



Digital Energy
Multilin



EPM 2200

**MULTI-FUNCTION
POWER METER**

Instruction Manual

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EPM 2200 Multi-function Power Metering System

Chapter 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 *EI 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 wye (Y). Fig. 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).

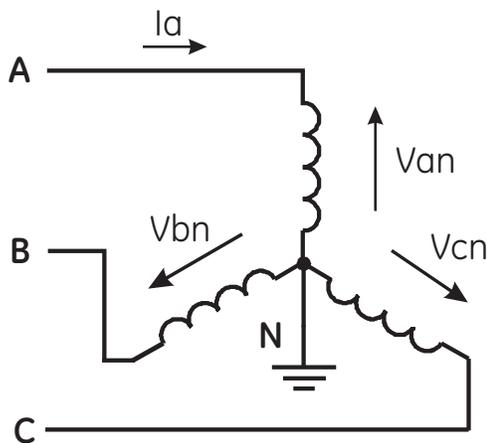


FIGURE 1-1: Three-phase Wye winding

The three voltages are separated by 120° electrically. Under balanced load conditions with unity power factor 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 below.

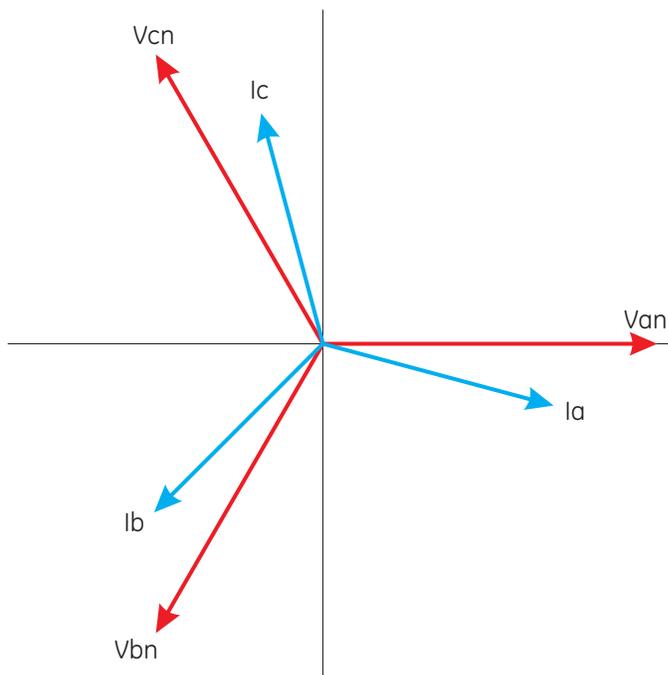


FIGURE 1-2: Three-phase Voltage and Current Phasors for Wye Winding

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.

The following table indicates the common voltages used in the United States for wye connected systems.

Table 1–1: Common Phase Voltages on Wye Services

Phase-to-Ground Voltage	Phase-to-Phase Voltage
120 volts	208 volts
277 volts	480 volts
2400 volts	4160 volts
7200 volts	12470 volts
7620 volts	13200 volts

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. The neutral wire is typically tied to the ground or center point of the wye (refer to the *Three-Phase Wye Winding* diagram above).

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 the table above, 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. The following figure shows the physical load connections for a delta service.

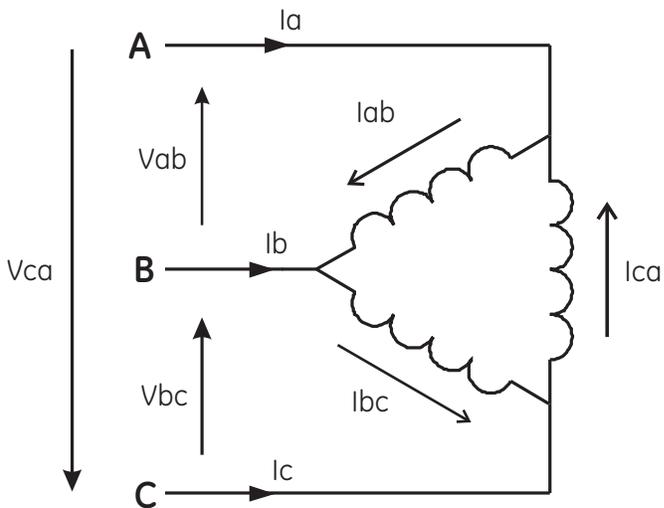


FIGURE 1-3: Three-phase Delta Winding Relationship

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.

