Set the serial parameters to the desired values by writing to the corresponding Modbus registers.
4. Write a "1" to the *Serial Commit* register **0x605**
5. Set the device's Modbus address to 1 (or any non-zero value).
6. Set the Modbus master device to communicate with the WattsOn at the address and serial settings from step 3.
7. Read any register from the WattsOn using the new settings within 3 minutes to make the change permanent.
Note that the WattsOn should remain powered during this time, or its settings will revert to their previous values.

6.6. Relay Output Configuration Registers

The WattsOn has two highly configurable relay outputs. These relays can be configured for pulse output, alarm output, or status output. They are configured using the following Modbus register block.

Name	Offset	Address	Size	Type	R/W	Default	Description
Relay K1 Register Offset	0x900	42305	16	U	RW	0x1000	Offset of an integer data register to control the output. Floating-point registers cannot be used.
Relay K1 Trigger Type	0x901	42306	16	U	RW	0 (Relative)	Indicates whether the output is based on the relative value of the register (i.e., for pulses), or the absolute value of the register (i.e., for alarming).
Relay K1 Upper Bound	0x902	42307	32	S	RW	1	Trigger the output when the value (either relative or absolute) goes above this value.
Relay K1 Lower Bound	0x904	42309	32	S	RW	0	Trigger the output when the value (either relative or absolute) goes below this value.
Relay K1 Min Duration	0x906	42311	16	U	RW	100	Minimum duration that the output is triggered, in milliseconds. If the Trigger Type is set to "0" (Relative), this is the duration of the pulse. If it is set to "1" (Absolute), the relay will remain triggered for at least this long, even if the threshold is crossed for a shorter period of time. To hold indefinitely, enter the maximum value "65535" (hexadecimal 0xFFFF) – this will hold the event until any register in this block is written.
Relay K1 Active Mode	0x907	42312	16	U	RW	0 (N.O.)	"0" indicates that the output is normally open, "1" indicates that it is normally closed, and "2" indicates that the output toggles each time it is triggered.
Reserved	0x908	42313	16	-	R	0	Reserved for future use. These registers output "0" when read. To ensure compatibility with future versions, these registers should not be written to.
Reserved	0x909	42314	16	-	R	0	
Relay K2 Register Offset	0x90A	42315	16	U	RW	0x1002	Offset of an integer data register to control the output. Floating-point registers cannot be used.
Relay K2 Trigger Type	0x90B	42316	16	U	RW	0 (Relative)	Indicates whether the output is based on the relative value of the register (i.e., for pulses), or the absolute value of the register (i.e., for alarming).
Relay K2 Upper Bound	0x90C	42317	32	S	RW	1	Trigger the output when the value (either relative or absolute) goes above this value.
Relay K2 Lower Bound	0x90E	42319	32	S	RW	0	Trigger the output when the value (either relative or absolute) goes below this value.
Relay K2 Min Duration	0x910	42321	16	U	RW	100	Minimum duration that the output is triggered, in milliseconds. If the Trigger Type is set to "0" (Relative), this is the duration of the pulse. If it is set to "1" (Absolute), the relay will remain triggered for at least this long, even if the threshold is crossed for a shorter period of time. To hold indefinitely, enter the maximum value "65535" (hexadecimal 0xFFFF) – this will hold the event until any register in this block is written.
Relay K2 Active Mode	0x911	42322	16	U	RW	0 (N.O.)	"0" indicates that the output is normally open, "1" indicates that it is normally closed, and "2" indicates that the output toggles each time it is triggered.

Common configurations of the relay outputs are described below.

6.6.1. Configuring a Pulse Output

The relay outputs may be configured to pulse upon accumulation of a specified quantity of energy. To do so, follow the steps below.

1. Select which energy register to use for pulses, such as the *Net Total Energy* register, at address **0x1000**, or another register from the list of **Resettable Integer Accumulated Data Registers** (p. 40) or **Revenue (Non-Resettable) Integer Accumulated Data Registers** (p. 42). Enter the register offset into the *Relay K1 Register Offset* register, **0x900**, to pulse on the relay output labelled K1 on the device, or into the *Relay K2 Register Offset* register, **0x90A**, to pulse on the relay output labelled K2 on the device.
2. Write "0" into the *Relay K1/K2 Register Offset* register, **0x901/0x902** to indicate relative mode. This causes the pulses to trigger when the register value changes, rather than on a set value.
3. To pulse on positive energy accumulation (consumption), enter a value into the *Relay K1/K2 Upper Bound* register, **0x902/0x90C**. By default, with the *Energy Integer Divider* register set to 1000, the energy accumulation registers increase by 1 for each 1000 Wh/VAh/VARh of energy. Therefore, enter "1" to pulse on

every 1000 Wh/VAh/VARh of energy accumulated, "10" for every 1.0 kWh/kVAh/kVARh, etc. To only pulse on negative energy accumulation (generation), write a "0" into this register.

4. To pulse on negative energy accumulation (generation), enter a value into the *Relay K1/K2 Lower Bound* register, **0x904/0x90E**. As above, by default, a value of "1" represents 0.1 Wh/VAh/VARh. Write "0" to ignore negative energy accumulation.
5. Enter the desired duration of the pulse in milliseconds into the *Relay K1/K2 Min Duration* register, **0x906/0x910**. For example, enter "100" for 100 millisecond pulses, or 1000 for 1 second pulses.
6. To have the relay close when a pulse is generated (normally open), enter a "0" into the *Relay K1/K2 Active Mode* register, **0x907/0x911**. To have the relay open when a pulse is generated (normally closed), enter a "1" into that register. To have the relay toggle between being opened and closed with each pulse, enter a "2" into that register.

6.6.2. Configuring a Threshold/Alarm Output

The relay outputs may be configured to open or close when a register raises above or falls below a certain threshold. To do so, follow the steps below. Instantaneous data registers, accumulated data registers, or configuration registers may be used.

1. Select which register to use for alarming from the list of *Integer Instantaneous Data Registers* (p. 37). Enter the register offset into the *Relay K1 Register Offset* register, **0x900**, to trigger on the relay output labelled K1 on the device, or into the *Relay K2 Register Offset* register, **0x90A**, to trigger on the relay output labelled K2 on the device. Note the scaling factor of that register from the register table.
2. Write a "1" into the *Relay K1/K2 Register Offset* register, **0x901/0x902** to indicate absolute mode. This causes the relay to trigger above or below set values, rather than on relative changes.
3. To trigger the output when the parameter rises *above* a threshold value, enter a threshold value into the *Relay K1/K2 Upper Bound* register, **0x902/0x90C**. The threshold value should be scaled to match the scaling factor of the register selected in step 1. To only trigger the output when the value falls *below* a certain threshold, write "2,147,483,647" (hexadecimal 0x7FFFFFFF) into this register to disable the high threshold.

Example: To activate the relay whenever the *Voltage A* value rises above 130V, enter the value 13000 (the *Voltage A* register has a scaling factor of 100).

4. To trigger the output when the parameter falls *below* a threshold value, enter a threshold value into the *Relay K1/K2 Lower Bound* register, **0x904/0x90E**. The threshold value should be scaled to match the scaling factor of the register selected in step 1. To only trigger the output when the value rises *above* a certain threshold, write "-2,147,483,648" (hexadecimal 0x80000000) into this register to disable the low threshold.

Example: To activate the relay whenever *Voltage A* value falls below 90V, enter the value 9000 (the *Voltage A* register has a scaling factor of 100).

5. Enter the desired minimum duration of trigger in milliseconds into the *Relay K1/K2 Min Duration* register, **0x906/0x910**. For example, to ensure that the output is triggered for at least 1 second, enter "1000" into that register. "0" can be used if no minimum duration is required; in that case, the alarm output will follow the duration of the event. Note that most registers are updated once every 500 milliseconds. To hold the alarm indefinitely, enter the maximum value of 65535 (hexadecimal 0xFFFF); in this case, the alarm can be manually cleared by writing to any register in this register block, such as writing 65535 to this register again.
6. To have the relay close when the parameter is over/under the specified thresholds (normally open), enter a "0" into the *Relay K1/K2 Active Mode* register, **0x907/0x911**. To have the relay open when the parameter is over/under the specified thresholds (normally closed), enter a "1" into the register. To have the relay alternate between being opened and closed each time the parameter crosses a threshold, enter a "2" into the register.

6.7. Customizing the Register Map (Advanced)

The addresses of each register in the WattsOn may be customized to obtain compatibility with other devices. This is done using up to 4 customizable register blocks which can contain any register and may be placed at any address.

Each customizable register block may contain up to 126 registers. The first register in each block is placed at a customizable address, and each subsequent register follows it at consecutive addresses.

This feature is disabled by default. To enable this feature, write "1" to the *Masking Enabled* register, **0x517**, in the Configuration and Status Registers (p. 44); By default, custom register blocks cannot be placed in the same locations as existing registers, as doing so complicates troubleshooting. To allow placing custom register blocks in the same locations as existing registers, write "1" to the *Masking Override* register, **0x518**.

To create a custom block, write the block's starting address to Address register, **0x1500** (for the first block, or **0x1600**, **0x1700**, or **0x1800**, for the second, third, and fourth blocks, respectively). Next, write the number of registers that the block will contain to the Size register, **0x1501** (or **0x1601**, **0x1701**, or **0x1801** for the second, third, and fourth blocks, respectively). Finally, write the Modbus address of each register that will be included in the block at addresses from **0x1502** to **0x157F** (or from **0x1602**, **0x1702**, or **0x1802** for the second, third, and fourth blocks, respectively).

Note: To include 32-bit registers, the two consecutive offsets will need to be written (for the higher and lower order register).

Example: To place the *Net Total Energy* and *Firmware Version* registers in a custom block starting at offset **0x400**, enter "0x400" into start address register **0x1500**. *Total Energy Consumption* is 32-bits long, so it occupies 2 registers, while *Firmware Version* is 16-bit, occupying 1 register, for a total of 3 registers occupied in total. Enter "3" into block size register **0x1501**.

Enter the values "0x1100", "0x1101", and "0x520" into the registers **0x1502** to **0x1504**. Because *Net Total Energy* is 32-bit, both "0x1100" and "0x1101" must be entered.

Setting the Size register to 0 will remove a custom Modbus block. In the event that a custom Modbus block is in the same location as the Masking Enabled or Masking Override registers, custom Modbus blocks can be removed by writing a "0" to each of the size registers, **0x1501**, **0x1601**, **0x1701**, and **0x1801**.

Custom Register Map Block 1

Name	Offset	Address	Size	Type	R/W	Default	Description
Custom Block 1 Address	0x1500	45377	16	U	RW	0	Modbus offset at which the 1 st custom Modbus block will be placed.
Custom Block 1 Size	0x1501	45378	16	U	RW	0	Number of registers in the 1 st custom Modbus block.
Custom Block 1 Register 1	0x1502	45379	16	U	RW	0	List of register offsets of the registers that will be included in the 1 st custom Modbus block. Register addresses beyond the count specified in the Size register will be ignored.
Custom Block 1 Register 2	0x1503	45380	16	U	RW	0	
	:						
Custom Block 1 Register 126	0x157F	45504	16	U	RW	0	

Custom Register Map Block 2

Name	Offset	Address	Size	Type	R/W	Default	Description
Custom Block 2 Address	0x1600	45633	16	U	RW	0	Modbus offset at which the 2 nd custom Modbus block will be placed.
Custom Block 2 Size	0x1601	45634	16	U	RW	0	Number of registers in the 2 nd custom Modbus block.
Custom Block 2 Register 1	0x1602	45635	16	U	RW	0	List of register offsets of the registers that will be included in the 2 nd custom Modbus block. Register addresses beyond the count specified in the Size register will be ignored.
Custom Block 2 Register 2	0x1603	45636	16	U	RW	0	
	:						
Custom Block 2 Register 126	0x167F	45760	16	U	RW	0	

Custom Register Map Block 3

Name	Offset	Address	Size	Type	R/W	Default	Description
Custom Block 3 Address	0x1700	45889	16	U	RW	0	Modbus offset at which the 3 rd custom Modbus block will be placed.
Custom Block 3 Size	0x1701	45890	16	U	RW	0	Number of registers in the 3 rd custom Modbus block.
Custom Block 3 Register 1	0x1702	45891	16	U	RW	0	List of register offsets of the registers that will be included in the 3 rd custom Modbus block. Register addresses beyond the count specified in the Size register will be ignored.
Custom Block 3 Register 2	0x1703	45892	16	U	RW	0	
	:						
Custom Block 3 Register 126	0x177F	46016	16	U	RW	0	

Custom Register Map Block 4

Name	Offset	Address	Size	Type	R/W	Default	Description
Custom Block 4 Address	0x1800	46145	16	U	RW	0	Modbus offset at which the 4 th custom Modbus block will be placed.
Custom Block 4 Size	0x1801	46146	16	U	RW	0	Number of registers in the 4 th custom Modbus block.
Custom Block 4 Register 1	0x1802	46147	16	U	RW	0	List of register offsets of the registers that will be included in the 4 th custom Modbus block. Register addresses beyond the count specified in the Size register will be ignored.
Custom Block 4 Register 2	0x1803	46148	16	U	RW	0	
	:						
Custom Block 4 Register 126	0x187F	46272	16	U	RW	0	

7. THE BACNET MS/TP PROTOCOL (For M2 models)

7.1. BACnet MS/TP Specifications

Parameters	
Baud Rates (bps)	9600, 19200, 38400, 57600, 76800, and 115200 <i>Default: 76800 bps</i>
Serial Parameters	No Parity, 1 Stop Bit (fixed)
MAC Address *	1-15 (dial), 0-127 (programmable) <i>Default: 1</i>
Device Name (<i>config via software only</i>)	Up to 16-characters <i>Default: WattsOn-Mark II</i>
Device Instance	Programmable (0..4,194,302) <i>Default: "28xxxx" where xxxxx is serial number</i>
Max Master	Programmable (0..127) <i>Default: 127</i>

* MAC address may be selected via the DIP switch (for values between 1-15). For other values (between 0 to 127), it is necessary to configure the setting via software, and set the DIP switch to 'F'. In setting 'F', the software configured MAC address takes effect.

