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EM-3000 Series Meter Installation and Operation Manual



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EM-3000 Series Meter Installation and Operation Manual

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Building Efficiency

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Use Of Product for Protection

Our products are not to be used for primary over-current protection. Any protection feature in our products is to be used for alarm or secondary protection only.

Statement of Calibration

Our instruments are inspected and tested in accordance with specifications published by Johnson Controls, Inc. The accuracy and a calibration of our instruments are traceable to the National Institute of Standards and Technology through equipment that is calibrated at planned intervals by comparison to certified standards. For optimal performance, Johnson Controls, Inc. recommends that any meter be verified for accuracy on a yearly interval using NIST traceable accuracy standards.

Disclaimer

The information presented in this publication has been carefully checked for reliability; however, no responsibility is assumed for inaccuracies. The information contained in this document is subject to change without notice.

Safety Symbols



In this manual, this symbol indicates that the operator must refer to an important WARNING or CAUTION in the operating instructions. Please see Chapter 4 for important safety information regarding installation and hookup of the meter.

Dans ce manuel, ce symbole indique que l'opérateur doit se référer à un important AVERTISSEMENT ou une MISE EN GARDE dans les instructions opérationnelles. Veuillez consulter le chapitre 4 pour des informations importantes relatives à l'installation et branchement du compteur.

The following safety symbols may be used on the meter itself:



This symbol alerts you to the presence of high voltage, which can cause dangerous electrical shock.

Ce symbole vous indique la présence d'une haute tension qui peut provoquer une décharge électrique dangereuse.



This symbol indicates the field wiring terminal that must be connected to earth ground before operating the meter, which protects against electrical shock in case of a fault condition.

Ce symbole indique que la borne de pose des canalisations in-situ qui doit être branchée dans la mise à terre avant de faire fonctionner le compteur qui est protégé contre une décharge électrique ou un état défectueux.



This symbol indicates that the user must refer to this manual for specific WARNING or CAUTION information to avoid personal injury or damage to the product.

Ce symbole indique que l'utilisateur doit se référer à ce manuel pour AVERTISSEMENT ou MISE EN GARDE l'information pour éviter toute blessure ou tout endommagement du produit.

FCC Information

Regarding the wireless module:

- This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: 1) this device may not cause harmful interference, and 2) this device must accept any interference received, including interference that may cause undesired operation.
- The antenna provided must not be replaced with a different type. Attaching a different antenna will void the FCC approval and the FCC ID can no longer be considered.

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1: Three-Phase Power Measurement

This introduction to three-phase power and power measurement is intended to provide only a brief overview of the subject. The professional meter engineer or meter technician should refer to more advanced documents such as the EEI Handbook for Electricity Metering and the application standards for more in-depth and technical coverage of the subject.

1.1: Three-Phase System Configurations

Three-phase power is most commonly used in situations where large amounts of power will be used because it is a more effective way to transmit the power and because it provides a smoother delivery of power to the end load. There are two commonly used connections for three-phase power, a wye connection or a delta connection. Each connection has several different manifestations in actual use.

When attempting to determine the type of connection in use, it is a good practice to follow the circuit back to the transformer that is serving the circuit. It is often not possible to conclusively determine the correct circuit connection simply by counting the wires in the service or checking voltages. Checking the transformer connection will provide conclusive evidence of the circuit connection and the relationships between the phase voltages and ground.

1.1.1: Wye Connection

The wye connection is so called because when you look at the phase relationships and the winding relationships between the phases it looks like a Y. Figure 1.1 depicts the winding relationships for a wye-connected service. In a wye service the neutral (or center point of the wye) is typically grounded. This leads to common voltages of 208/120 and 480/277 (where the first number represents the phase-to-phase voltage and the second number represents the phase-to-ground voltage).

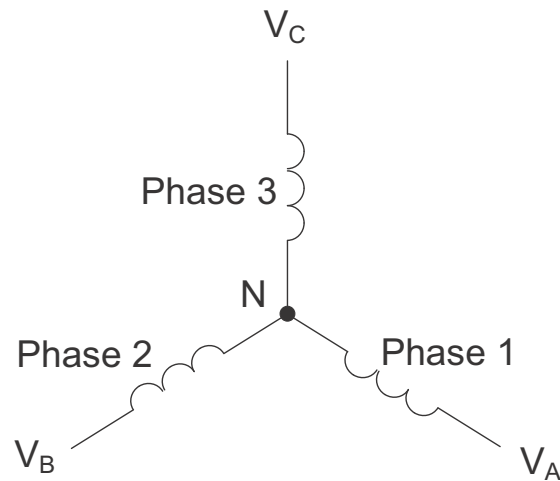


Figure 1.1: Three-phase Wye Winding

The three voltages are separated by 120° electrically. Under balanced load conditions the currents are also separated by 120° . However, unbalanced loads and other conditions can cause the currents to depart from the ideal 120° separation. Three-phase voltages and currents are usually represented with a phasor diagram. A phasor diagram for the typical connected voltages and currents is shown in Figure 1.2.

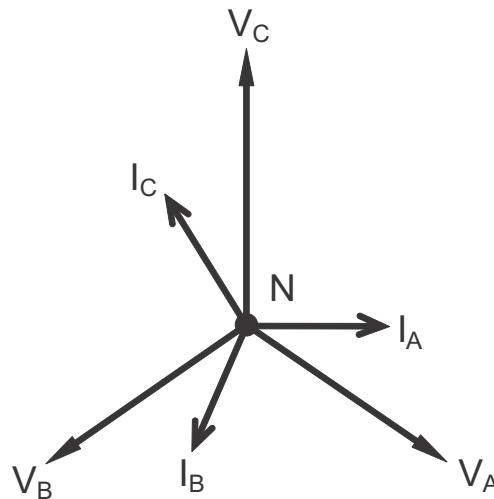


Figure 1.2: Phasor Diagram Showing Three-phase Voltages and Currents

The phasor diagram shows the 120° angular separation between the phase voltages. The phase-to-phase voltage in a balanced three-phase wye system is 1.732 times the phase-to-neutral voltage. The center point of the wye is tied together and is typically grounded. Table 1.1 shows the common voltages used in the United States for wye-connected systems.

Phase to Ground Voltage	Phase to Phase Voltage
120 volts	208 volts
277 volts	480 volts
2,400 volts	4,160 volts
7,200 volts	12,470 volts
7,620 volts	13,200 volts

Table 1: Common Phase Voltages on Wye Services

Usually a wye-connected service will have four wires: three wires for the phases and one for the neutral. The three-phase wires connect to the three phases (as shown in Figure 1.1). The neutral wire is typically tied to the ground or center point of the wye.

In many industrial applications the facility will be fed with a four-wire wye service but only three wires will be run to individual loads. The load is then often referred to as a delta-connected load but the service to the facility is still a wye service; it contains four wires if you trace the circuit back to its source (usually a transformer). In this type of connection the phase to ground voltage will be the phase-to-ground voltage indicated in Table 1, even though a neutral or ground wire is not physically present at the load. The transformer is the best place to determine the circuit connection type because this is a location where the voltage reference to ground can be conclusively identified.

1.1.2: Delta Connection

Delta-connected services may be fed with either three wires or four wires. In a three-phase delta service the load windings are connected from phase-to-phase rather than from phase-to-ground. Figure 1.3 shows the physical load connections for a delta service.

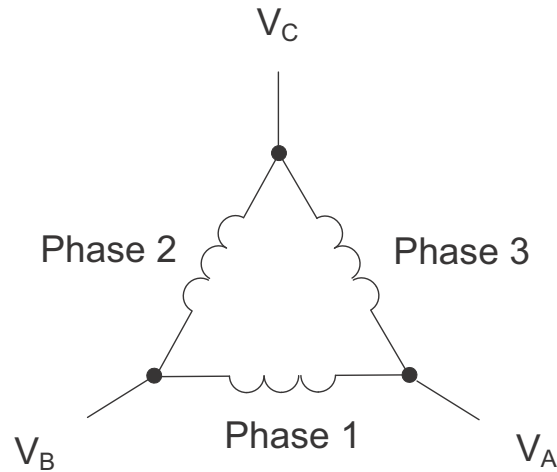


Figure 1.3: Three-phase Delta Winding Relationship

In this example of a delta service, three wires will transmit the power to the load. In a true delta service, the phase-to-ground voltage will usually not be balanced because the ground is not at the center of the delta.

Figure 1.4 shows the phasor relationships between voltage and current on a three-phase delta circuit.

In many delta services, one corner of the delta is grounded. This means the phase to ground voltage will be zero for one phase and will be full phase-to-phase voltage for the other two phases. This is done for protective purposes.

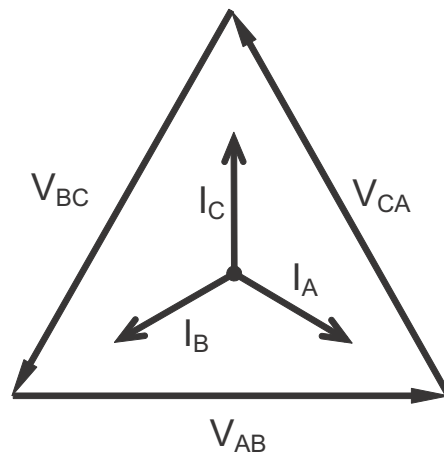


Figure 1.4: Phasor Diagram, Three-Phase Voltages and Currents, Delta-Connected

Another common delta connection is the four-wire, grounded delta used for lighting loads. In this connection the center point of one winding is grounded. On a 120/240 volt, four-wire, grounded delta service the phase-to-ground voltage would be 120 volts on two phases and 208 volts on the third phase. Figure 1.5 shows the phasor diagram for the voltages in a three-phase, four-wire delta system.

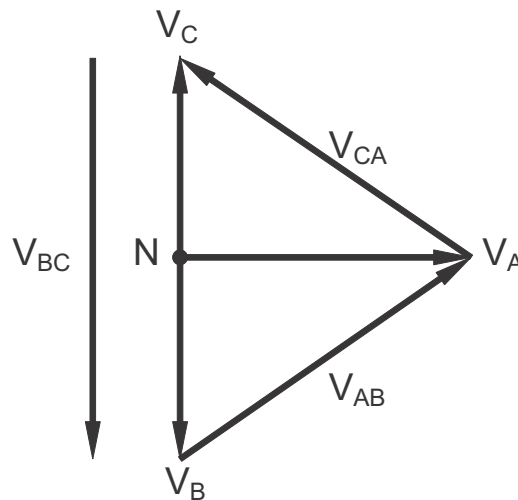


Figure 1.5: Phasor Diagram Showing Three-phase Four-Wire Delta-Connected System

1.1.3: Blondel's Theorem and Three Phase Measurement

In 1893 an engineer and mathematician named Andre E. Blondel set forth the first scientific basis for polyphase metering. His theorem states:

If energy is supplied to any system of conductors through N wires, the total power in the system is given by the algebraic sum of the readings of N wattmeters so arranged that each of the N wires contains one current coil, the corresponding potential coil being connected between that wire and some common point. If this common point is on one of the N wires, the measurement may be made by the use of N-1 Wattmeters.

The theorem may be stated more simply, in modern language:

In a system of N conductors, N-1 meter elements will measure the power or energy taken provided that all the potential coils have a common tie to the conductor in which there is no current coil.

Three-phase power measurement is accomplished by measuring the three individual phases and adding them together to obtain the total three phase value. In older analog meters, this measurement was accomplished using up to three separate elements. Each element combined the single-phase voltage and current to produce a torque on the meter disk. All three elements were arranged around the disk so that the disk was subjected to the combined torque of the three elements. As a result the disk would turn at a higher speed and register power supplied by each of the three wires.

According to Blondel's Theorem, it was possible to reduce the number of elements under certain conditions. For example, a three-phase, three-wire delta system could be correctly measured with two elements (two potential coils and two current coils) if the potential coils were connected between the three phases with one phase in common.

In a three-phase, four-wire wye system it is necessary to use three elements. Three voltage coils are connected between the three phases and the common neutral conductor. A current coil is required in each of the three phases.

In modern digital meters, Blondel's Theorem is still applied to obtain proper metering. The difference in modern meters is that the digital meter measures each phase voltage and current and calculates the single-phase power for each phase. The meter then sums the three phase powers to a single three-phase reading.

Some digital meters measure the individual phase power values one phase at a time. This means the meter samples the voltage and current on one phase and calculates a power value. Then it samples the second phase and calculates the power for the second phase. Finally, it samples the third phase and calculates that phase power. After sampling all three phases, the meter adds the three readings to create the equivalent three-phase power value. Using mathematical averaging techniques, this method can derive a quite accurate measurement of three-phase power.

More advanced meters actually sample all three phases of voltage and current simultaneously and calculate the individual phase and three-phase power values. The advantage of simultaneous sampling is the reduction of error introduced due to the difference in time when the samples were taken.

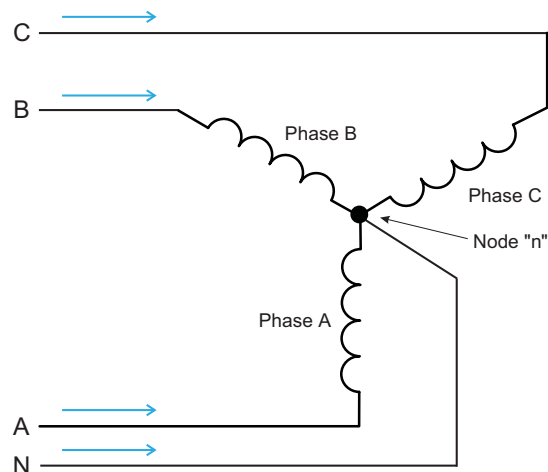


Figure 1.6: Three-Phase Wye Load Illustrating Kirchhoff's Law and Blondel's Theorem

Blondel's Theorem is a derivation that results from Kirchhoff's Law. Kirchhoff's Law states that the sum of the currents into a node is zero. Another way of stating the same thing is that the current into a node (connection point) must equal the current out of the node. The law can be applied to measuring three-phase loads. Figure 1.6 shows a typical connection of a three-phase load applied to a three-phase, four-wire service. Kirchhoff's Law holds that the sum of currents A, B, C and N must equal zero or that the sum of currents into Node "n" must equal zero.

If we measure the currents in wires A, B and C, we then know the current in wire N by Kirchhoff's Law and it is not necessary to measure it. This fact leads us to the conclusion of Blondel's Theorem- that we only need to measure the power in three of

the four wires if they are connected by a common node. In the circuit of Figure 1.6 we must measure the power flow in three wires. This will require three voltage coils and three current coils (a three-element meter). Similar figures and conclusions could be reached for other circuit configurations involving Delta-connected loads.

1.2: Power, Energy and Demand

It is quite common to exchange power, energy and demand without differentiating between the three. Because this practice can lead to confusion, the differences between these three measurements will be discussed.

Power is an instantaneous reading. The power reading provided by a meter is the present flow of watts. Power is measured immediately just like current. In many digital meters, the power value is actually measured and calculated over a one second interval because it takes some amount of time to calculate the RMS values of voltage and current. But this time interval is kept small to preserve the instantaneous nature of power.

Energy is always based on some time increment; it is the integration of power over a defined time increment. Energy is an important value because almost all electric bills are based, in part, on the amount of energy used.

Typically, electrical energy is measured in units of kilowatt-hours (kWh). A kilowatt-hour represents a constant load of one thousand watts (one kilowatt) for one hour. Stated another way, if the power delivered (instantaneous watts) is measured as 1,000 watts and the load was served for a one hour time interval then the load would have absorbed one kilowatt-hour of energy. A different load may have a constant power requirement of 4,000 watts. If the load were served for one hour it would absorb four kWh. If the load were served for 15 minutes it would absorb $\frac{1}{4}$ of that total or one kWh.

Figure 1.7 shows a graph of power and the resulting energy that would be transmitted as a result of the illustrated power values. For this illustration, it is assumed that the power level is held constant for each minute when a measurement is taken. Each bar in the graph will represent the power load for the one-minute increment of time. In real life the power value moves almost constantly.

The data from Figure 1.7 is reproduced in Table 2 to illustrate the calculation of energy. Since the time increment of the measurement is one minute and since we

specified that the load is constant over that minute, we can convert the power reading to an equivalent consumed energy reading by multiplying the power reading times 1/60 (converting the time base from minutes to hours).

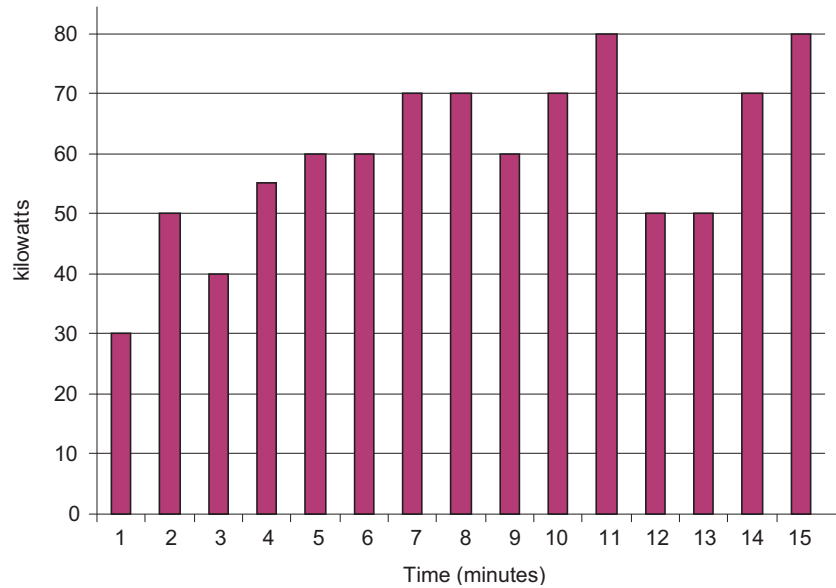


Figure 1.7: Power Use over Time

Time Interval (minute)	Power (kW)	Energy (kWh)	Accumulated Energy (kWh)
1	30	0.50	0.50
2	50	0.83	1.33
3	40	0.67	2.00
4	55	0.92	2.92
5	60	1.00	3.92
6	60	1.00	4.92
7	70	1.17	6.09
8	70	1.17	7.26
9	60	1.00	8.26
10	70	1.17	9.43
11	80	1.33	10.76
12	50	0.83	12.42
13	50	0.83	12.42
14	70	1.17	13.59
15	80	1.33	14.92

Table 1.2: Power and Energy Relationship over Time

As in Table 1.2, the accumulated energy for the power load profile of Figure 1.7 is 14.92 kWh.

Demand is also a time-based value. The demand is the average rate of energy use over time. The actual label for demand is kilowatt-hours/hour but this is normally reduced to kilowatts. This makes it easy to confuse demand with power, but demand is not an instantaneous value. To calculate demand it is necessary to accumulate the energy readings (as illustrated in Figure 1.7) and adjust the energy reading to an hourly value that constitutes the demand.

In the example, the accumulated energy is 14.92 kWh. But this measurement was made over a 15-minute interval. To convert the reading to a demand value, it must be normalized to a 60-minute interval. If the pattern were repeated for an additional three 15-minute intervals the total energy would be four times the measured value or

59.68 kWh. The same process is applied to calculate the 15-minute demand value. The demand value associated with the example load is 59.68 kWh/hr or 59.68 kWd. Note that the peak instantaneous value of power is 80 kW, significantly more than the demand value.

Figure 1.8 shows another example of energy and demand. In this case, each bar represents the energy consumed in a 15-minute interval. The energy use in each interval typically falls between 50 and 70 kWh. However, during two intervals the energy rises sharply and peaks at 100 kWh in interval number 7. This peak of usage will result in setting a high demand reading. For each interval shown the demand value would be four times the indicated energy reading. So interval 1 would have an associated demand of 240 kWh/hr. Interval 7 will have a demand value of 400 kWh/hr. In the data shown, this is the peak demand value and would be the number that would set the demand charge on the utility bill.

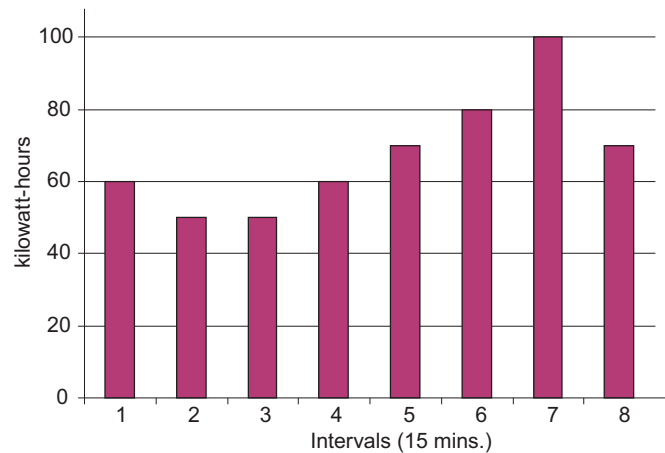


Figure 1.8: Energy Use and Demand

As can be seen from this example, it is important to recognize the relationships between power, energy and demand in order to control loads effectively or to monitor use correctly.

1.3: Reactive Energy and Power Factor

The real power and energy measurements discussed in the previous section relate to the quantities that are most used in electrical systems. But it is often not sufficient to only measure real power and energy. Reactive power is a critical component of the total power picture because almost all real-life applications have an impact on reactive power. Reactive power and power factor concepts relate to both load and generation applications. However, this discussion will be limited to analysis of reactive power and power factor as they relate to loads. To simplify the discussion, generation will not be considered.

Real power (and energy) is the component of power that is the combination of the voltage and the value of corresponding current that is directly in phase with the voltage. However, in actual practice the total current is almost never in phase with the voltage. Since the current is not in phase with the voltage, it is necessary to consider both the inphase component and the component that is at quadrature (angularly rotated 90° or perpendicular) to the voltage. Figure 1.9 shows a single-phase voltage and current and breaks the current into its in-phase and quadrature components.

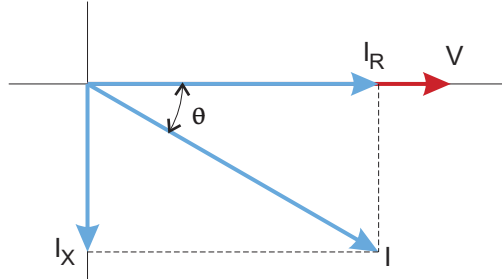


Figure 1.9: Voltage and Complex Current

The voltage (V) and the total current (I) can be combined to calculate the apparent power or VA . The voltage and the in-phase current (I_R) are combined to produce the real power or watts. The voltage and the quadrature current (I_X) are combined to calculate the reactive power.

The quadrature current may be lagging the voltage (as shown in Figure 1.9) or it may lead the voltage. When the quadrature current lags the voltage the load is requiring both real power (watts) and reactive power (VARs). When the quadrature current

leads the voltage the load is requiring real power (watts) but is delivering reactive power (VARs) back into the system; that is VARs are flowing in the opposite direction of the real power flow.

Reactive power (VARs) is required in all power systems. Any equipment that uses magnetization to operate requires VARs. Usually the magnitude of VARs is relatively low compared to the real power quantities. Utilities have an interest in maintaining VAR requirements at the customer to a low value in order to maximize the return on plant invested to deliver energy. When lines are carrying VARs, they cannot carry as many watts. So keeping the VAR content low allows a line to carry its full capacity of watts. In order to encourage customers to keep VAR requirements low, some utilities impose a penalty if the VAR content of the load rises above a specified value.

A common method of measuring reactive power requirements is power factor. Power factor can be defined in two different ways. The more common method of calculating power factor is the ratio of the real power to the apparent power. This relationship is expressed in the following formula:

$$\text{Total PF} = \text{real power} / \text{apparent power} = \text{watts/VA}$$

This formula calculates a power factor quantity known as Total Power Factor. It is called Total PF because it is based on the ratios of the power delivered. The delivered power quantities will include the impacts of any existing harmonic content. If the voltage or current includes high levels of harmonic distortion the power values will be affected. By calculating power factor from the power values, the power factor will include the impact of harmonic distortion. In many cases this is the preferred method of calculation because the entire impact of the actual voltage and current are included.

A second type of power factor is Displacement Power Factor. Displacement PF is based on the angular relationship between the voltage and current. Displacement power factor does not consider the magnitudes of voltage, current or power. It is solely based on the phase angle differences. As a result, it does not include the impact of

harmonic distortion. Displacement power factor is calculated using the following equation:

$$\text{Displacement PF} = \cos\theta$$

where θ is the angle between the voltage and the current (see Fig. 1.9).

In applications where the voltage and current are not distorted, the Total Power Factor will equal the Displacement Power Factor. But if harmonic distortion is present, the two power factors will not be equal.

1.4: Harmonic Distortion

Harmonic distortion is primarily the result of high concentrations of non-linear loads. Devices such as computer power supplies, variable speed drives and fluorescent light ballasts make current demands that do not match the sinusoidal waveform of AC electricity. As a result, the current waveform feeding these loads is periodic but not sinusoidal. Figure 1.10 shows a normal, sinusoidal current waveform. This example has no distortion.

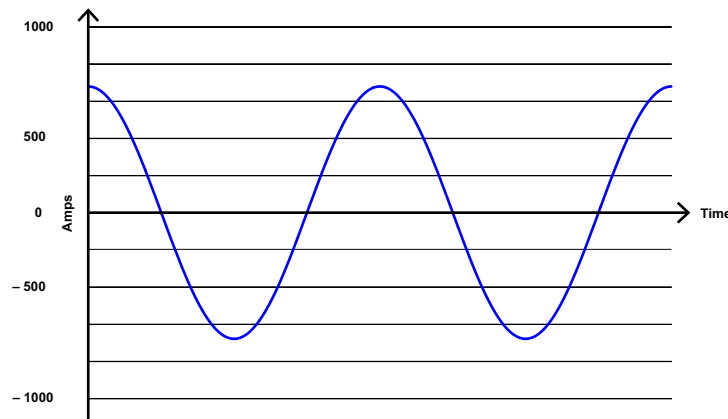


Figure 1.10: Nondistorted Current Waveform

Figure 1.11 shows a current waveform with a slight amount of harmonic distortion. The waveform is still periodic and is fluctuating at the normal 60 Hz frequency. However, the waveform is not a smooth sinusoidal form as seen in Figure 1.10.

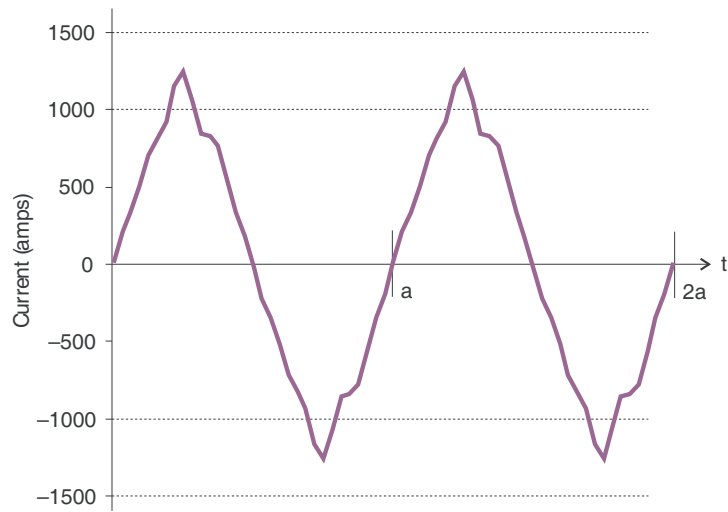


Figure 1.11: Distorted Current Waveform

The distortion observed in Figure 1.11 can be modeled as the sum of several sinusoidal waveforms of frequencies that are multiples of the fundamental 60 Hz frequency. This modeling is performed by mathematically disassembling the distorted waveform into a collection of higher frequency waveforms.

These higher frequency waveforms are referred to as harmonics. Figure 1.12 shows the content of the harmonic frequencies that make up the distortion portion of the waveform in Figure 1.11.

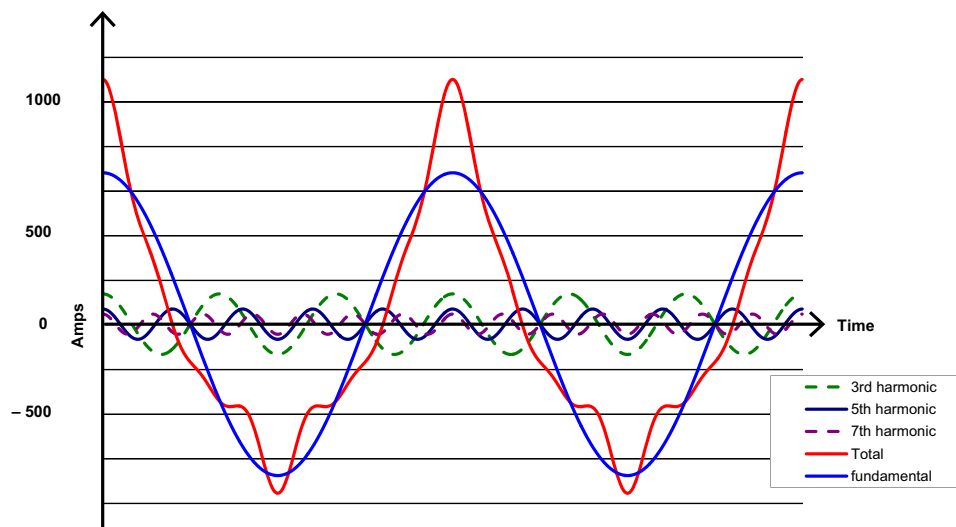


Figure 1.12: Waveforms of the Harmonics

The waveforms shown in Figure 1.12 are not smoothed but do provide an indication of the impact of combining multiple harmonic frequencies together.

When harmonics are present it is important to remember that these quantities are operating at higher frequencies. Therefore, they do not always respond in the same manner as 60 Hz values.

Inductive and capacitive impedance are present in all power systems. We are accustomed to thinking about these impedances as they perform at 60 Hz. However, these impedances are subject to frequency variation.

$$X_L = j\omega L \quad \text{and}$$

$$X_C = 1/j\omega C$$

At 60 Hz, $\omega = 377$; but at 300 Hz (5th harmonic) $\omega = 1,885$. As frequency changes impedance changes and system impedance characteristics that are normal at 60 Hz may behave entirely differently in the presence of higher order harmonic waveforms.