The following diagram 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.

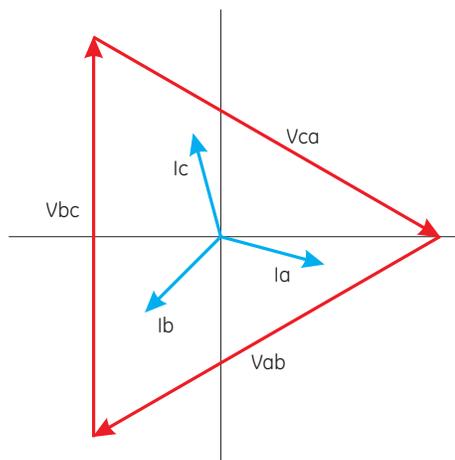


FIGURE 1-4: Three-Phase Voltage and Current Phasors for Delta Winding

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. The phasor diagram for the voltages in a three-phase, four-wire delta system is shown below.

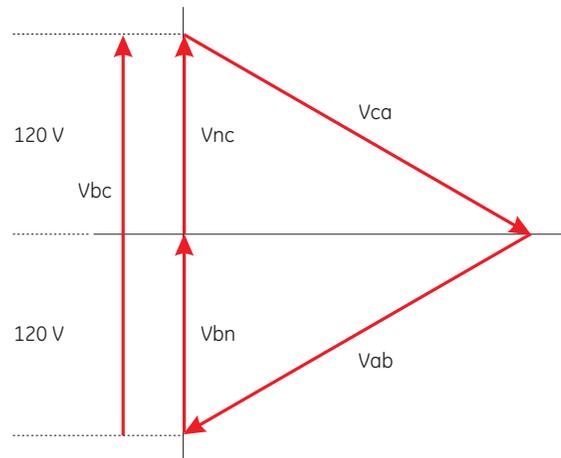


FIGURE 1-5: Three-Phase, Four-Wire Delta Phasors

1.1.3 Blondell's Theorem and Three Phase Measurement

In 1893 an engineer and mathematician named Andre E. Blondell set forth the first scientific basis for poly phase 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 Blondell'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, Blondell'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 calculate 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 combines 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.

Blondell'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 Laws hold 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.

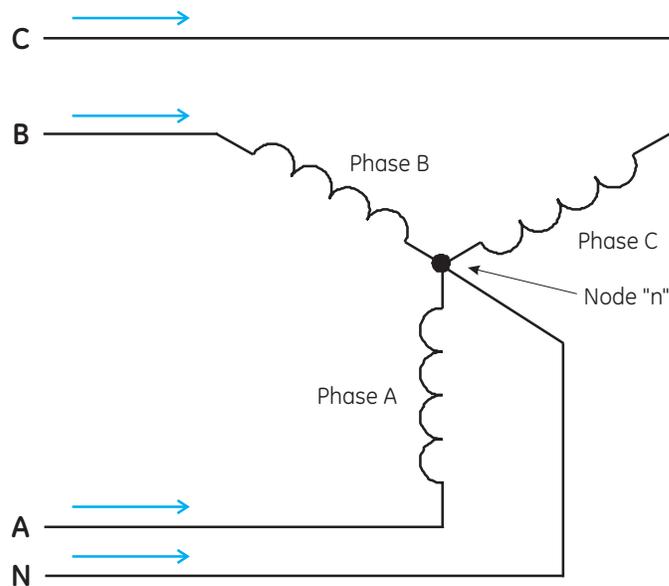


FIGURE 1-6: Three-Phase Load Illustrating Kirchhoff's Law and Blondell's Theorem

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 Blondell'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 1 kWh.

The following figure 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.