NOTE: The BACnet MS/TP parameters are configurable via software and/or the LCD module.

The device must be reset (either software or hardware) for any settings changes to take effect.

7.2. BACnet Protocol Implementation Conformance Statement (PICS)

Date: November 9, 2015
Vendor Name: Elkor Technologies, Inc.
Product Name: WattsOn-Mark II
Product Model Number: W2-M2-xxxx
Applications Software Version: V1.300
Firmware Revision: V10.60
BACnet Protocol Revision: 2
Product Description:

The WattsOn-Mark II is a three-phase, four-quadrant, revenue grade precision power and energy meter. This product supports native BACnet, connecting directly to the MS/TP LAN using baud rates of 9600, 19200, 38400, 57600, 76800, and 115200.

BACnet Standard Device Profile (Annex L):

- BACnet Operator Workstation (B-OWS)
- BACnet Building Controller (B-BC)
- BACnet Advanced Application Controller (B-AAC)
- BACnet Application Specific Controller (B-ASC)
- BACnet Smart Sensor (B-SS)
- BACnet Smart Actuator (B-SA)

BACnet Interoperability Building Blocks Supported (Annex K):

- Data Sharing – ReadProperty-A (DS-RP-A)
- Data Sharing – ReadProperty-B (DS-RP-B)
- Data Sharing – ReadPropertyMultiple-B (DS-RPM-B)
- Data Sharing – WriteProperty-A (DS-WP-A)
- Data Sharing – WriteProperty-B (DS-WP-B)
- Data Sharing – WritePropertyMultiple-B (DS-WPM-B)

- Data Sharing – COV-B (DS-COV-B)
- Device Management – Dynamic Device Binding-A (DM-DDB-A)
- Device Management – Dynamic Device Binding-B (DM-DDB-B)
- Device Management – Dynamic Object Binding-B (DM-DOB-B)
- Device Management – DeviceCommunicationControl-B (DM-DCC-B)
- Device Management – ReinitializeDevice-B (DM-RD-B)

Segmentation Capability:

None

- Segmented requests supported Window Size _____
- Segmented responses supported Window Size _____

Standard Object Types Supported:

See "Object Types/Property Support Table" for object details.

Data Link Layer Options:

- BACnet IP, (Annex J)
- BACnet IP, (Annex J), Foreign Device
- ISO 8802-3, Ethernet (Clause 7)
- ANSI/ATA 878.1, 2.5 Mb. ARCNET (Clause 8)
- ANSI/ATA 878.1, RS-485 ARCNET (Clause 8), baud rate(s) _____
- MS/TP master (Clause 9), baud rate(s): 4800, 9600, 19200, 38400, 57600, 76800, 115200
- MS/TP slave (Clause 9), baud rate(s): _____
- Point-To-Point, EIA 232 (Clause 10), baud rate(s): _____
- Point-To-Point, modem, (Clause 10), baud rate(s): _____
- LonTalk, (Clause 11), medium: _____
- Other: _____

Device Address Binding:

Is static device binding supported? (This is currently for two-way communication with MS/TP slaves and certain other devices.) Yes No

Networking Options:

- Router, Clause 6 - List all routing configurations
- Annex H, BACnet Tunneling Router over IP
- BACnet/IP Broadcast Management Device (BBMD)
- Does the BBMD support registrations by Foreign Devices? Yes No

Character Sets Supported:

Indicating support for multiple character sets does not imply that they can all be supported simultaneously.

- ANSI X3.4 IBM™/Microsoft™ DBCS ISO 8859-1
- ISO 10646 (UCS-2) ISO 10646 (UCS-4) JIS C 6226

Data Types Supported:

The following table summarizes the data types that are accepted (in the case of a write property service) and returned (in the case of a read property service) when targeting the present value property of each supported object type.

Object Type	Service	
	Read Property	Write Property
Analog Output Analog Value	Real	Real, Unsigned, Integer, Null
Analog Input	Real	N/A
Binary Output Binary Value	Enumerated	Enumerated, Boolean, Real, Unsigned, Integer, Null
Binary Input	Enumerated	N/A
Multi-state Output Multi-state Value	Unsigned	Real, Enumerated, Unsigned, Integer, Null
Multi-state Input	Unsigned	N/A

Object Types/Property Support Table

The following table summarizes the Object Types/Properties supported.

Property	Object Type									
	Device	Binary Input	Binary Output	Binary Value	Analog Input	Analog Output	Analog Value	Multi-state Input	Multi-state Output	Multi-state Value
Object Identifier	R	R	R	R	R	R	R	R	R	R
Object Name	R	R	R	R	R	R	R	R	R	R
Object Type	R	R	R	R	R	R	R	R	R	R
System Status	R									
Vendor Name	R									
Vendor Identifier	R									
Model Name	R									
Firmware Revision	R									
App Software Revision	R									
Protocol Version	R									
Protocol Revision	R									
Services Supported	R									
Object Types Supported	R									
Object List	R									
Max APDU Length	R									
Segmentation Support	R									
APDU Timeout	R									
Number APDU Retries	R									
Max Master	R									
Max Info Frames	R									
Device Address Binding	R									
Database Revision	R									
Present Value		R	W	W	R	W	W	R	W	W
Status Flags		R	R	R	R	R	R	R	R	R
Event State		R	R	R	R	R	R	R	R	R
Out-of-Service		R	R	R	R	R	R	R	R	R
Number of States								R	R	R
Units					R	R	R			
Priority Array			R	R		R	R			
Relinquish Default			R	R		R	R			
COV Increment					W	W	W			
Polarity		R	R							
Inactive Text		R	R	R						
Active Text		R	R	R						

R – readable using BACnet services

W – readable and writable using BACnet services

7.3. BACnet Object List

7.3.1. Object Properties

- **Object Type (AI = Analog Input, AV = Analog Value)**
- **RW: Read/Write Capable**
- **R: Read Only**

Object Type	Object Name	Instance	Units	Unit Value	R/W	Comments	Manual Page
AI	Uptime	1	seconds	73	R		
AI	kW_Total	4	kilowatts	48	R		
AI	kVAR_Total	5	kilovolt-amperes	12	R		
AI	kVA_Total	6	kilovolt-amperes-reactive	9	R		
AI	Volts_LN_Avg	7	volts	5	R		
AI	Volts_LL_Avg	8	volts	5	R		
AI	Current_Avg	9	amperes	3	R		
AI	PF_Total	10	power-factor	15	R		
AI	Frequency	11	Hertz	27	R		
AI	Volts_Angle_Avg	12	degrees-angular	90	R		
AI	Quadrant_Total	13	No Units		R		
AI	Volts_AN	14	volts	5	R		
AI	Volts_BN	15	volts	5	R		
AI	Volts_CN	16	volts	5	R		
AI	Volts_AB	17	volts	5	R		
AI	Volts_BC	18	volts	5	R		
AI	Volts_AC	20	volts	5	R		
AI	Current_A	21	amps	3	R		
AI	Current_B	22	amps	3	R		
AI	Current_C	23	amps	3	R		
AI	kW_A	24	kilowatts	48	R		
AI	kW_B	25	kilowatts	48	R		
AI	kW_C	26	kilowatts	48	R		
AI	kVAR_A	27	kilovolt-amperes	12	R		
AI	kVAR_B	28	kilovolt-amperes	12	R		
AI	kVAR_C	29	kilovolt-amperes	12	R		
AI	kVA_A	30	kilovolt-amperes-reactive	9	R		
AI	kVA_B	31	kilovolt-amperes-reactive	9	R		
AI	kVA_C	32	kilovolt-amperes-reactive	9	R		
AI	PF_A	33	power-factor	15	R		
AI	PF_B	34	power-factor	15	R		
AI	PF_C	35	power-factor	15	R		
AI	Volts_Angle_AB	36	degrees-angular	90	R		
AI	Volts_Angle_BC	37	degrees-angular	90	R		
AI	Volts_Angle_AC	38	degrees-angular	90	R		
AI	Quadrant_A	39	No Units		R		
AI	Quadrant_B	40	No Units		R		
AI	Quadrant_C	41	No Units		R		
AI	kW_Demand	42	kilowatts	48	R		
AI	kWh_Net_Ttl	43	kilowatt-hours	19	R		
AI	kVAh_Net_Ttl	44	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kWh_Import_Ttl	45	kilowatt-hours	19	R		
AI	kWh_Export_Ttl	46	kilowatt-hours	19	R		
AI	kVAh_Import_Ttl	47	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	Q1_VARh_Ttl	48	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	Q2_VARh_Ttl	49	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	Q3_VARh_Ttl	50	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	Q4_VARh_Ttl	51	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	Q1+Q2_VARh_Ttl	52	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	Q3+Q4_VARh_Ttl	53	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kWh_Net_A	54	kilowatt-hours	19	R		

Object Type	Object Name	Instance	Units	Unit Value	R/W	Comments	Manual Page
AI	kWh_Net_B	55	kilowatt-hours	19	R		
AI	kWh_Net_C	56	kilowatt-hours	19	R		
AI	kVA_Net_A	57	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kVA_Net_B	58	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kVA_Net_C	59	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kWh_Import_A	60	kilowatt-hours	19	R		
AI	kWh_Import_B	61	kilowatt-hours	19	R		
AI	kWh_Import_C	62	kilowatt-hours	19	R		
AI	kWh_Export_A	63	kilowatt-hours	19	R		
AI	kWh_Export_B	64	kilowatt-hours	19	R		
AI	kWh_Export_C	65	kilowatt-hours	19	R		
AI	kVA_Import_A	66	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kVA_Import_B	67	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kVA_Import_C	68	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kVA_Export_A	69	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kVA_Export_B	70	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kVA_Export_C	71	kilowatt-hours	19	R	The actual unit is "kVAh"	
AI	kVARh_Q1_A	72	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q1_B	73	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q1_C	74	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q2_A	75	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q2_B	76	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q2_C	77	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q3_A	78	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q3_B	79	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q3_C	80	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q4_A	81	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q4_B	82	kilowatt-hours	19	R	The actual unit is "kVARh"	
AI	kVARh_Q4_C	83	kilowatt-hours	19	R	The actual unit is "kVARh"	
AV	CT_Primary_All	0	No Units		R/W	Setting this value will set the CT (Primary) for all three phases identically	44
AV	CT_Secondary_All	1	No Units		R/W	Setting this value will set the CT (Secondary) for all three phases identically	44
AV	CT_Primary_A	2	No Units		R/W	CT Ratio (Primary & Secondary) for each phase (A,B,C) may be individually set	44
AV	CT_Secondary_A	3	No Units		R/W		44
AV	CT_Primary_B	4	No Units		R/W		44
AV	CT_Secondary_B	5	No Units		R/W		44
AV	CT_Primary_C	6	No Units		R/W		44
AV	CT_Secondary_C	7	No Units		R/W		44
AV	PT_Primary_All	8	No Units		R/W	Setting this value will set the PT (Primary) for all three phases identically	46
AV	PT_Secondary_All	9	No Units		R/W	Setting this value will set the PT (Secondary) for all three phases identically	46
AV	PT_Primary_A	10	No Units		R/W	PT Ratio (Primary & Secondary) for each phase (A,B,C) may be individually set	46
AV	PT_Secondary_A	11	No Units		R/W		46
AV	PT_Primary_B	12	No Units		R/W		46
AV	PT_Secondary_B	13	No Units		R/W		46
AV	PT_Primary_C	14	No Units		R/W		46
AV	PT_Secondary_C	15	No Units		R/W		46
AV	Phase_Comp_All	16	No Units		R/W	Phase compensation (set equally for all phases)	49
AV	Phase_Comp_A	17	No Units		R/W	Phase compensation for each phase may be individually set	49
AV	Phase_Comp_B	18	No Units		R/W		49
AV	Phase_Comp_C	19	No Units		R/W		49
AV	Window_Length	20	No Units		R/W	The length in seconds of a sub-interval for sliding window power	49
AV	Window_Count	21	No Units		R/W	The number of sub-intervals for sliding window power	49