Traditionally, the most common harmonics have been the low order, odd frequencies, such as the 3rd, 5th, 7th, and 9th. However newer, non-linear loads are introducing significant quantities of higher order harmonics.

Since much voltage monitoring and almost all current monitoring is performed using instrument transformers, the higher order harmonics are often not visible. Instrument transformers are designed to pass 60 Hz quantities with high accuracy. These devices, when designed for accuracy at low frequency, do not pass high frequencies with high accuracy; at frequencies above about 1200 Hz they pass almost no information. So when instrument transformers are used, they effectively filter out higher frequency harmonic distortion making it impossible to see.

However, when monitors can be connected directly to the measured circuit (such as direct connection to a 480 volt bus) the user may often see higher order harmonic distortion. An important rule in any harmonics study is to evaluate the type of equipment and connections before drawing a conclusion. Not being able to see harmonic distortion is not the same as not having harmonic distortion.

It is common in advanced meters to perform a function commonly referred to as waveform capture. Waveform capture is the ability of a meter to capture a present picture of the voltage or current waveform for viewing and harmonic analysis.

Typically a waveform capture will be one or two cycles in duration and can be viewed as the actual waveform, as a spectral view of the harmonic content, or a tabular view showing the magnitude and phase shift of each harmonic value. Data collected with waveform capture is typically not saved to memory. Waveform capture is a real-time data collection event.

Waveform capture should not be confused with waveform recording that is used to record multiple cycles of all voltage and current waveforms in response to a transient condition.

1.5: Power Quality

Power quality can mean several different things. The terms "power quality" and "power quality problem" have been applied to all types of conditions. A simple definition of "power quality problem" is any voltage, current or frequency deviation that results in mis-operation or failure of customer equipment or systems. The causes of power quality problems vary widely and may originate in the customer equipment, in an adjacent customer facility or with the utility.

In his book Power Quality Primer, Barry Kennedy provided information on different types of power quality problems. Some of that information is summarized in Table 1.3.

Cause	Disturbance Type	Source
Impulse transient	Transient voltage disturbance, sub-cycle duration	Lightning Electrostatic discharge Load switching Capacitor switching
Oscillatory transient with decay	Transient voltage, sub-cycle duration	Line/cable switching Capacitor switching Load switching
Sag/swell	RMS voltage, multiple cycle duration	Remote system faults
Interruptions	RMS voltage, multiple seconds or longer duration	System protection Circuit breakers Fuses Maintenance
Under voltage/over voltage	RMS voltage, steady state, multiple seconds or longer duration	Motor starting Load variations Load dropping
Voltage flicker	RMS voltage, steady state, repetitive condition	Intermittent loads Motor starting Arc furnaces
Harmonic distortion	Steady state current or voltage, long-term duration	Non-linear loads System resonance

Table 1.3: Typical Power Quality Problems and Sources

It is often assumed that power quality problems originate with the utility. While it is true that many power quality problems can originate with the utility system, many problems originate with customer equipment. Customer-caused problems may manifest themselves inside the customer location or they may be transported by the utility system to another adjacent customer. Often, equipment that is sensitive to power quality problems may in fact also be the cause of the problem.

If a power quality problem is suspected, it is generally wise to consult a power quality professional for assistance in defining the cause and possible solutions to the problem.

2: EM-3000 Series Meter Overview and Specifications

2.1: Hardware Overview

The EM-3000 Series multifunction submeter is designed to measure revenue grade electrical energy usage and communicate that information via various communication media. The unit supports RJ45 wired Ethernet or IEEE 802.11 WiFi Ethernet connections. This allows the EM-3000 Series meter to be placed anywhere within an industrial or commercial facility and still communicate quickly and easily back to central software. The unit also has a front IrDA port that can be read and configured with an IrDA-equipped device, such as a laptop PC.



The unit is designed with advanced measurement capabilities, allowing it to achieve high performance accuracy. The EM-3000 Series meter is specified as a 0.2% class energy meter for billing applications. To verify the meter's performance and calibration, power providers use field test standards to verify that the unit's energy measurements are correct. The EM-3000 Series meter is a traceable revenue meter and contains a utility grade test pulse to verify rated accuracy.

EM-3000 Series meter features detailed in this manual are:

- 0.2% Class Revenue Certifiable Energy and Demand Submeter
- Meets ANSI C12.20 (0.2%) and IEC 62053-22 (0.2%) Classes
- Multifunction Measurement including Voltage, Current, Power, Frequency, Energy, etc.
- Power quality measurements (% THD and alarm limits)
- Three line 0.56" bright red LED display
- Percentage of Load bar for Analog meter perception

- Modbus TCP
- Ethernet and wireless Ethernet (WiFi)
- Easy to use faceplate programming
- IrDA port for laptop PC remote read
- Direct interface with most Building Management systems

The EM-3000 Series meter uses standard 5 or 1 Amp CTs (either split or donut). It surface mounts to any wall and is easily programmed. The unit is designed specifically for easy installation and advanced communication.

2.1.1: Model Number plus Option Numbers

Product Series	Network Protocol	Freq.	Power Supply	Current Class	Mounting	V-Switch™ Pack	0	0
EM-3 EM-3000 Series Meter	8 WiFi	50 50 Hz System	-0 (90-400) VAC (100-370) VDC	5 5 Amp Secondary	-W Default	E Default with Energy Counters		
		60 60 Hz System		1 1 Amp Secondary		F Above with Harmonics and Limits		

Example:

EM-3860-05-WE00

which translates to an EM-3000 Series meter with a 60Hz system, default power supply, 5 Amp Secondary current class, default mounting, and default V-Switch key. The last two options do not pertain to the EM-3000 Series meter, so the ordering code contains 0s for them.

2.1.2: Measured Values

The EM-3000 Series meter provides the following measured values all in real time and some additionally as average, maximum and minimum values.

EM-3000 Series Meter Measured Values				
Measured Values	Real Time	Average	Maximum	Minimum
Voltage L-N	X		X	X
Voltage L-L	X		X	X
Current per Phase	X	X	X	X
Current Neutral	X			
Watts	X	X	X	X
VAR	X	X	X	X
VA	X	X	X	X
PF	X	X	X	X
+Watt-hr	X			
-Watt-hr	X			
Watt-hr Net	X			
+VAR-hr	X			
-VAR-hr	X			
VAR-hr Net	X			
VA-hr	X			
Frequency	X		X	X
%THD**	X		X	X
Voltage Angles	X			
Current Angles	X			
% of Load Bar	X			

** The EM-3000 Series meter measures harmonics up to the 7th order for Current and up to the 3rd order for Voltage.

2.1.3: Utility Peak Demand

The EM-3000 Series meter provides user-configured Block (Fixed) window or Rolling window Demand. This feature allows you to set up a customized Demand profile. Block window Demand is Demand used over a user-configured Demand period (usually 5, 15 or 30 minutes). Rolling window Demand is a fixed window Demand that moves for a user-specified subinterval period.

For example, a 15-minute Demand using 3 subintervals and providing a new Demand reading every 5 minutes, based on the last 15 minutes.

Utility Demand features can be used to calculate kW, kVAR, kVA and PF readings. All other parameters offer Max and Min capability over the user-selectable averaging period. Voltage provides an Instantaneous Max and Min reading which displays the highest surge and lowest sag seen by the meter

2.2: Specifications

Power Supply

Range:	Universal, (90 to 400)VAC @50/60Hz or (100 to 370)VDC
Power Consumption:	16 VA Maximum

Voltage Inputs (Measurement Category III)

Range:	Universal, Auto-ranging up to 416VAC L-N, 721VAC L-L
Supported hookups:	3 Element Wye, 2.5 Element Wye, 2 Element Delta, 4 Wire Delta
Input Impedance:	1M Ohm/Phase
Burden:	0.36VA/Phase Max at 600V, 0.0144VA/Phase at 120V
Pickup Voltage:	10VAC
Connection:	Screw terminal - #6 - 32 screws See Figure 4.1

Input Wire Gauge:	AWG#16 - 26
Fault Withstand:	Meets IEEE C37.90.1 (Surge Withstand Capability)
Reading:	Programmable Full Scale to any PT Ratio

Current Inputs

Class 10:	5A Nominal, 10 Amp Maximum
Class 2:	1A Nominal, 2 Amp Secondary
Burden:	0.005VA Per Phase Max at 11 Amps
Pickup Current:	0.1% of Nominal
Connections:	Screw terminal - #6-32 screws (Diagram 4.1)
Current Surge Withstand:	100A/10 seconds at 23° C
Reading:	Programmable Full Scale to any CT Ratio*

***NOTE:** Current transformers are not included with EM series electrical power meters. When selecting current transformers to meet the needs of a metering application, you need to know the amperage of the current being measured, and whether the EM series model is a Class 2 - 1A secondary model or a Class 10 - 5A secondary model. The current ratio required for a metering application is the maximum measured Amps divided by the secondary Amps which the meter model supports.

Current transformers can be purchased from the Electro Industries store at <http://www.electroind.com/store/> or from a local distributor.

For Example, an EM-3860-05-WE00 that has a 5 Amp secondary that is used to measure a 400A load would need current transformers with a 400/5 ratio.

Isolation

All Inputs and Outputs are galvanically isolated and tested to 2500VAC

Environmental Rating

Storage:	(-20 to +70)° C
Operating:	(-20 to +70)° C
Humidity:	to 95% RH Non-condensing
Faceplate Rating:	NEMA12 (Water Resistant)

Measurement Methods

Voltage, Current:	True RMS
Power:	Sampling at 400+ Samples per Cycle on All Channels Measured Readings Simultaneously
Harmonic %THD	% of Total Harmonic Distortion
A/D Conversion:	6 Simultaneous 24 bit Analog to Digital Converters

Update Rate

Watts, VAR and VA:	Every 6 cycles, e.g., 100 milliseconds (Ten times per second) @60Hz
All other parameters:	Every 60 cycles, e.g, 1 second @60Hz

Communication FormatIrDA Port through Face Plate

Protocol:	Modbus ASCII
Com Port Baud Rate:	57600 bps
Com Port Address:	1

Wireless Ethernet

802.11b Wireless or 10/100BaseT Ethernet	WiFi or RJ45 Connection
Wireless Security	64 bit or 128 bit WEP; WPA; WPA-2
Protocol:	Modbus TCP
Com Port Baud Rate:	9600 to 57600 bps
Com Port Address:	001-247
Data Format:	8 Bit, No Parity

Mechanical Parameters

Dimensions:	(H7.9 x W7.6 x D3.2) inches, (H200.7 x W193.0 x D81.3) mm
Weight:	4 pounds/1.81 kilograms

KYZ Output - Wh Pulse

KYZ output contacts (and infrared LED light pulses through face plate; see Section 7.4 for Kh values):

Pulse Width:	40ms
Full Scale Frequency:	~6Hz
Contact type:	Solid State – SPDT (NO – C – NC)
Relay type:	Solid state
Peak switching voltage:	DC ±350V
Continuous load current:	120mA
Peak load current:	350mA for 10ms
On resistance, max.:	35Ω
Leakage current:	1μA@350V
Isolation:	AC 3750V

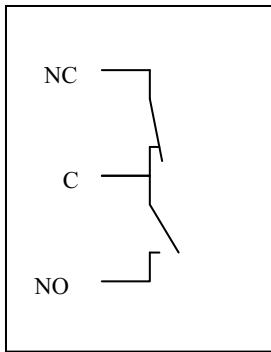
Reset State: (NC - C) Closed; (NO - C) Open

Infrared LED:

Peak Spectral Wavelength: 940nm

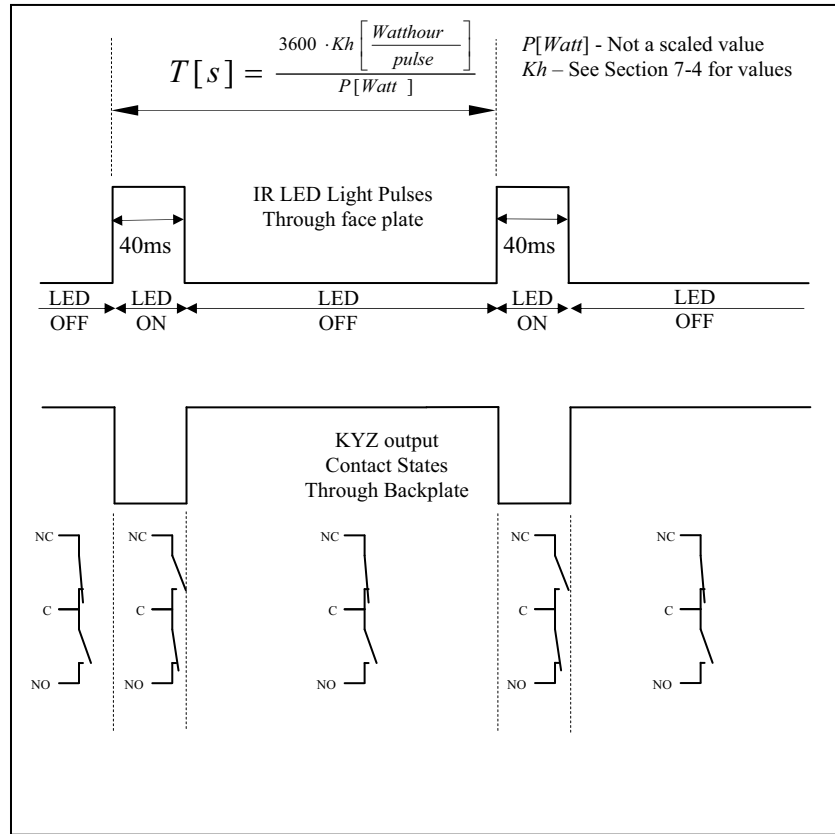
Reset State: Off

Internal Schematic:



(De-energized state)

Output Timing:



2.3: Compliance

- IEC 62053-22 (0.2% Accuracy)
- ANSI C12.20 (0.2% Accuracy)
- ANSI (IEEE) C37.90.1 Surge Withstand
- ANSI C62.41 (Burst)
- EN61000-6-2 Immunity for Industrial Environments: 2005
- EN61000-6-4 Emission Standards for Industrial Environments: 2007
- EN61326-1 EMC Requirements: 2006
- UL Listed
- CE Compliant

2.4: Accuracy

For 23°C, 3 Phase balanced Wye or Delta load, at 50 or 60 Hz (as per order), 5A (Class 10) nominal unit:

Parameter	Accuracy	Accuracy Input Range
Voltage L-N [V]	0.1% of reading ²	(69 to 480)V
Voltage L-L [V]	0.1% of reading	(120 to 600)V
Current Phase [A]	0.1% of reading ¹	(0.15 to 5)A
Current Neutral (calculated) [A]	2.0% of Full Scale ¹	(0.15 to 5)A @ (45 to 65)Hz
Active Power Total [W]	0.2% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Active Energy Total [Wh]	0.2% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Reactive Power Total [VAR]	0.2% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0 to 0.8) lag/lead PF
Reactive Energy Total [VARh]	0.2% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0 to 0.8) lag/lead PF
Apparent Power Total [VA]	0.2% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Apparent Energy Total [VAh]	0.2% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Power Factor	0.2% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Frequency	+/- 0.01Hz	(45 to 65)Hz
Total Harmonic Distortion (%)	5.0% ¹	(0.5 to 10)A or (69 to 480)V, measurement range (1 to 99.99)%
Load Bar	+/- 1 segment ¹	(0.005 to 6)A

¹ For 2.5 element programmed units, degrade accuracy by an additional 0.5% of reading.

- For 1A (Class 2) Nominal, degrade accuracy by an additional 0.5% of reading.
- For 1A (Class 2) Nominal, the input current range for Accuracy specification is 20% of the values listed in the table.

² For unbalanced voltage inputs where at least one crosses the 150V auto-scale threshold (for example, 120V/120V/208V system), degrade accuracy by additional 0.4%.

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3: Mechanical Installation

3.1: Overview

The EM-3000 Series meter can be installed on any wall. See Chapter 4 for wiring diagrams.

Mount the meter in a dry location, which is free from dirt and corrosive substances.

Recommended Tools for EM-3000 Series meter Installation

- #2 Phillips screwdriver
- Wire cutters



WARNING! During normal operation of the EM-3000 Series meter, dangerous voltages flow through many parts of the meter, including: Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O Modules (Inputs and Outputs) and their circuits. All Primary and Secondary circuits can, at times, produce lethal voltages and currents. Avoid contact with any current-carrying surfaces. **Before performing ANY work on the meter, make sure the meter is powered down and all connected circuits are de-energized.**

AVERTISSEMENT! Pendant le fonctionnement normal du compteur EM-3000 Series des tensions dangereuses suivent de nombreuses pièces, notamment, les bornes et tous les transformateurs de courant branchés, les transformateurs de tension, toutes les sorties, les entrées et leurs circuits. Tous les circuits secondaires et primaires peuvent parfois produire des tensions de létal et des courants. Évitez le contact avec les surfaces sous tensions. **Avant de faire un travail dans le compteur, assurez-vous d'éteindre l'alimentation et de mettre tous les circuits branchés hors tension.**



WARNING: Risk of Electric Shock.

Ground the meter according to local, national, and regional regulations. Failure to ground the meter may result in electric shock and severe personal injury or death.

AVERTISSEMENT : risque de décharge électrique

Effectuer la mise à terre selon les règlements locaux, nationaux et régionaux. La non mise à la terre du compteur peut provoquer une décharge électrique, des blessures graves ou provoquer la mort.

3.2: Install the Base

1. Determine where you want to install the submeter.
2. **With the submeter power off**, open the top of the submeter. Use the front cover support to keep the cover open as you perform the installation (see Figure 3.1).

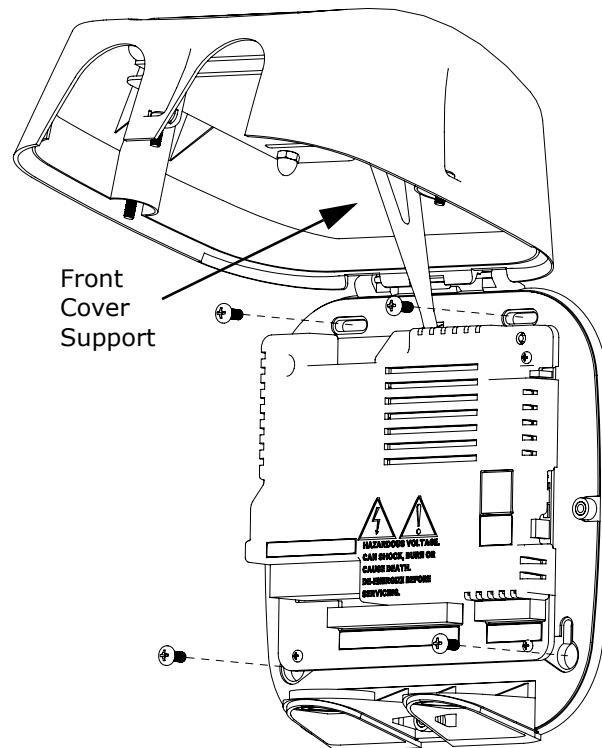


Figure 3.1: EM-3000 Series Meter with Cover Open: see **WARNING!** on previous page

CAUTIONS!

- Remove the antenna before opening the unit.
 - Only use the front cover support if you are able to open the front cover to the extent that you can fit the front cover support into its base. **DO NOT** rest the front cover support on the inside of the meter, even for a short time - by doing so, you may damage components on the board assembly.
3. Find the 4 Installation Slots and insert screws through each slot into the wall or panel.
 4. Fasten securely - **DO NOT** overtighten.

3.2.1: Mounting Diagrams

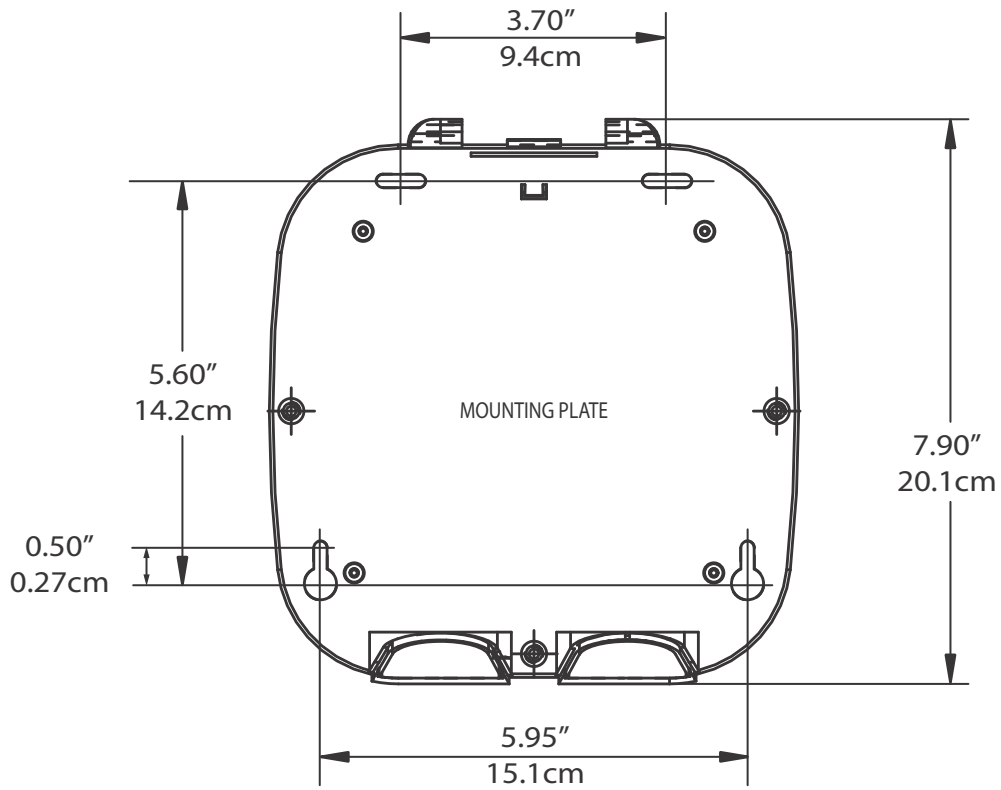
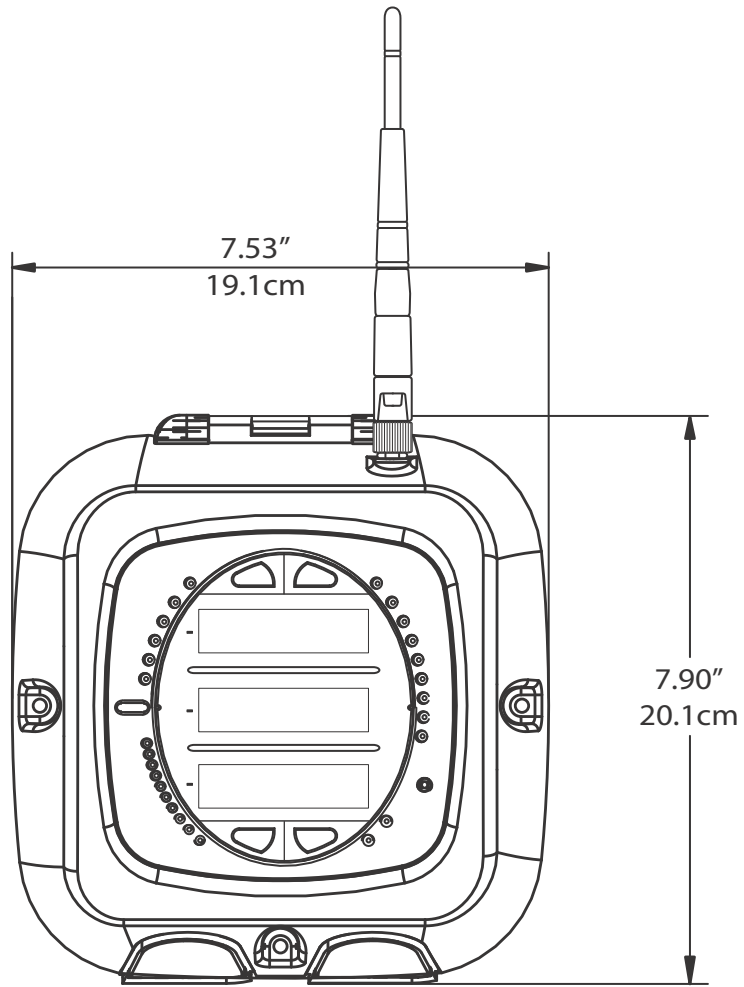


Figure 3.2: Mounting Plate Dimensions



Antenna Length: 4.4" (11.2cm)

Figure 3.3: Front Dimensions

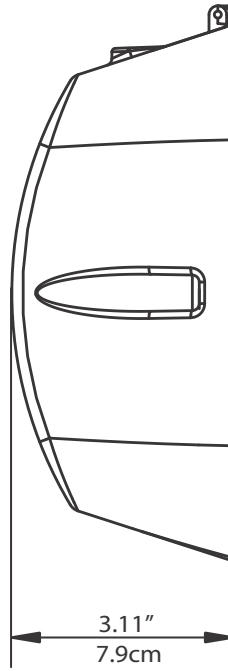


Figure 3.4: Side Dimensions

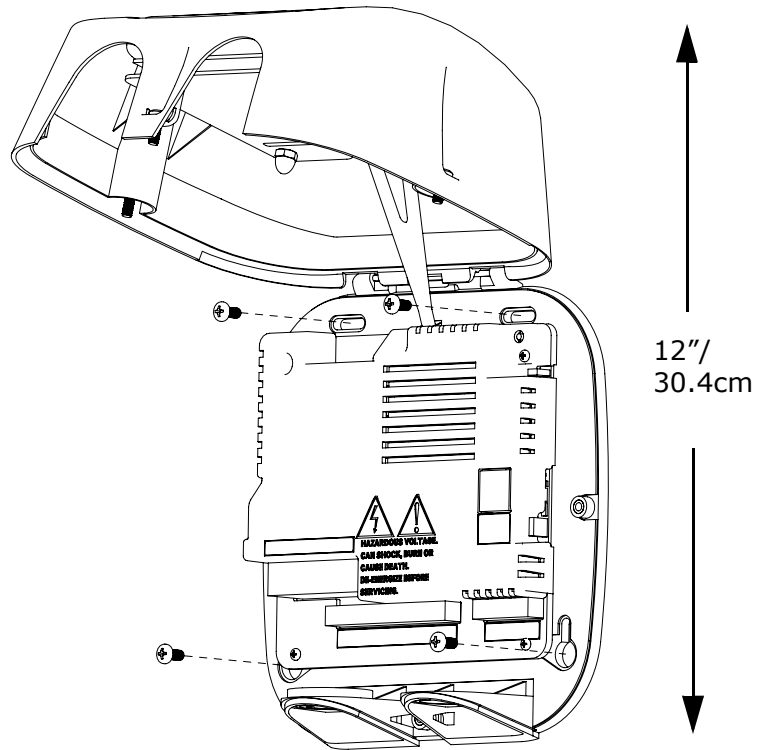


Figure 3.5: Open Cover Dimensions

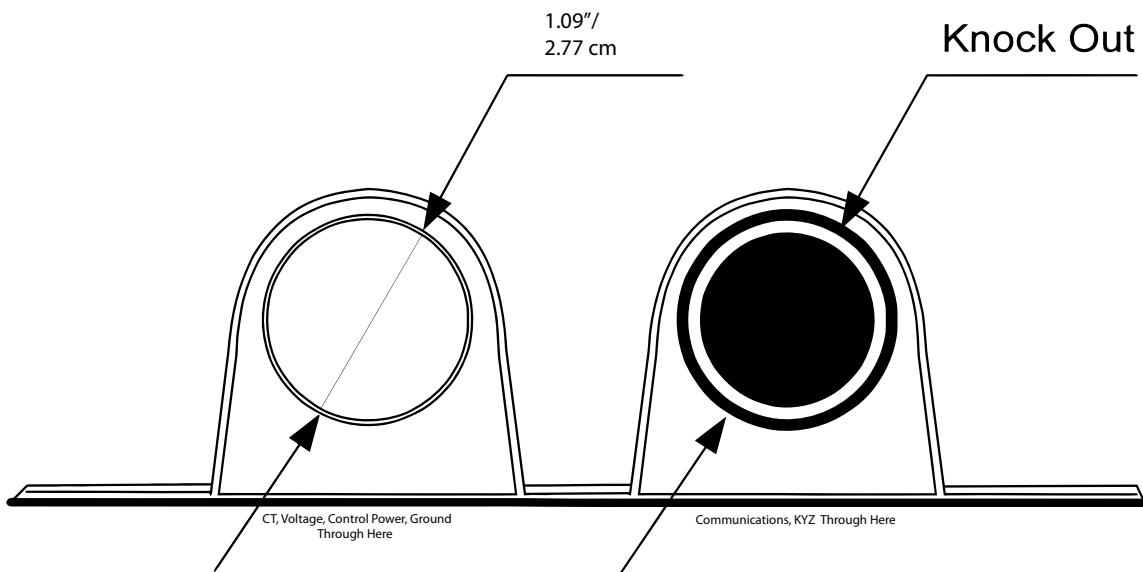


Figure 3.6: Bottom View with Access Holes

3.3: Secure the Cover

1. Close the cover, making sure that power and communications wires exit the submeter through the openings at the base (see Figure 3.6).

CAUTION! To avoid damaging components on the board assembly, make sure the front cover support is in the upright position before closing the front cover.

2. Using the 3 enclosed screws, secure the cover to the base in three places - DO NOT overtighten (you may damage the cover).
3. The unit can be sealed after the front cover is closed. To seal the unit, thread the seal tag through the housing located between the bottom access holes (see figures 3.6 and 3.7).
4. Reattach the antenna, if applicable.