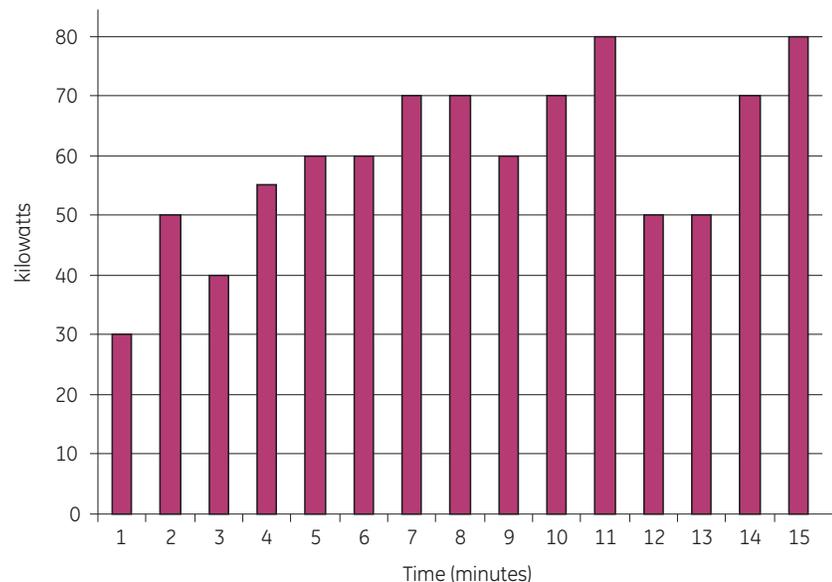


FIGURE 1-7: Power Use Over Time

The data from Figure 1-7 is reproduced in the table below 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).

Table 1-2: Power and Energy Relationship Over Time

Time Interval (Minutes)	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

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.

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.

1.2.1 Demand

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 and adjust the energy reading to an hourly value that constitutes the demand.

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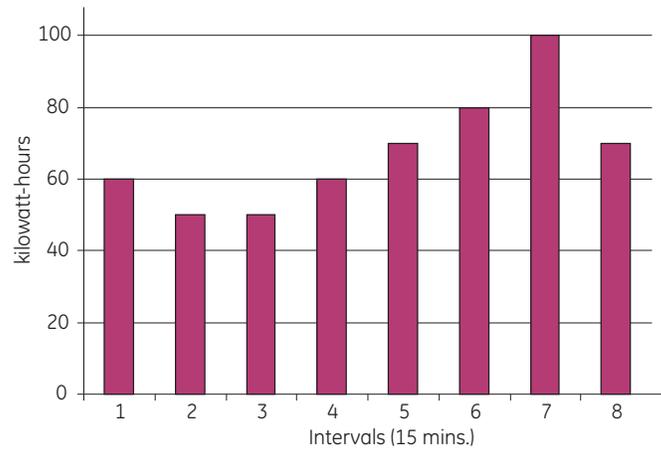


FIGURE 1-8: Energy Use and Demand Intervals

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

1.3 Reactive Energy and Power Factor

1.3.1 Real, Reactive, and Apparent Power

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 in-phase 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.

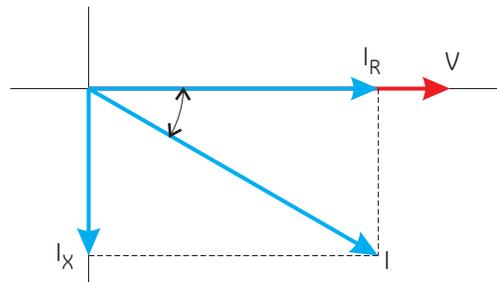


FIGURE 1-9: Voltage and Complex Current

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, most utilities impose a penalty if the VAR content of the load rises above a specified value.

1.3.2 Power Factor

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:

:

$$\text{Total PF} = \frac{\text{real power}}{\text{apparent power}} = \frac{\text{watts}}{\text{VA}} \quad \text{(EQ 1.1)}$$

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:

$$\text{Displacement PF} = \cos \theta \quad \text{(EQ 1.2)}$$

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.