Object Type	Object Name	Instance	Units	Unit Value	R/W	Comments	Manual Page
AV	Window_Sync	22	No Units		R/W	Resets the timer of the sliding window power calculation	49
AV	Freq_Auto	23	No Units		R/W	Auto-select a valid voltage channel for frequency measurements	50
AV	Freq_Channel	24	No Units		R/W	Voltage channel used to measure frequency. 0, 1, 2, for A, B, C	50
AV	PF_Sign_Mode	25	No Units		R/W	Indicates how the sign of the power factor is calculated	47
AI	Serial_Number	100	No Units		R	Factory programmed Serial Number of the device	
AI	Debug_Register	101	No Units		R	Always returns 1234.567. Useful for verifying proper communications with the device	
AI	Hardware_Ver	102	No Units		R	Device Hardware Version	
AI	Firmware_Ver	103	No Units		R	Device Firmware Version	
AI	Bootloader_Ver	104	No Units		R	Device Bootloader Version	
AI	Model_Number	105	No Units		R	Two-byte ASCII string. 19762 indicates "M2" model	
AI	Input_Config	106	No Units		R	"1" for mA CTs, "2" for mV CTs, "3" for 5A CTs, "4" for Rogowski Coil, "0" for Custom Setup	
AV	K1_Reg_Offset	26	No Units		R/W	Offset Register for K1 Relay	54
AV	K1_Trigger_Type	27	No Units		R/W	Trigger type for K1 Relay	54
AV	K1_Upper_Bound	28	No Units		R/W	Upper Bound for K1 Relay	54
AV	K1_Lower_Bound	29	No Units		R/W	Lower Bound for K1 Relay	54
AV	K1_Min_Duration	30	No Units		R/W	Minimum Duration for K1 Relay	54
AV	K1_Active_Mode	31	No Units		R/W	Output Mode for K2 Relay	54
AV	K2_Reg_Offset	32	No Units		R/W	Offset Register for K2 Relay	54
AV	K2_Trigger_Type	33	No Units		R/W	Trigger type for K2 Relay	54
AV	K2_Upper_Bound	34	No Units		R/W	Upper Bound for K2 Relay	54
AV	K2_Lower_Bound	35	No Units		R/W	Lower Bound for K2 Relay	54
AV	K2_Min_Duration	36	No Units		R/W	Minimum Duration for K2 Relay	54
AV	K2_Active_Mode	37	No Units		R/W	Output Mode for K2 Relay	54
AV	Passcode	38	No Units		R/W	Used for entering a passcode when locking or unlocking the device.	48
AV	Lock	39	No Units		R/W	"0" indicates unlocked. "1" indicates locked. With a passcode entered above, write "0" to unlock, "1" to lock, or "2" to change passcode.	48
AV	Reset_Energy	40	No Units		R/W	Write 0xA5A5 (42405) to reset the accumulated energy to 0	47
AV	Reboot_Device	41	No Units		R/W	Write 0xAA55 (43605) to reboot the device. Always reads "0"	

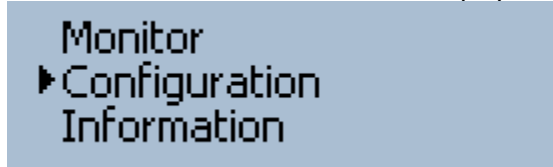
7.4. BACnet Configuration

Configuration of the WattsOn-Mark II BACnet MS/TP network parameters may be done using the on-board display or the Expansion Bus (second RS-485 port) using a Windows based PC.

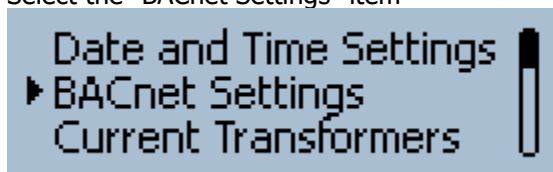
7.4.1. Configuration using the on-board Display (if equipped with -DL option)

If the WattsOn-Mark II is equipped with the optional DL (Datalogging and LCD module), the BACnet MS/TP parameters may be configured using the screen and buttons.

1. Press the BACK button to enter the display menu, and select the "Configuration" item.



2. Select the "BACnet Settings" item



3. Configure the Items from the menu as necessary:
 - **MAC on DIP 'F'** (between 0 and 127)
 - **BAUD rate** (9600, 19.2 kbps, 38.4 kbps, 57.6 kbps, 76.8 kbps, 115.2 kbps)
 - **Instance** (between 0 and 4,194,302)
 - **Max Master** (between 1 and 127)
4. Once the settings are configured as desired, the option "**Commit**" must be selected for the BACnet MS/TP network settings to take effect. Alternatively, the device may be power cycled.

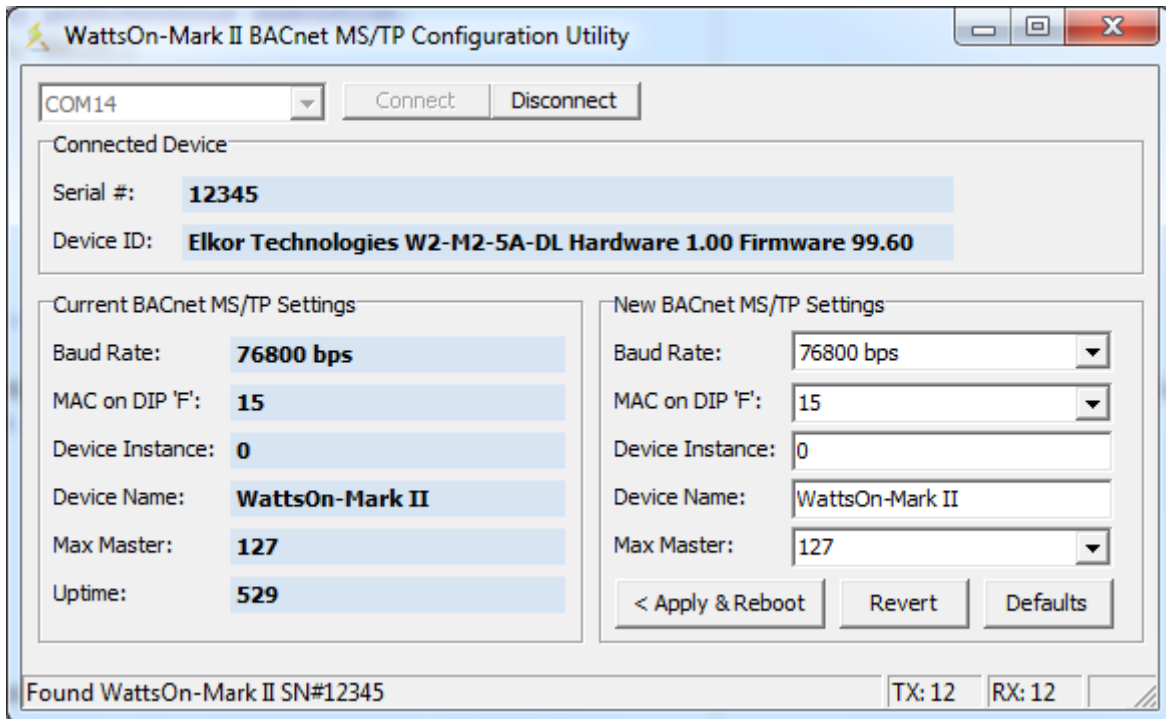
7.4.2. Configuration using software utility

The BACnet MS/TP parameters may be configured via a free configuration utility, available at the Elkor Technologies Inc. Website (http://www.elkor.net/bin/W2_BACnet_cfg.zip)

To use the utility, a PC running Windows and an RS-485 serial port are required. The RS-485 port may be a USB-to-RS-485 cable such as Elkor's ET485U. The software drivers for the cable must be installed, and the port must be visible under device manager (refer to converter documentation). The COM port number of the installed cable must be known.

1. Connect the RS-485 cable to your computer. Make sure you know its COM port number.
2. Wire the RS-485 cable to the **EXPANSION BUS (X. Bus)** terminals of the WattsOn-Mark II. Do NOT wire the converter to the RS-485 Modbus/RTU port, as it will not work in this way.
3. Extract the software to a known location on your hard drive and execute it. The software is a one-file executable, and does not require a specific installation.
4. Upon execution of the program, the drop down list will be populated with a list of available COM ports on the PC. If the desired COM port is not listed, please refer to troubleshooting/installation of the RS-485 converter.
5. Select the COM port, and click "Connect".

6. Wait a few seconds until the fields are populated with the device information. Ensure that the device shows as a "Elkor Technologies Inc W2-M2" device.
7. The software will populated the "Current BACnet MS/TP Settings" window with the configuration as currently stored on the WattsOn-Mark II
8. Make the necessary adjustments in the "New BACnet MS/TP Settings" window.
9. Once adjustments are made, press "Apply & Reboot" to write the values to the WattsOn-Mark II and send a software reboot. The reboot is necessary for the new BACnet MS/TP settings to take effect.



7.4.3. Configuration using Modbus/RTU

Although the W2-M2 model does not have full Modbus/RTU support (the Modbus/RTU port is replaced by the BACnet MS/TP port), it is possible to use Modbus/RTU through the Expansion Bus (X. Bus) terminal. To do so, the Modbus/RTU master must be correctly wired to the X. Bus terminal. Additionally, the serial configuration must be set to 115200,N,8,1. The WattsOn will answer to *any* Modbus address on which it is queried. By default, it is recommended to use address "1".

List of BACnet MS/TP configuration registers

Name	Offset	Address	Size	Type	R/W	Default	Description
MAC on DIP 'F'	0x550	41361	16	U	R/W	15	MAC address to be used when DIP is set to 'F'.
BAUD Rate	0x551	41362	16	U	R/W	768	BAUD rate for the BACnet MS/TP network.
Instance	0x552	41363	32	U	R/W	<serial number>	Device instance for this meter
Max Master	0x554	41365	16	U	R/W	127	MAX Master setting for the BACnet MS/TP network
Commit	0x555	41366	16	U	R/W	0	Reset the BACnet MS/TP network and apply the new settings.
Name [0]	0x556	41367	16	U	R/W	0x5761	Up to 16-character Device Name. Default is "WattsOn-Mark II"
Name [1]	0x557	41368	16	U	R/W	0x7474	
Name [2]	0x558	41369	16	U	R/W	0x734F	
Name [3]	0x559	41370	16	U	R/W	0x6E2D	
Name [4]	0x560	41371	16	U	R/W	0x4D61	
Name [5]	0x561	41372	16	U	R/W	0x726B	
Name [6]	0x562	41373	16	U	R/W	0x2049	
Name [7]	0x563	41374	16	U	R/W	0x4900	

Register details:

MAC on DIP 'F': The BACnet MS/TP MAC address to be used when the DIP switch is set to position 'F'. In positions 1-14 ('E'), the physical position of the DIP switch sets the MAC address. NOTE: DIP switch position '0' is invalid, and must not be used. If a MAC address of "0" is desired, then the DIP switch must be placed into position 'F' and this register must be set to "0". An invalid setting will cause the BACnet MS/TP network to fail on startup.

BAUD Rate: The value written here is the baud rate in bps divided by 100. ie: 9600 = 96, 19200 = 192, 115200 = 1152. No error checking is done, and an invalid setting will cause the BACnet MS/TP network not to function. Valid values are: 96, 192, 384, 576, 768, 1152). An invalid setting will cause the BACnet MS/TP network to fail on startup.

Device Instance: The desired device instance. No error checking is done. Value must be between 0 to 4194302. An invalid setting will cause the BACnet MS/TP network to fail on startup.

Max Master: The desired MAX MASTER setting. No error checking is done. Value must be between 0 to 127. An invalid setting will cause the BACnet MS/TP network to fail on startup.

Commit: A CHANGE in this value will cause the BACnet MS/TP network to reset with any changed parameters. This resets the network only, and not the entire WattsOn-Mark II device.

Name [0]-[7]: The device name, as stored in the BACnet Device Object. This is a 16-character string. Each character ASCII value is encoded sequentially in the registers as two-bytes per register. If the string is shorter than 16-characters, then the remaining characters must be "0".

8. THE WEB INTERFACE (FOR E3/E4 MODELS)

8.1. Accessing the Web Interface

To access the web interface for the E3/E4-model WattsOn Mk. II, open a web browser and direct it to the device's IP address. (To discover the device's IP address for the first time, refer to **Section 2, Installation** (p. 10). We recommend using Mozilla Firefox or Google Chrome to access the web interface, but other standards-compliant web browsers should work fine.

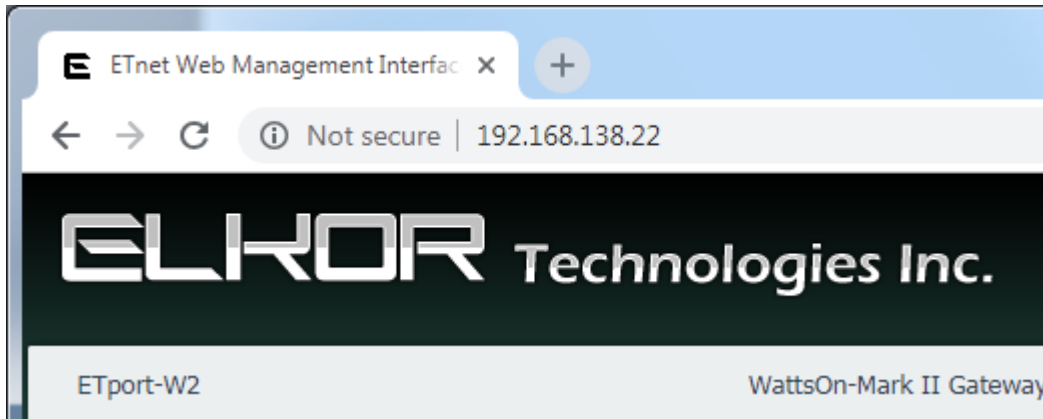


Figure 1. Accessing the Web Interface

The web interface provides a number of status indicators and configuration features.

Note — Default Password: By default, the configuration pages are protected with a password. The first time you access the web interface, the default username and password will be **admin** and **admin**. This password can be changed, if desired; see **8.8, Changing the Administrator Password** (p. 71).

The left-hand side of the web interface contains the different configuration pages available. They are divided into two sections, Connected Device, which contains features related to the attached WattsOn device, and Gateway, which contains features that pertain to the Ethernet/Wi-Fi gateway itself. The center of the interface shows the current configuration/status page – Information, by default.