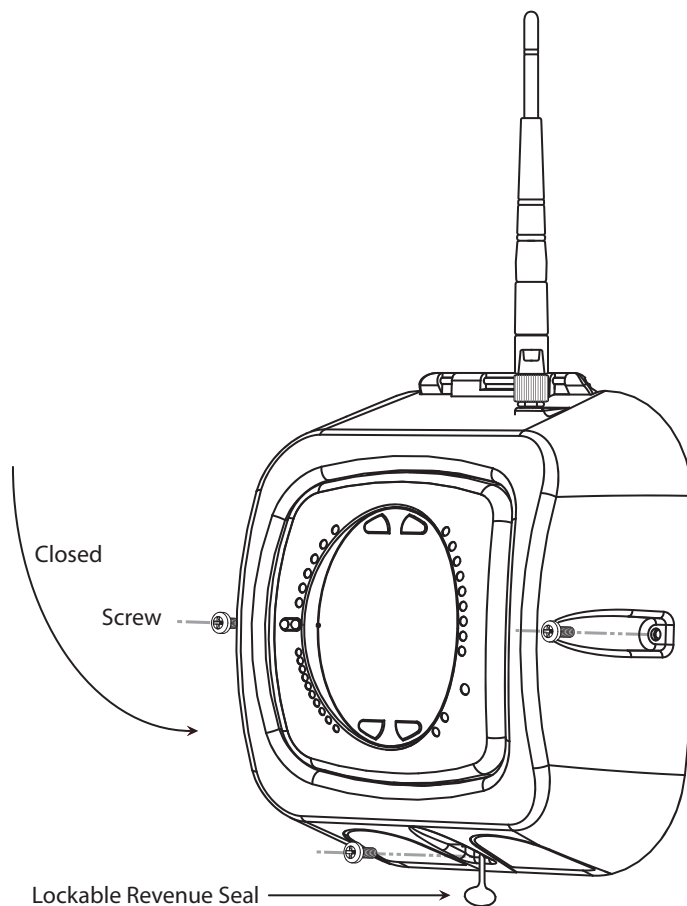


Figure 3.7: Submeter with Closed Cover

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4: Electrical Installation

4.1: Considerations When Installing Meters



Installation of the EM-3000 Series meter must be performed only by qualified personnel who follow standard safety precautions during all procedures. Those personnel should have appropriate training and experience with high voltage devices. Appropriate safety gloves, safety glasses and protective clothing is recommended.

WARNING! During normal operation of the EM-3000 Series meter, dangerous voltages flow through many parts of the meter, including: Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O Modules (Inputs and Outputs) and their circuits. All Primary and Secondary circuits can, at times, produce lethal voltages and currents. Avoid contact with any current-carrying surfaces. **Before performing ANY work on the meter, make sure the meter is powered down and all connected circuits are de-energized.**

Do not use the meter or any I/O Output Device for primary protection or in an energy-limiting capacity. The meter can only be used as secondary protection.

Do not use the meter for applications where failure of the meter may cause harm or death.

Do not use the meter for any application where there may be a risk of fire.

All meter terminals should be inaccessible after installation.

Do not apply more than the maximum voltage the meter or any attached device can withstand. Refer to meter and/or device labels and to the Specifications for all devices before applying voltages.



Caution: Risk of Property Damage.

Do not apply power to the system before checking all wiring connections. Short circuited or improperly connected wires may result in permanent damage to the equipment.

Do not HIPOT/Dielectric test any Outputs, Inputs or Communications terminals.

Johnson Controls, Inc. recommends the use of Fuses for voltage leads and power supply and Shorting Blocks to prevent hazardous voltage conditions or damage to CTs, if the meter needs to be removed from service. One side of the CT must be grounded.

NOTE: The current inputs are only to be connected to external current transformers provided by the installer. The CT's shall be Approved or Certified and rated for the current of the meter used.



Caution: Risk of Property Damage.

Ensure that the power source conforms to the requirements of the equipment. Failure to use a correct power source may result in permanent damage to the equipment.



L'installation des compteurs de EM-3000 Series doit être effectuée seulement par un personnel qualifié qui suit les normes relatives aux précautions de sécurité pendant toute la procédure. Le personnel doit avoir la formation appropriée et l'expérience avec les appareils de haute tension. Des gants de sécurité, des verres et des vêtements de protection appropriés sont recommandés.

AVERTISSEMENT! Pendant le fonctionnement normal du compteur EM-3000 Series des tensions dangereuses suivant de nombreuses pièces, notamment, les bornes et tous les transformateurs de courant branchés, les transformateurs de tension, toutes les sorties, les entrées et leurs circuits. **Tous les circuits secondaires et primaires peuvent parfois produire des tensions de léthal et des courants. Évitez le contact avec les surfaces sous tensions. Avant de faire un travail dans le compteur, assurez-vous d'éteindre l'alimentation et de mettre tous les circuits branchés hors tension.**

Ne pas utiliser les compteurs ou sorties d'appareil pour une protection primaire ou capacité de limite d'énergie. Le compteur peut seulement être utilisé comme une protection secondaire.

Ne pas utiliser le compteur pour application dans laquelle une panne de compteur peut causer la mort ou des blessures graves.

Ne pas utiliser le compteur ou pour toute application dans laquelle un risque d'incendie est susceptible.

Toutes les bornes de compteur doivent être inaccessibles après l'installation.

Ne pas appliquer plus que la tension maximale que le compteur ou appareil relatif peut résister. Référez-vous au compteur ou aux étiquettes de l'appareil et les spécifications de tous les appareils avant d'appliquer les tensions. Ne pas faire de test HIPOT/diélectrique, une sortie, une entrée ou un terminal de réseau.

Les entrées actuelles doivent seulement être branchées aux transformateurs externes actuels.

Johnson Controls recommande d'utiliser les fusibles pour les fils de tension et alimentations électriques, ainsi que des coupe-circuits pour prévenir les tensions dangereuses ou endommagements de transformateur de courant si l'unité EM-3000 Series doit être enlevée du service. Un côté du transformateur de courant doit être mis à terre.

NOTE: les entrées actuelles doivent seulement être branchées dans le transformateur externe actuel par l'installateur. Le transformateur de courant doit être approuvé ou certifié et déterminé pour le compteur actuel utilisé.

IMPORTANT!



- IF THE EQUIPMENT IS USED IN A MANNER NOT SPECIFIED BY THE MANUFACTURER, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.
- THERE IS NO REQUIRED PREVENTIVE MAINTENANCE OR INSPECTION NECESSARY FOR SAFETY. HOWEVER, ANY REPAIR OR MAINTENANCE SHOULD BE PERFORMED BY THE FACTORY.



DISCONNECT DEVICE: The following part is considered the equipment disconnect device. A SWITCH OR CIRCUIT-BREAKER SHALL BE INCLUDED IN THE END-USE EQUIPMENT OR BUILDING INSTALLATION. THE SWITCH SHALL BE IN CLOSE PROXIMITY TO THE EQUIPMENT AND WITHIN EASY REACH OF THE OPERATOR. THE SWITCH SHALL BE MARKED AS THE DISCONNECTING DEVICE FOR THE EQUIPMENT.



IMPORTANT! SI L'ÉQUIPEMENT EST UTILISÉ D'UNE FAÇON NON SPÉCIFIÉE PAR LE FABRICANT, LA PROTECTION FOURNIE PAR L'ÉQUIPEMENT PEUT ÊTRE ENDOMMAGÉE.

NOTE: IL N'Y A AUCUNE MAINTENANCE REQUISE POUR LA PRÉVENTION OU INSPECTION NÉCESSAIRE POUR LA SÉCURITÉ. CEPENDANT, TOUTE RÉPARATION OU MAINTENANCE DEVRAIT ÊTRE RÉALISÉE PAR LE FABRICANT.



DÉBRANCHEMENT DE L'APPAREIL : la partie suivante est considérée l'appareil de débranchement de l'équipement.

UN INTERRUPTEUR OU UN DISJONCTEUR DEVRAIT ÊTRE INCLUS DANS L'UTILISATION FINALE DE L'ÉQUIPEMENT OU L'INSTALLATION. L'INTERRUPTEUR DOIT ÊTRE DANS UNE PROXIMITÉ PROCHE DE L'ÉQUIPEMENT ET A LA PORTÉE DE L'OPÉRATEUR. L'INTERRUPTEUR DOIT AVOIR LA MENTION DÉBRANCHEMENT DE L'APPAREIL POUR L'ÉQUIPEMENT.

4.2: Electrical Connections

All wiring for the EM-3000 Series meter is done through the front of the unit (lifting the cover with the power to the unit OFF) so that the unit can be surface mounted. Connecting cables exit the unit via two openings in the base plate (see figures 3.6 and 4.1).



WARNING! During normal operation of the EM-3000 Series meter, dangerous voltages flow through many parts of the meter, including:

Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O Modules (Inputs and Outputs) and their circuits. All Primary and Secondary circuits can, at times, produce lethal voltages and

currents. Avoid contact with any current-carrying surfaces. **Before performing ANY work on the meter, make sure the meter is powered down and all connected circuits are de-energized.**

AVERTISSEMENT! Pendant le fonctionnement normal du compteur EM-3000 Series des tensions dangereuses suivent de nombreuses pièces, notamment, les bornes et tous les transformateurs de courant branchés, les transformateurs de tension, toutes les sorties, les entrées et leurs circuits. Tous les circuits secondaires et primaires peuvent parfois produire des tensions de léthal et des courants. Évitez le contact avec les surfaces sous tensions. **Avant de faire un travail dans le compteur, assurez-vous d'éteindre l'alimentation et de mettre tous les circuits branchés hors tension.**

CAUTION! DO NOT over-torque screws.



WARNING: Risk of Electric Shock.

Disconnect the power supply before making electrical connections.

Contact with components carrying hazardous voltage can cause electric shock and may result in severe personal injury or death.

AVERTISSEMENT: risque de décharge électrique

Débranchez l'alimentation électrique avant de faire un branchement électrique. Le contact avec des composants ayant des tensions importantes peut provoquer une décharge électrique, des blessures personnelles graves ou la mort.

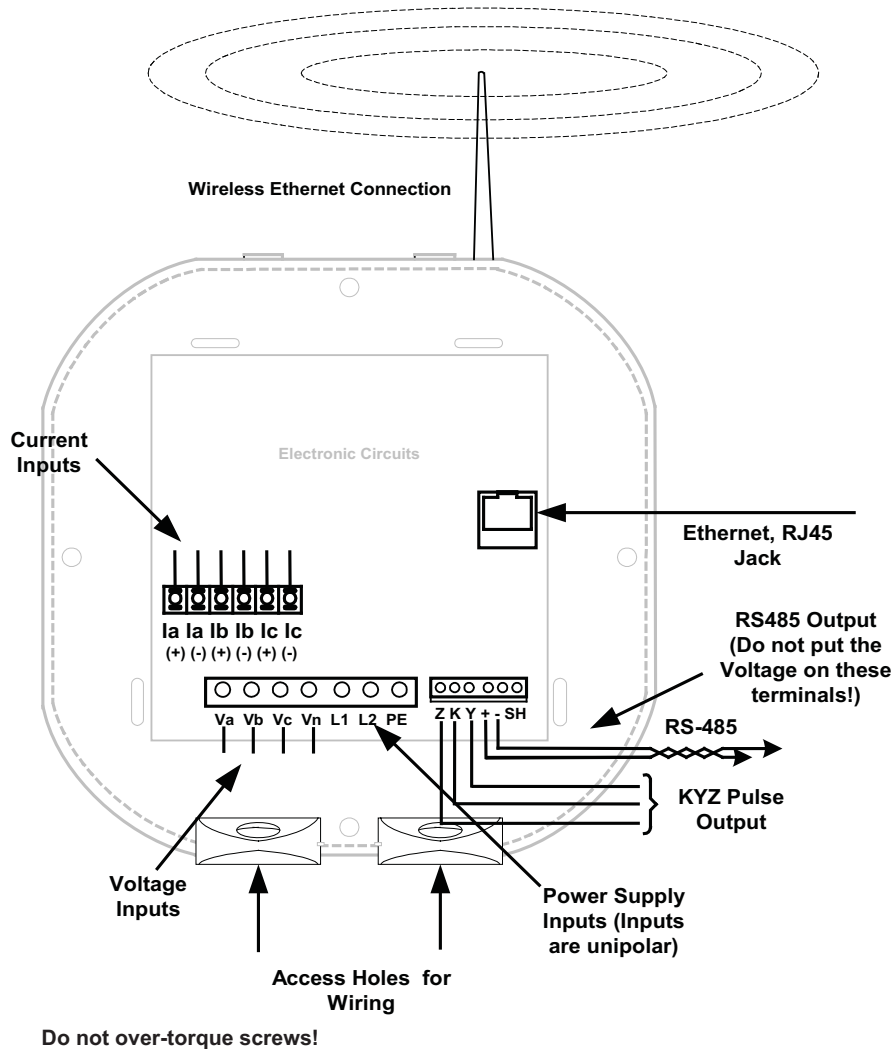


Figure 4.1: Submeter Connections

4.3: Ground Connections

The meter's Ground Terminal (PE) should be connected directly to the installation's protective earth ground.



WARNING: Risk of electric shock.

Ground the meter according to local, national, and regional regulations. Failure to ground the meter may result in electric shock and severe personal injury or death.

AVERTISSEMENT: risque de décharge électrique

Effectuer la mise à terre selon les règlements locaux, nationaux et régionaux. La non mise à la terre du compteur peut provoquer une décharge électrique, des blessures graves ou provoquer la mort.

4.4: Voltage Fuses

Johnson Controls, Inc. recommends the use of fuses on each of the sense voltages and on the control power, even though the wiring diagrams in this chapter do not show them.

- Use a 0.1 Amp fuse on each Voltage input.
- Use a 3 Amp fuse on the power supply.

4.5: Electrical Connection Diagrams

Choose the diagram that best suits your application. Make sure the CT polarity is correct.

1. Three Phase, Four-Wire System Wye with Direct Voltage, 3 Element
 - a. Dual Phase Hookup
 - b. Single Phase Hookup
2. Three Phase, Four-Wire System Wye with Direct Voltage, 2.5 Element
3. Three-Phase, Four-Wire Wye with PTs, 3 Element
4. Three-Phase, Four-Wire Wye with PTs, 2.5 Element
5. Three-Phase, Three-Wire Delta with Direct Voltage (No PTs, 2 CTs)
6. Three-Phase, Three-Wire Delta with Direct Voltage (No PTs, 3 CTs)
7. Three-Phase, Three-Wire Delta with 2 PTs, 2 CTs
8. Three-Phase, Three-Wire Delta with 2 PTs, 3 CTs
9. Current Only Measurement (Three Phase)
10. Current Only Measurement (Dual Phase)
11. Current Only Measurement (Single Phase)



WARNING: Risk of Electric Shock.

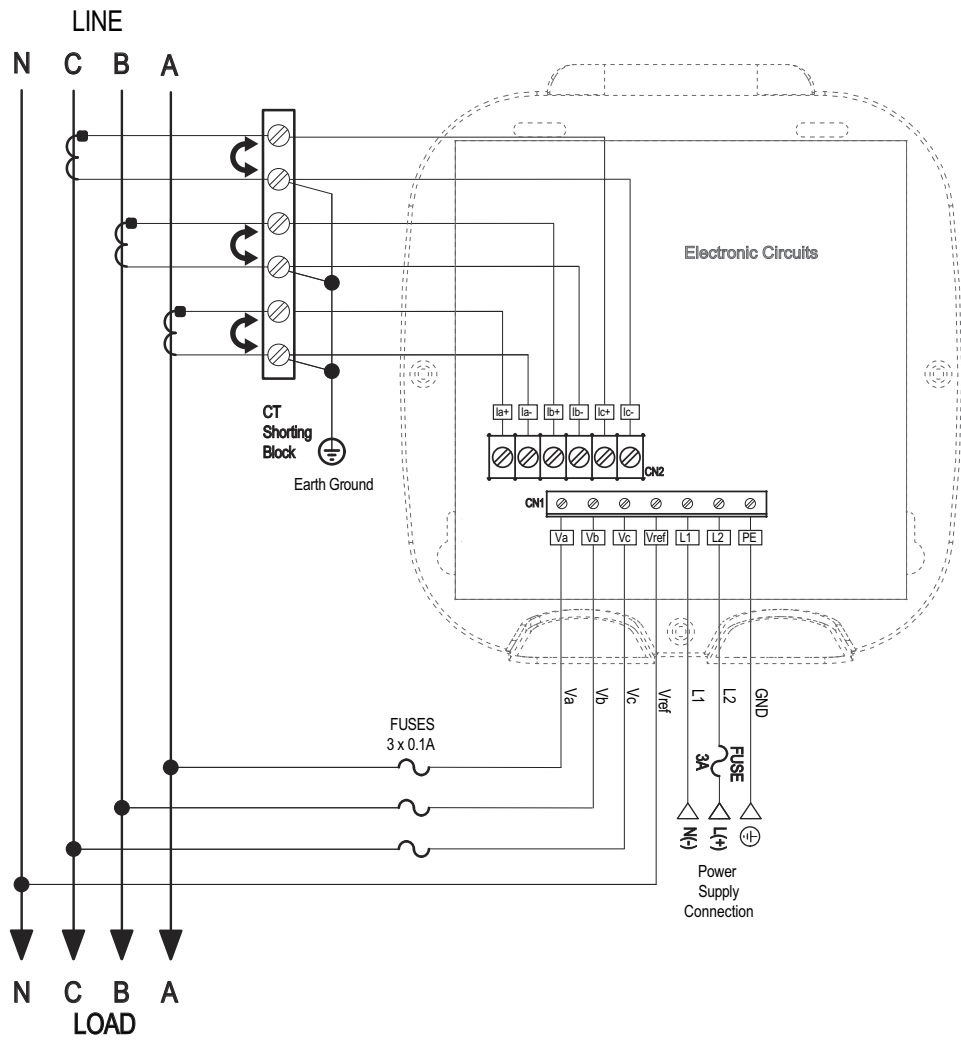
Disconnect the power supply before making electrical connections.

Contact with components carrying hazardous voltage can cause electric shock and may result in severe personal injury or death.

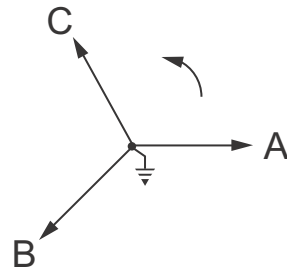
AVERTISSEMENT: risque de décharge électrique

Débranchez l'alimentation électrique avant de faire un branchement électrique. Le contact avec des composants ayant des tensions importantes peut provoquer une décharge électrique, des blessures personnelles graves ou la mort.

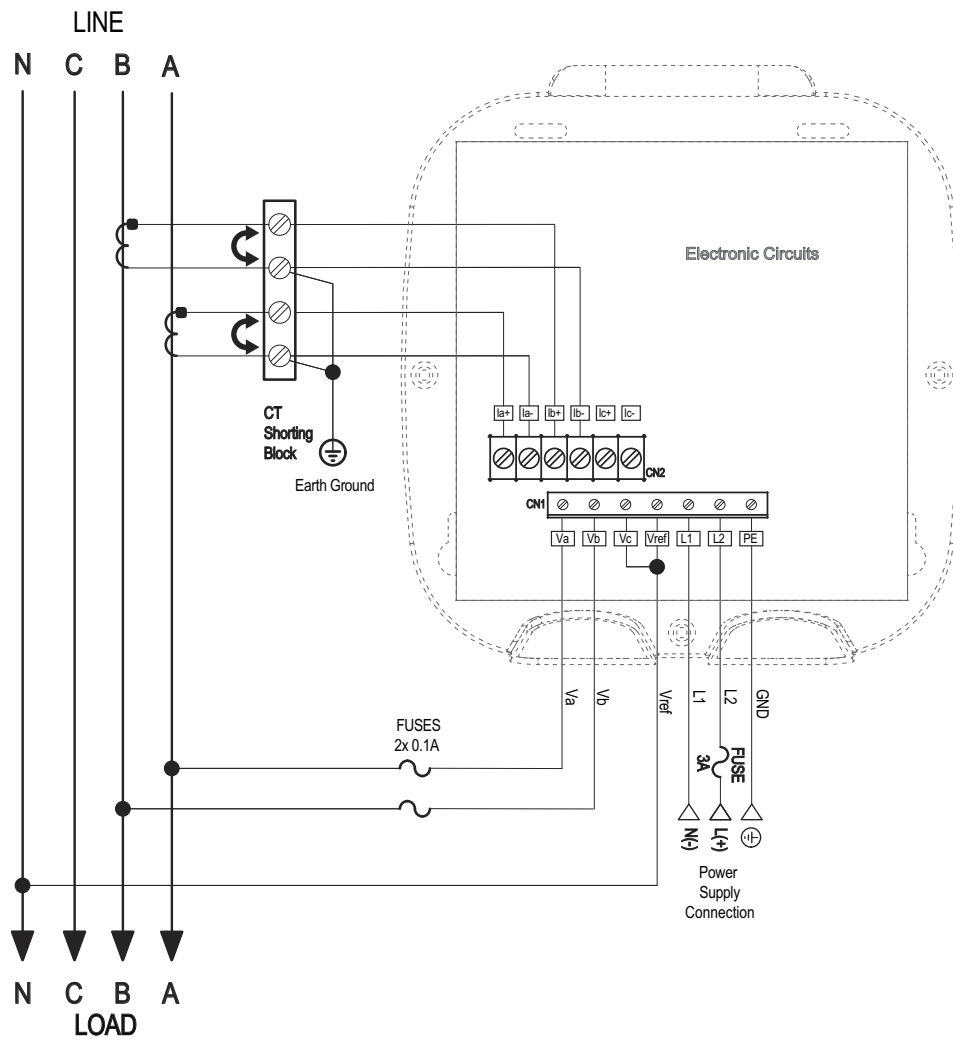
1. Service: WYE, 4-Wire with No PTs, 3 CTs



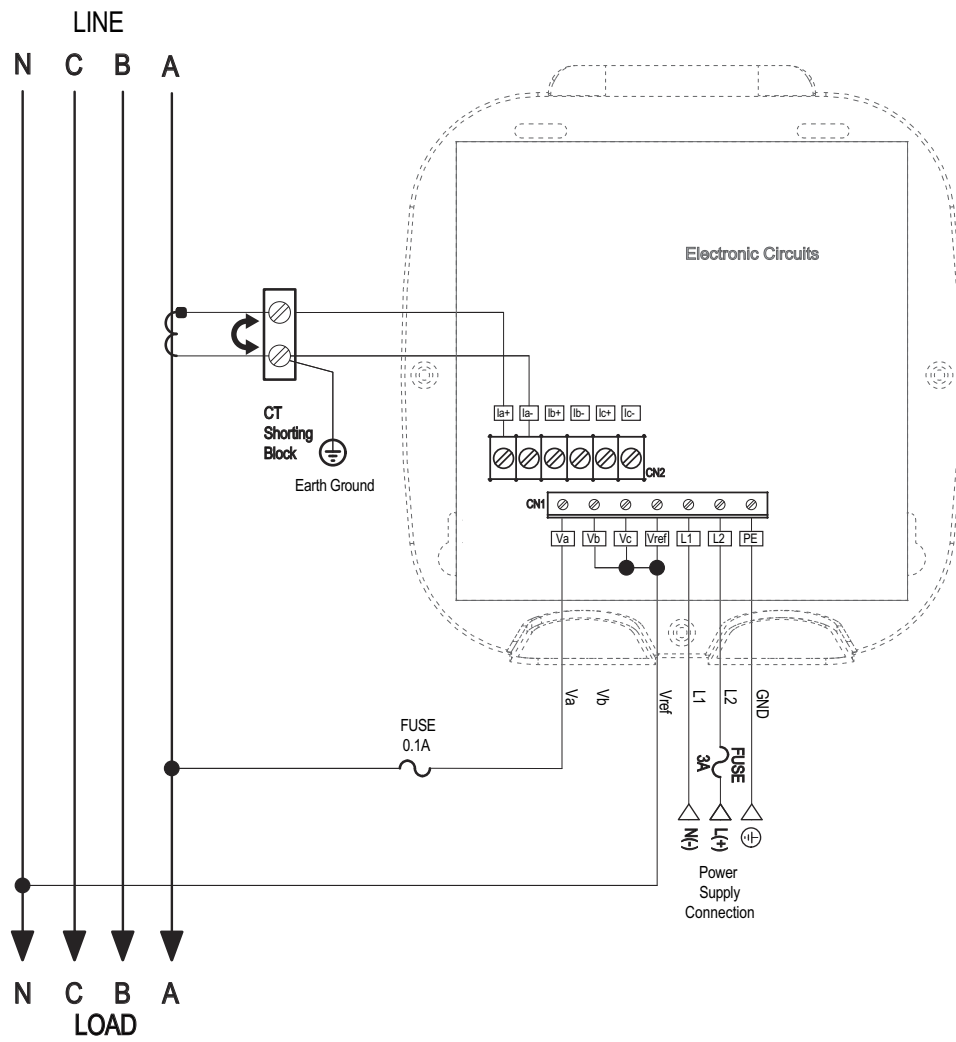
Select: "3 EL WYE" (3 Element Wye) in Meter Programming setup.



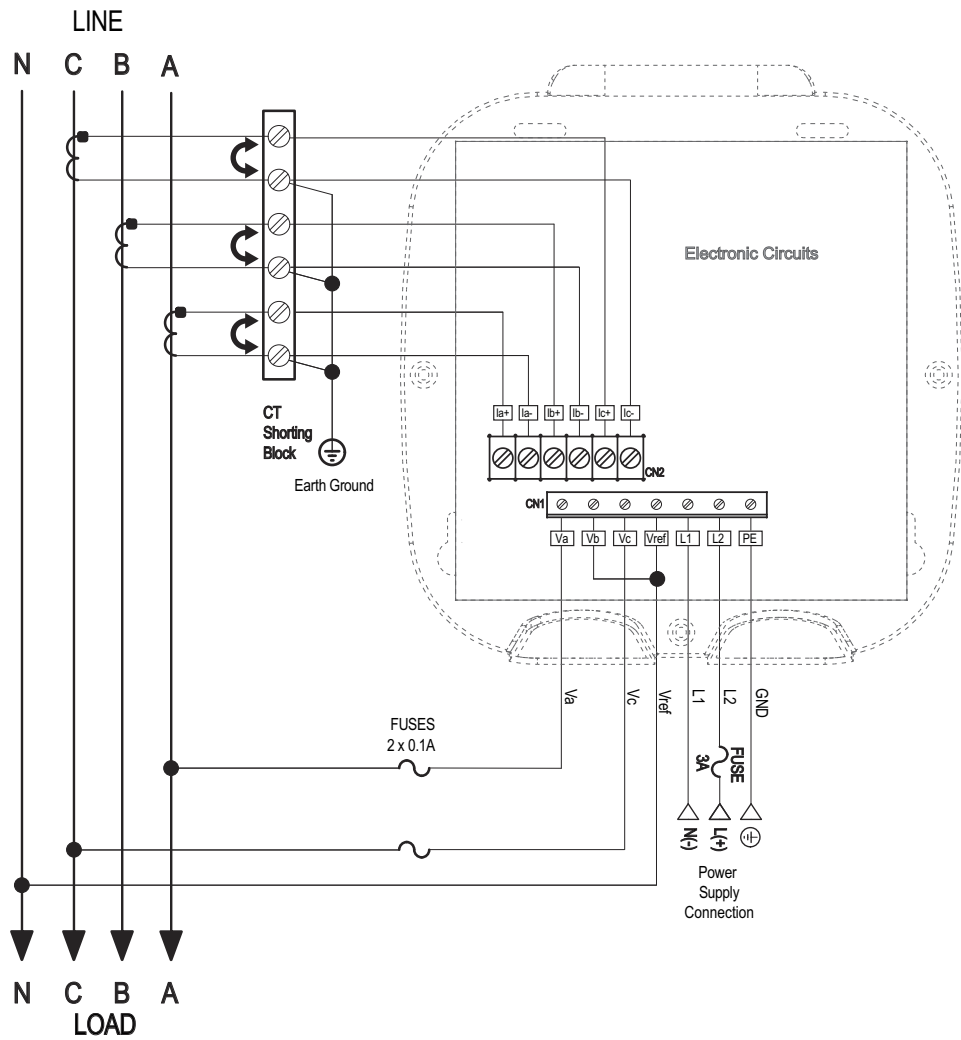
1a. Dual Phase Hookup



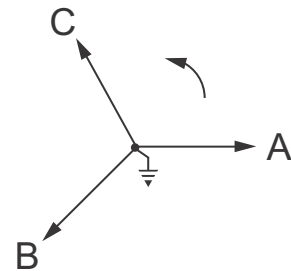
1b. Single Phase Hookup



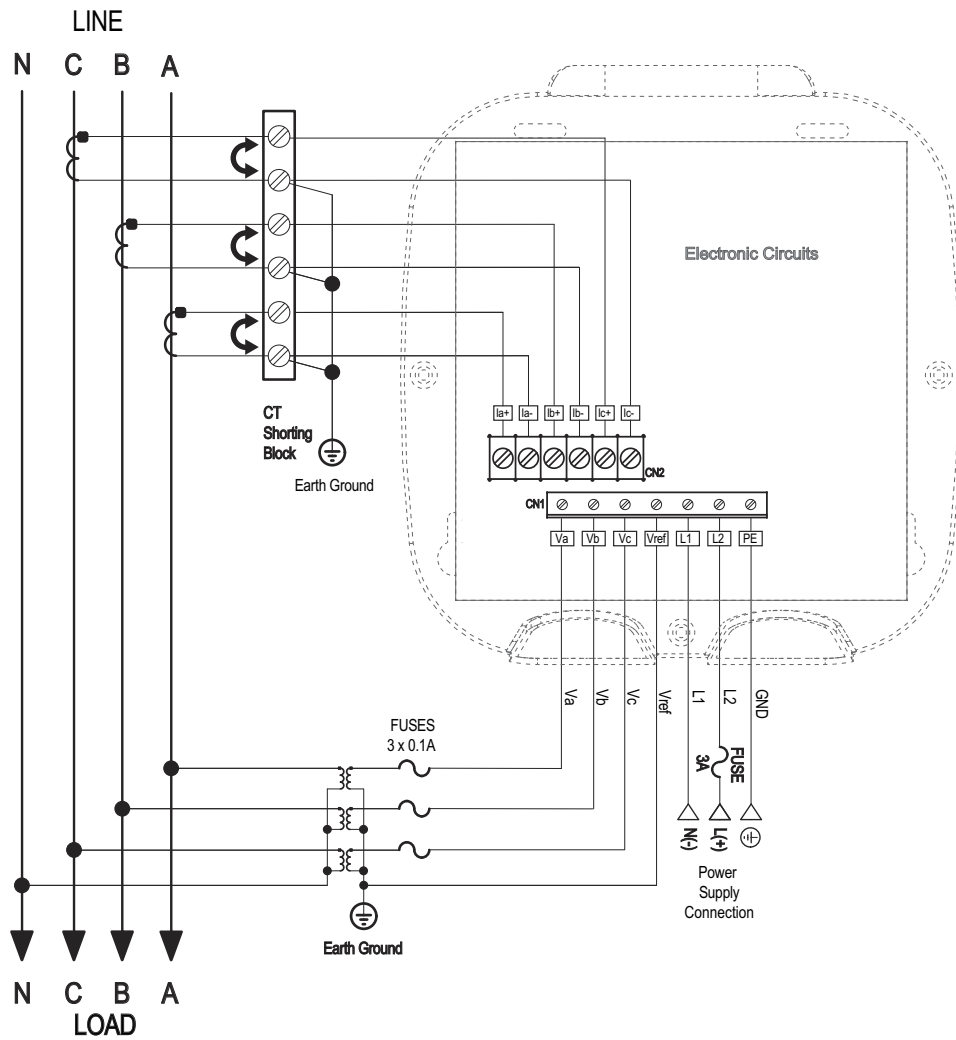
2. Service: 2.5 Element WYE, 4-Wire with No PTs, 3 CTs



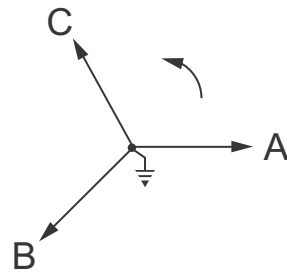
Select: "2.5 EL WYE" (2.5 Element Wye) in Meter Programming setup.