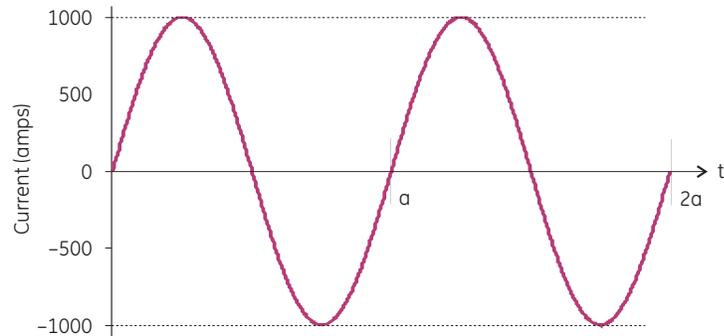


FIGURE 1-10: Non-distorted current waveform

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.

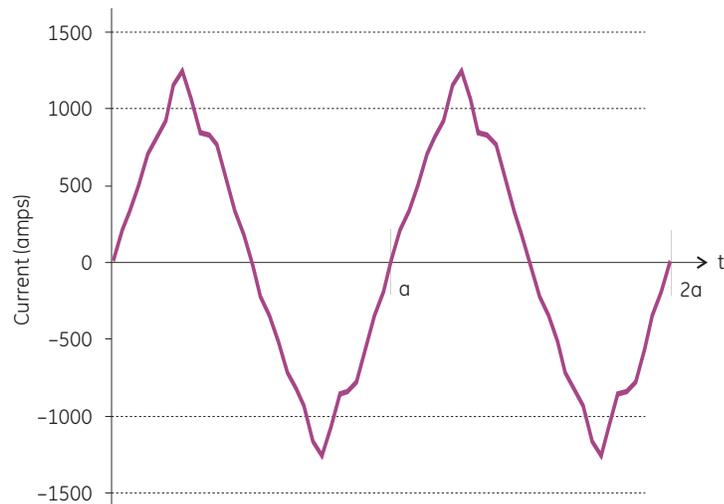


FIGURE 1-11: Distorted current wave

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.

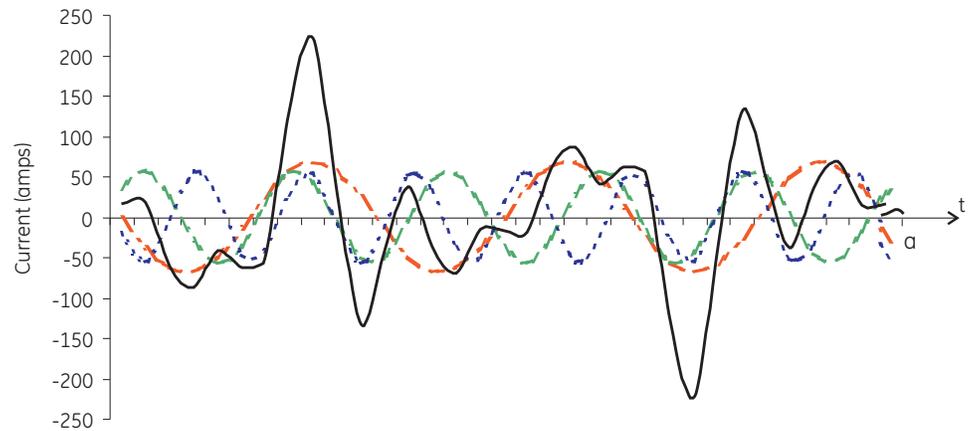


FIGURE 1-12: Waveforms of the harmonics

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.

1.4.1 Inductive and capacitive impedance

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.

$$X_L = j\omega L \quad \text{and} \quad X_C = 1/j\omega C \quad (\text{EQ 1.3})$$

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 different in 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.

1.4.2 Voltage and Current Monitoring

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 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.

1.4.3 Waveform Capture

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 below.

Table 1-3: Typical Power Quality Problems and Sources

Cause	Disturbance Type	Source(s)
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 second or longer duration	System protection; Circuit breakers; Fuses; Maintenance
Undervoltage/Overvoltage	RMS voltage, steady state, multiple second 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

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.