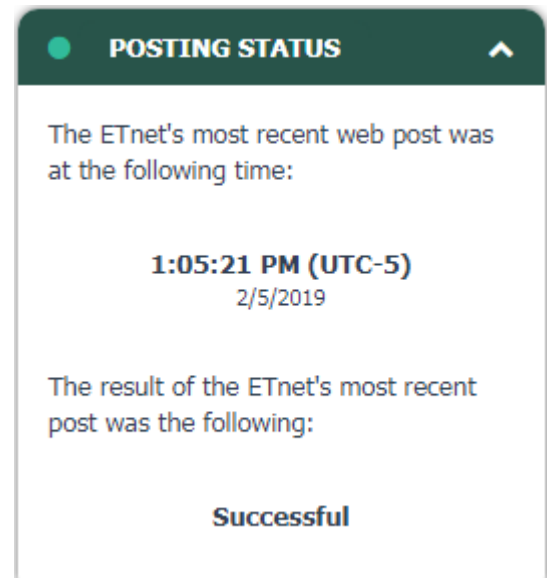
8.2. Posting Status

Below the Connection Status box is the Posting Status box. If the Web Posting feature is enabled, this box shows the status of the most recent web post that has been made since the device was powered on. It will display the time of the most recent post attempt, in the local time zone of your computer. It will also display whether or not the most recent post was successful or not, including (if applicable) the HTTP error code that was returned from the server. Any connection problems are shown in the top-right corner of the box.

For details on configuring the web posting feature, as well as getting a more detailed status response, see **8.13, Posting Data** (p. 73).

8.3. Information Page

By default, the web interface displays general information, including information about the device's firmware, and its current networking settings. The format differs slightly depending on the device model.



METER INFORMATION	
Device:	WattsOn-Mark II
Part Number:	W2-E4-5A
Serial Number:	0
Firmware Version:	12.00
Hardware Version:	1.30

GATEWAY INFORMATION	
Name:	WattsOn-Mark II Gateway
Device Name:	ETport-W2
Uptime:	01:38:46
Firmware Version:	0.83
Firmware Release Date:	Jan 3 2019 10:37:14
Operating System:	Platform v3.1.2e1 / Kernel V8.2.0

NETWORKING INFORMATION	
Interface:	Ethernet
MAC Address:	24:0a:c4:17:cf:2b
IP Address:	192.168.138.22 (DHCP)
Subnet Mask:	255.255.255.0 (DHCP)
Default Gateway:	192.168.138.1 (DHCP)
Primary DNS:	192.168.138.1 (DHCP)
Secondary DNS:	0.0.0.0 (DHCP)

8.4. Diagnostics Page

Click "Diagnostics" to view the diagnostics page. On this page, you can view several internal details about the device, including RAM details, and the processes that are currently running. Generally you will not need to check the diagnostics page unless there is a problem.

8.5. Filesystem Page

Click "Filesystem" to view the filesystem page. On this page, you can view, download, and upload files that are stored on the device's flash file system, as well as enable or disable FTP and TFTP protocol access. The in-browser file explorer is provided for convenience; generally, we recommend using an FTP client to interact with the device's filesystem, as that will provide a more powerful interface. TFTP access is a simpler protocol often used in other embedded devices, which may be useful for integrating the device in a larger system of embedded electronics.

8.5.1. To view or download a file using the browser

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Web File Explorer box, click on the name of the file you wish to view.
3. Clicking on a file will either cause its contents will either be shown in the browser (if it is a text file), or the browser will ask you if you wish to download the file to your computer.
4. If you wish to download a text file rather than view it, you can use your browser's "Save Page" function, which varies slightly depending on your browser:
 - a. In recent versions of Mozilla Firefox, click on the Firefox button, and then click "Save Page As"
 - b. In recent versions of Google Chrome, click on the wrench button, and then click "Save page as"
 - c. In recent versions of Microsoft Internet Explorer, click on the gear button (tools), click on the File menu, and then click on "Save as"
 - d. For other browsers, consult that browser's documentation for details on how to save a page.
5. If you clicked on a directory (E3 model), the contents of the directory will be shown in the directory hierarchy. You can return to the previous directory by clicking the *Up* entry in the hierarchy.

8.5.2. To delete a file or directory using the browser

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Web File Explorer box, click on the red "X" next to the name of the file or directory you wish to delete.
3. If you are deleting a directory, it must be empty before you can delete it. Delete all of the files in the directory before deleting the directory itself.

8.5.3. To upload a file using the browser

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Web File Explorer box, click the *Upload* button under the Operations heading.
3. Click on the *Browse* button (*Choose File* on Google Chrome) to select a file on your computer to upload.
4. Click on the *Upload* button.
5. Your file or directory will appear in the directory tree shown above.

The E3 model supports a number of additional operations for convenience that can be performed using the browser itself. The following subsections describe the operations available.

8.5.4. To create a file or directory using the browser (E3 model only)

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Web File Explorer box, click the *New* button under the Operations heading.
3. If you are creating a file, enter a file name in the text field labelled *File* and click the *Create* button.
4. If you are creating a directory, enter a file name in the text field labelled *Directory* and click the *Create* button.
5. Your file or directory will appear in the directory tree shown above.

8.5.5. To copy or move a file to another location on the filesystem using the browser (E3 model only)

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Web File Explorer box, click the *Copy* or *Move* button under the Operations heading, depending on which operation you would like to perform.
3. Enter the path of the source and destination filenames in the text fields.
 - a. For a file that is currently displayed in the directory hierarchy, simply enter the file's name.
 - b. For a file in another directory, enter a full file path. File paths start with a "/" character, indicating the root of the filesystem. For example, to indicate a file called *register_post.tpl* in the *templates* directory, use the path */templates/register_post.tpl*.
4. Click on the *Move* or *Copy* button below the text fields.

8.5.6. To transfer a file to or from an external TFTP server (E3 model only)

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Web File Explorer box, click the *TFTP* button under the Operations heading.
3. Select *Get* to transfer a file from an external TFTP server onto the filesystem. Select *Put* to transfer a file from the filesystem to an external TFTP server.
4. Select the desired mode. Generally, *Binary* mode is recommended.
5. Enter the path of the file on the file system. If you are getting a file, this is the path on the device where that file will be placed. If you are putting a file, this is the path to the file to be sent to the external TFTP server.
6. Enter the path of the file on the external TFTP server's file system. If you are putting a file, this is the path on the external TFTP server where that file will be placed. If you are getting a file, this is the path to the file to be sent to the device.
7. Enter the host name or IP address of the external TFTP server.
8. Enter the port number of the external TFTP server. By default, this is usually port 69.
9. Click the *Transfer* button.

The E3 model also supports remove access to the filesystem via FTP and TFTP, as described below.

8.5.7. To enable FTP access (E3 model only)

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Remote Access box, towards the bottom, click the *Change* button under the FTP Server Status heading.
3. Click in the *Enabled* box to enable the FTP server.
4. Enter a username and password for the FTP server in the text fields below.

5. Click the *Submit* button to save your changes.
6. You can now access the file system via an FTP client.

8.5.8. To enable TFTP access (E3 model only)

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Remote Access box, towards the bottom, click the *Change* button under the TFTP Server Status heading.
3. Click in the *Enabled* box to enable the FTP server.
4. Optionally enable or disable specific features of the TFTP server as shown, such as file creation or firmware updates.
5. Click the *Submit* button to save your changes.
6. You can now access the file system via a TFTP client.

8.5.9. Formatting the File System (E3 model only)

Note — Not Recommended: We do not generally recommend formatting the entire filesystem. Use with caution.

Formatting removes all files and directories from the filesystem, and reboots the device. Certain files and directories required by the device's firmware will be rebuilt with default settings after formatting. In general, we do not recommend formatting the filesystem.

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Filesystem Information box, click on the *Format* button under the Current Usage heading.
3. Formatting the filesystem can take some time. You will be directed to a different page while the formatting and rebooting operations take place. Wait for the countdown to complete, and you will be automatically redirected back to the browser's main page.
 - a. If the device acquires its IP address automatically using DHCP, it is possible that your router will assign a different IP address to the device after a reboot, and you will need to enter that IP Address manually in your browser to return to the web interface. For details on discovering the device's IP address, see **Section 2, Installation** (p. 10).

8.5.10. Compacting the File System (E3 model only)

Note — Automatic: The compacting process normally occurs automatically. Starting the process manually is generally not necessary.

The device's flash memory is divided into two equal-sized banks. To extend the lifetime of the device's flash memory, data in the filesystem is overwritten as rarely as possible. Instead, each time a file is written to the flash memory, new data is written to the end of the file system; space occupied by deleted or changed files is not freed immediately. This space is referred to as being "dirty." Once the end of the filesystem is reached, the device will copy all of its files to the second memory bank, and erase the first bank, freeing up space used by deleted or changed files. This process is called *compacting*.

The compacting process occurs automatically, there is generally no need to start the process manually. The process can take a few minutes, however, so to avoid a delay in the future, you may wish to compact the filesystem sooner if a large number of files are dirty. The process for doing so is described below:

1. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
2. In the Filesystem Information box, click on the *Compact* button under the Dirty Space heading.
3. Compacting the filesystem can take some time. Please wait until this process has completed – progress messages will show on the page as the process completes.

8.6. Network Page

The network page allows you to configure how the device gets its IP address, and lets you set the hostname and domain. The device supports automatic acquisition of an IP address using either DHCP or BOOTP, as well as setting a static IP. The process for doing so is described below:

8.6.1. To set the IP address statically

1. Click "Network" on the left-hand side of the web interface to access the network configuration page.
2. Enter a hostname and/or domain into the corresponding text fields, if desired. (Optional, E3 model only)
3. Click in the *Static (Set Manually)* checkbox under the IP Configuration heading.
4. Enter the IP information. The values that are currently in use will be present in the text fields by default.
5. Click the *Submit* button to save your changes. The device will reboot and then reload the web interface automatically.
 - a. If the device acquires its IP address automatically using DHCP, it is possible that your router will assign a different IP address to the device after a reboot, and you will need to enter that IP Address manually in your browser to return to the web interface. For details on discovering the device's IP address, see **Section 2, Installation** (p. 10).

8.6.2. To set the IP address automatically

1. Click "Network" on the left-hand side of the web interface to access the network configuration page.
2. Enter a hostname and/or domain into the corresponding text fields, if desired. (Optional)
3. Click in the *DHCP* (default) or *BOOTP* (E3 model only) checkbox under the IP Configuration heading.
4. Click the *Submit* button to save your changes. The device will reboot and then reload the web interface automatically.
 - a. If the device acquires its IP address automatically using DHCP, it is possible that your router will assign a different IP address to the device after a reboot, and you will need to enter that IP Address manually in your browser to return to the web interface. For details on discovering the device's IP address, see **Section 2, Installation** (p. 10).

8.7. System Page

The system page allows you to reboot the device, restore its settings to the factory default configuration, or change the firmware that is installed.

Note — Not Recommended: We do not generally recommend changing the firmware unless absolutely necessary, as a power failure during the process could corrupt the firmware, requiring a special procedure to recover the device. Use with caution.

8.8. Changing the Administrator Password

For the E4 model:

1. Click "System" on the left-hand side of the web interface to access the system configuration page.
2. Type the desired password twice, in each of the two boxes to the right of the *Admin Password* field.
3. Click the *Submit* button.

For the E3 model:

1. Click "Web Interface" on the left-hand side of the web interface to access the web interface configuration page.
2. In the Authentication box under the Protected Directories heading, click the *Add Realm* button.
3. Under the Add Protected Directory heading, enter the directory of the web interface to be protected. To protect read-only pages, enter **/config** (unprotected by default). To protect read-write pages, enter **/protected** (protected by default). To protect both sets of pages, you will need to add two realms, one for each.
4. Enter a display name for this protection realm. This is just for display purposes, and can be any name.
5. Enter the type of authentication protocol to be used. The SSL authentication types are available only if an SSL certificate has been created or uploaded to the device. Select at least "Basic".
6. Enter the username and password of a user in this realm.
7. Click the *Submit* button.

Note — Security Concerns: When using "Basic" or "Digest" authentication without SSL, passwords transmitted over the network may be visible to observers. These methods are easy to set up, but are easily broken and suitable for basic interface-level security only. For serious security concerns, use SSL, or do not expose the web interface to the un-trusted individuals (i.e. with a firewall).

8.9. Advanced Web Interface Settings (E3 model only)

The web interface page allows you to configure the internal web server, authentication, and SSL certificates. You can protect all or part of the web interface by using a password.

8.9.1. To change the settings for the HTTP/HTTPS server (E3 model only)

1. Click "Web Interface" on the left-hand side of the web interface to access the web interface configuration page.
2. In the HTTP/HTTPS Configuration box, under the Current Settings, click the *Edit Settings* button.
3. To disable the web server, click the *Disabled* radio button under the Edit HTTP Settings heading.
4. To change the port number that the HTTP web server uses, enter a new number in the *Port* text field under the Edit HTTP Settings heading. The default is port 80.
5. To change the port number that the HTTPS web server uses, enter a new number in the *Port* text field under the Edit Secure HTTP Settings heading. The default port is 443.
6. To enable or disable HTTPS authentication protocols, click the corresponding check box next to SSL 3, TLS 1.0, or TLS 1.1 under the Edit Secure HTTP Settings heading.
7. Click the *Submit* button to save your changes.

Note — HTTPS and Certificates: The HTTPS server will not work until you configure an SSL certificate in the SSL Certificates box.