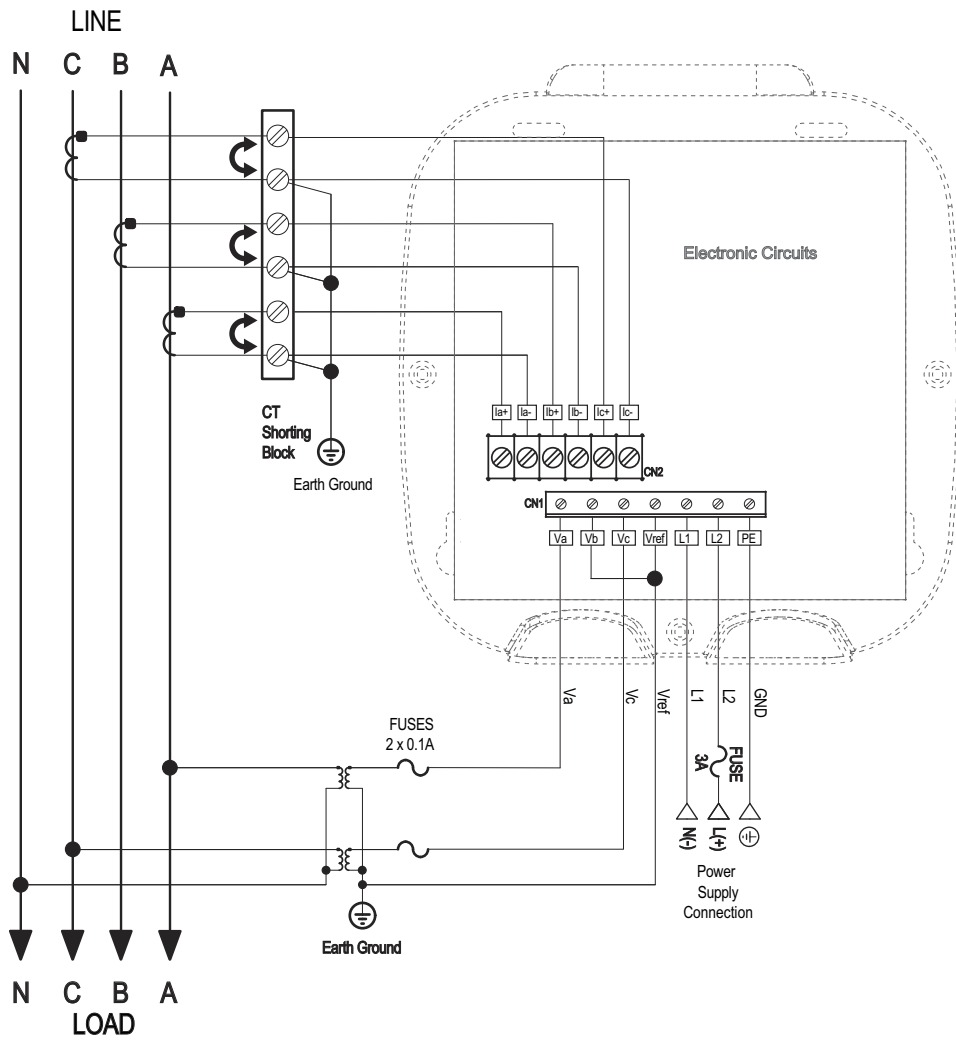
3. Service: WYE, 4-Wire with 3 PTs, 3 CTs



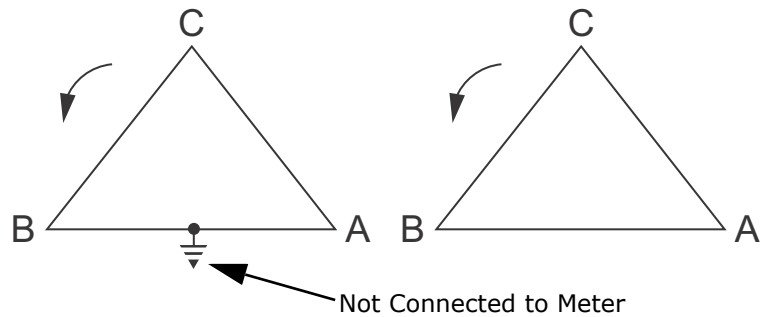
Select: "3 EL WYE" (3 Element Wye) in Meter Programming setup.



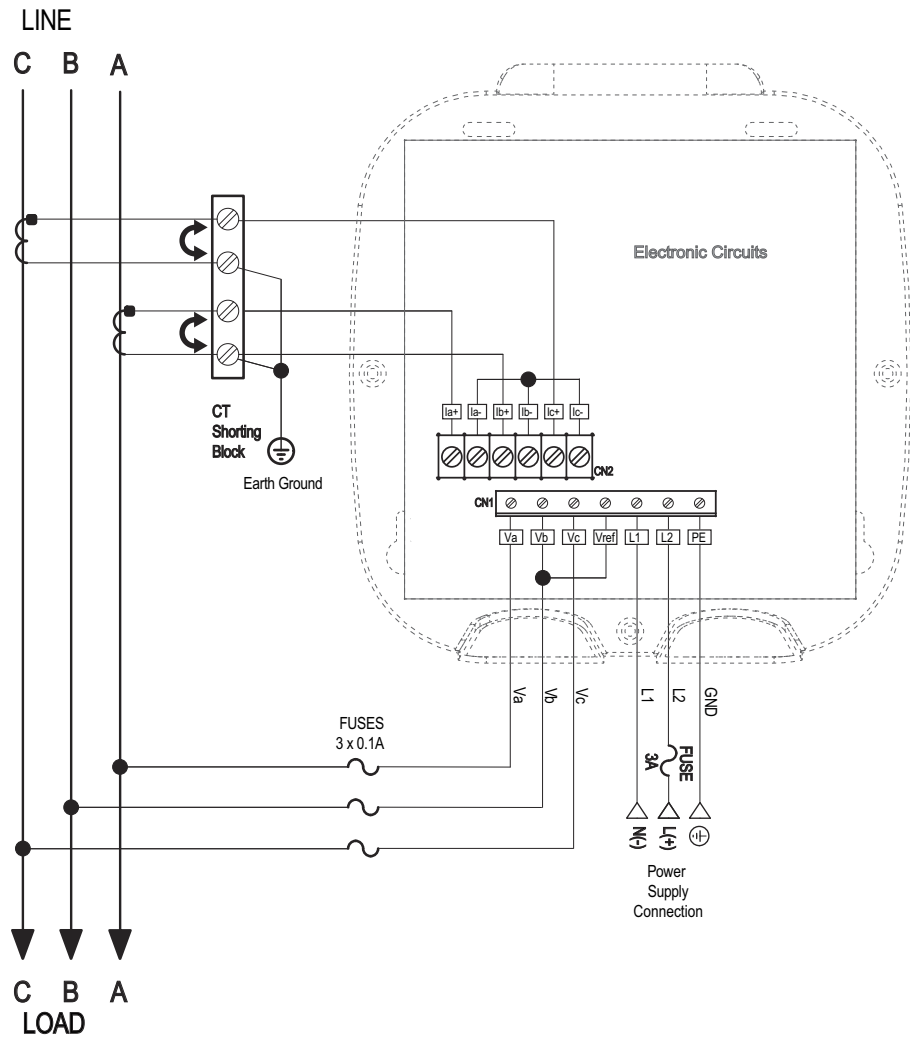
4. Service: 2.5 Element WYE, 4-Wire with 2 PTs, 3 CTs



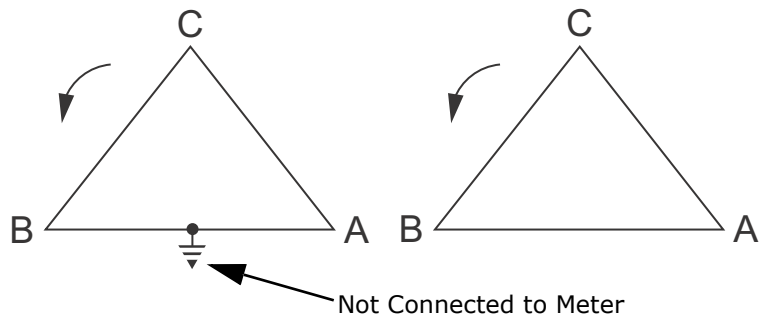
Select: "2.5 EL WYE" (2.5 Element Wye) in Meter Programming setup.



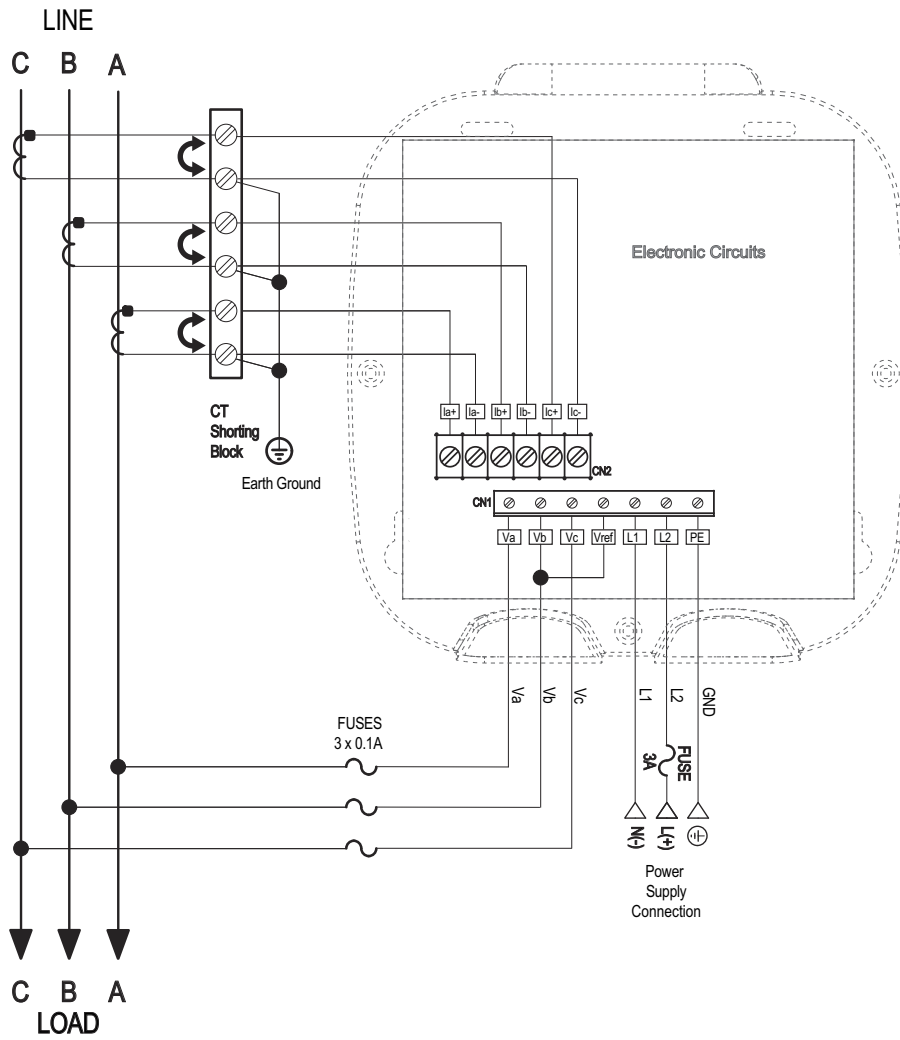
5. Service: Delta, 3-Wire with No PTs, 2 CTs



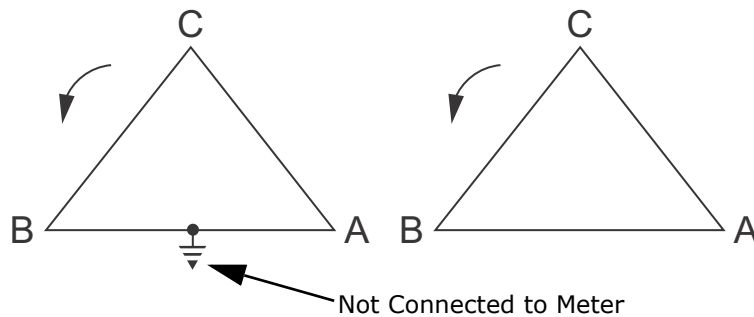
Select: "2 Ct dEL" (2 CT Delta) in Meter Programming setup.



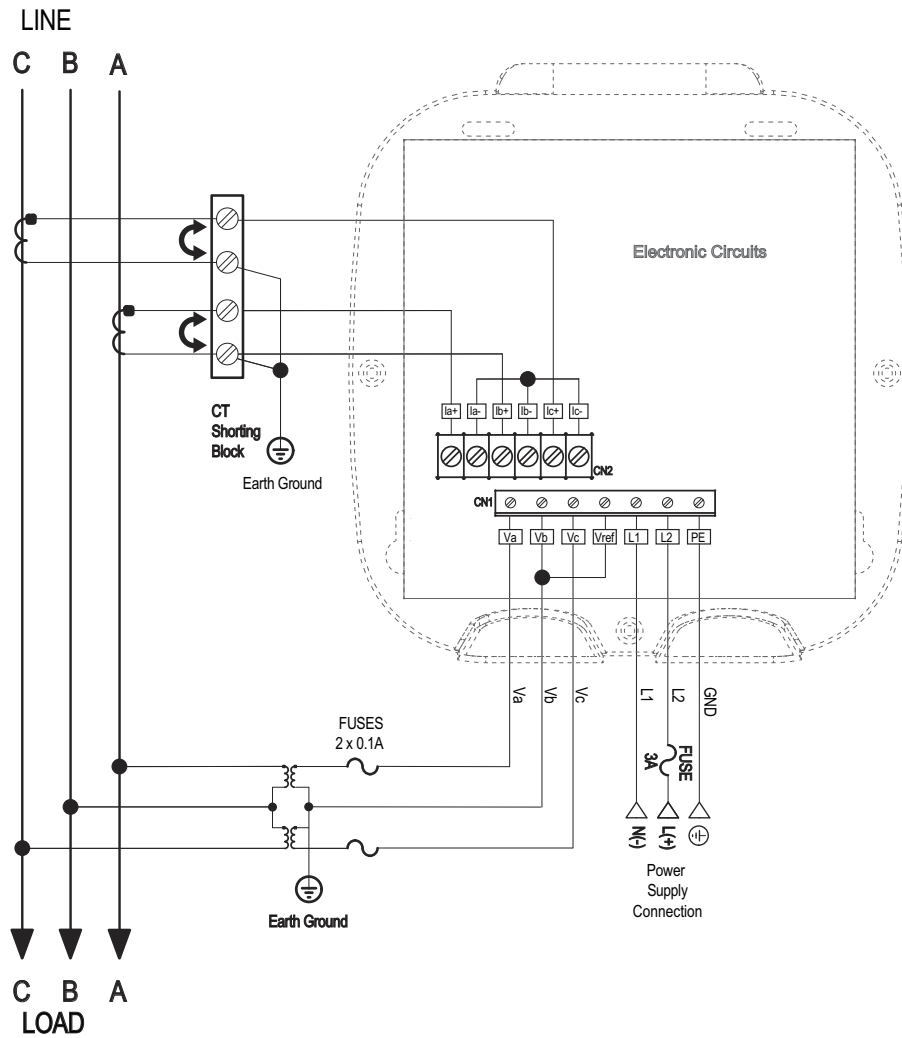
6. Service: Delta, 3-Wire with No PTs, 3 CTs



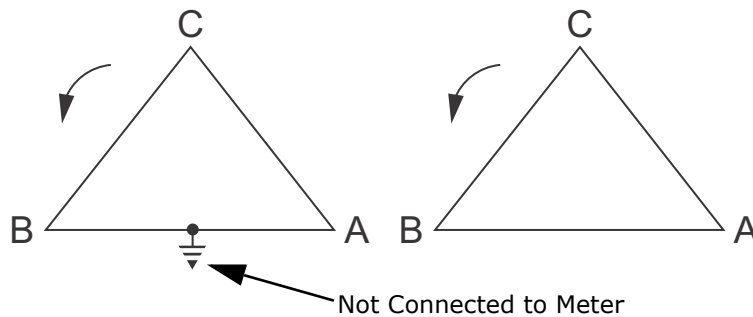
Select: "2 Ct dEL" (2 CT Delta) in Meter Programming setup.



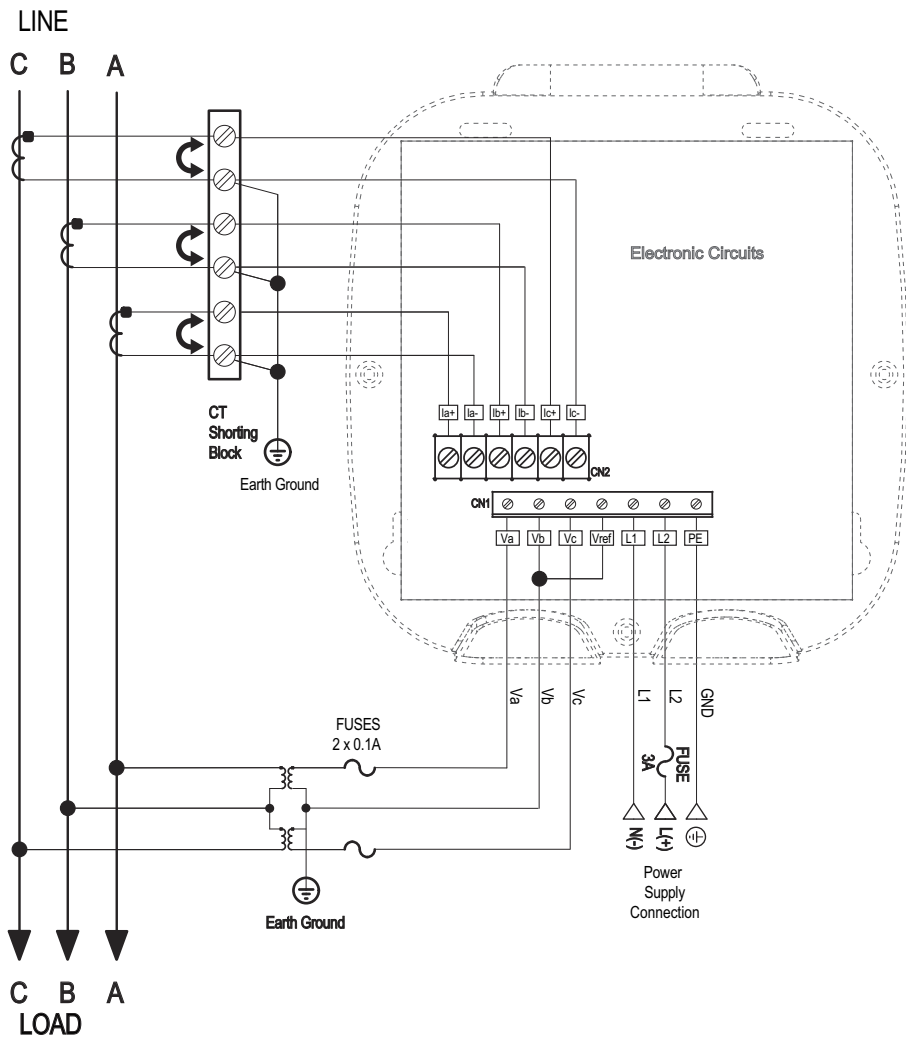
7. Service: Delta, 3-Wire with 2 PTs, 2 CTs



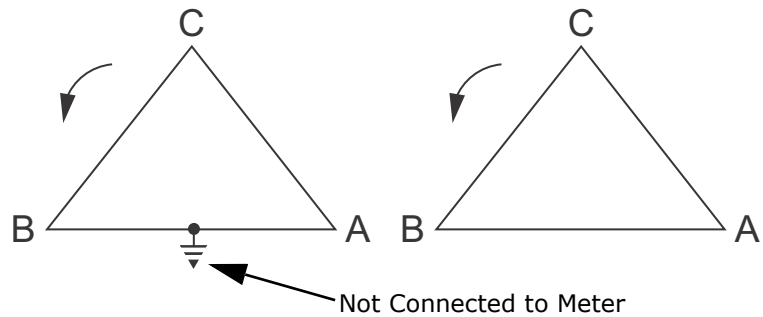
Select: "2 Ct dEL" (2 CT Delta) in Meter Programming setup.



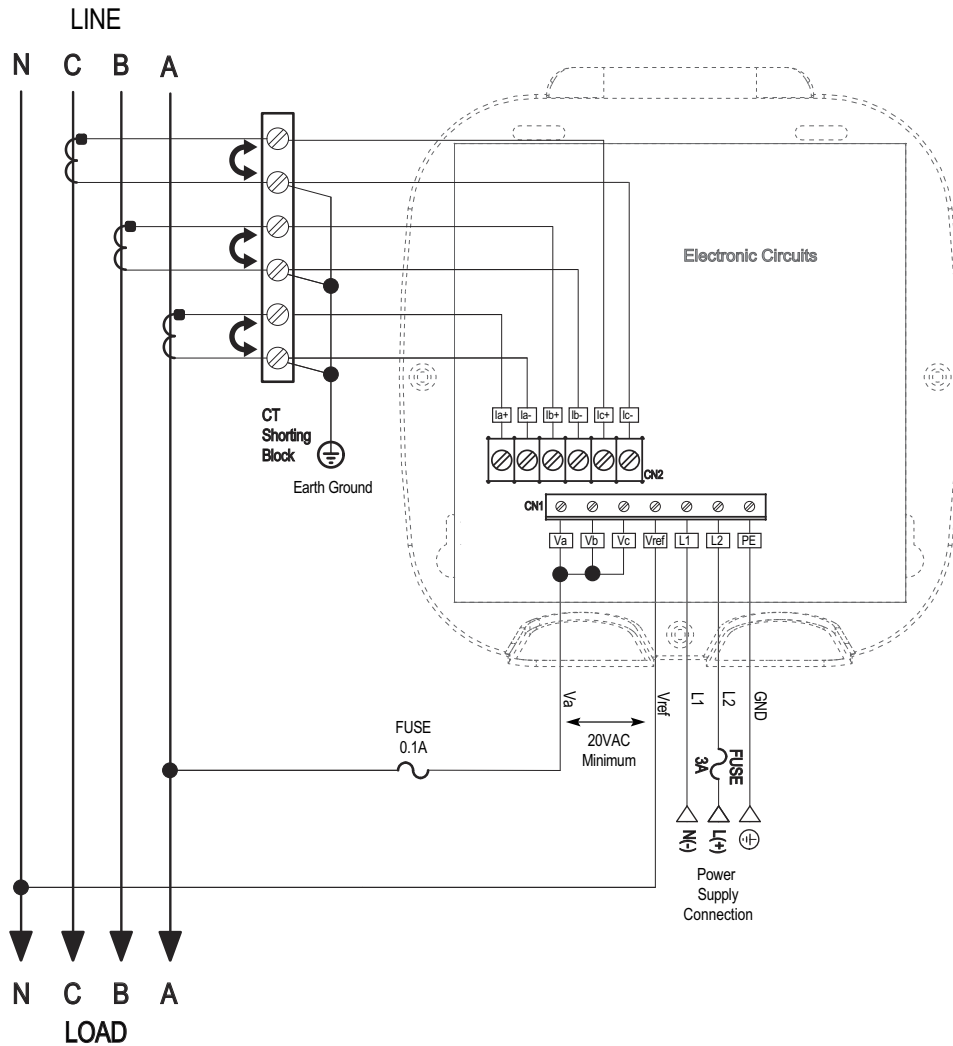
8. Service: Delta, 3-Wire with 2 PTs, 3 CTs



Select: "2 Ct dEL" (2 CT Delta) in Meter Programming setup.



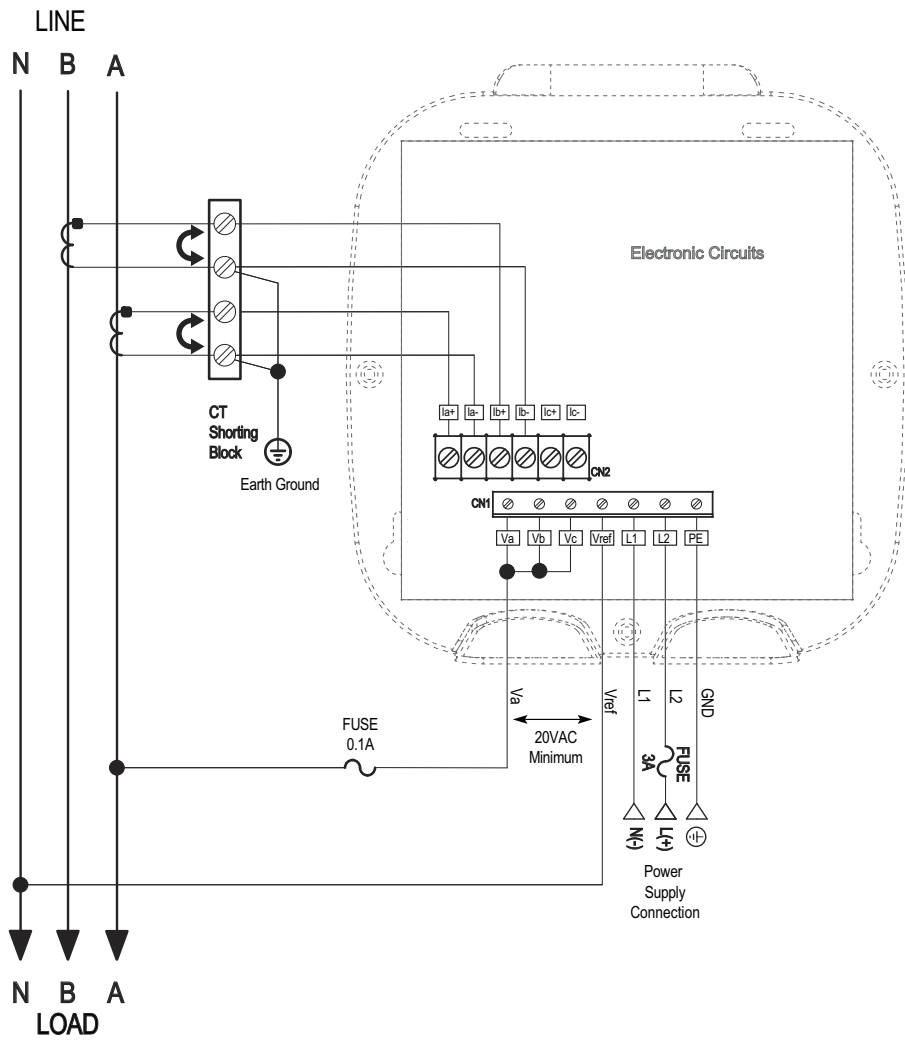
9. Service: Current Only Measurement (Three Phase)



Select: "3 EL WYE" (3 Element Wye) in Meter Programming setup.

NOTE: Even if the meter is used for only Amp readings, the unit requires a Volts AN reference. Please make sure that the Voltage input is attached to the meter. AC Control Power can be used to provide the reference signal.

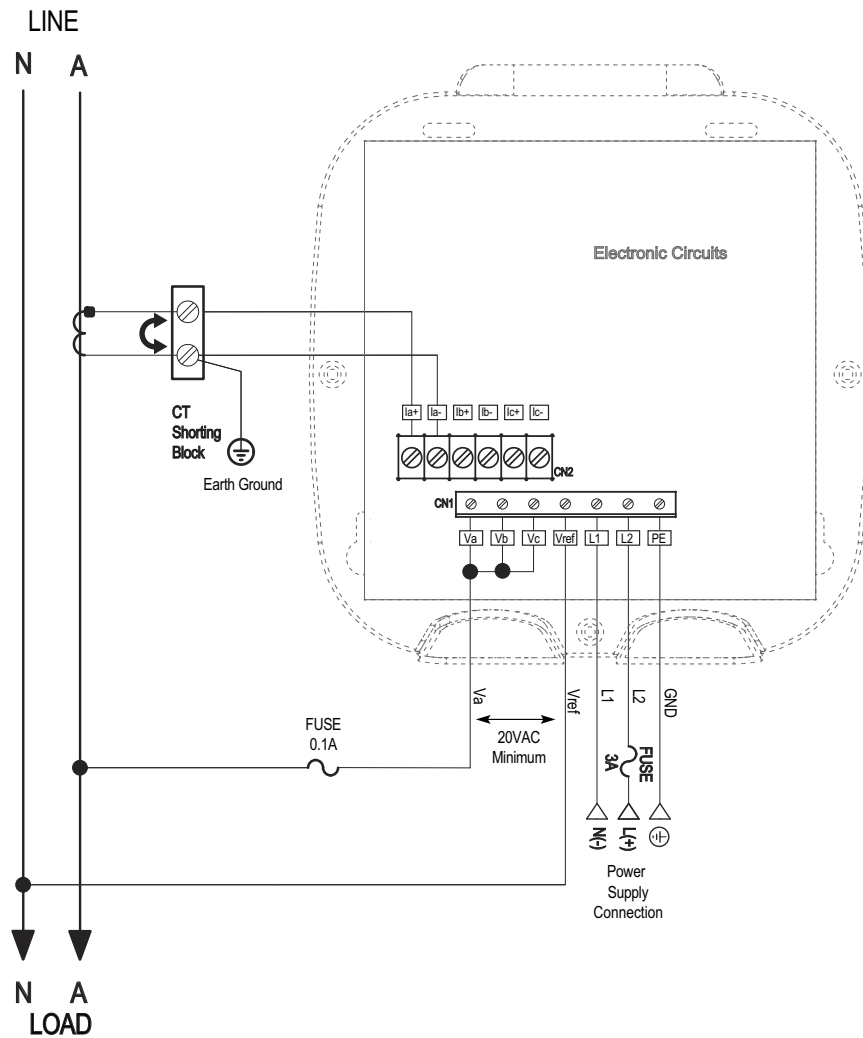
10. Service: Current Only Measurement (Dual Phase)



Select: "3 EL WYE" (3 Element Wye) in Meter Programming setup.