8.9.2. To remove password protection from the web interface (E3 model only)

1. By default, one protected directory is listed under the Protected Directories heading in the Authentication box.
2. To remove password protection, click the *Delete* button next to this entry.

8.9.3. To add a user to an existing protection realm (E3 model only)

1. In the Authentication box under the Protected Directories heading, click the [add user] link.
2. Under the Add Protected Directory heading, enter a username and password for this new user.
3. Click the *Submit* button and the user will appear in the Users list.

8.9.4. To upload an SSL Certificate (E3 model only)

1. In the SSL Certificates section, under the Upload Certificate heading, next to *New Certificate* click the *Browse* button (*Choose File* on Google Chrome), and select your SSL certificate file.
2. Next to *Private Key*, click on the *Browse* button (*Choose File* on Google Chrome), and select your private key file.
3. Click the *Submit* button.

8.9.5. To upload a certificate authority certificate (E3 model only)

1. In the SSL Certificates section, under the Upload Authority section, click the *Browse* button (*Choose File* on Google Chrome) and select an authority certificate file.
2. Click the *Submit* button.

8.9.6. To create a self-signed certificate (E3 model only)

1. Under the Create Self-Signed Certificate heading, fill out the form with information about your organization, which can be seen by visitors to the web interface.
2. Choose a key length. Note that longer keys are more secure, but take much longer to create and increase access times to the server.
3. Chose a key type. DSA is recommended.
4. Click the *Submit* button.

8.10. Viewing Real-Time Data

To monitor real time sensor data from the meter, access the web interface, and click on *Monitor*. Data will begin to appear after a moment. In the first box, titled Reading Timestamp, a timestamp of when the data was last read is displayed. The timestamp is shown in your local time zone (as determined by your computer's system time).

The second box displays the current real-time parameters that are being measured, including instantaneous voltage, current, and power. The third box displays accumulated energy values. These values accumulate over time.

8.11. Viewing the Meter Configuration

To view meter configuration settings, access the web interface, and click on *View Config*. Data will begin to appear after a moment.

The current values programmed into the meter are displayed. These values can help you debug configuration issues with the device.

8.12. Posting Data to the Elkor Cloud

You can have your device post to the Elkor Cloud website to easily view graphs of data from any web browser anywhere in the world. A video tutorial on the Elkor Cloud is available at: https://www.youtube.com/watch?v=iW_6Wzvl1jE.

8.12.1. To configure your device to post to the Elkor Cloud

1. Click "Web Posting" on the left-hand side to access the web posting configuration page.
2. Click the *Change* button next to the *Posting* field.
3. Click the *Preconfigured Profiles* drop-down box, and select *Elkor Cloud*.
4. Check the *Enable Posting* checkbox.
5. Click the *Submit* button.
6. If you have not yet created an Elkor Cloud account, click the *create a new account* link.
7. Click the *Add this device* link to add your device to your Elkor Cloud account. The Elkor Cloud site will prompt you to login if necessary.

8.13. Posting Data to your own Web Server (Advanced Feature)

The device can periodically transmit data from the connected WattsOn meter to a local or remote web site. This is done by sending an HTTP POST message to a given URL (website address, such as <http://www.your-server.com/>). This message can be interpreted by server-side scripts, such as those written in PHP, ASP, JSP, CGI, and similar technologies. Such scripts could log the information, upload it to a database, control some other device with the information, and so on.

The format of the HTTP POST is customizable using a template. By default, the device ships with a template that posts in JSON format, but by customizing the template, you could post in any other format, such as XML, CSV, or proprietary formats specific to your company or organization. Details for customizing your template are provided in **8.14, Customizing the Web Posting Format (Advanced Feature)** on page 76.

8.13.1. Examples

Hyper-Text Transfer Protocol (HTTP) is the protocol used on the internet to request web pages and upload information back to them. While the details of the HTTP protocol are beyond the scope of this document, an example POST is shown below.

```
POST /post/ HTTP/1.1
Content-Type: application/json
Content-Length: 1484

payload={
  "device": "ETport-W2-00:11:22:33:44:55",
  "device_firmware_version": "1.00",
  "meter_serial": 50001,
  "meter_firmware_version": 12.00,
  "time": "2012-05-15T18:22Z",
  "live_data": "true",
  "data": {
    "net_total_energy_cumulative_kWh": 26086.6,
    "real_power_ab_total_kW": 2.240,
    "reactive_power_ab_total_kVAR": 0.090,
    "apparent_power_ab_total_kVA": 2.410,
    "power_factor_ab_total_none": 0.929,
    "frequency_instantaneous_Hz": 60.0,
    "real_power_demand_ab_average_kW": 2.2,
    "voltage_a_instantaneous_V": 118.9,
    "voltage_b_instantaneous_V": 116.2,
    "voltage_ab_instantaneous_V": 235.1,
```

```

"current_a_instantaneous_A": 7.100,
"current_b_instantaneous_A": 13.780,
"real_power_a_instantaneous_kW": 0.799,
"real_power_b_instantaneous_kW": 1.442,
"reactive_power_a_instantaneous_kVAR": 0.145,
"reactive_power_b_instantaneous_kVAR": -0.055,
"apparent_power_a_instantaneous_kVA": 0.845,
"apparent_power_b_instantaneous_kVA": 1.561,
"power_factor_a_instantaneous_none": 0.945,
"power_factor_b_instantaneous_none": -0.924,
"import_energy_a_cumulative_KWh": 11436.0,
"import_energy_b_cumulative_KWh": 14650.7,
"ttl_import_energy_ab_total_KWh": 26086.6,
"export_energy_a_cumulative_KWh": 0.0,
"export_energy_b_cumulative_KWh": 0.0,
"ttl_export_energy_ab_total_KWh": 0.0,
"net_real_energy_a_cumulative_KWh": 11436.0,
"net_real_energy_b_cumulative_KWh": 14650.7,
"status": 0
}
}

```

While the details of server-side scripting are beyond the scope of this document, a sample script written in the PHP scripting language is provided below for reference. The script reads the data from the HTTP POST and appends that data to the end of the log file called "posts.log".

```

<?php

// Place the contents of the HTTP POST into a variable
$postdata = file_get_contents("php://input");

// Save the data to a log file
$handle = fopen("posts.log", "a");
fwrite($handle, $postdata);
fclose($handle);

?>

```

For a slightly more sophisticated (and useful) example, see the example on the following page. In this example, the JSON data POSTed to the server is parsed, and appended to the end of a CSV file for each device. These CSV files can be easily read by many spreadsheet applications, such as Microsoft Excel or LibreOffice Calc, which can use the data to create graphs, etc.

```

<?php
// Parse the data (which, when using the default template, is in JSON format) into a PHP object
$post = json_decode(file_get_contents("php://input"));

// The filename to save the data under. For example, meter_12345.csv
$filename = "meter_" . $post->payload->meter_serial . ".csv";

// If it's the first post for this device, write a header at the top of the file
if (!file_exists($filename)) {
    file_put_contents(
        $filename,
        "date,kW,kVAR,kVA,V,V-LL,I,PF,Hz,Va,Vb,Vc,Vab,Vbc,Vac,Ia,Ib,Ic,kWa,kWb,kWc," .
        "kVARa,kVARb,kVARc,kVAa,kVAb,kVAc,PFa,PFb,PFc,kW-SW,kWh,kWha,kWhb,kWhc," .
        "kWh+a,kWh+b,kWh+c,kWh-a,kWh-b,kWh-c\r\n"
    );
}

// Parse the timestamp, which is in ISO8601 format in the default template, and in UTC
$date = date_create_from_format("Y-m-d\TH:iZ", $post->payload->time, new DateTimeZone("UTC"));

// Write the data to the file
file_put_contents(
    $filename,
    date_format($date, "d M Y H:i") . ",, " .
    $post->payload->data->active_power_total_kW . ",, " .
    $post->payload->data->reactive_power_total_kVAR . ",, " .
    $post->payload->data->apparent_power_total_kVA . ",, " .
    $post->payload->data->voltage_LN_average_V . ",, " .
    $post->payload->data->voltage_LL_average_V . ",, " .
    $post->payload->data->current_average_A . ",, " .
    $post->payload->data->power_factor_total_none . ",, " .
    $post->payload->data->frequency_Hz . ",, " .
    $post->payload->data->voltage_a_instantaneous_V . ",, " .
    $post->payload->data->voltage_b_instantaneous_V . ",, " .
    $post->payload->data->voltage_c_instantaneous_V . ",, " .
    $post->payload->data->voltage_ab_instantaneous_V . ",, " .
    $post->payload->data->voltage_bc_instantaneous_V . ",, " .
    $post->payload->data->voltage_ac_instantaneous_V . ",, " .
    $post->payload->data->current_a_instantaneous_A . ",, " .
    $post->payload->data->current_b_instantaneous_A . ",, " .
    $post->payload->data->current_c_instantaneous_A . ",, " .
    $post->payload->data->active_power_a_instantaneous_kW . ",, " .
    $post->payload->data->active_power_b_instantaneous_kW . ",, " .
    $post->payload->data->active_power_c_instantaneous_kW . ",, " .
    $post->payload->data->reactive_power_a_instantaneous_kVAR . ",, " .
    $post->payload->data->reactive_power_b_instantaneous_kVAR . ",, " .
    $post->payload->data->reactive_power_c_instantaneous_kVAR . ",, " .
    $post->payload->data->apparent_power_a_instantaneous_kVA . ",, " .
    $post->payload->data->apparent_power_b_instantaneous_kVA . ",, " .
    $post->payload->data->apparent_power_c_instantaneous_kVA . ",, " .
    $post->payload->data->power_factor_a_instantaneous_none . ",, " .
    $post->payload->data->power_factor_b_instantaneous_none . ",, " .
    $post->payload->data->power_factor_c_instantaneous_none . ",, " .
    $post->payload->data->sliding_window_power_average_kW . ",, " .
    $post->payload->data->net_real_energy_total_kWh . ",, " .
    $post->payload->data->net_real_energy_a_kWh . ",, " .
    $post->payload->data->net_real_energy_b_kWh . ",, " .
    $post->payload->data->net_real_energy_c_kWh . ",, " .
    $post->payload->data->import_real_energy_a_kWh . ",, " .
    $post->payload->data->import_real_energy_b_kWh . ",, " .
    $post->payload->data->import_real_energy_c_kWh . ",, " .
    $post->payload->data->export_real_energy_a_kWh . ",, " .
    $post->payload->data->export_real_energy_b_kWh . ",, " .
    $post->payload->data->export_real_energy_c_kWh . "\r\n",
    FILE_APPEND
);
?>

```

8.13.2. Enabling Web Posting

To configure the web posting, you must access the web interface, and click on the *Web Posting* button on the left-hand side of the page.

1. In the Web Posting box, under the Current Posting Settings heading, click the *Change* button.
2. Check the *Enable Posting* box.
3. Choose how often the device will post its data to the server. To select, for instance, every 15 minutes, enter "15" into the text field, and select "minutes" from the drop-down box. You can enter times in minutes or hours.
4. Enter the URL (web address) of the web server to which posts should be made.

Note — Trailing Slashes: If the URL you are entering does not end in a file extension (like .htm or .html), some web servers require that you end it with a trailing slash /. For instance, http://www.your-server.com/data/

5. Click the *Submit* button to save your changes.

If the device previously had web posting disabled, it will immediately make its first post after the settings are applied, and then make subsequent posts after the designated interval. You can test your configuration by clicking the *Post Now* button at the bottom of the Web Posting box.

8.13.3. Enabling HTTP Authentication

If your web server requires basic HTTP authentication, you can enable it by entering a username and password.

1. In the Web Posting box, under the HTTP Authentication heading, click the *Change* button.
2. Click the *Enable* check box.
3. Enter the username and password in the text fields
4. Click the *Submit* button to save your changes.

8.13.4. Testing the Configuration

You can test your configuration by clicking the *Post Now* button at the bottom of the Web Posting box. The Previous Post Response box will display the HTTP response, if any, of the previous posting attempt. You can use this to help debug connection or formatting problems with the post or posting template.

8.14. Customizing the Web Posting Format (Advanced Feature)

The format that the device uses to post data to the web server can be completely customized by editing a template. The template is stored on the device, and can be viewed or downloaded using the web interface. The file is called templates/register_post.tpl. For details on how to view or download a file using the web interface, see **8.5, Filesystem Page** (p. 68).

8.14.1. Editing the Template

The template can be opened and edited in any simple text editor, such as *Notepad* on Microsoft Windows. The template contains both text that will be posted to the web server verbatim, and symbols which will be replaced with values read from the WattsOn meter (or other information) when the data is posted.

Symbols are inserted into the template, which are replaced with real-time values each time the data is posted. Symbols start with a dollar sign \$ to separate them from the text content of the template; if you need to use a literal \$ in your template, enter it using two dollar signs \$\$, which will be replaced with a single \$ when the data is posted. The following sections list the symbols that you can use in your template.

After you have modified the template (or created a new one) as desired, you can upload it by following the instructions in section **8.5, Filesystem Page** (p. 68).

8.14.2. Symbol List (E4 model)

On the E4 model, the symbols represent "functions", some of which accept input parameters, which are replaced with values when posting. Many of the functions accept a Modbus register address as a parameter; see chapter **6, The Modbus Protocol** (p. 34) for the list of Modbus registers that can be used with these functions.

`$short(address [, count=n])`

Returns the 2-byte integer value of the given Modbus register *address*. If *count* is given, *n* results will be returned.

`$int(address [, count=n])`

Returns the 4-byte integer value of the given Modbus register address. If *count* is given, *n* results will be returned.

`$float(address [, count=n], [precision=p])`

Returns the 4-byte floating point value of the given Modbus register address. If *count* is given, *n* results will be returned. If *precision* is given, the result will be rounded to *p* decimal places (from 0 to 10, default 6).

`$ushort(address [, count=n])`

Returns the 2-byte unsigned value of the given Modbus register address. If *count* is given, *n* results will be returned.

`$uint(address [, count=n])`

Returns the 4-byte unsigned value of the given Modbus register address. If *count* is given, *n* results will be returned.

`$fixedshort(address, decimal_point [, count=n])`

Returns the 2-byte fixed-point value of the given Modbus register address with the decimal place at the given point. For example, if the value of register 1 is 100, `$fixedshort(1, 2)` will return 1.00. If *count* is given, *n* results will be returned.

`$slave-id([output=o])`

Returns the device's slave ID code or string (as reported by Modbus function 17 Report Slave ID). If *output* is not given, the slave ID code, run indicator flag, and text will be returned. Output may be one of "code", "run-indicator", or "text" to only return the indicated value.

`$string(address, length)`

Returns the string value of the given Modbus register address with the given maximum *length*. The higher-order byte and the lower-order byte of each register are interpreted as individual ASCII characters, displayed sequentially.

`$block(address, length)`

Pre-loads a Modbus block into a cache, making subsequent smaller queries to the addresses in that block very fast. This function is simply removed from the template, rather than being replaced with anything.

`$mb(byte1[, byte2][, ...])`

Send an arbitrary modbus query byte-by-byte and receive the response (including exception responses). Any number of bytes can be passed to this function.

`$gateway-device()`

Returns the part name of this device (the gateway).

`$gateway-name()`

Returns the name of this device (the gateway).

`$gateway-version()`

Returns the version number of this device (the gateway).

`$live()`

Returns false if this post is buffered, true otherwise.

`$mac()`

Returns the MAC address of this device (depending on which interface is being used).

8.14.3. Symbol List (E3 model)

On the E3 model, the symbols represent variables which are replaced with a value when posting.

System Variables

The following variables provide general information about the device.

Variable	Description
\$dev_name	Name of the device, including the MAC address. For example, ETnet-00:11:22:33:44:55
\$etnet_version_firmware	The firmware version of the gateway.
\$dev_serial	The serial number of the device to which the gateway is connected.
\$time_unix	Timestamp of the last set of values read from the meter, given in Unix format. If the time could not be acquired from the internet, the variable is replaced with "Time Not Available." See Section 8.14.4, Time Synchronization .
\$time_ISO8601	Timestamp of the last set of values read from the meter, in ISO8601 format. If the time could not be acquired from the internet, the variable is replaced with "Time Not Available." See Section 8.14.4, Time Synchronization .
\$dev_uptime	Number of seconds that the device has been on.
\$dev_time_sync_age	Number of seconds since the device last synchronized its clock via the internet. By default, it synchronizes the clock on boot-up, and subsequently every 24 hours.
\$live_data	Replaced with "yes" if the data is live, or "no" if the data is buffered data. See Section 8.14.5, Buffering and Failure Handling). This variable is available from firmware version 1.2.1 and up.
\$\$	Replaced with \$. Use this if you need to insert a literal dollar sign into the template.

Register Variables

To read Modbus registers corresponding to specific floating-point registers on the WattsOn or WattsOn Mk. II, use '\$r' character followed by the register address, in hexadecimal, of the register you wish to read. For example, the variable \$r1000 will read the register at Modbus address 0x1000. The device knows the widths and types of the registers for the WattsOn and WattsOn Mk. II, so they do not need to be specified. see chapter **6, The Modbus Protocol** (p. 34) for the list of Modbus registers that can be used with these functions.

8.14.4. Time Synchronization

The device does not have a battery-backed real time clock. To obtain the timestamps used in several of the web posting symbols, the device synchronizes the time over the internet. It attempts to synchronize the time when it first boots up, and will subsequently synchronize the time at least every 24 hours (by default). All time-related variables are replaced with the message "**Time Not Available**" if no time has been acquired since boot up.

The device acquires the time on a best-effort basis. Because it can not guarantee that it will be able to acquire the time from the internet due to any number of network problems, server software should not rely exclusively on its time-related variables. It is meant to be used as a cross-check against the server's local time, such as to identify buffered data (see the section below).

(i) Changing the Default Time Servers (Advanced Feature)

The device supports two protocols for retrieving the time from the internet. It supports the Network Time Protocol (NTP) and the TIME protocol (E3 model only). A list of public timeservers is built-in from which it will attempt to acquire the time. You can change these time servers by modifying the device's configuration file.

For the E4 model:

1. Click "System" on the left-hand side of the web interface to access the system configuration page.
2. Click the *Advanced Configuration* button.
3. Enter *ntp_server* in the *Search* field.
4. Up to three NTP servers can be entered in the *Value* column of the table, next to *ntp_server_0*, *ntp_server_1*, and *ntp_server_2*.
5. Click *Save Settings* at the top of the page to save the changes.

For the E3 model:

To upload a modified configuration file, you can use either a program supporting the File Transfer Protocol, or the web interface. A procedure using the web interface is as follows:

6. Click "Filesystem" on the left-hand side of the web interface to access the filesystem configuration page.
7. Click on the "conf" directory.
8. Click on the **etnet-dynamic.conf** file. Depending on your browser, it may offer to save this file to disk, or open it for viewing. Save it to disk, or copy and paste the text into a text editor and save it with the name **etnet-dynamic.conf**.

9. Open the file in a text editor. Locate the text between the `<clock>` and `</clock>` tags. Between these lines are definitions for a primary time server and up to four backups (backups are available from firmware version **1.1.0** and up). Change the text between the `<host>` and `</host>` below one of the `<server>` or `<backup-server>` entries to change the time server.
10. Save the file.

Note — Backup Copy: You should make a backup copy of this file before replacing it on the Filesystem.

11. In the Web File Explorer box in the web interface, click the *Upload* button under the Operations heading.
12. Click on the *Browse* button (*Choose File* on Google Chrome) to select the modified template file on your computer to upload. This file **must** be named **etnet-dynamic.conf**.
13. Click on the *Upload* button.
14. Your file will appear in the directory tree shown in the Web File Explorer box.

8.14.5. Buffering and Failure Handling

If the device cannot successfully post to the configured web server due to a connection problem, it will store failed posts in its internal memory and retry that post later on. Posts are retried at the same interval that is configured for making new posts. The device has four megabytes of internal storage available for buffered posts, with each post being approximately the size of the posting template.

Buffered posts can be viewed by exploring the `/buffer` directory in the Filesystem; see **8.5, Filesystem Page** (p. 68).

9. FIRMWARE UPDATES AND THE BOOTLOADER

The WattsOn device contains a bootloader, a small program used to update the device's firmware. While running in bootloader mode, the device supports only the System registers listed in section **5.7** for adjusting Modbus settings and rebooting the device.

The device enters bootloader mode under three conditions:

- With the M1 or E3/E4 models, when the value "0xB001" is written to the *Reset to Bootloader* register at address **0x60A** via Modbus RTU or Modbus TCP.
- The device is restarted with its Modbus address DIP switch set to 0.
- The device's firmware is corrupt, possibly due to a failed attempt to update the firmware.

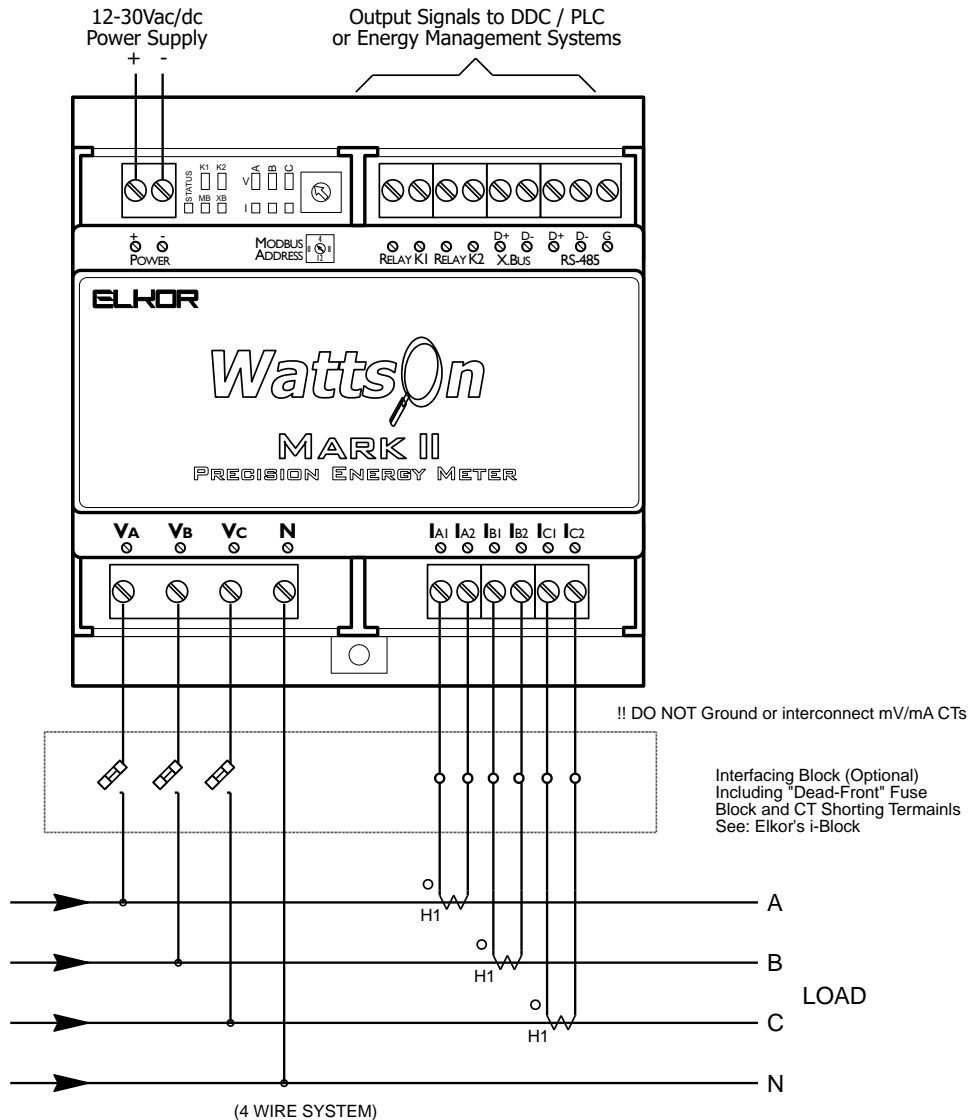
While in bootloader mode, the device's status LED periodically flashes twice. If the device's firmware is corrupt, the LED flashes red, otherwise it flashes green. See section **1.7.1, Status Indicator Codes** (p. 9) for details.

To exit bootloader mode, ensure the Modbus address DIP switch is not set to 0, and either power cycle the unit, or (on the M1 or E3/E4 models) write the value "0xAA55" to the *Reset to Firmware* register at address **0x609** via Modbus RTU or Modbus TCP. If the device's firmware is corrupt, new firmware must be uploaded to the device before it can leave bootloader mode.

If communications is done via a PC, Elkor's software may be used to update the device firmware. Please contact Elkor for details on the firmware update protocol if required.

10. APPENDIX A, WIRING DIAGRAMS

10.1. Four-Wire (Wye) Wiring Diagram



The wiring shown is applicable for all CT types.

In the case of 5A CTs, additional grounding may be required as per local electrical codes.