NOTE: Even if the meter is used for only Amp readings, the unit requires a Volts AN reference. Please make sure that the Voltage input is attached to the meter. AC Control Power can be used to provide the reference signal.

11. Service: Current Only Measurement (Single Phase)



Select: "3 EL WYE" (3 Element Wye) in Meter Programming setup.

NOTE: Even if the meter is used for only Amp readings, the unit requires a Volts AN reference. Please make sure that the Voltage input is attached to the meter. AC Control Power can be used to provide the reference signal.

5: Communication Installation

5.1: EM-3000 Series Meter Communication

The EM-3000 Series meter provides two independent communication ports plus a KYZ pulse output. The first port, Com 1, is an IrDA Port, which uses Modbus ASCII. The second port, Com 2, provides RJ45 Ethernet or WiFi Ethernet communication (see Chapter 6 for Ethernet configuration).

5.1.1: IrDA Port (Com 1)

The Com 1 IrDA port is located on the face of the submeter. The IrDA Port allows the unit to be set up and programmed with any device capable of IrDA communication, such as an IrDA-equipped laptop PC or a USB/IrDA converter wand. Note that you do not need to use the IrDA port to configure the meter - configuration can be done through the faceplate buttons - see Chapter 7 for instructions.

IrDA port settings are

Address: 1

Baud Rate: 57600 Baud

Protocol: Modbus ASCII



Figure 5.1: IrDA Communication

5.1.2: KYZ Output

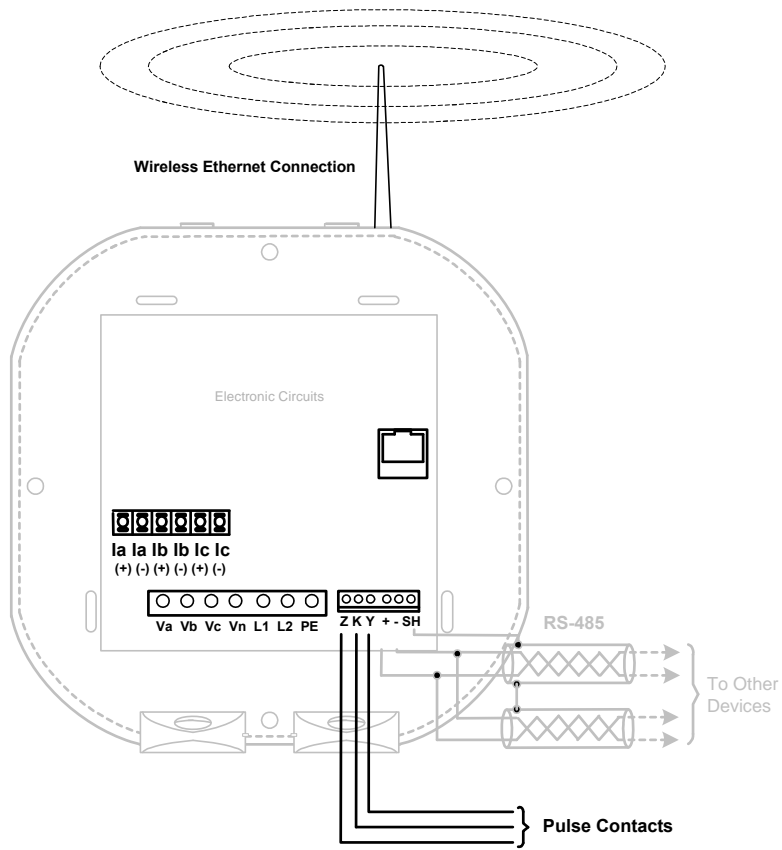
The KYZ pulse output provides pulsing energy values that verify the submeter's readings and accuracy. The KYZ Pulse Output is located on the face of the meter, under the cover (see figure on the next page).



WARNING! During normal operation of the EM-3000 Series meter, dangerous voltages flow through many parts of the meter, including: Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O Modules (Inputs and Outputs) and their circuits. All Primary and Secondary circuits can, at times, produce lethal voltages and currents. Avoid contact with any current-carrying surfaces. **Before performing ANY work on the meter, make sure the meter is powered down and all connected circuits are de-energized.**

AVERTISSEMENT! Pendant le fonctionnement normal du compteur EM-3000 Series des tensions dangereuses suivant de nombreuses pièces, notamment, les bornes et tous les transformateurs de courant branchés, les transformateurs de tension, toutes les sorties, les entrées et leurs circuits. **Tous les circuits secondaires et primaires peuvent parfois produire des tensions de létal et des courants. Évitez le contact avec les surfaces sous tensions. Avant de faire un travail dans le compteur, assurez-vous d'éteindre l'alimentation et de mettre tous les circuits branchés hors tension.**

See Section 2.2 for the KYZ output specifications; see Section 7.3.1 for pulse constants.



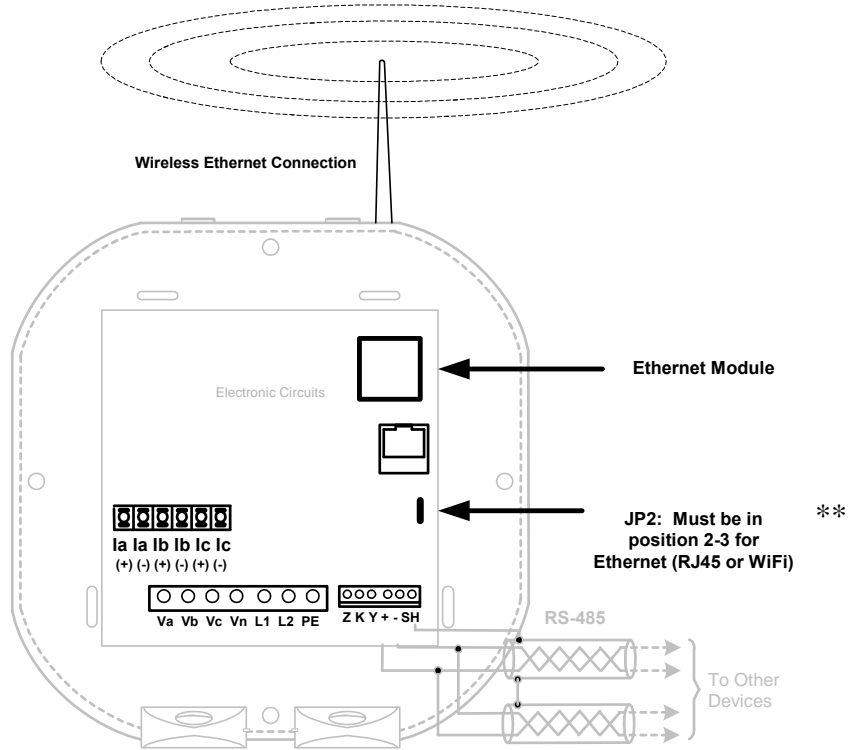
5.1.3: Ethernet Connection

In order to use the EM-3000 Series meter's Ethernet, JP2 must be set to positions 2-3. With this setting, you can use either wired Ethernet or WiFi.

- For wired Ethernet, use Standard RJ45 10/100BaseT cable to connect to the EM-3000 Series meter. The RJ45 line is inserted into the RJ45 port of the meter.

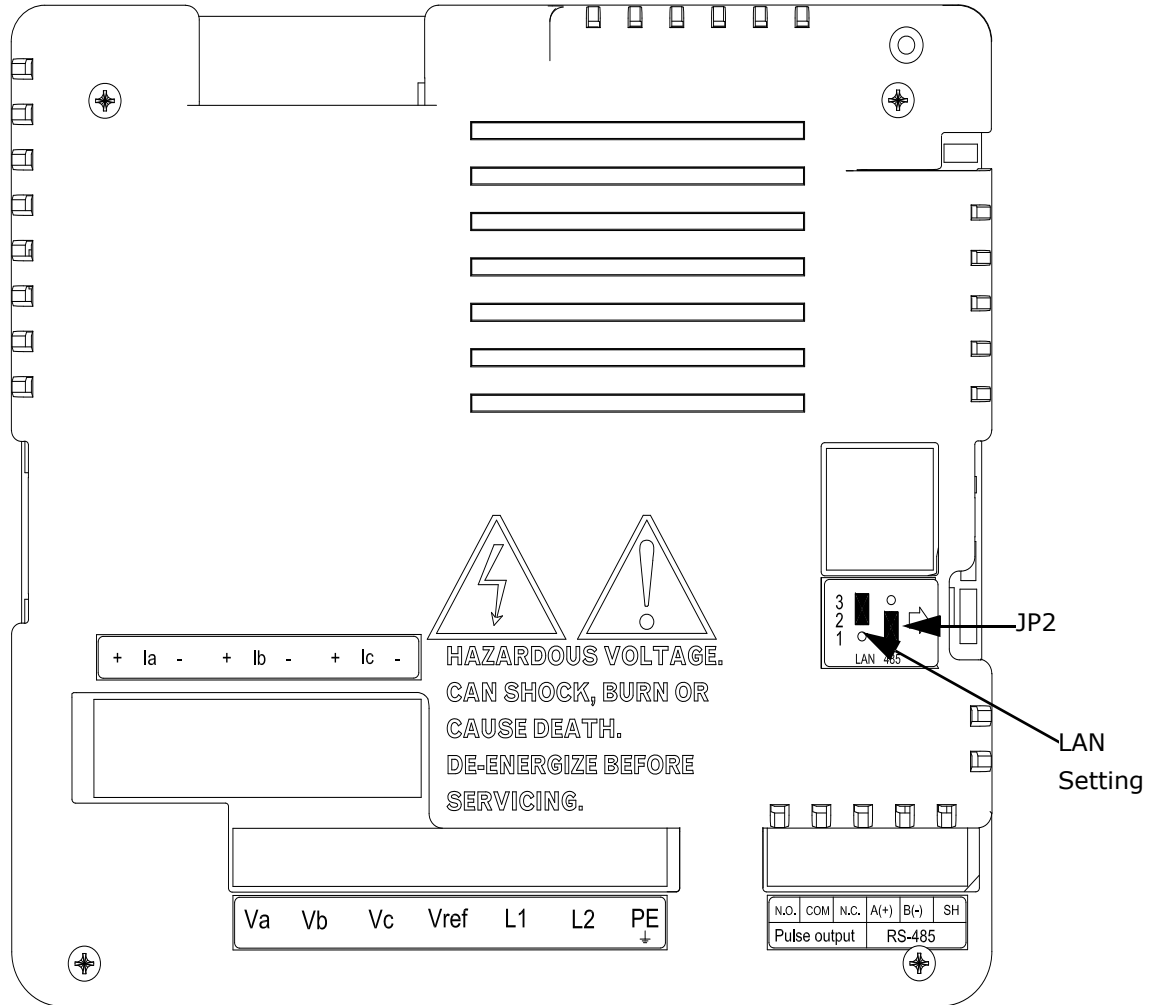


For WiFi connections, make sure you have the correct antenna attached to the meter. **WARNING!** During normal operation of the EM-3000 Series meter, dangerous voltages flow through many parts of the meter, including: Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O Modules (Inputs and Outputs) and their circuits. All Primary and Secondary circuits can, at times, produce lethal voltages and currents. Avoid contact with any current-carrying surfaces. **Before performing ANY work on the meter, make sure the meter is powered down and all connected circuits are de-energized.** **AVERTISSEMENT!** Pendant le fonctionnement normal du compteur EM-3000 Series des tensions dangereuses suivant de nombreuses pièces, notamment, les bornes et tous les transformateurs de courant branchés, les transformateurs de tension, toutes les sorties, les entrées et leurs circuits. **Tous les circuits secondaires et primaires peuvent parfois produire des tensions de létal et des courants. Évitez le contact avec les surfaces sous tensions. Avant de faire un travail dans le compteur, assurez-vous d'éteindre l'alimentation et de mettre tous les circuits branchés hors tension.**



• Refer to Chapter 6 for instructions on how to set up the Network Module.

**See diagram on next page for detailed view



6: Ethernet Configuration

6.1: Introduction

The EM-3000 Series meter has an option for a WiFi (Wireless) or RJ45 Ethernet connection. The WiFi option lets you set up the submeter for use in a LAN (Local Area Network), using standard WiFi base stations. Meter configuration for these connections is easily accomplished through your PC using Telnet connections. Then you can access the submeter to perform meter functions directly through any computer on your LAN: the EM-3000 Series meter does not need to be directly connected (wired) to these computers for it to be accessed.

This chapter outlines the procedures you use to set up the EM-3000 Series meter to function via its Ethernet configuration and instructions for integrating the EM-3000 Series meter into a wireless local area network (WLAN).



WARNING! During normal operation of the EM-3000 Series meter, dangerous voltages flow through many parts of the meter, including: Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O Modules (Inputs and Outputs) and their circuits. All Primary and Secondary circuits can, at times, produce lethal voltages and currents. Avoid contact with any current-carrying surfaces. **Before performing ANY work on the meter, make sure the meter is powered down and all connected circuits are de-energized.**

AVERTISSEMENT! Pendant le fonctionnement normal du compteur EM-3000 Series des tensions dangereuses suivent de nombreuses pièces, notamment, les bornes et tous les transformateurs de courant branchés, les transformateurs de tension, toutes les sorties, les entrées et leurs circuits. **Tous les circuits secondaires et primaires peuvent parfois produire des tensions de létal et des courants. Évitez le contact avec les surfaces sous tensions. Avant de faire un travail dans le compteur, assurez-vous d'éteindre l'alimentation et de mettre tous les circuits branchés hors tension.**

**WARNING: Risk of Electric Shock.**

Ground the meter according to local, national, and regional regulations. Failure to ground the meter may result in electric shock and severe personal injury or death.

AVERTISSEMENT: risque de décharge électrique

Débranchez l'alimentation électrique avant de faire un branchement électrique. Le contact avec des composants ayant des tensions importantes peut provoquer une décharge électrique, des blessures personnelles graves ou la mort.

6.2: Factory Default Settings

The settings shown in Section 6.2.1 are the default settings for the EM-3000 Series meter: they are the settings programmed into your meter when it is shipped to you. You may need to modify some of these settings when you set up your Ethernet configuration.

NOTES:

- Change Settings 1, 6, and 7 ONLY (these settings are shown in bold). Settings 2, 3, and 4 MUST be the same as shown in Section 6.2.1. If they are not, reset them to the values shown in Section 6.2.1, following the Reset procedure in Section 6.4.
- If setting 3 is not CP0..! Defaults (In), the procedure for Network Module Hardware Initialization (Section 6.4) will not work.

6.2.1: Modbus/TCP to RTU Bridge Setup

1) Network/IP Settings:

Network Mode.....Wired Only
IP Address.....10.0.0.1
Default Gateway.....--- not set ---
Netmask.....255.255.255.0

2) Serial & Mode Settings:

Protocol.....Modbus/RTU,Slave<s> attached
Serial Interface.....57600,8,N,1,RS232,CH1

3) Modem/Configurable Pin Settings:

CP0..! Defaults <In> Wired CP1..! GPIO <In> CP2..! GPIO <In>
CP3..! GPIO <In> CP4..! GPIO <In> CP5..! GPIO <In>
CP6..! GPIO <In> CP7..! GPIO <In> CP8..! GPIO <In>
CP9..! GPIO <In> CP10..! GPIO <In>
RTS OutputFixed High/Active

4) Advanced Modbus Protocol settings:

Slave Addr/Unit Id Source.....Modbus/TCP header
Modbus Serial Broadcasts.....Disabled (Id=0 auto-mapped to 1)
MB/TCP Exception Codes.....Yes (return 00AH and 00BH)
Char, Message Timeout.....00050msec, 05000msec

6) WLAN Settings:

WLAN.....Disabled, network:LTRX_IBSS
Topology.....AdHoc, Country: US, Channel: 11

Security.....none

TX Data rate.....54 Mbps auto fallback

Power management.....Disabled

Soft AP Roaming.....N/A

Ad-hoc merging.....Enabled

WLAN Max failed packets.....0

7) Security Settings:

SNMP.....Enabled

SNMP Community Name.....public

Telnet Setup.....Enabled

TFTP Download.....Enabled

Port 77FEh.....Enabled

Enhanced Password.....Disabled

D)efault settings, S)ave, Q)uit without save

Select Command or parameter set (1..7) to change:

6.3: Configure Network Module

These procedures detail how to set up the EM-3000 Series meter on the Network Module.

Only one person at a time can be logged into the network port. This eliminates the possibility of several people trying to configure the Ethernet interface simultaneously.

6.3.1: Configuration Requirements

- You may want to consult your Network Administrator before performing these procedures, since some functions may be restricted to the Network Administrator.
- If you have only one Ethernet adapter (network card), the screen displays only that configuration. You will use this Ethernet adapter to access the EM-3000 Series

meter's Network Module. You may have to configure the Ethernet adapter in order to use it with the EM-3000 Series meter's Network Module, using the instructions in Section 6.4.2.

- If you have multiple Ethernet adapters (network cards) installed on your computer, you must choose, configure and use the correct one to access the Network Module.
- The Ethernet Adapter must be set up for point-to-point connection in order for it to connect to the EM-3000 Series meter's Network module, as follows:

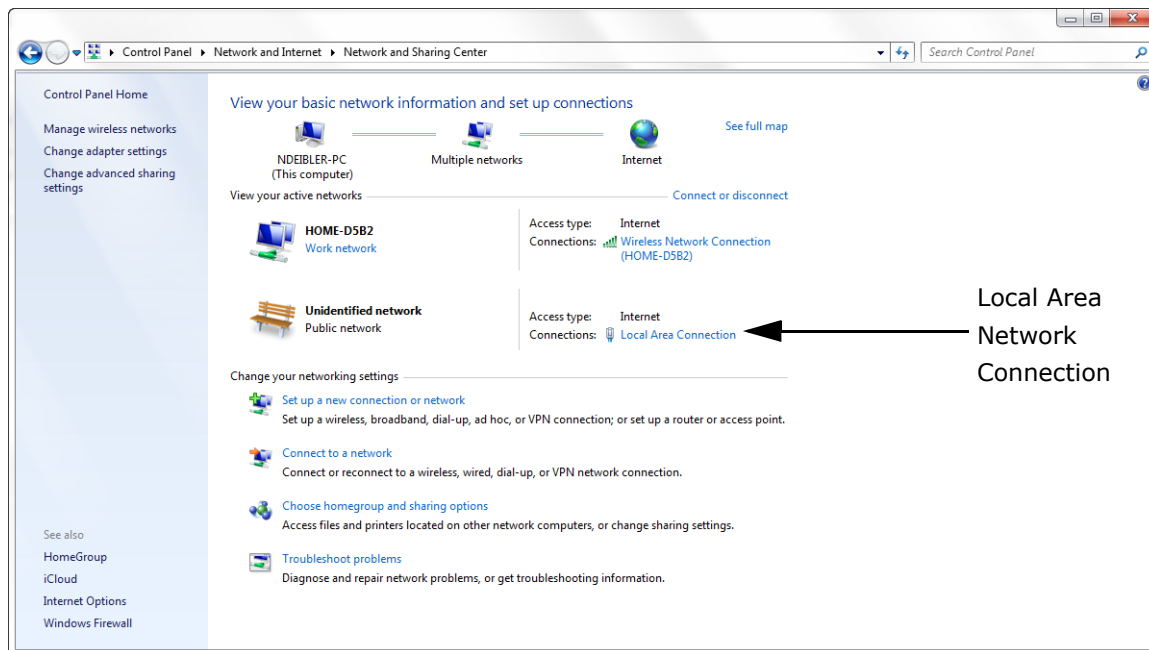
IP Address should be 10.0.0.2

Subnet Mask should be 255.255.255.0

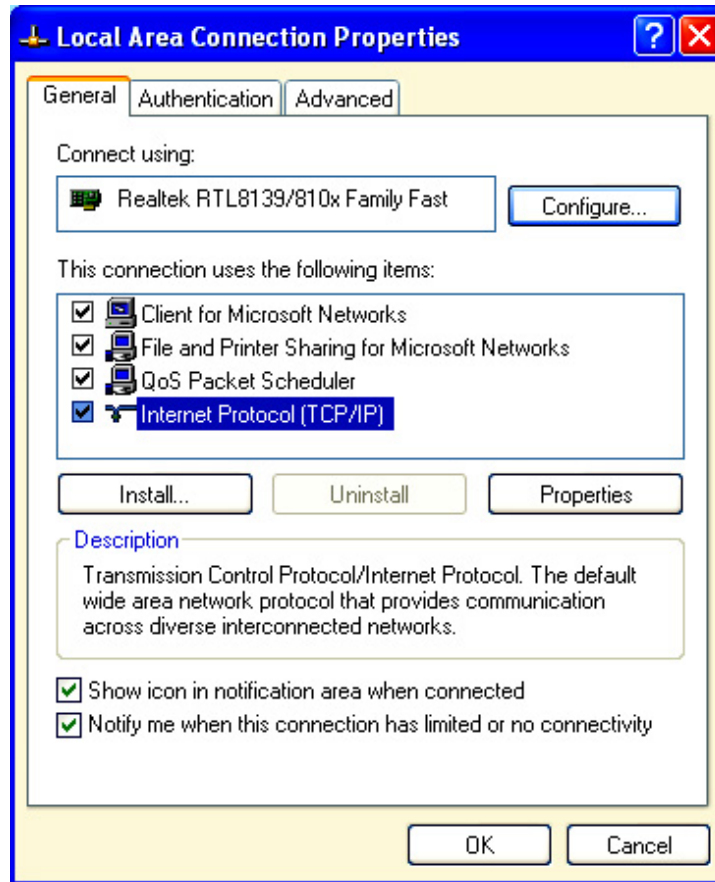
These settings can be made in the Ethernet Adapter. Follow the procedure in Section 6.3.2.

6.3.2: Configuring the Ethernet Adapter

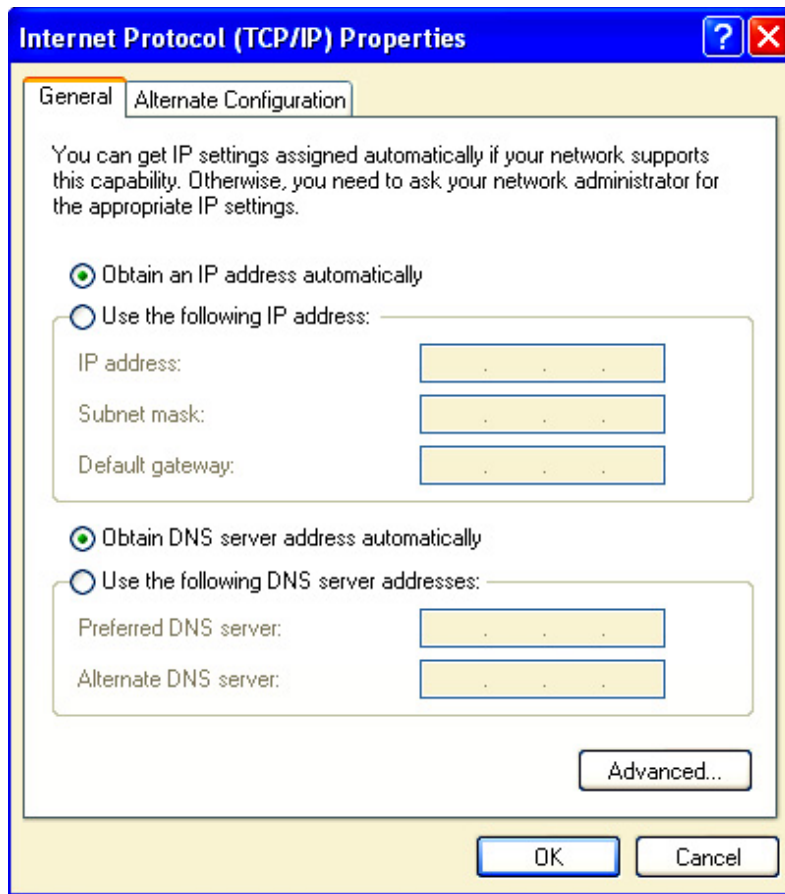
1. From the PC's Start Menu, select **Control Panel>Network Connections** or **Control Panel>Network and Internet>Network and Sharing Center**. You will see a screen showing your network connections. An example is shown below. Depending on your Operating system, the screen you see may look a bit different.



2. Right click on the Local Area Network connection you will be using to connect to the EM-3000 Series meter, and select Properties from the pull-down menu. You will see a screen similar to the one shown below.



3. Select Internet Protocol [TCP/IP] from the middle of the screen and click the Properties button. You will see the screen shown on the next page.



4. Click the Use the Following IP Address radio button. The screen changes to allow you to enter the IP Address and Subnet Mask.
 - a. Enter 10.0.0.2 in the IP Address field.
 - b. Enter 255.255.255.0 in the Subnet Mask field.
3. Click the **OK** button.
4. You can now close the Local Area Connection Properties and Network Connection windows.

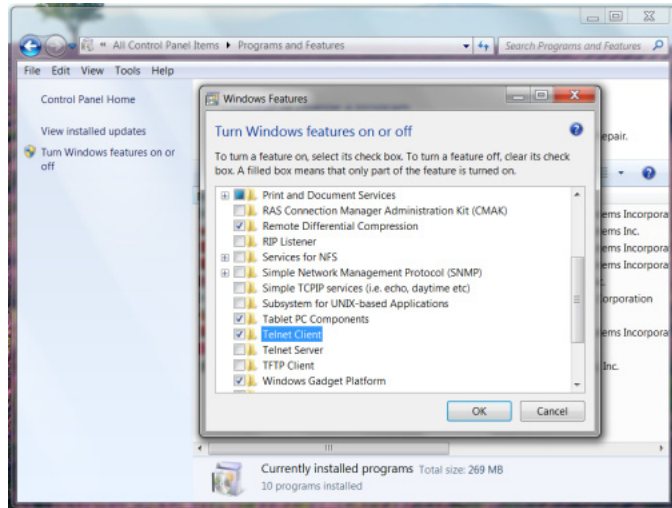
6.3.3: Detailed Configuration Parameters

Certain parameters must be configured before the Ethernet interface can function on a network. The following procedure can be locally or remotely configured.

Use a Telnet connection to configure the unit over the network. The Ethernet interface's configuration is stored in meter memory and is retained without power. The configuration can be changed at any time. The Ethernet interface performs a reset after the configuration has been changed and stored.

NOTE: If your PC is running Windows 7, you need to enable Telnet before using it.

1. Open the Control Panel.
2. Select Programs and Features.
3. Select Turn Windows features on or off.
4. Check the box for Telnet Client.
5. Click OK. The Telnet client is now available.



Establish a Telnet connection to port 9999:

1. From the Windows Start menu, click **Run** and type 'cmd'.
2. Click the **OK** button to bring up Windows's Command Prompt window.
3. In the Command Prompt window, type:
 - telnet 10.0.0.1 9999** and press the **Enter** key.

NOTE: Be sure to include a space between the IP address and 9999.

You will see the following information.

```

C:\> Telnet 172.20.167.133
Modbus/TCP to RTU Bridge
MAC address 00204ACED2DC
Software version U3.3.25.0RC3 <130429>
Press Enter for Setup Mode
  
```

4. Press **Enter**.

5. You are now in Setup Mode. You can configure the parameters for the software you are using by either:
 - Keying a new value next to a setting and pressing Enter
 - Keeping the default value (the value in brackets after a setting) by just pressing Enter without keying in anything
6. Be sure to press "S" once you are finished, in order to store any new settings. The Ethernet interface will then perform a power reset.

6.3.4: Setup Details

This section illustrates how each section of settings appears on the screen, when you select the setting number (1, 6, or 7).

CAUTION! Change Settings 1, 6, and 7 ONLY. Settings 2, 3, and 4 MUST be the same as shown in Section 8.2.1. If they are not, reset them to the values shown in Section 8.2.1, using the reset instructions in Section 8.4.

Network IP Settings Detail (1) (Set device with static IP Address.)

Network Mode: 0=Wired only, 1=Wireless Only <0> ? Key 1 and press Enter for WiFi mode.

IP Address <010> 192.<000> 168.<000> .<000> .<001> You can change the IP address in this setting.

Set Gateway IP Address <N> ? Y (If you want to change the Gateway address.)

Gateway IP Address : <192> .<168> .<000> .<001> (You can change the Gateway address in this setting.)

Set Netmask <N for default> <Y> ? Y (If you want to change the Netmask.)

<255> .<255> .<255> .<000> (You can change the Netmask in this setting.)

Change telnet config password <N> ? N

WLAN Settings Detail (6) (The settings shown are recommended by for use with the EM-3000 Series meter. You will only be able to access these settings if you have set Network Mode to "1" (to select Wireless mode) in the Network IP Settings Detail, shown previously.)

Topology: 0=Infrastructure, 1=Ad-Hoc <1> ? 0

Network Name: MY_NETWORK

Security suite: 0=none, 1=WEP, 2=WPA, 3=WPA2/802.11i <0> ? Enter the number of the encryption method are using, e.g., 3 for WPA2/802.11i.

- **If you select "1" (WEP), you will see the following settings:**

Authentication 0=open/none, 1=shared <0> ? (Enter 1 if you want the encryption key matched with a communication partner before messages are passed through.)

Encryption 1=WEP64, 2=WEP128 <1> 2

Change Key <N> Y

Display Key <N> N

Key Type 0=hex, 1=passphrase <0> 0

Enter Key:

You can manually enter 26 hexadecimal characters (required for 128-bit encryption) or you can use a WEP Key provider online (for example: www.powerdog.com/wepkey.cgi). WEP Key providers should note on their website that their encryption algorithm is for the Wired Equivalent Privacy portion of IEEE 802.11b/g.