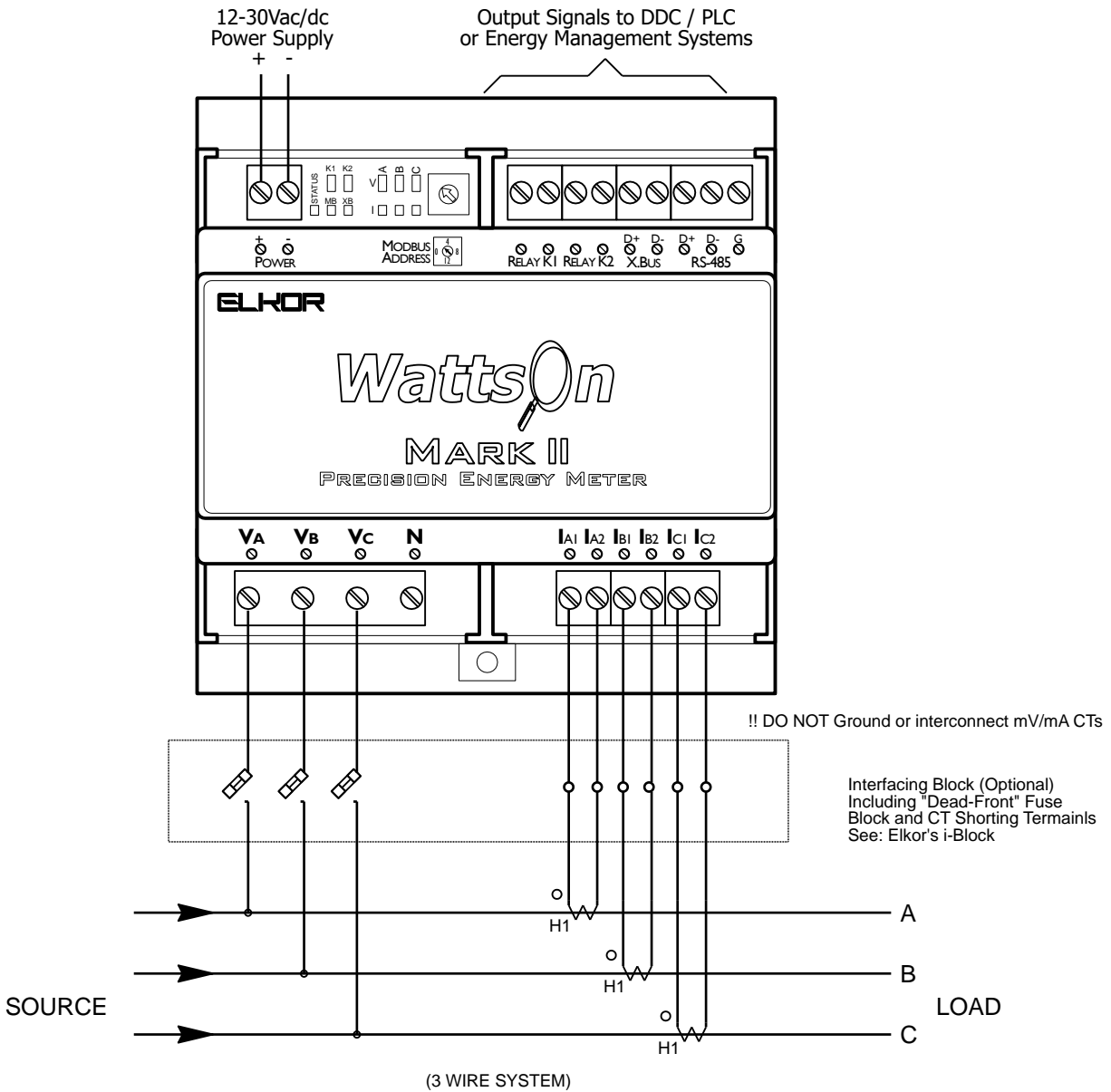
mV and mA CTs **must NOT** be grounded or interconnected in any way. Each CT wire pair, must be terminated at the corresponding input terminals. mV and mA CTs must not be used to feed multiple equipment.

mV and Elkor's mA CTs do not require the use of a shorting mechanism. Their outputs are low energy, voltage limited.

CT Orientation (on the conductor), CT Polarity (into the meter) and CT phasing (relationship to voltage phase) MUST be observed for correct meter operation.

System voltage and CT insulation class (typically 600V) must be observed.

10.2. Three-Wire (Delta) Wiring Diagram (Three CTs)



The wiring shown is applicable for all CT types.

In the case of 5A CTs, additional grounding may be required as per local electrical codes.

mV and mA CTs **must NOT** be grounded or interconnected in any way.
 Each CT wire pair, must be terminated at the corresponding input terminals.
 mV and mA CTs must not be used to feed multiple equipment.

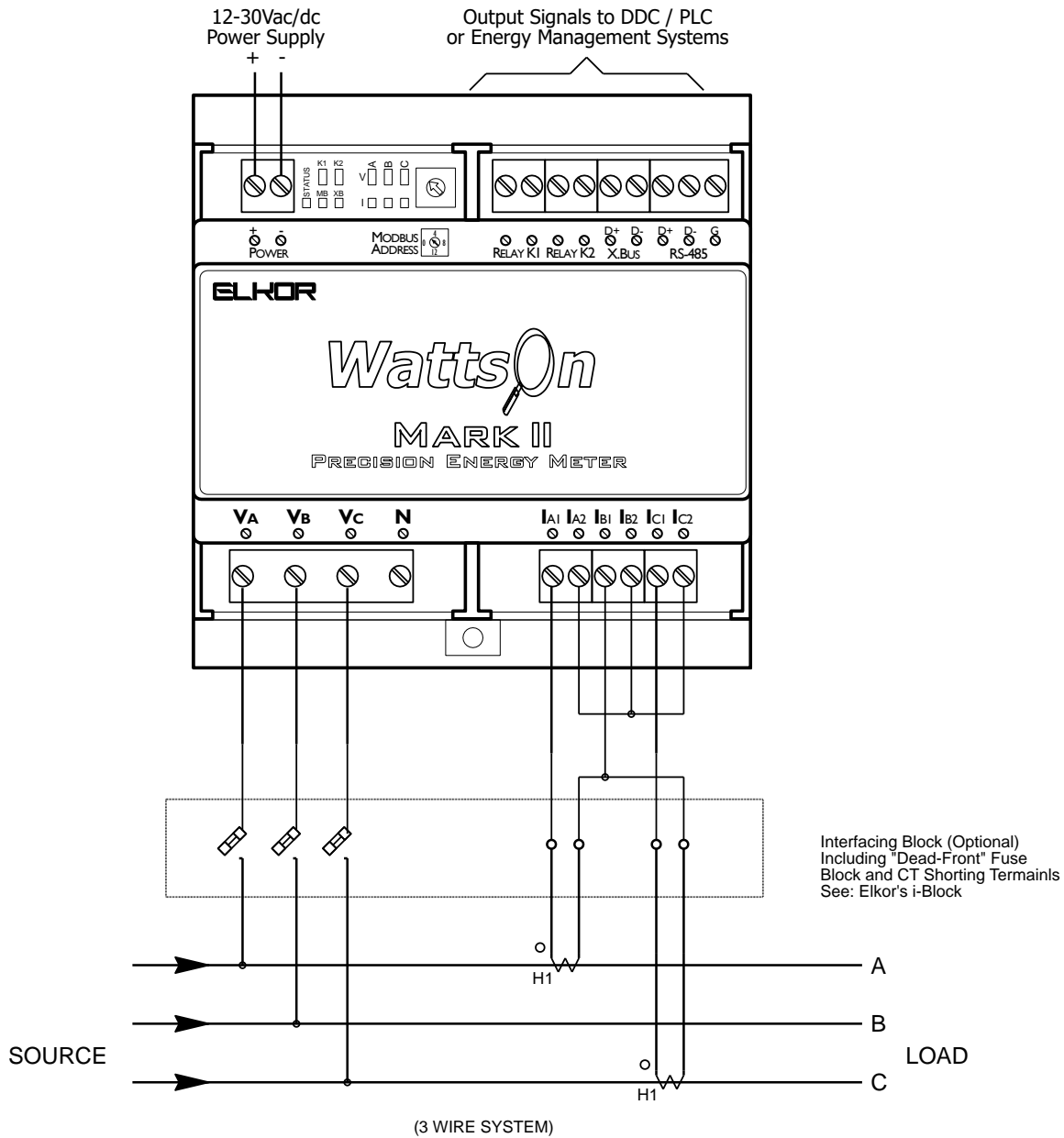
mV and Elkor's mA CTs do not require the use of a shorting mechanism. Their outputs are low energy, voltage limited.

CT Orientation (on the conductor), CT Polarity (into the meter) and CT phasing (relationship to voltage phase) **MUST** be observed for correct meter operation.

System voltage and CT insulation class (typically 600V) must be observed.

10.3. Three-Wire (Delta) Wiring Diagram (Two CTs)

NOTE: This wiring method may only be used with the 5A input versions



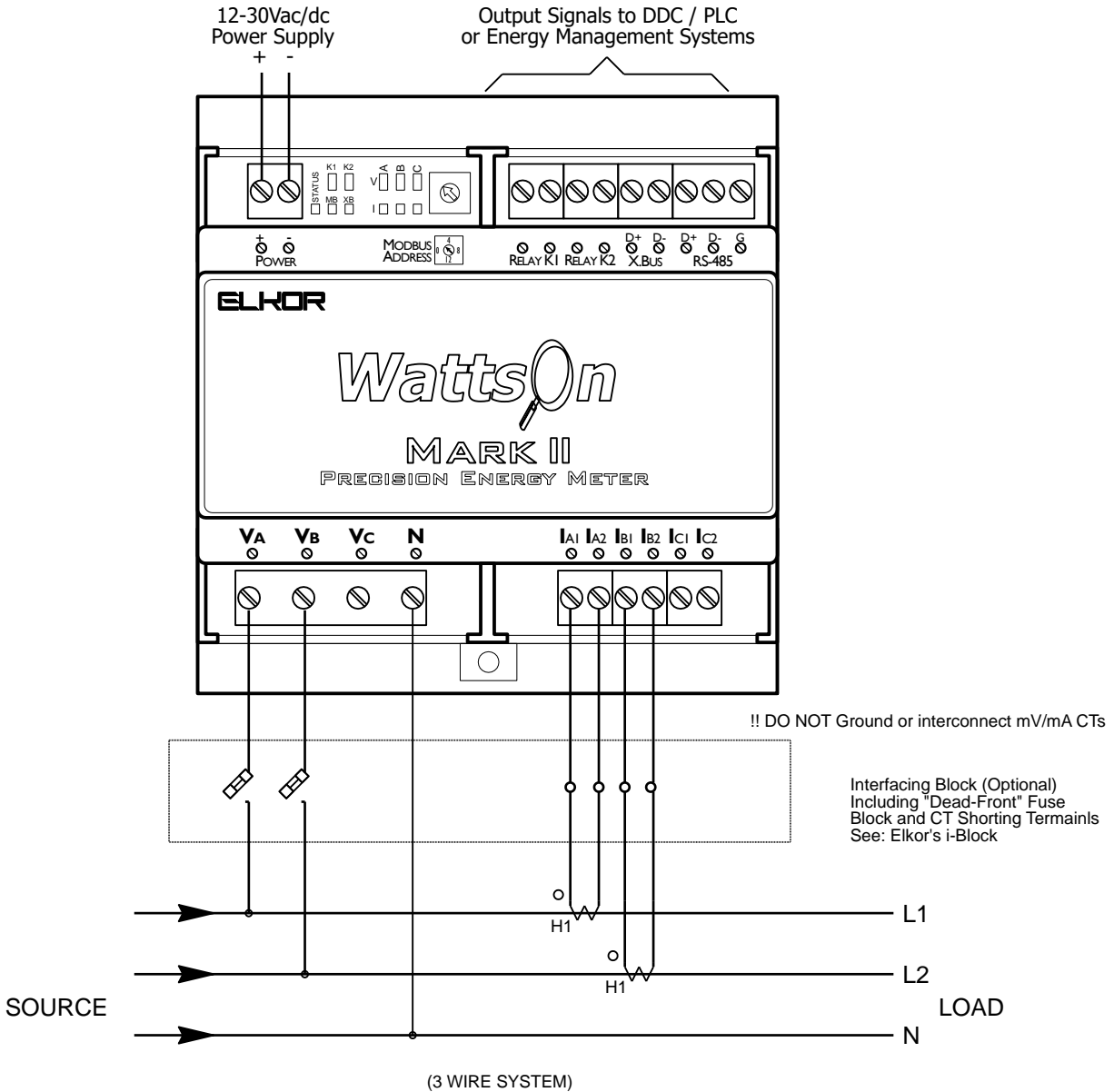
WARNING: This wiring method works only with 5A meters/CTs. When using mV or mA CTs, the 3 wire, 3 CT method must be used (see section 3.9)

In this configuration, additional grounding may be required as per local electrical codes.

CT Orientation (on the conductor), CT Polarity (into the meter) and CT phasing (relationship to voltage phase) MUST be observed for correct meter operation.

System voltage and CT insulation class (typically 600V) must be observed.

10.4. Split-Phase Wiring Diagram



The wiring shown is applicable for all CT types.

In the case of 5A CTs, additional grounding may be required as per local electrical codes.

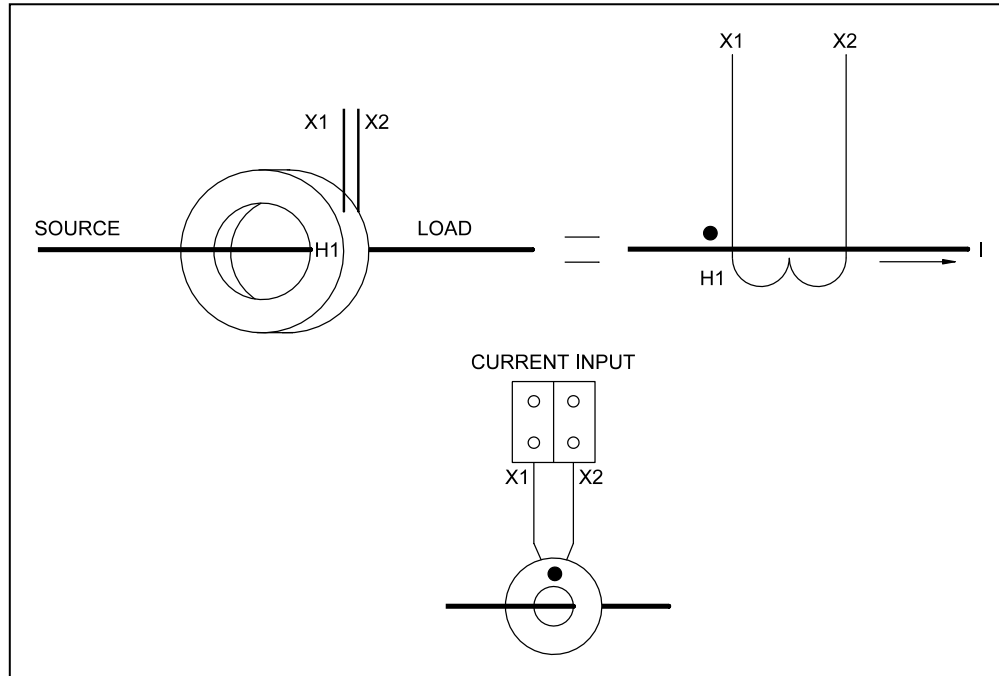
mV and mA CTs **must NOT** be grounded or interconnected in any way.
Each CT wire pair, must be terminated at the corresponding input terminals.
mV and mA CTs must not be used to feed multiple equipment.

mV and Elkor's mA CTs do not require the use of a shorting mechanism. Their outputs are low energy, voltage limited.