WEP Key Provider Steps

1. Input 26 alphanumeric characters as your Passphrase.

IMPORTANT! Remember your Passphrase.

PASSPHRASE TO HEXADECIMAL WEP KEYS

Enter the passphrase below.

1009egbck001036ab

2. Click the Generate Keys button. Your Hexadecimal WEP Keys display.

PASSPHRASE TO HEXADECIMAL WEP KEYS

The passphrase 1009egbcke001306ab produces the following keys:

64-BIT (40-BIT KEYS)

1. AA43FB768D
2. 637D8DB9CE
3. AFDE50AF61
4. 0c35E73E25

128-BIT (104-BIT) KEY

041D7773D8B2C1D97BE9531DC

3. Enter the 128-bit Key.

TX Key Index <1> ? 1 (The WEP key used for transmissions - must be a value between 1 and 4.)

TX Data Rate: 0=fixed, 1=auto fallback <1> ? 1

TX Data rate: 0=1, 1=2, 2=5.5, 3=11, 4=18, 5=24, 6=36, 7=54 Mbps <7> ?
Enter data transmission rate, e.g., 7 for 54Mbps.

Minimum Tx Data rate: 0=1, 1=2, 2=5.5, 3=11, 4=18, 5=24, 6=36,
7=54 Mbps <0> ? 0

Enable Power management <N> ? Y

Enable Soft AP Roaming <N> ? N

Max Failed Packets (6-64, 255=disable) <6>? 6

- **If you select "2" (WPA), you will make the following settings:**

Change Key <N> Y

Display Key <N> N

Key Type 0=hex, 1=passphrase <0> 1

Enter Key: (The maximum length of the passphrase is 63 characters. We recommend using a passphrase of 20 characters or more for maximum security.)

Encryption: 0=TKIP, 1=TKIP+WEP <0> ? Set the type to the minimum required security level. The "+" sign indicates that the group (broadcast) encryption method is different from the pairwise (unicast) encryption (WEP and TKIP).

TX Data rate: 0=fixed, 1=auto fallback <1> ? 1

TX Data rate: 0=1, 1=2, 2=5.5, 3=11, 4=18, 5=24, 6=36, 7=54 Mbps <7> ?
Enter data transmission rate, e.g., 7 for 54Mbps.

Minimum Tx Data rate: 0=1, 1=2, 2=5.5, 3=11, 4=18, 5=24, 6=36,
7=54 Mbps <0> ? 0

Enable Power management <N> ? Y

Enable Soft AP Roaming <N> ? N

Max Failed Packets (6-64, 255=disable) <6> ? 6

- **If you select "3" (WPA2/802.11i), you will make the following settings:**

Change Key <N> Y

Display Key <N> N

Key Type 0=hex, 1=passphrase <0> 1

Enter Key: (The maximum length of the passphrase is 63 characters. We recommend using a passphrase of 20 characters or more for maximum security.)

Encryption: 0=CCMP, 1=CCMP+TKIP, 2=CCMP+WEP, 3=TKIP, 4=TKIP+WEP
<3> ? (Set the type to the minimum required security level. The "+" sign indicates that the group (broadcast) encryption method is different from the pair-

wise (unicast) encryption. For example, for CCMP+TKIP, CCMP is the pairwise encryption and TKIP is the group encryption. CCMP is the default for WPA2.)

TX Data rate: 0=fixed, 1=auto fallback <1> ? 1

TX Data rate: 0=1, 1=2, 2=5.5, 3=11, 4=18, 5=24, 6=36, 7=54 Mbps <7> ?
Enter data transmission rate, e.g., 7 for 54Mbps.

Minimum Tx Data rate: 0=1, 1=2, 2=5.5, 3=11, 4=18, 5=24, 6=36,
7=54 Mbps <0> ? 0

Enable Power management <N> ? Y

Enable Soft AP Roaming <N> ? N

Max Failed Packets (6-64, 255=disable) <6> ? 6

Security Settings (7)

Disable SNMP <N> ? N

SNMP Community Name <public>: (You can enter an SNMP community name here.)

Disable Telnet Setup <N> ? N (If you change this setting to Y, you will not be able to use Telnet to re-configure the Network card once you save the settings, without resetting the Network card, as shown in Section 8.4. However, you may want to disable Telnet setup and Port 77FEh to prevent users from accessing the setup from the network.)

Disable TFTP Firmware Update <N> ? N

Disable Port 77FEh <N> ? N (For security purposes, you may want to disable Telnet setup and Port 77FEh to prevent users from accessing the setup from the network.)

Enable Enhanced Password <N> ? N

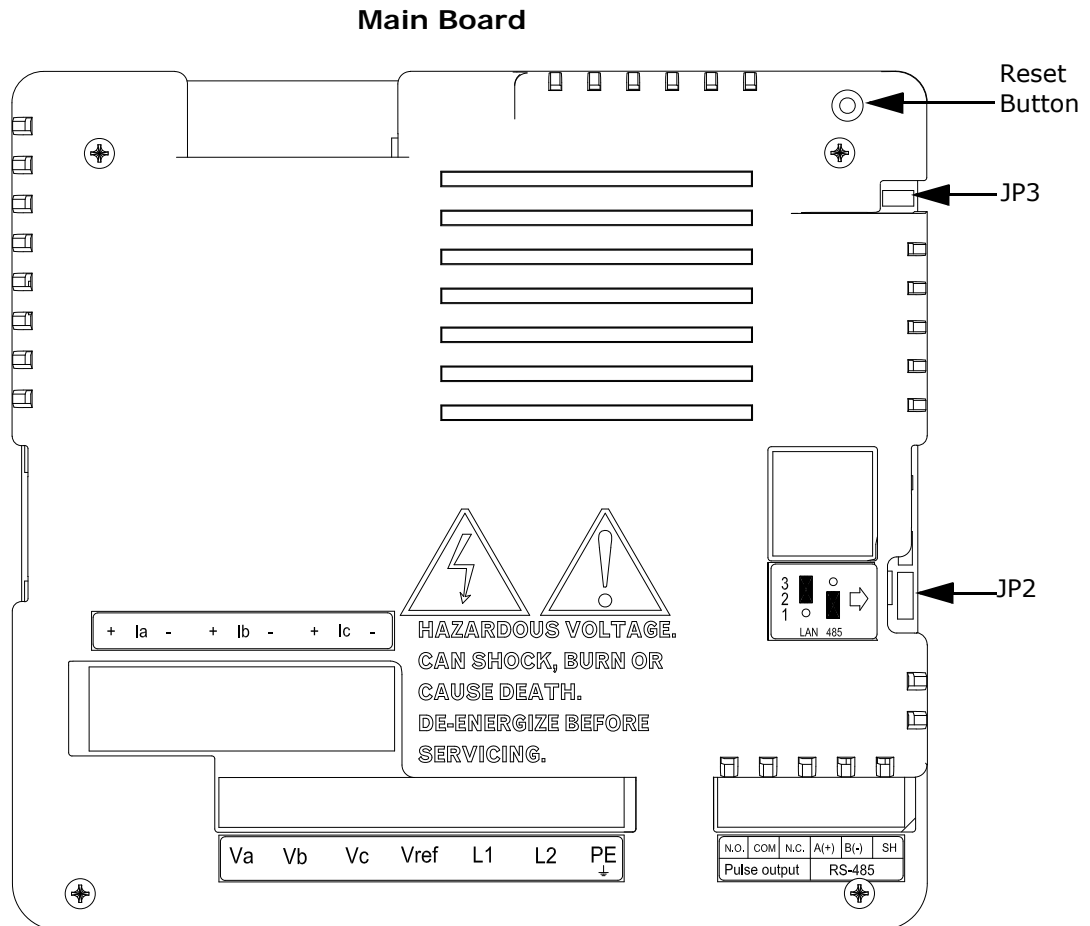
Exiting the screen

CAUTION! DO NOT PRESS 'D': that will restore the Default Settings.

Press 'S' to Save the settings you've entered.

6.4: Network Module Hardware Initialization

If you don't know your current Network Module settings, or if the settings are lost, you can use this method to initialize the hardware with known settings you can then work with.



WARNING! During normal operation of the EM-3000 Series meter, dangerous voltages flow through many parts of the meter, including: Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O Modules (Inputs and Outputs) and their circuits. All Primary and Secondary circuits can, at times, produce lethal voltages and currents. Avoid contact with any current-carrying surfaces. **Before performing ANY work on the meter, make sure the meter is powered down and all connected circuits are de-energized.**

AVERTISSEMENT! Pendant le fonctionnement normal du compteur EM-3000 Series des tensions dangereuses suivant de nombreuses pièces, notamment, les bornes et tous les

transformateurs de courant branchés, les transformateurs de tension, toutes les sorties, les entrées et leurs circuits. Tous les circuits secondaires et primaires peuvent parfois produire des tensions de léta et des courants. Évitez le contact avec les surfaces sous tensions. **Avant de faire un travail dans le compteur, assurez-vous d'éteindre l'alimentation et de mettre tous les circuits branchés hors tension.**



WARNING: Risk of Electric Shock.

Disconnect the power supply before making electrical connections.

Contact with components carrying hazardous voltage can cause electric shock and may result in severe personal injury or death.

AVERTISSEMENT: risque de décharge électrique

Débranchez l'alimentation électrique avant de faire un branchement électrique. Le contact avec des composants ayant des tensions importantes peut provoquer une décharge électrique, des blessures personnelles graves ou la mort.

1. Place a shorting block on JP3 and press the **Reset** button on the main board.

NOTE: JP3 is located on the right hand side, upper corner of the main board. The shorting block can be "borrowed" from JP2, located at the middle, right hand side. See the figure shown on the previous page.

2. After you press the **Reset** button, move the jumper back to JP2.
3. Make sure your settings are the same as those in Section 6.2.1. Follow the steps in Section 6.3 to configure the Network Module.

6.5: Integrating the EM-3000 Series Meter into a WLAN

A WLAN uses a controller to manage wireless access points (WAPs), devices that enable wireless devices, such as the EM-3000 Series meter, to be connected to a wired network.

To integrate the EM-3000 Series meter into a WLAN, you must first set up the WAP it will be configured with. For this you will need:

- Two Ethernet cables
- A WAP with port forwarding configuration capabilities

Follow these steps:

1. Using an Ethernet cable, connect the WAP's Internet port to an Ethernet hub. The Ethernet hub must be on the same subnet as the WLAN controller.
2. Connect a PC via wireless mode to the WAP. Using the PC's web browser, access the WAP's online configuration utility.
NOTE: To access this utility, type the WAP's IP address into the address bar of any standard web browser. The default IP address for the majority of WAPs is 192.168.0.1. The IP address is typically found on the bottom of the WAP.
3. From the web utility, review the LAN DHCP settings.
 - a. Find and record the DHCP IP address range.
 - b. Record the WAP's Internet IP address, SSID, and subnet mask.
 - c. **NOTE:** Check with the building's IT department before placing the EM-3000 Series meter on the building's network with a static IP address.
You need to make a DHCP reservation for the EM-3000 Series meter to connect to the WAP. This reserves a selected IP address within the DHCP range, and assigns it to any device which associates to the network that has the correct MAC address. Enter the MAC address of the EM-3000 Series meter for the DHCP reservation and assign the MAC address to a currently open IP address. (You can find the MAC address for the EM-3000 Series meter at the beginning of the telnet procedure - see Section 6.3.3.)
4. Configure the EM-3000 Series meter in the local network by following the procedure given in Section 6.3:
 - a. Set the meter's IP address to the IP address used in the DHCP reservation.
 - b. Set the default gateway address to the WAP's LAN IP address.
 - c. Set the subnet mask to the same subnet mask used with the WAP.
 - d. Set the network name parameter to the SSID of the WAP.
5. The next step in configuration is to configure the proper port forwarding settings. Initiation of communication comes from the WLAN controller, which will be configured to communicate to the WAP's Internet IP address. The WAP then needs to direct all traffic on this port to the EM-3000 Series meter's LAN address. This mapping is accomplished using the port forwarding settings on the WAP, set through the WAP's web interface:

- a. Give the port forwarding setting a meaningful name such as "EM-3000 Series meter's Port Access" and enter the EM-3000 Series meter's LAN IP address.
 - b. Enter port 502 for both TCP and UDP protocols; deactivate any inbound filters.
 - c. Save these settings using the WAP's web interface.
6. The final step in configuration is on the WLAN controller side. After adding a Modbus TCP Network device, the IP address and port need to be modified to establish a connection to the EM-3000 Series meter:
- a. Set the device IP address to the WAP's Internet IP address and designate the port as 502. Note that port 502 is always reserved for Modbus TCP/IP communication.
 - b. If configuration is successful, the device should appear as online in the WLAN controller's interface.

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7: Using the Submeter

7.1: Introduction

The EM-3000 Series meter can be configured and a variety of functions can be accomplished by using the Elements and the Buttons on the submeter face. This chapter reviews front panel navigation. See Appendix A for complete Navigation maps.

7.1.1: Understanding Submeter Face Elements

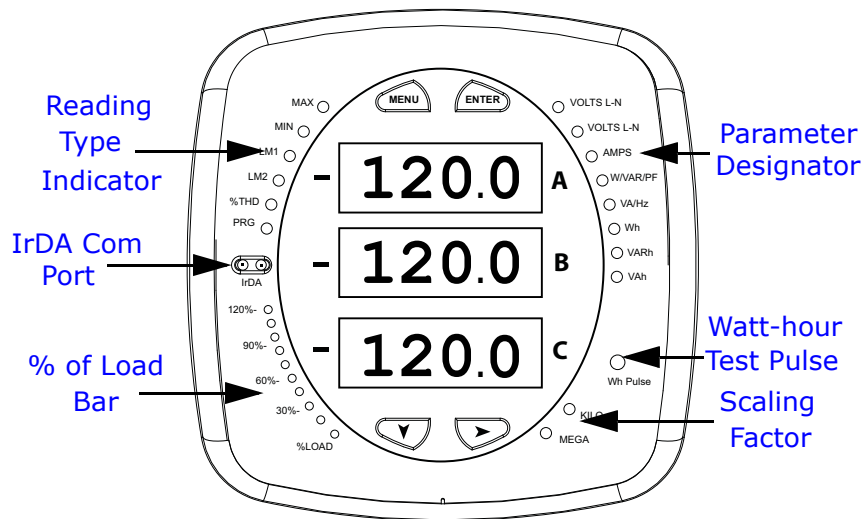


Figure 7.1: Faceplate with Elements

The meter face features the following elements:

- Reading Type Indicator: e.g., Max
- Parameter Designator: e.g., Volts L-N
- Watt-Hour Test Pulse: Energy pulse output to test accuracy
- Scaling Factor: Kilo or Mega multiplier of displayed readings
- % of Load Bar: Graphic Display of Amps as % of the Load (Refer to Section 7.3 for additional information.)
- IrDA Communication Port: Com 1 port for wireless communication

7.1.2: Understanding Submeter Face Buttons

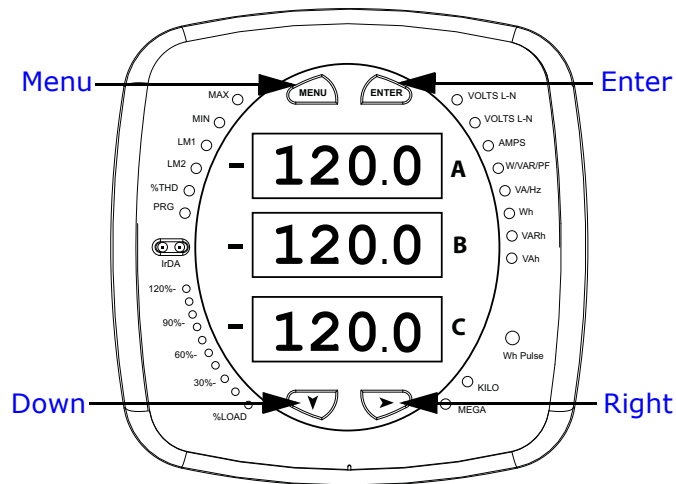


Figure 7.2: Faceplate with Buttons

The meter face has **Menu**, **Enter**, **Down** and **Right** buttons, which let you perform the following functions:

- View Meter Information
- Enter Display Modes
- Configure Parameters (may be Password Protected)
- Perform Resets (may be Password Protected)
- Perform LED Checks
- Change Settings
- View Parameter Values
- Scroll Parameter Values
- View Limit States (V-4)

7.2: Using the Front Panel

You can access four modes using the EM-3000 Series meter's front panel buttons:

- Operating mode (Default)
- Reset mode
- Configuration mode
- Information mode - Information mode displays a sequence of screens that show model information, such as Frequency, Amps, V-Switch, etc.

Use the **Menu**, **Enter**, **Down** and **Right** buttons to navigate through each mode and its related screens.

NOTE: See Appendix A for the complete display mode Navigation maps.

7.2.1: Understanding Startup and Default Displays

Upon Power Up, the meter displays a sequence of screens:

- Lamp Test screen where all LEDs are lit
- Lamp Test screen where all digits are lit
- Firmware screen showing build number
- Error screen (if an error exists)

After startup, if auto-scrolling is enabled, the EM-3000 Series meter scrolls the parameter readings on the right side of the front panel. The Kilo or Mega LED lights, showing the scale for the Wh, VARh and VAh readings. Figure 7.3 shows an example of a Wh reading.

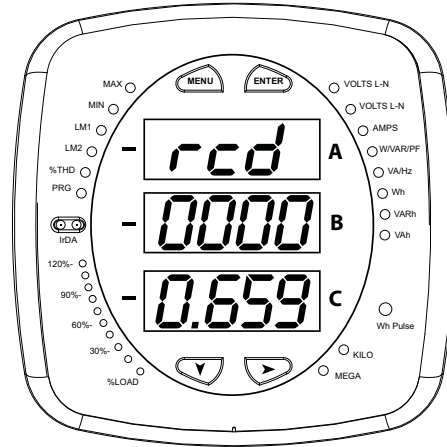


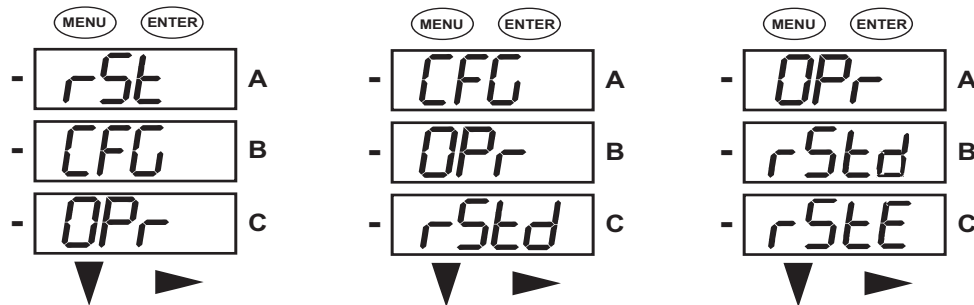
Figure 7.3: Display Showing Watt-hr Reading

The EM-3000 Series meter continues to provide scrolling readings until one of the buttons on the front panel is pressed, causing the meter to enter one of the other Modes.

7.2.2: Using the Main Menu

1. Press the **Menu** button. The Main Menu screen appears.

- The Reset (rStd) mode appears in the A window. Use the Down button to scroll, causing the Configuration (CFG), Operating (OPr), and Information (InFo) modes to move to the A window.
- The mode that is currently flashing in the A window is the “Active” mode, which means it is the mode that can be configured.



For example: Press Down Once - CFG moves to A window. Press Down Once - OPr moves to A window.

- Press the **Enter** button from the Main Menu to view the Parameters screen for the mode that is currently active.

7.2.3: Using Reset Mode

- Press the Enter button while rSt is in the A window.

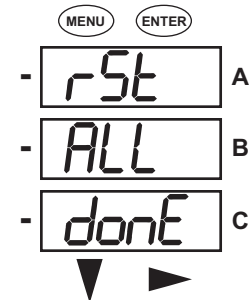
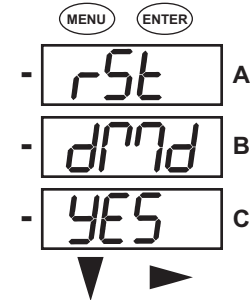
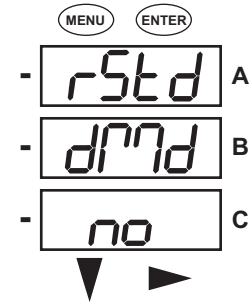
The "rSt (Reset) ALL? no" screen appears.

- If you press the **Enter** button again, the Main Menu appears, with the next mode in the A window. (The **Down** button does not affect this screen.)
- If you press the **Right** button, the "rSt ALL? YES" screen appears. Press **Enter** to perform a reset.

CAUTION! All Max and Min values will be reset.

NOTE: If Password protection is enabled for reset, you must enter the four digit password before you can reset the meter. To enter a password, follow the instructions in Section 7.2.4.

- Once you have performed a reset, the screen displays "rSt ALL donE" and then resumes auto-scrolling parameters.

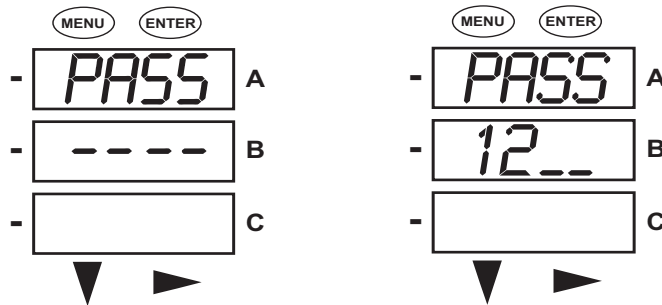


7.2.4: Entering a Password

If Password protection has been enabled in the software for reset and/or configuration, a screen appears requesting a password when you try to reset the meter and/or configure settings through the front panel.

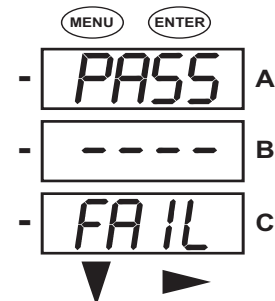
- PASS appears in the A window and 4 dashes appear in the B window. The leftmost dash is flashing.
1. Press the **Down** button to scroll numbers from 0 to 9 for the flashing dash. When the correct number appears for that dash, use the **Right** button to move to the next dash.

Example: The left screen, below, shows four dashes. The right screen shows the display after the first two digits of the password have been entered.



2. When all 4 digits of the password have been selected, press the **Enter** button.
 - If you are in Reset Mode and you enter the correct password, "rSt ALL donE" appears and the screen resumes auto-scrolling parameters.
 - If you are in Configuration Mode and you enter the correct password, the display returns to the screen that required a password.
 - If you enter an incorrect password, "PASS ---- FAIL" appears and:

- The previous screen is re-displayed, if you are in Reset Mode.
- The previous Operating mode screen is re-displayed, if you are in Configuration mode.



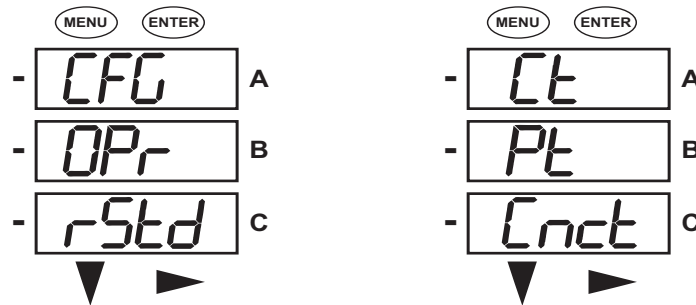
7.2.5: Using Configuration Mode

Configuration mode follows Reset: Energy on the Main Menu.

To access Configuration mode

1. Press the **Menu** button while the meter is auto-scrolling parameters.
2. Press the **Down** button until the Configuration Mode option (CFG) is in the A window.
3. Press the **Enter** button. The Configuration Parameters screen appears.
4. Press the **Down** button to scroll through the configuration parameters: Scroll (SCrL), CT, PT, Connection (Cnct) and Port. The parameter currently 'Active,' i.e., configurable, flashes in the A window.
5. Press the **Enter** button to access the Setting screen for the currently active parameter.

NOTE: You can use the **Enter** button to scroll through all of the Configuration parameters and their Setting screens, in order.



Press **Enter** when CFG is in A window - Parameter screen appears -

Press **Down**- Press **Enter** when

Parameter you want is in A window

6. The parameter screen appears, showing the current settings. To change the settings:
 - Use either the **Down** button or the **Right** button to select an option.

- To enter a number value, use the **Down** button to select the number value for a digit and the **Right** button to move to the next digit.

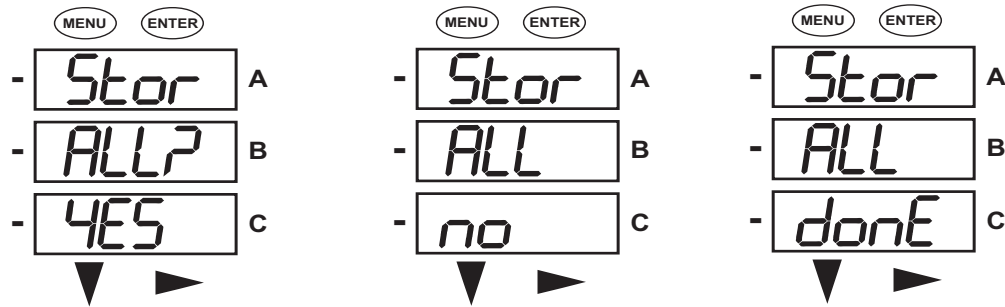
NOTE: When you try to change the current setting and Password protection is enabled for the meter, the Password screen appears. See Section 7.2.4 for instructions on entering a password.

7. Once you have entered the new setting, press the **Menu** button twice.

8. The Store ALL YES screen appears. You can either:

- Press the **Enter** button to save the new setting.
- Press the **Right** button to access the Store ALL no screen; then press the **Enter** button to cancel the Save.

9. If you have saved the settings, the Store ALL done screen appears and the meter resets.



Press the **Enter** button to save the settings. Press the **Right** button for Stor All no screen.

Press the **Enter** button to Cancel the Save.

The settings have been saved.

7.2.5.1: Configuring the Scroll Feature

When in Auto Scroll mode, the meter performs a scrolling display, showing each parameter for 7 seconds, with a 1 second pause between parameters. The parameters that the meter displays are determined by the following conditions:

- They have been selected through software.
- They are enabled by the ordered V-Switch pack (see Section 2.1.1).

To enable or disable Auto-scrolling:

1. Press the **Enter** button when SCrL is in the A window. The Scroll YES screen appears.

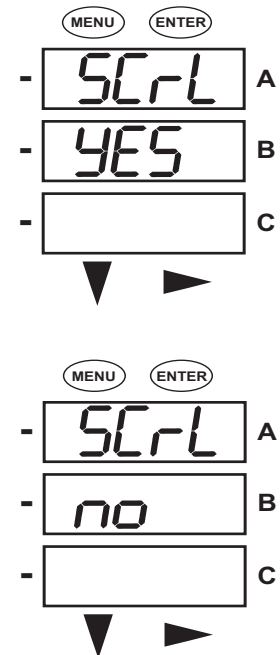
2. Press either the **Right** or **Down** button if you want to access the Scroll no screen. To return to the Scroll YES screen, press either button.

3. Press the **Enter** button on either the Scroll YES screen (to enable auto-scrolling) or the Scroll no screen (to disable auto-scrolling).

4. The CT- n screen appears (this is the next Configuration mode parameter).

NOTES:

- To exit the screen without changing scrolling options, press the **Menu** button.
- To return to the Main Menu screen, press the **Menu** button twice.
- To return to the scrolling (or non-scrolling) parameters display, press the **Menu** button three times.



7.2.5.2: Configuring CT Setting

The CT Setting has three parts: Ct-n (numerator), Ct-d (denominator), and Ct-S (scaling).

1. Press the **Enter** button when Ct is in the A window. The Ct-n screen appears. You can either:

- Change the value for the CT numerator.
- Access one of the other CT screens by pressing the **Enter** button: press **Enter** once to access the Ct-d screen, twice to access the Ct-S screen.

NOTE: The Ct-d screen is preset to a 5 amp or 1 amp value at the factory and cannot be changed.

a. To change the value for the CT numerator:

From the Ct-n screen:

- Use the Down button to select the number value for a digit.
- Use the Right button to move to the next digit.

b. To change the value for CT scaling

From the Ct-S screen:

Use the **Right** button or the **Down** button to choose the scaling you want. The Ct-S setting can be 1, 10, or 100.

NOTE: If you are prompted to enter a password, refer to Section 7.2.4 for instructions on doing so.

2. When the new setting is entered, press the **Menu** button twice.

3. The Store ALL YES screen appears. Press **Enter** to save the new CT setting.

Example CT Settings:

200/5 Amps: Set the Ct-n value for 200 and the Ct-S value for 1.

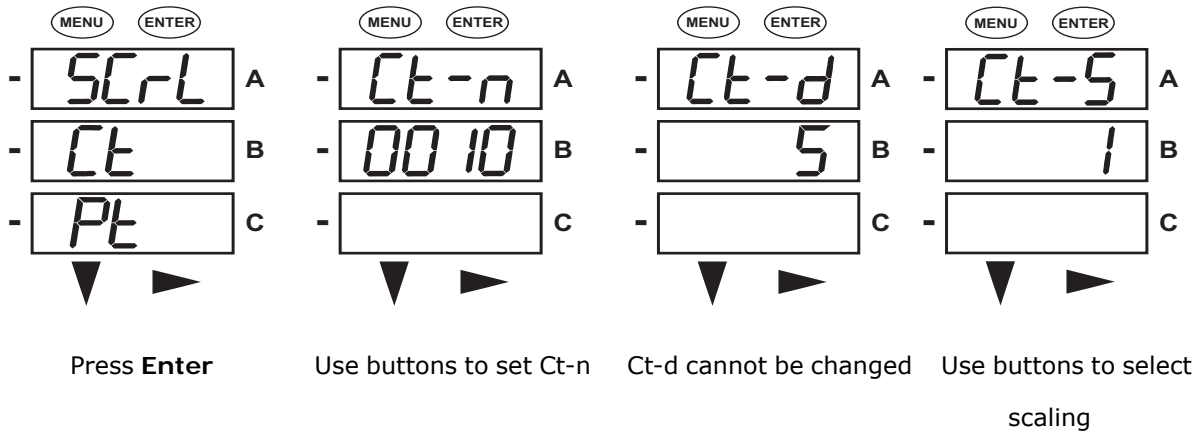
800/5 Amps: Set the Ct-n value for 800 and the Ct-S value for 1.

2,000/5 Amps: Set the Ct-n value for 2000 and the Ct-S value for 1.

10,000/5 Amps: Set the Ct-n value for 1000 and the Ct-S value for 10.

NOTES:

- The value for Amps is a product of the Ct-n value and the Ct-S value.
- Ct-n and Ct-S are dictated by primary current; Ct-d is secondary current.



7.2.5.3: Configuring PT Setting

The PT Setting has three parts: Pt-n (numerator), Pt-d (denominator), and Pt-S (scaling).

1. Press the **Enter** button when Pt is in the A window. The PT-n screen appears. You can either:

- Change the value for the PT numerator.
- Access one of the other PT screens by pressing the **Enter** button: press **Enter** once to access the Pt-d screen, twice to access the Pt-S screen.

a. To change the value for the PT numerator or denominator:

From the Pt-n or Pt-d screen:

- Use the **Down** button to select the number value for a digit.
- Use the **Right** button to move to the next digit.

b. To change the value for the PT scaling:

From the Pt-S screen:

Use the **Right** button or the **Down** button to choose the scaling you want. The Pt-S setting can be 1, 10, 100, or 1000.

NOTE: If you are prompted to enter a password, refer to Section 7.2.4 for instructions on doing so.

2. When the new setting is entered, press the **Menu** button twice.

3. The STOR ALL YES screen appears. Press **Enter** to save the new PT setting.

Example PT Settings:

277/277 Volts: Pt-n value is 277, Pt-d value is 277, Pt-S value is 1.

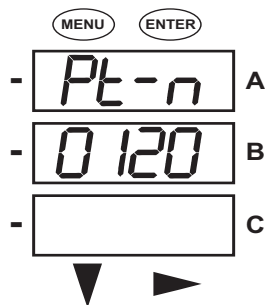
14,400/120 Volts: Pt-n value is 1440, Pt-d value is 120, Pt-S value is 10.

138,000/69 Volts: Pt-n value is 1380, Pt-d value is 69, Pt-S value is 100.

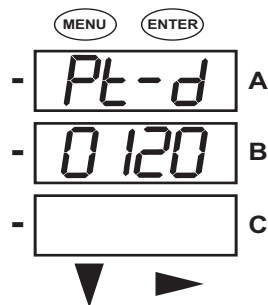
345,000/115 Volts: Pt-n value is 3450, Pt-d value is 115, Pt-S value is 100.

345,000/69 Volts: Pt-n value is 345, Pt-d value is 69, Pt-S value is 1000.

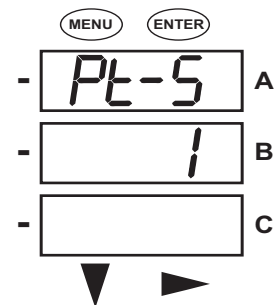
NOTE: Pt-n and Pt-S are dictated by primary voltage; Pt-d is secondary voltage.



Use buttons to set Pt-n



Use buttons to set Pt-d



Use buttons to select scaling

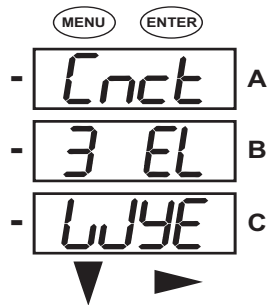
7.2.5.4: Configuring Connection Setting

1. Press the **Enter** button when Cnct is in the A window. The Cnct screen appears.
2. Press the **Right** button or **Down** button to select a configuration. The choices are:

- 3 Element Wye (3 EL WYE)
- 2.5 Element Wye (2.5EL WYE)
- 2 CT Delta (2 Ct dEL)

NOTE: If you are prompted to enter a password, refer to Section 7.2.4 for instructions on doing so.

3. When you have made your selection, press the **Menu** button twice.
4. The STOR ALL YES screen appears. Press **Enter** to save the setting.



Use buttons to select configuration

7.2.5.5: Configuring Communication Port Setting

Port configuration consists of: Address (a three digit number), Baud Rate (9600; 19200; 38400; or 57600), and Protocol (DNP 3.0; Modbus RTU; or Modbus ASCII).

1. Press the **Enter** button when PORT is in the A window. The Adr (address) screen appears. You can either:
 - Enter the address.
 - Access one of the other Port screens by pressing the **Enter** button: press **Enter** once to access the bAUd screen (Baud Rate), twice to access the Prot screen (Protocol).

- a. To enter the Address

From the Adr screen:

- Use the **Down** button to select the number value for a digit.
- Use the **Right** button to move to the next digit.

- b. To select the Baud Rate:

From the bAUd screen:

Use the **Right** button or the **Down** button to select the setting you want.

- c. To select the Protocol:

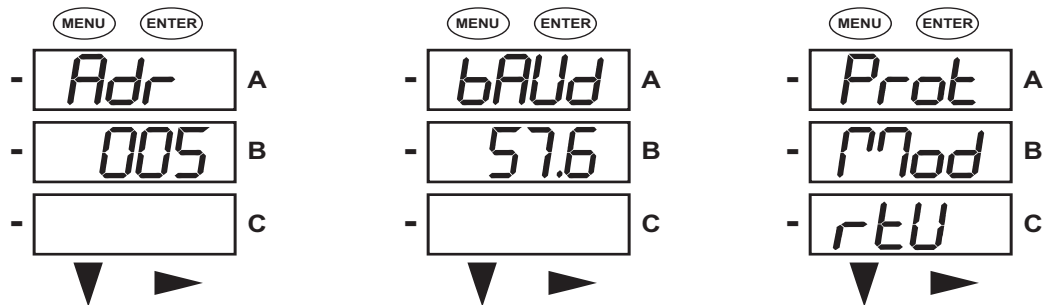
From the Prot screen:

Press the **Right** button or the **Down** button to select the setting you want.

NOTE: If you are prompted to enter a password, refer to Section 7.2.4 for instructions on doing so.

2. When you have finished making your selections, press the **Menu** button twice.

3. The STOR ALL YES screen appears. Press **Enter** to save the settings.



Use buttons to enter Address Use buttons to select Baud Rate Use buttons to select Protocol

7.2.6: Using Operating Mode

Operating mode is the EM-3000 Series meter's default mode, that is, the standard front panel display. After starting up, the meter automatically scrolls through the parameter screens, if scrolling is enabled. Each parameter is shown for 7 seconds, with a 1 second pause between parameters. Scrolling is suspended for 3 minutes after any button is pressed.

1. Press the **Down** button to scroll all the parameters in Operating mode. The currently "Active," i.e., displayed, parameter has the Indicator light next to it, on the right face of the meter.
2. Press the **Right** button to view additional readings for that parameter. The table below shows possible readings for Operating mode. Sheet 2 in Appendix A shows the Operating mode Navigation map.

NOTE: Readings or groups of readings are skipped if not applicable to the meter type or hookup, or if they are disabled in the programmable settings.

OPERATING MODE PARAMETER READINGS

POSSIBLE READINGS

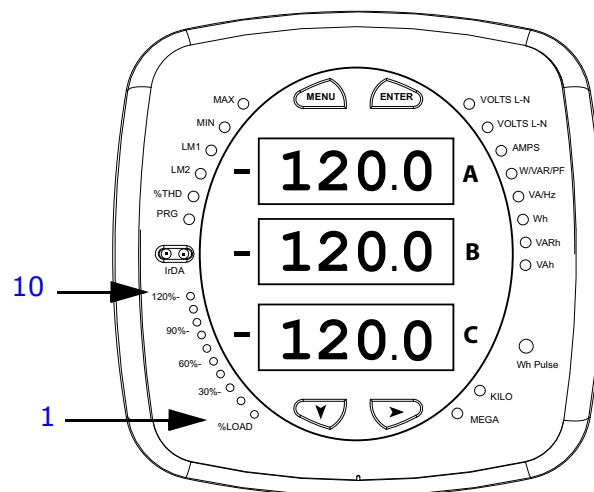
VOLTS L-N	VOLTS_LN	VOLTS_LN_MAX	VOLTS_LN_MIN		VOLTS_LN_THD
VOLTS L-L	VOLTS_LL	VOLTS_LL_MAX	VOLTS_LL_MIN		
AMPS	AMPS	AMPS_NEUTRAL	AMPS_MAX	AMPS_MIN	AMPS_THD
W/VAR/PF	W_VAR_PF	W_VAR_PF_MAX_POS	W_VAR_PF_MIN_POS	W_VAR_PF_MIN_NEG	
VA/Hz	VA_FREQ	VA_FREQ_MAX	VA_FREQ_MIN		
Wh	KWH_REC	KWH_DEL	KWH_NET	KWH_TOT	
VARh	KVARH_POS	KVARH_NEG	KVARH_NET	KVARH_TOT	
VAh	KVAH				

7.3: Understanding the % of Load Bar

The 10-segment LED bar graph at the bottom left of the EM-3000 Series meter's front panel provides a graphic representation of Amps. The segments light according to the load, as shown in the table below.

When the Load is over 120% of Full Load, all segments flash "On" (1.5 secs) and "Off" (0.5 secs).

Segments	Load \geq % Full Load
none	no load
1	1%
1-2	15%
1-3	30%
1-4	45%
1-5	60%
1-6	72%
1-7	84%
1-8	96%
1-9	108%
1-10	120%
All Blink	>120%



7.4: Performing Watt-Hour Accuracy Testing (Verification)

To be certified for revenue metering, power providers and utility companies must verify that the billing energy meter performs to the stated accuracy. To confirm the meter's performance and calibration, power providers use field test standards to ensure that the unit's energy measurements are correct. Since the EM-3000 Series meter is a traceable revenue meter, it contains a utility grade test pulse that can be used to gate an accuracy standard. This is an essential feature required of all billing grade meters.

- Refer to Figure 7.5 for an example of how this process works.
- Refer to Table 7.1 for the Wh/Pulse constants for accuracy testing.

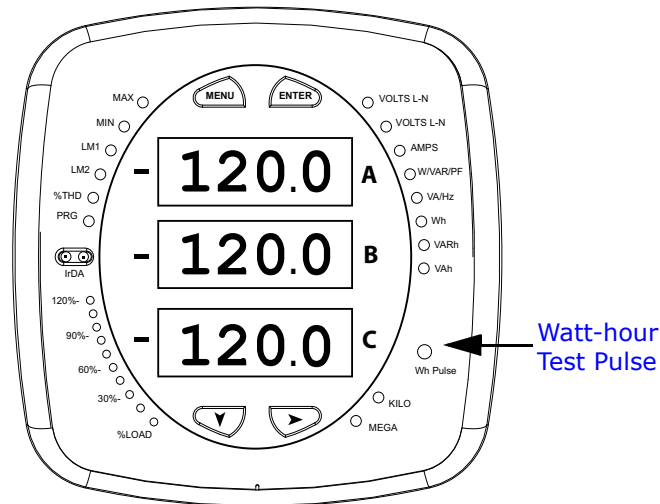


Figure 7.4: Watt-hour Test Pulse

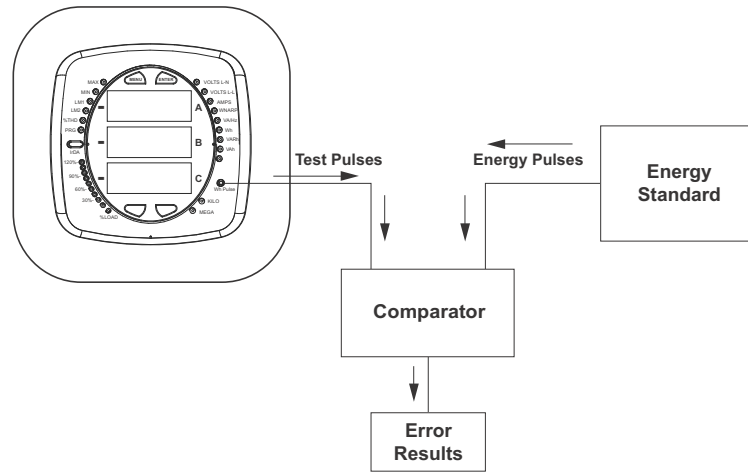


Figure 7.5: Using the Watt-hour Test Pulse

Input Voltage Level	Class 10 Models	Class 2 Models
Below 150V	0.2505759630	0.0501151926
Above 150V	1.0023038521	0.2004607704

Table 7.1: Infrared & KYZ Pulse Constants for Accuracy Testing - Kh Watt-hour per pulse

NOTES:

- Minimum pulse width is 40 milliseconds.
- Refer to Chapter 2, Section 2.2, for Wh Pulse specifications.

A: EM-3000 Series Meter's Navigation Maps

A.1: Introduction

You can configure the EM-3000 Series meter and perform related tasks using the buttons on the meter face. Chapter 7 contains a description of the buttons on the meter face and instructions for programming the meter using them.

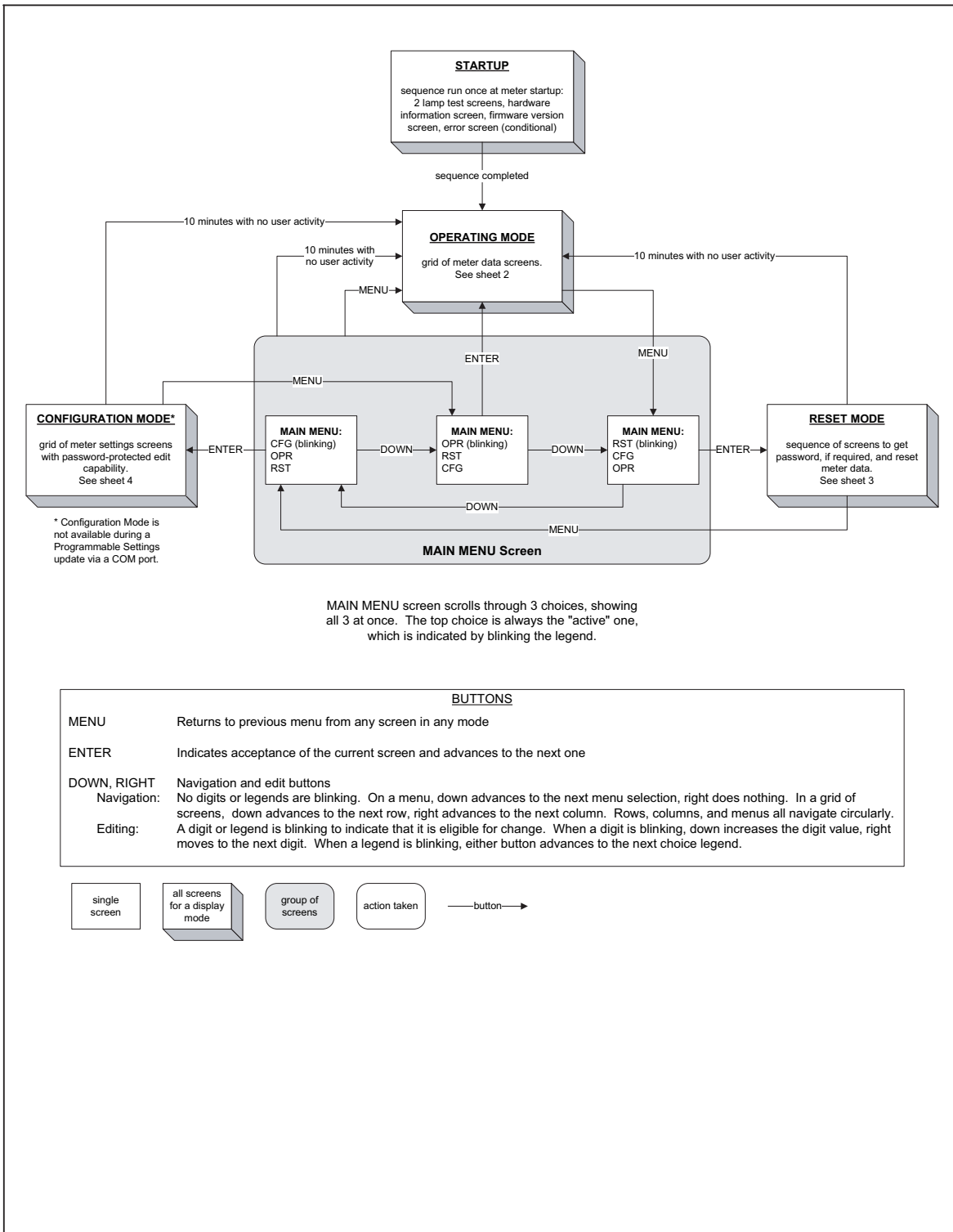
A.2: Navigation Maps (Sheets 1 to 4)

The EM-3000 Series meter's Navigation maps begin on the next page. The maps show in detail how to move from one screen to another and from one display mode to another using the buttons on the face of the meter. All display modes automatically return to Operating mode after 10 minutes with no user activity.

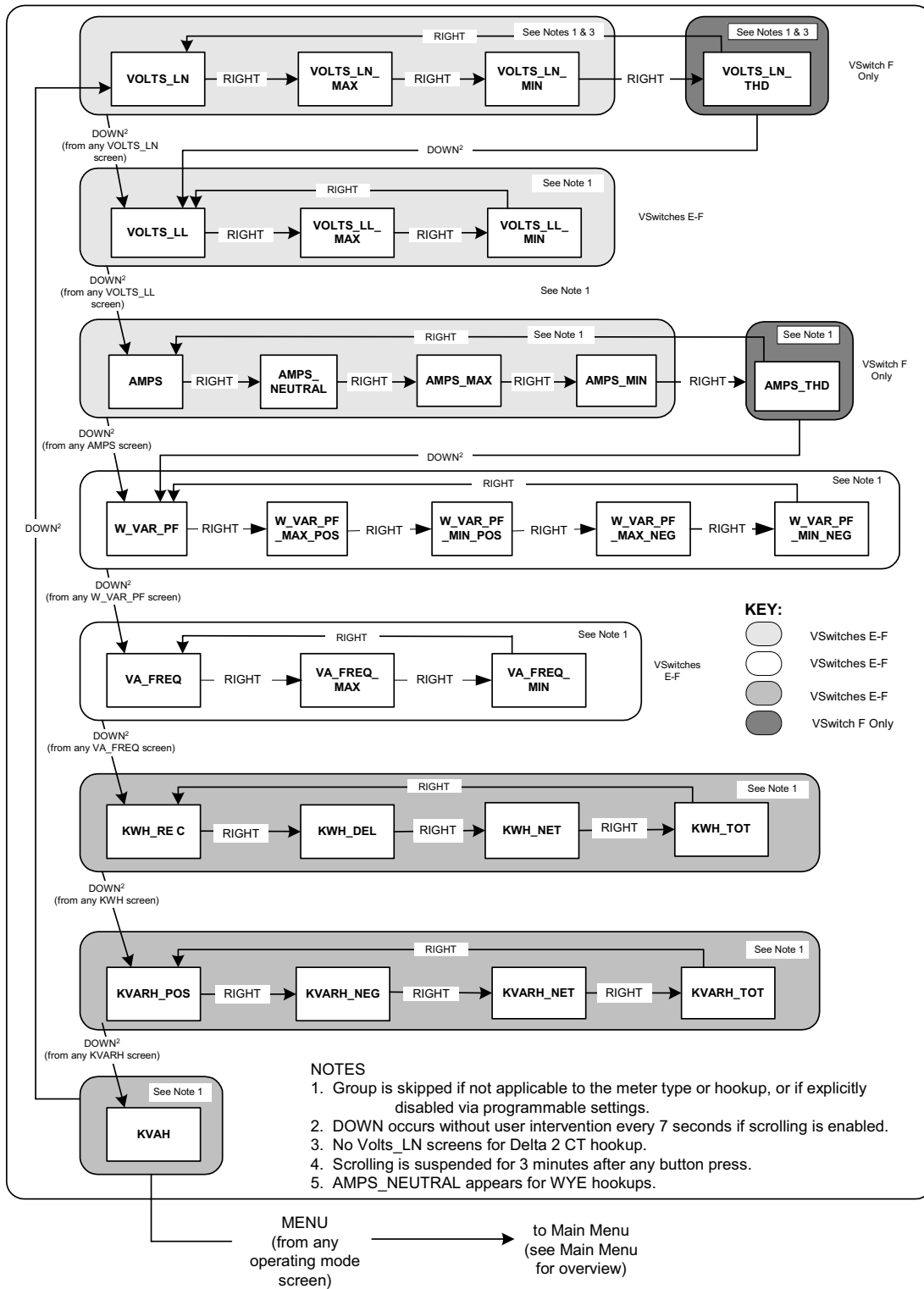
EM-3000 Series meter Navigation map titles

- Main Menu Screens (Sheet 1)
- Operating mode screens (Sheet 2)
- Reset mode screens (Sheet 3)
- Configuration mode screens (Sheet 4)

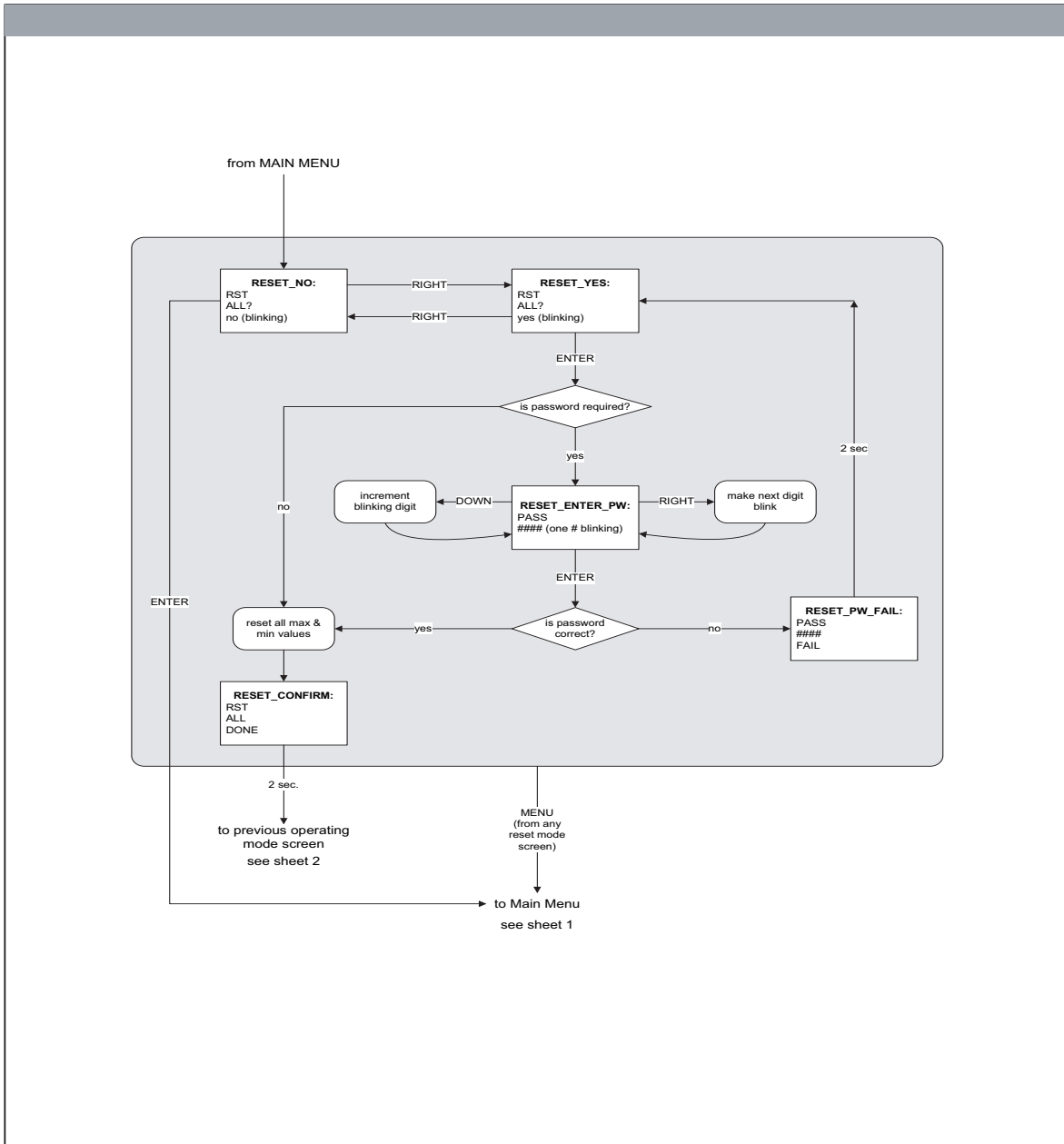
Main Menu Screens (Sheet 1)



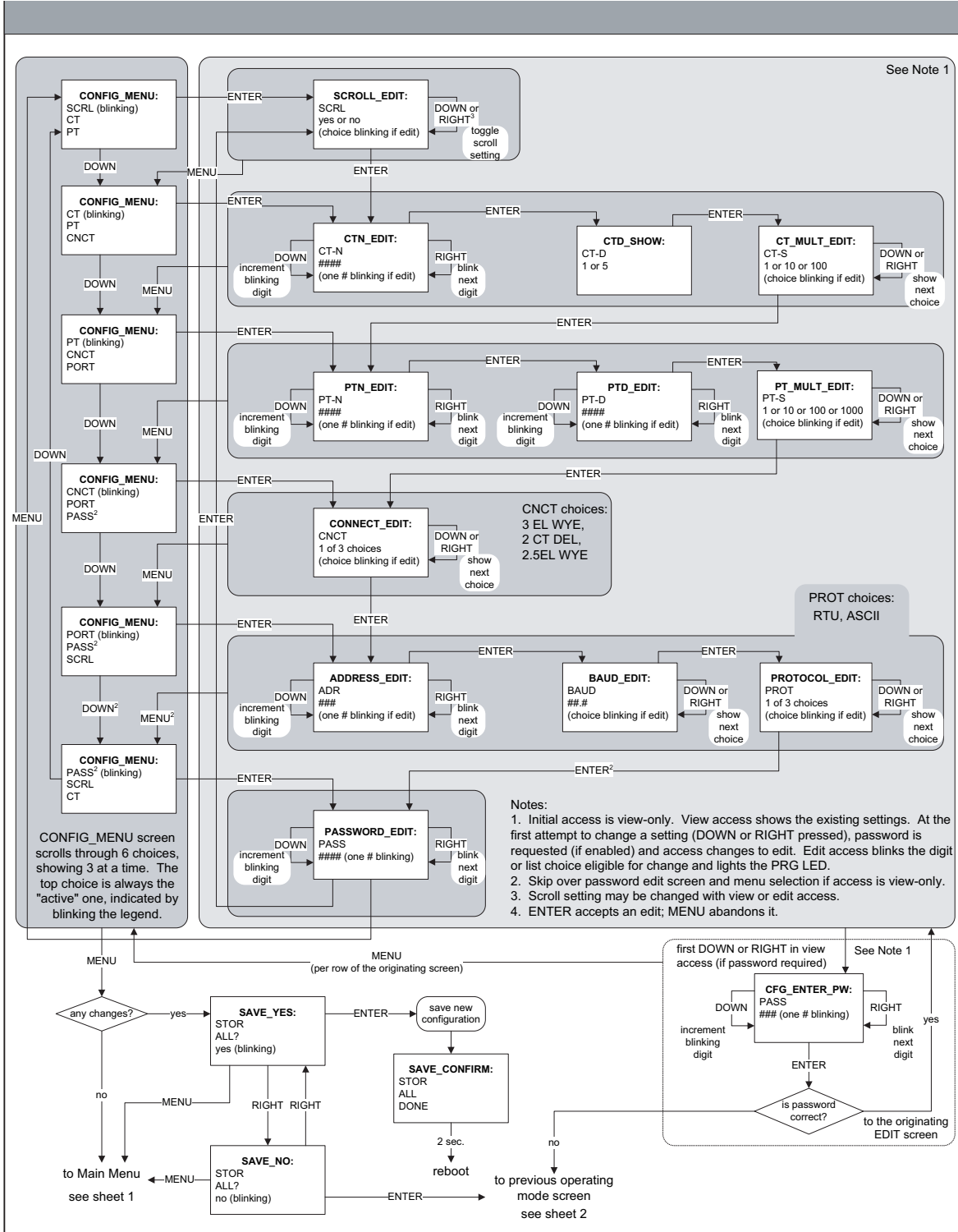
Operating Mode Screens (Sheet 2)



Reset Mode Screens (Sheet 3)



Configuration Mode Screens (Sheet 4)



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B: EM-3000 Series Meter's Modbus Map

B.1: Introduction

The Modbus Map for the EM-3000 Series Meter gives details and information about the possible readings of the meter and about the programming of the meter.

The EM-3000 Series can be programmed using the buttons on the face plate of the meter (Chapter 7).

B.2: Modbus Register Map Sections

The EM-3000 Series meter's Modbus Register Map includes the following sections:

Fixed Data Section, Registers 1- 47, details the Meter's Fixed Information described in Section 8.2.

Meter Data Section, Registers 1000 - 5003, details the Meter's Readings, including Primary Readings, Energy Block, Demand Block, Maximum and Minimum Blocks, THD Block, Phase Angle Block and Status Block. Operating Mode readings are described in Section 7.2.6.

Commands Section, Registers 20000 - 26011, details the Meter's Resets Block, Programming Block, Other Commands Block and Encryption Block.

Programmable Settings Section, Registers 30000 - 30067, details the Meter's Basic Setups.

Secondary Readings Section, Registers 40001 - 40100, details the Meter's Secondary Readings Setups.

B.3: Data Formats

ASCII:	ASCII characters packed 2 per register in high, low order and without any termination characters.
SINT16/UINT16:	16-bit signed/unsigned integer.
SINT32/UINT32:	32-bit signed/unsigned integer spanning 2 registers. The lower-addressed register is the high order half.
FLOAT:	32-bit IEEE floating point number spanning 2

registers. The lower-addressed register is the high order half (i.e., contains the exponent).