CT Orientation (on the conductor), CT Polarity (into the meter) and CT phasing (relationship to voltage phase) **MUST** be observed for correct meter operation.

System voltage and CT insulation class (typically 600V) must be observed.

10.5. CT Wiring Notes



Note: Usually, CTs are marked as shown above, where the 'H1' indicates the primary current input and 'X1' the corresponding secondary current terminal (or lead).

- While specifying CTs, one should consider both the electrical and mechanical parameters such as primary wire size, mounting arrangement, insulation level, the expected load current and accuracy requirements.
- If the load is unknown, the bus rating, or better still, the transformer size may be used for the maximum current calculations. CTs can tolerate large over-current conditions without damage and the WattsOn can accept a 20% continuous input overload.
- 5A CTs are designed to operate with their secondary winding in permanent short, or very close to the short condition. The 5A WattsOn models provide 0.05Ω burden. If the secondary winding is open while a primary current is present, high voltage will be generated on the output. **This voltage may create a hazard to the personnel and in some situations it may damage the CT insulation.** Provisions should be made to short the secondary winding before any re-wiring is performed. We recommend using a metering Test Switch or CT Shunting Blocks to be wired between 5A CTs/PTs and WattsOn meter (ie: Elkor i-Block™).
- mV and Elkor's mA CTs feature voltage limited outputs, and shorting mechanisms may be omitted.
- Grounding may be required for 5A CTs *only*. 5A WattsOn models have isolated current inputs and 5A CT grounding is permissible. For two element systems (3 wires), grounding of CTs and PTs should be carefully observed.
- For mV and mA meter models, CTs must *not* be grounded, or interconnected with each other or any device. Each CT wire pair must be terminated at the corresponding meter current inputs.

CT Orientation (on the conductor), CT Polarity (into the meter) and CT phasing (relationship to voltage phase) MUST be observed for correct meter operation.

11. APPENDIX B, MODBUS PROTOCOL DETAILS

Modbus RTU is a protocol used to read and write information from a variety of devices such as the WattsOn. Generally, the details of the protocol are handled by the Modbus master software or device, so that the user need not be familiar with their implementation. For full details regarding the Modbus protocol, see the official Modbus specification available for free from <http://www.modbus.org/specs.php>. This section summarizes the Modbus RTU protocol as it pertains to the WattsOn device.

11.1. Modbus Frames on RS-485 Networks

Modbus messages are represented as frames of no more than 256 bytes each. The start of a frame is defined as no transmissions for at least 3.5 character periods, followed by the Modbus address (a one-byte number between 1 and 247) and the Modbus function code (a one-byte number). The contents of the frame vary between different function codes. At the end of the frame, comes a 2-byte checksum value used to verify that the frame was not corrupted during reception. Fields of 2 bytes or more, including the checksum, are transmitted with the most-significant byte first (big-endian order).

The Modbus master device sends "request" messages to a slave device, which responds with a "response" message. Both request and response messages share the same basic format:

Start	Modbus Address	Function Code	Frame Contents	CRC
3.5 character times	(1 byte)	(1 byte)	(up to 252 bytes)	(2 bytes)

Start: No transmission for 3.5 character times. This is about 3.65 milliseconds with default serial settings.

Example: At a baud rate of 9600 bits per second, with one stop bit, one character requires 10 bits to transmit (one start bit, eight data bits, and one stop bit). Each bit takes 1/9600 seconds to transmit. Transmitting 3.5 characters of 10 bits each, therefore, takes 35/9600 seconds, or about 3.65 milliseconds.

Modbus Address: This should match the address indicated on the hardware address switch, or match the software-configured value if the switch is set to "F".

Function Code: Available function codes are described in subsequent sections.

Frame Contents: Varies with the function code, as described in subsequent sections.

CRC: Modbus 16-bit cyclic redundancy checksum. This value is described in the following section.

11.2. Modbus Frames on Ethernet/Wi-Fi Networks

Modbus TCP works similarly to Modbus RTU, but without the 2 byte CRC (as TCP already contains an error correction mechanism), and with an additional 6 byte header. This Modbus TCP frame is sent as the payload of a TCP packet.

Transaction ID	Protocol ID	Length	Modbus Address	Function Code	Frame Contents
(2 bytes)	(2 bytes)	(2 bytes)	(1 byte)	(1 byte)	(up to 252 bytes)

The transaction ID may be any number; the Transaction ID of the request will be repeated in the response. The Protocol ID must be 0. The length is the number of bytes that follow in this frame, to a maximum of 254 (despite being a 2-byte field, the upper byte is not used). These header fields are transmitted in big-endian format.

The following pages show frames assuming that Modbus RTU is used; for Modbus TCP, omit the final CRC, and add the above three header fields.

11.3. Cyclic Redundancy Checksum

Each Modbus RTU frame (but not Modbus TCP frames) ends in a cyclic redundancy checksum. This is computed from the other bytes in the message when transmitting the message. When the message is received, the checksum is computed again, and checked against the checksum found in the message. If the results differ, the message was corrupted during transmission. Below is a simple algorithm for calculating the CRC value, shown in pseudo-code. The variable $d[i]$ is defined as the i^{th} byte of the message, and the variable $size$ denotes the number of bytes in the message. The result of

each bit of a *XOR* (exclusive or) operation is 0 if the corresponding bits of each input are the same, or 1 if the corresponding bits of each input are different.

```

crc ← 0xFFFF

loop i from 0 to size - 1
  crc ← crc XOR d[i]

  loop j from 0 to 7
    lsb ← crc AND 0x0001
    crc ← crc LEFT-SHIFT 1

  if lsb = 1 then
    crc ← crc XOR 0xA001
  
```

11.4. Read Holding Registers

This is the basic command used to read information from the device. The structure of its frames is as follows.

Request:

Modbus Address	Function Code	Starting Address	Register Count	CRC
1-63	3	0-65535	1-125	(CRC)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)	(2 bytes)

Response:

Modbus Address	Function Code	Byte Count	First Value		...	CRC
1-63	3	2-250	Hi-byte	Lo-byte		(CRC)
(1 byte)	(1 byte)	(1 byte)	(2 bytes)			(2 bytes)

11.5. Read Input Registers

On this device, this command is identical to Read Holding Registers, above, but uses function code 4 instead of 3.

11.6. Write Single Register

This is the basic command used to write data to a single configuration register. The structure of its frames is as follows:

Request:

Modbus Address	Function Code	Address	Value		CRC
1-63	6	0-65535	Hi-byte	Lo-byte	(CRC)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)		(2 bytes)

Response (identical to the response):

Modbus Address	Function Code	Address	Value		CRC
1-63	6	0-65535	Hi-byte	Lo-byte	(CRC)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)		(2 bytes)

11.7. Write Multiple Registers

This command writes data to multiple configuration registers. The structure of its frames is as follows:

Request:

Modbus Address	Function Code	Starting Address	Register Count	Byte Count	First Value		...	CRC
1-63	16	0-65535	1-123	2-246	Hi-byte	Lo-byte		(CRC)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)	(1 byte)	(2 bytes)			(2 bytes)

Response:

Modbus Address	Function Code	Starting Address	Register Count	CRC
1-63	16	0-65535	1-123	(CRC)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)	(2 bytes)

11.8. Mask Write Register

This command is used to modify bits in an individual register, based on an AND mask and an OR mask. The register is written to based on the result of the following expression:

$$\text{Result} = (\text{Current Contents AND AndMask}) \text{ OR } (\text{OrMask AND (NOT AndMask)})$$

Example 1: To clear the 1st bit of a register to 0, use an AND mask of 0xFFFE and an OR mask of 0x0000.

Example 2: To set the 1st bit of a register to 1, use an AND mask of 0xFFFE and an OR mask of 0x0001.

Example 3: To AND the value of a register with 0x5555, use an AND mask of 0x5555 and an OR mask of 0.

The structure of its frames is as follows:

Request:

Modbus Address	Function Code	Address	And Mask		Or Mask		CRC
1-63	22	0-65535	Hi-byte	Lo-byte	Hi-byte	Lo-byte	(CRC)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)		(2 bytes)		(2 bytes)

Response (identical to the request):

Modbus Address	Function Code	Address	And Mask		Or Mask		CRC
1-63	22	0-65535	Hi-byte	Lo-byte	Hi-byte	Lo-byte	(CRC)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)		(2 bytes)		(2 bytes)

11.9. Read/Write Multiple Registers

This function performs reads and writes in a single command. The writes occur before the reads. The structure of its frames is as follows:

Request:

Modbus Address	Function Code	Read Starting Address	Read Count	Write Starting Address	Write Count	Write Byte Count	First Value		...	CRC
1-63	23	0-65535	1-125	0-65535	1-121	2-246	Hi-byte	Lo-byte		(CRC)
(1 byte)	(1 byte)	(2 bytes)	(2 bytes)	(2 bytes)	(2 bytes)	(1 byte)	(2 bytes)			(2 bytes)

Response:

Modbus Address	Function Code	Byte Count	First Value		...	CRC
1-63	23	2-250	Hi-byte	Lo-byte		(CRC)
(1 byte)	(1 byte)	(1 byte)	(2 bytes)			(2 bytes)

Note: The response format for Read/Write Multiple Registers is identical to that of Read Holding Registers, aside from the function code.

11.10. Diagnostic Functions

This function contains a series of sub-functions used to perform diagnostic operations on the device and the communication line. The sub-functions are described below.

11.10.1. *Echo Query Data*

This function simply returns the data sent to it, for testing purposes.

Request:

Modbus Address	Function Code	Sub-function Code	Data	CRC
1-63	8	0	Any value	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

Response (identical to the request):

Modbus Address	Function Code	Sub-function Code	Data	CRC
1-63	8	0	The sent value	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

11.10.2. *Clear Counters*

This function clears the device's count of all messages, slave messages, communication errors, and exceptions since power-up.

Request:

Modbus Address	Function Code	Sub-function Code	Data (always 0)	CRC
1-63	8	10	0	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

Response (identical to the request):

Modbus Address	Function Code	Sub-function Code	Data (always 0)	CRC
1-63	8	10	0	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

11.10.3. *Return Bus Message Count*

This function returns a count of all Modbus message this device has seen on the bus since power-up, regardless of whether they were addressed to this device or another device on the line.

Request:

Modbus Address	Function Code	Sub-function Code	Data (always 0)	CRC
1-63	8	11	0	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

Response:

Modbus Address	Function Code	Sub-function Code	Data	CRC
1-63	8	11	Counter value	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

11.10.4. *Return Slave Message Count*

This function returns a count of all Modbus messages addressed to this device that it has received since power-up.

Request:

Modbus Address	Function Code	Sub-function Code	Data (always 0)	CRC
1-63	8	14	0	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

Response:

Modbus Address	Function Code	Sub-function Code	Data	CRC
1-63	8	14	Counter value	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

11.10.5. *Return Communication Error Count*

This function returns a count of all Modbus messages that failed the CRC check upon reception.

Request:

Modbus Address	Function Code	Sub-function Code	Data (always 0)	CRC
1-63	8	12	0	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

Response:

Modbus Address	Function Code	Sub-function Code	Data	CRC
1-63	8	12	Counter value	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

11.10.6. *Return Exception Count*

This function returns a count of all Modbus messages that this device responded with an exception response.

Modbus Address	Function Code	Sub-function Code	Data (always 0)	CRC
1-63	8	13	0	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

Response:

Modbus Address	Function Code	Sub-function Code	Data	CRC
1-63	8	13	Counter value	(CRC)
(1 byte)	(1 byte)	(1 bytes)	(2 bytes)	(2 bytes)

11.11. Get Comm Event Counter

This function returns a count of all Modbus messages that were successfully completed without error or exception. The structure of its frames is as follows:

Request:

Modbus Address	Function Code	CRC
1-63	11	(CRC)

(1 byte) (1 byte) (2 bytes)

Response:

Modbus Address	Function Code	Status (always 0)	Event Count	CRC
1-63	8	0	Counter value	(CRC)

(1 byte) (1 byte) (2 bytes) (2 bytes) (2 bytes)

11.12. Report Slave ID

This function returns an ID number, a status code, and a text string identifying the device. The status code is 0x00 when the device is in bootloader mode, and 0xFF otherwise. The text string is an ASCII text string containing the name of the product, its input configuration (mA, mV, or 5A), and its hardware and software version. The string is null-terminated, meaning a 0 is transmitted after the last character.

Example String: "Elkor Technologies W2-M1-mA Hardware 1.00 Firmware 1.00".

While in bootloader mode, the string returned contains the bootloader version, for example, "Elkor Technologies Bootloader 1.00".

The structure of its frames is as follows:

Request:

Modbus Address	Function Code	CRC
1-63	17	(CRC)

(1 byte) (1 byte) (2 bytes)

Response:

Modbus Address	Function Code	Byte Count	Slave ID	Status	String identifier	CRC
1-63	17	3-249	130	0x00 or 0xFF	A null-terminated string identifying the device.	(CRC)

(1 byte) (1 byte) (1 byte) (1 byte) (1 byte) (Up to 250 bytes) (2 bytes)

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