B.4: Floating Point Values

Floating Point Values are represented in the following format:

Register	0																1															
Byte	0								1								0								1							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Meaning	s	e	e	e	e	e	e	e	e	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
	sign		exponent						mantissa																							

The formula to interpret a Floating Point Value is:

$$-1^{sign} \times 2^{exponent-127} \times 1.mantissa = 0x0C4E11DB9$$

$$-1^{sign} \times 2^{137-127} \times 1.1000010001110110111001$$

$$-1 \times 2^{10} \times 1.75871956$$

$$-1800.929$$

Register	0x0C4E1																0x01DB9															
Byte	0x0C4								0x0E1								0x01D								0x0B9v							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	1	1	0	0	0	1	0	0	1	1	1	0	0	0	0	1	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	0
Meaning	s	e	e	e	e	e	e	e	e	m	m	m	m	m	m	m																
	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m																
	sign		exponent						mantissa																							
	1		0x089 + 137						0b011000010001110110111001																							

Formula Explanation:

$$C4E11DB9 \text{ (hex)} \qquad 11000100 \ 11100001 \ 00011101 \ 10111001$$

(binary)

The sign of the mantissa (and therefore the number) is 1, which represents a negative value.

The Exponent is 10001001 (binary) or 137 decimal.

The Exponent is a value in excess 127. So, the Exponent value is 10.

The Mantissa is 11000010001110110111001 binary.

With the implied leading 1, the Mantissa is (1).611DB9 (hex).

The Floating Point Representation is therefore -1.75871956 times 2 to the 10.

Decimal equivalent: -1800.929

NOTES:

- Exponent = the whole number before the decimal point.
- Mantissa = the positive fraction after the decimal point.

B.5: Modbus Register Map

The EM-3000 Series meter's Modbus register map begins on the following page.

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Modbus Address		Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Hex	Decimal						
Fixed Data Section							
Identification Block							read-only
0000 - 0007	1 - 8	Reserved					8
0008 - 000F	9 - 16	Meter Serial Number	ASCII	16 char	none		8
0010 - 0010	17 - 17	Meter Type	UINT16	bit-mapped	-----t -----vvv	t = 0, vvv = V-switch	1
0011 - 0012	18 - 19	Firmware Version	ASCII	4 char	none		2
0013 - 0013	20 - 20	Map Version	UINT16	0 to 65535	none		1
0014 - 0014	21 - 21	Meter Configuration	UINT16	bit-mapped	----- --fffff	fffff = calibration frequency (50 or 60)	1
0015 - 0015	22 - 22	ASIC Version	UINT16	0-65535	none		1
0016 - 0026	23 - 39	Reserved					17
0027 - 002E	40 - 47	Meter Name	ASCII	16 char	none		8
Block Size:							47
Meter Data Section²							
Primary Readings Block, 6 cycles (IEEE Floating Point)							read-only
0383 - 0384	900 - 901	Watts, 3-Ph total	FLOAT	-9999 M to +9999 M	watts		2
0385 - 0386	902 - 903	VARs, 3-Ph total	FLOAT	-9999 M to +9999 M	VARs		2
0387 - 0388	904 - 905	VA, 3-Ph total	FLOAT	-9999 M to +9999 M	VA		2
Block Size:							6
Primary Readings Block, 60 cycles (IEEE Floating Point)							read-only
03E7 - 03E8	1000 - 1001	Volts A-N	FLOAT	0 to 9999 M	volts		2
03E9 - 03EA	1002 - 1003	Volts B-N	FLOAT	0 to 9999 M	volts		2
03EB - 03EC	1004 - 1005	Volts C-N	FLOAT	0 to 9999 M	volts		2
03ED - 03EE	1006 - 1007	Volts A-B	FLOAT	0 to 9999 M	volts		2
03EF - 03F0	1008 - 1009	Volts B-C	FLOAT	0 to 9999 M	volts		2
03F1 - 03F2	1010 - 1011	Volts C-A	FLOAT	0 to 9999 M	volts		2
03F3 - 03F4	1012 - 1013	Amps A	FLOAT	0 to 9999 M	amps		2
03F5 - 03F6	1014 - 1015	Amps B	FLOAT	0 to 9999 M	amps		2
03F7 - 03F8	1016 - 1017	Amps C	FLOAT	0 to 9999 M	amps		2
03F9 - 03FA	1018 - 1019	Watts, 3-Ph total	FLOAT	-9999 M to +9999 M	watts		2
03FB - 03FC	1020 - 1021	VARs, 3-Ph total	FLOAT	-9999 M to +9999 M	VARs		2
03FD - 03FE	1022 - 1023	VA, 3-Ph total	FLOAT	-9999 M to +9999 M	VA		2
03FF - 0400	1024 - 1025	Power Factor, 3-Ph total	FLOAT	-1.00 to +1.00	none		2
0401 - 0402	1026 - 1027	Frequency	FLOAT	0 to 65.00	Hz		2
0403 - 0404	1028 - 1029	Neutral Current	FLOAT	0 to 9999 M	amps		2
Block Size:							30

Modbus Address		Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Hex	Decimal						
Primary Energy Block							
read-only							
044B - 044C	1100 - 1101	W-hours, Received	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format	* Wh received & delivered always have opposite signs	2
044D - 044E	1102 - 1103	W-hours, Delivered	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format	* Wh received is positive for "view as load", delivered is positive for "view as generator"	2
044F - 0450	1104 - 1105	W-hours, Net	SINT32	-99999999 to 99999999	Wh per energy format		2
0451 - 0452	1106 - 1107	W-hours, Total	SINT32	0 to 99999999	Wh per energy format	* 5 to 8 digits	2
0453 - 0454	1108 - 1109	VAR-hours, Positive	SINT32	0 to 99999999	VARh per energy format		2
0455 - 0456	1110 - 1111	VAR-hours, Negative	SINT32	0 to -99999999	VARh per energy format	* decimal point implied, per energy format	2
0457 - 0458	1112 - 1113	VAR-hours, Net	SINT32	-99999999 to 99999999	VARh per energy format	* resolution of digit before decimal point = units, kilo, or mega, per energy format	2
0459 - 045A	1114 - 1115	VAR-hours, Total	SINT32	0 to 99999999	VARh per energy format		2
045B - 045C	1116 - 1117	VA-hours, Total	SINT32	0 to 99999999	VAh per energy format	* see note 10	2
Block Size:							18
Primary Demand Block (IEEE Floating Point)							
read-only							
07CF - 07D0	2000 - 2001	Amps A, Average	FLOAT	0 to 9999 M	amps		2
07D1 - 07D2	2002 - 2003	Amps B, Average	FLOAT	0 to 9999 M	amps		2
07D3 - 07D4	2004 - 2005	Amps C, Average	FLOAT	0 to 9999 M	amps		2
07D5 - 07D6	2006 - 2007	Positive Watts, 3-Ph, Average	FLOAT	-9999 M to +9999 M	watts		2
07D7 - 07D8	2008 - 2009	Positive VARs, 3-Ph, Average	FLOAT	-9999 M to +9999 M	VARs		2
07D9 - 07DA	2010 - 2011	Negative Watts, 3-Ph, Average	FLOAT	-9999 M to +9999 M	watts		2
07DB - 07DC	2012 - 2013	Negative VARs, 3-Ph, Average	FLOAT	-9999 M to +9999 M	VARs		2
07DD - 07DE	2014 - 2015	VAs, 3-Ph, Average	FLOAT	-9999 M to +9999 M	VAs		2
07DF - 07E0	2016 - 2017	Positive PF, 3-Ph, Average	FLOAT	-1.00 to +1.00	none		2
07E1 - 07E2	2018 - 2019	Negative PF, 3-PF, Average	FLOAT	-1.00 to +1.00	none		2
Block Size:							20
Primary Minimum Block (IEEE Floating Point)							
read-only							
0BB7 - 0BB8	3000 - 3001	Volts A-N, Minimum	FLOAT	0 to 9999 M	volts		2
0BB9 - 0BBA	3002 - 3003	Volts B-N, Minimum	FLOAT	0 to 9999 M	volts		2
0BBB - 0BBC	3004 - 3005	Volts C-N, Minimum	FLOAT	0 to 9999 M	volts		2
0BBD - 0BBE	3006 - 3007	Volts A-B, Minimum	FLOAT	0 to 9999 M	volts		2
0BBF - 0BC0	3008 - 3009	Volts B-C, Minimum	FLOAT	0 to 9999 M	volts		2
0BC1 - 0BC2	3010 - 3011	Volts C-A, Minimum	FLOAT	0 to 9999 M	volts		2
0BC3 - 0BC4	3012 - 3013	Amps A, Minimum Avg Demand	FLOAT	0 to 9999 M	amps		2
0BC5 - 0BC6	3014 - 3015	Amps B, Minimum Avg Demand	FLOAT	0 to 9999 M	amps		2
0BC7 - 0BC8	3016 - 3017	Amps C, Minimum Avg Demand	FLOAT	0 to 9999 M	amps		2
0BC9 - 0BCA	3018 - 3019	Positive Watts, 3-Ph, Minimum Avg Demand	FLOAT	0 to +9999 M	watts		2
0BCB - 0BCC	3020 - 3021	Positive VARs, 3-Ph, Minimum Avg Demand	FLOAT	0 to +9999 M	VARs		2
0BCD - 0BCE	3022 - 3023	Negative Watts, 3-Ph, Minimum Avg Demand	FLOAT	0 to +9999 M	watts		2
0BCF - 0BD0	3024 - 3025	Negative VARs, 3-Ph, Minimum Avg Demand	FLOAT	0 to +9999 M	VARs		2
0BD1 - 0BD2	3026 - 3027	VAs, 3-Ph, Minimum Avg Demand	FLOAT	-9999 M to +9999 M	VAs		2
0BD3 - 0BD4	3028 - 3029	Positive Power Factor, 3-Ph, Minimum Avg Demand	FLOAT	-1.00 to +1.00	none		2

Modbus Address		Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Hex	Decimal						
0BD5 - 0BD6	3030 - 3031	Negative Power Factor, 3-Ph, Minimum Avg Demand	FLOAT	-1.00 to +1.00	none		2
0BD7 - 0BD8	3032 - 3033	Frequency, Minimum	FLOAT	0 to 65.00	Hz		2
						Block Size:	34
Primary Maximum Block (IEEE Floating Point)							read-only
0C1B - 0C1C	3100 - 3101	Volts A-N, Maximum	FLOAT	0 to 9999 M	volts		2
0C1D - 0C1E	3102 - 3103	Volts B-N, Maximum	FLOAT	0 to 9999 M	volts		2
0C1F - 0C20	3104 - 3105	Volts C-N, Maximum	FLOAT	0 to 9999 M	volts		2
0C21 - 0C22	3106 - 3107	Volts A-B, Maximum	FLOAT	0 to 9999 M	volts		2
0C23 - 0C24	3108 - 3109	Volts B-C, Maximum	FLOAT	0 to 9999 M	volts		2
0C25 - 0C26	3110 - 3111	Volts C-A, Maximum	FLOAT	0 to 9999 M	volts		2
0C27 - 0C28	3112 - 3113	Amps A, Maximum Avg Demand	FLOAT	0 to 9999 M	amps		2
0C29 - 0C2A	3114 - 3115	Amps B, Maximum Avg Demand	FLOAT	0 to 9999 M	amps		2
0C2B - 0C2C	3116 - 3117	Amps C, Maximum Avg Demand	FLOAT	0 to 9999 M	amps		2
0C2D - 0C2E	3118 - 3119	Positive Watts, 3-Ph, Maximum Avg Demand	FLOAT	0 to +9999 M	watts		2
0C2F - 0C30	3120 - 3121	Positive VARs, 3-Ph, Maximum Avg Demand	FLOAT	0 to +9999 M	VARs		2
0C31 - 0C32	3122 - 3123	Negative Watts, 3-Ph, Maximum Avg Demand	FLOAT	0 to +9999 M	watts		2
0C33 - 0C34	3124 - 3125	Negative VARs, 3-Ph, Maximum Avg Demand	FLOAT	0 to +9999 M	VARs		2
0C35 - 0C36	3126 - 3127	VA's, 3-Ph, Maximum Avg Demand	FLOAT	-9999 M to +9999 M	VA's		2
0C37 - 0C38	3128 - 3129	Positive Power Factor, 3-Ph, Maximum Avg Demand	FLOAT	-1.00 to +1.00	none		2
0C39 - 0C3A	3130 - 3131	Negative Power Factor, 3-Ph, Maximum Avg Demand	FLOAT	-1.00 to +1.00	none		2
0C3B - 0C3C	3132 - 3133	Frequency, Maximum	FLOAT	0 to 65.00	Hz		2
						Block Size:	34
THD Block ²⁻¹³							read-only
0F9F - 0F9F	4000 - 4000	Volts A-N, %THD	UINT16	0 to 9999, or 65535	0.1%		1
0FA0 - 0FA0	4001 - 4001	Volts B-N, %THD	UINT16	0 to 9999, or 65535	0.1%		1
0FA1 - 0FA1	4002 - 4002	Volts C-N, %THD	UINT16	0 to 9999, or 65535	0.1%		1
0FA2 - 0FA2	4003 - 4003	Amps A, %THD	UINT16	0 to 9999, or 65535	0.1%		1
0FA3 - 0FA3	4004 - 4004	Amps B, %THD	UINT16	0 to 9999, or 65535	0.1%		1
0FA4 - 0FA4	4005 - 4005	Amps C, %THD	UINT16	0 to 9999, or 65535	0.1%		1
0FA5 - 0FA5	4006 - 4006	Phase A Current 0th harmonic magnitude	UINT16	0 to 65535	none		1
0FA6 - 0FA6	4007 - 4007	Phase A Current 1st harmonic magnitude	UINT16	0 to 65535	none		1
0FA7 - 0FA7	4008 - 4008	Phase A Current 2nd harmonic magnitude	UINT16	0 to 65535	none		1
0FA8 - 0FA8	4009 - 4009	Phase A Current 3rd harmonic magnitude	UINT16	0 to 65535	none		1
0FA9 - 0FA9	4010 - 4010	Phase A Current 4th harmonic magnitude	UINT16	0 to 65535	none		1
0FAA - 0FAA	4011 - 4011	Phase A Current 5th harmonic magnitude	UINT16	0 to 65535	none		1
0FAB - 0FAB	4012 - 4012	Phase A Current 6th harmonic magnitude	UINT16	0 to 65535	none		1
0FAC - 0FAC	4013 - 4013	Phase A Current 7th harmonic magnitude	UINT16	0 to 65535	none		1
0FAD - 0FAD	4014 - 4014	Phase A Voltage 0th harmonic magnitude	UINT16	0 to 65535	none		1
0FAE - 0FAE	4015 - 4015	Phase A Voltage 1st harmonic magnitude	UINT16	0 to 65535	none		1
0FAF - 0FAF	4016 - 4016	Phase A Voltage 2nd harmonic magnitude	UINT16	0 to 65535	none		1
0FB0 - 0FB0	4017 - 4017	Phase A Voltage 3rd harmonic magnitude	UINT16	0 to 65535	none		1
0FB1 - 0FB8	4018 - 4025	Phase B Current harmonic magnitudes		same as Phase A Current 0th to 7th harmonic magnitudes			8
0FB9 - 0FBC	4026 - 4029	Phase B Voltage harmonic magnitudes		same as Phase A Voltage 0th to 3rd harmonic magnitude:			4
0FBD - 0FC4	4030 - 4037	Phase C Current harmonic magnitudes		same as Phase A Current 0th to 7th harmonic magnitudes:			8
0FC5 - 0FC8	4038 - 4041	Phase C Voltage harmonic magnitudes		same as Phase A Voltage 0th to 3rd harmonic magnitude:			4
						Block Size:	42

Modbus Address		Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Hex	Decimal						
Phase Angle Block ¹⁴							
1003 - 1003	4100 - 4100	Phase A Current	SINT16	-1800 to +1800	0.1 degree	read-only	1
1004 - 1004	4101 - 4101	Phase B Current	SINT16	-1800 to +1800	0.1 degree		1
1005 - 1005	4102 - 4102	Phase C Current	SINT16	-1800 to +1800	0.1 degree		1
1006 - 1006	4103 - 4103	Angle, Volts A-B	SINT16	-1800 to +1800	0.1 degree		1
1007 - 1007	4104 - 4104	Angle, Volts B-C	SINT16	-1800 to +1800	0.1 degree		1
1008 - 1008	4105 - 4105	Angle, Volts C-A	SINT16	-1800 to +1800	0.1 degree		1
						Block Size:	6
Status Block							
1387 - 1387	5000 - 5000	Meter Status	UINT16	bit-mapped	--exnpch ssssssss	exnpch = EEPROM block OK flags (e=energy, x=max, n=min, p=programmable settings, c=calibration, h=header), ssssssss = state (1=Run, 2=Limp, 10=Prog Set Update via buttons, 11=Prog Set Update via IrDA, 12=Prog Set Update via COM2)	1
1388 - 1388	5001 - 5001	Limits Status ⁷	UINT16	bit-mapped	87654321 87654321	high byte is setpt 1, 0=in, 1=out low byte is setpt 2, 0=in, 1=out	1
1389 - 138A	5002 - 5003	Time Since Reset	UINT32	0 to 4294967294	4 msec	wraps around after max coun!	2
						Block Size:	4
Commands Section⁴							
Resets Block ³							
4E1F - 4E1F	20000 - 20000	Reset Max/Min Blocks	UINT16	password ⁵		write-only	1
4E20 - 4E20	20001 - 20001	Reset Energy Accumulators	UINT16	password ⁵			1
						Block Size:	2
Meter Programming Block							
55EF - 55EF	22000 - 22000	Initiate Programmable Settings Update	UINT16	password ⁵		meter enters PS update mode	1
55F0 - 55F0	22001 - 22001	Terminate Programmable Settings Update ³	UINT16	any value			1
55F1 - 55F1	22002 - 22002	Calculate Programmable Settings Checksum ³	UINT16			meter leaves PS update mode via reset meter calculates checksum on RAM copy of PS block	1
55F2 - 55F2	22003 - 22003	Programmable Settings Checksum ³	UINT16			read/write checksum register; PS block saved in EEPROM on write ⁸	1
55F3 - 55F3	22004 - 22004	Write New Password ³	UINT16	0000 to 9999			1
						write-only register; always reads zero	
59D7 - 59D7	23000 - 23000	Initiate Meter Firmware Reprogramming	UINT16	password ⁵			1
						Block Size:	6

Modbus Address		Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Hex	Decimal						
Other Commands Block							
61A7 - 61A7	25000 - 25000	Force Meter Restart	UINT16	password ⁵		causes a watchdog reset, always reads 0	1
						Block Size:	1
Encryption Block							
658F - 659A	26000 - 26011	Perform a Secure Operation	UINT16			encrypted command to read password or change meter type	12
						Block Size:	12
Programmable Settings Section							
Basic Setups Block							
752F - 752F	30000 - 30000	CT multiplier & denominator	UINT16	bit-mapped	ddddddd rrrrrrrrrrr	high byte is denominator (1 or 5, read-only), low byte is multiplier (1, 10, or 100)	1
7530 - 7530	30001 - 30001	CT numerator	UINT16	1 to 9999	none		1
7531 - 7531	30002 - 30002	PT numerator	UINT16	1 to 9999	none		1
7532 - 7532	30003 - 30003	PT denominator	UINT16	1 to 9999	none		1
7533 - 7533	30004 - 30004	PT multiplier & hookup	UINT16	bit-mapped	rrrrrrrrrr MMMMhhhh	MMMMmmmmmm is PT multiplier (1, 10, 100, 1000), hhhh is hookup enumeration (0 = 3 element wye[9S], 1 = delta 2 CTs[5S], 3 = 2.5 element wye[6S])	1
7534 - 7534	30005 - 30005	Averaging Method	UINT16	bit-mapped	--iiiiii b----sss	iiiiii = interval (5,15,30,60) b = 0-block or 1-rolling sss = # subintervals (1,2,3,4)	1
7535 - 7535	30006 - 30006	Power & Energy Format	UINT16	bit-mapped	pppp--nn -eee-ddd	pppp = power scale (0-unit, 3-kilo, 6-mega, 8-auto) nn = number of energy digits (5-8 --> 0-3) eee = energy scale (0-unit, 3-kilo, 6-mega) ddd = energy digits after decimal point (0-6) See note 10.	1
7536 - 7536	30007 - 30007	Operating Mode Screen Enables	UINT16	bit-mapped	00000000 eeeeeeee	eeeeeeee = op mode screen rows on(1) or off(0), rows top to bottom are bits low order to high order	1
7537 - 753D	30008 - 30014	Reserved					7

Modbus Address		Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Hex	Decimal						
753E - 753E	30015 - 30015	User Settings Flags	UINT16	bit-mapped	---g--nn srp--wF-	g = enable alternate full scale bargraph current (1=on, 0=off) nn = number of phases for voltage & current screens (3=ABC, 2=AB, 1=A, 0=ABC) s = scroll (1=on, 0=off) r = password for reset in use (1=on, 0=off) p = password for configuration in use (1=on, 0=off) w = pwr dir (0-view as load, 1-view as generator) f = flip power factor sign (1=yes, 0=no)	1
753F - 753F	30016 - 30016	Full Scale Current (for load % bargraph)	UINT16	0 to 9999	none	If non-zero and user settings bit g is set, this value replaces CT numerator in the full scale current calculation.	1
7540 - 7547	30017 - 30024	Meter Designation	ASCII	16 char	none		8
7548 - 7548	30025 - 30025	COM1 setup	UINT16	bit-mapped	----dddd -0100110	dddd = reply delay (* 50 msec) ppp = protocol (1-Modbus RTU, 2-Modbus ASCII, 3-DNP)	1
7549 - 7549	30026 - 30026	COM2 setup	UINT16	bit-mapped	----dddd -ppp-bbb	bbb = baud rate (1-9600, 2-19200, 4-38400, 6-57600)	1
754A - 754A	30027 - 30027	COM2 address	UINT16	1 to 247	none		1
754B - 754B	30028 - 30028	Limit #1 Identifier	UINT16	0 to 65535		use Modbus address as the identifier (see notes 7, 11, 12)	1
754C - 754C	30029 - 30029	Limit #1 Out High Setpoint	SINT16	-200.0 to +200.0	0.1% of full scale	Setpoint for the "above" limit (LM1), see notes 11-12.	1
754D - 754D	30030 - 30030	Limit #1 In High Threshold	SINT16	-200.0 to +200.0	0.1% of full scale	Threshold at which "above" limit clears; normally less than or equal to the "above" setpoint; see notes 11-12.	1
754E - 754E	30031 - 30031	Limit #1 Out Low Setpoint	SINT16	-200.0 to +200.0	0.1% of full scale	Setpoint for the "below" limit (LM2), see notes 11-12.	1
754F - 754F	30032 - 30032	Limit #1 In Low Threshold	SINT16	-200.0 to +200.0	0.1% of full scale	Threshold at which "below" limit clears; normally greater than or equal to the "below" setpoint; see notes 11-12.	1
7550 - 7554	30033 - 30037	Limit #2	SINT16	same as Limit #1	same as Limit #1	same as Limit #1	5
7555 - 7559	30038 - 30042	Limit #3	SINT16				5
755A - 755E	30043 - 30047	Limit #4	SINT16				5
755F - 7563	30048 - 30052	Limit #5	SINT16				5
7564 - 7568	30053 - 30057	Limit #6	SINT16				5
7569 - 756D	30058 - 30062	Limit #7	SINT16				5
756E - 7572	30063 - 30067	Limit #8	SINT16				5
Block Size:							68

Modbus Address		Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Hex	Decimal						
12-Bit Readings Section							
12-Bit Block							
9C40 - 9C40	40001 - 40001	System Sanity Indicator	UINT16	0 or 1	none	0 indicates proper meter operation	1
9C41 - 9C41	40002 - 40002	Volts A-N	UINT16	2047 to 4095	volts	2047= 0, 4095= +150	1
9C42 - 9C42	40003 - 40003	Volts B-N	UINT16	2047 to 4095	volts		1
9C43 - 9C43	40004 - 40004	Volts C-N	UINT16	2047 to 4095	volts	volts = 150 * (register - 2047) / 2047	1
9C44 - 9C44	40005 - 40005	Amps A	UINT16	0 to 4095	amps	0= -10, 2047= 0, 4095= +10	1
9C45 - 9C45	40006 - 40006	Amps B	UINT16	0 to 4095	amps		1
9C46 - 9C46	40007 - 40007	Amps C	UINT16	0 to 4095	amps	amps = 10 * (register - 2047) / 2047	1
9C47 - 9C47	40008 - 40008	Watts, 3-Ph total	UINT16	0 to 4095	watts	0= -3000, 2047= 0, 4095= +3000	1
9C48 - 9C48	40009 - 40009	VARs, 3-Ph total	UINT16	0 to 4095	VARs	watts, VARs, VAs =	1
9C49 - 9C49	40010 - 40010	VAs, 3-Ph total	UINT16	2047 to 4095	VAs	3000 * (register - 2047) / 2047	1
9C4A - 9C4A	40011 - 40011	Power Factor, 3-Ph total	UINT16	1047 to 3047	none	1047= -1, 2047= 0, 3047= +1 pf = (register - 2047) / 1000	1
9C4B - 9C4B	40012 - 40012	Frequency	UINT16	0 to 2730	Hz	0= 45 or less, 2047= 60, 2730= 65 or more freq = 45 + ((register / 4095) * 30)	1
9C4C - 9C4C	40013 - 40013	Volts A-B	UINT16	2047 to 4095	volts	2047= 0, 4095= +300	1
9C4D - 9C4D	40014 - 40014	Volts B-C	UINT16	2047 to 4095	volts		1
9C4E - 9C4E	40015 - 40015	Volts C-A	UINT16	2047 to 4095	volts	volts = 300 * (register - 2047) / 2047	1
9C4F - 9C4F	40016 - 40016	CT numerator	UINT16	1 to 9999	none		1
9C50 - 9C50	40017 - 40017	CT multiplier	UINT16	1, 10, 100	none	CT = numerator * multiplier / denominator	1
9C51 - 9C51	40018 - 40018	CT denominator	UINT16	1 or 5	none		1
9C52 - 9C52	40019 - 40019	PT numerator	UINT16	1 to 9999	none		1
9C53 - 9C53	40020 - 40020	PT multiplier	UINT16	1, 10, 100	none	PT = numerator * multiplier / denominator	1
9C54 - 9C54	40021 - 40021	PT denominator	UINT16	1 to 9999	none		1
9C55 - 9C56	40022 - 40023	W-hours, Positive	UINT32	0 to 99999999	Wh per energy format	* 5 to 8 digits	2
9C57 - 9C58	40024 - 40025	W-hours, Negative	UINT32	0 to 99999999	Wh per energy format	* decimal point implied, per energy format	2
9C59 - 9C5A	40026 - 40027	VAR-hours, Positive	UINT32	0 to 99999999	VARh per energy format	* decimal point = resolution of digit before energy format	2
9C5B - 9C5C	40028 - 40029	VAR-hours, Negative	UINT32	0 to 99999999	VARh per energy format		2
9C5D - 9C5E	40030 - 40031	VA-hours	UINT32	0 to 99999999	VAh per energy format	* see note 10	2
9C5F - 9C5F	40032 - 40032	Neutral Current	UINT16	0 to 4095	amps	see Amps A/B/C above	1
9C60 - 9CA2	40033 - 40099	Reserved	N/A	N/A	none		67
9CA3 - 9CA3	40100 - 40100	Reset Energy Accumulators	UINT16	password ⁵		write-only register; always reads as 0	1
Block Size:							100
End of Map							

SINT32 / UINT32 32-bit signed / unsigned integer spanning 2 registers. The lower-addressed register is the high order half
 FLOAT 32-bit IEEE floating point number spanning 2 registers. The lower-addressed register is the high order half (i.e., contains the exponent)

- 1 All registers not explicitly listed in the table read as 0. Writes to these registers will be accepted but won't actually change the register (since it doesn't exist).
- 2 Meter Data Section items read as 0 until first readings are available or if the meter is not in operating mode. Writes to these registers will be accepted but won't actually change the register.
- 3 Register valid only in programmable settings update mode. In other modes these registers read as 0 and return an illegal data address exception if a write is attempted.
- 4 Meter command registers always read as 0. They may be written only when the meter is in a suitable mode. The registers return an illegal data address exception if a write is attempted in an incorrect mode.
- 5 If the password is incorrect, a valid response is returned but the command is not executed. Use 5555 for the password if passwords are disabled in the programmable settings.

- 6 M denotes a 1,000,000 multiplier.
- 7 Not applicable to V-Switch E.
- 8 Writing this register causes data to be saved permanently in EEPROM. If there is an error while saving, a slave device failure exception is returned and programmable settings mode automatically terminates via reset.
- 9 Reset commands make no sense if the meter state is LIMP. An illegal function exception will be returned.
- 10 Energy registers should be reset after a format change.
- 11 Entities to be monitored against limits are identified by Modbus address. Entities occupying multiple Modbus registers, such as floating point values, are identified by the lower register address. If any of the 8 limits is unused, set its identifier to zero. If the indicated Modbus register is not used or is a non-sensical entity for limits, it will behave as an unused limit.

- 12 There are 2 setpoints per limit, one above and one below the expected range of values. LM1 is the "too high" limit, LM2 is "too low". The entity goes "out of limit" on LM1 when its value is greater than the setpoint. It remains "out of limit" until the value drops below the in threshold. LM2 works similarly, in the opposite direction. If limits in only one direction are of interest, set the in threshold on the "wrong" side of the setpoint. Limits are specified as % of full scale, where full scale is automatically set appropriately for the entity being monitored:
 - current FS = CT numerator * CT multiplier
 - voltage FS = PT numerator * PT multiplier
 - power FS = CT numerator * CT multiplier * PT numerator * PT multiplier * 3 [* SQRT(3) for delta hookup]
 - frequency FS = 60 (or 50)
 - power factor FS = 1.0
 - percentage FS = 100.0
 - angle FS = 180.0
- 13 THD not available shows 65535 (=0xFFFF) in all THD and harmonic magnitude registers for the channel when V-switch=E. THD may be unavailable due to low V or I amplitude, or delta hookup (V only).
- 14 All 3 voltage angles are measured for Wye and Delta hookups. For 2.5 Element, Vac is measured and Vab & Vbc are calculated. If a voltage phase is missing, the two voltage angles in which it participates are set to zero. A and C phase current angles are measured for all hookups. B phase current angle is measured for Wye and is zero for other hookups. If a voltage phase is missing, its current angle is zero.