EPM 2200 Multi-function Power Metering System

Chapter 2: Overview and Specifications

2.1 Hardware Overview

The EPM2200 monitor is a 0.5% class electrical panel meter. Using bright and large .56" LED displays, it is designed to be used in electrical panels and switchgear. The meter has a unique anti-dither algorithm to improve reading stability. The EPM2200 meter uses high-speed DSP technology with high-resolution A/D conversion to provide stable and reliable measurements.

The EPM2200 meter is a meter and transducer in one compact unit. Featuring an optional RS485 port, it can be programmed using the faceplate of the meter or through software. ANSI or DIN mounting may be used..

EPM2200 meter features that are detailed in this manual are as follows:

- 0.5% Class Accuracy
- Multifunction Measurement including Voltage, Current, Power, Frequency, Energy, etc.
- Percentage of Load Bar for Analog Meter Perception
- Easy to Use Faceplate Programming
- RS485 Modbus Communication

2.1.1 Voltage and Current Inputs

Universal Voltage Inputs

Voltage Inputs allow measurement to 416 Volts Line-to-Neutral and 721 Volts Line-to-Line. This insures proper meter safety when wiring directly to high voltage systems. One unit will perform to specification on 69 Volt, 120 Volt, 230 Volt, 277 Volt, 277 Volt and 347 Volt power systems.

Current Inputs

The EPM2200 meter's Current Inputs use a unique dual input method:

Method 1: CT Pass Through.

The CT passes directly through the meter without any physical termination on the meter. This insures that the meter cannot be a point of failure on the CT circuit. This is preferable for utility users when sharing relay class CTs. No Burden is added to the secondary CT circuit.

Method 2: Current “Gills”.

This unit additionally provides ultra-rugged Termination Pass Through Bars that allow CT leads to be terminated on the meter. This, too, eliminates any possible point of failure at the meter. This is a preferred technique for insuring that relay class CT integrity is not compromised (the CT will not open in a fault condition).

2.1.2 Order Codes

The order codes for the EPM 2200 are indicated below.

Table 2–1: EPM 2200 Order Codes

PL2200	-	*	-	*
Option	A1		Volts and Amps Meter	
	B1		Volts, Amps, Power & Frequency	
	C1		Volts, Amps, Power, Frequency & Energy Counters	
Communications	X		None	
	S		RS485 + Pulse	

For example, to order an EPM 2200 to measure Volts, Amps, Power & Frequency, with RS485 + Pulse communications, use PL2200-B-S.

2.1.3 Measured Values

The following table lists the measured values available in real time, average, maximum, and minimum.

Table 2–2: EPM 2200 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
VARs	X	X	X	X
VA	X	X	X	X
Power Factor (PF)	X	X	X	X
Positive watt-hours	X			

Table 2-2: EPM 2200 Measured Values

Measured Values	Real Time	Average	Maximum	Minimum
Negative watt-hours	X			
Net watt-hours	X			
Positive VAR-hours	X			
Negative VAR-hours	X			
Net VAR-hours	X			
VA-hours	X			
Frequency	X		X	X
Voltage angles	X			
Current angles	X			
% of load bar	X			

2.1.4 Utility Peak Demand

The EPM 2200 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 maximum and minimum capability over the user-selectable averaging period. Voltage provides an instantaneous maximum and minimum reading which displays the highest surge and lowest sag seen by the meter.

2.2 Specifications

POWER SUPPLY

Range:..... Universal, (90 to 265) VAC @50/60Hz
 Power consumption:..... 5 VA

VOLTAGE INPUTS (MEASUREMENT CATEGORY III)

Range:..... Universal, Auto-ranging up to 416 V AC L-N, 721 V AC L-L
 Supported hookups:..... 3-element Wye, 2.5-element Wye, 2-element Delta,
 4-wire Delta
 Input impedance:..... 1 MOhm/phase
 Burden:..... 0.0144 VA/phase at 120 Volts
 Pickup voltage:..... 10 V AC
 Connection:..... Screw terminal
 Maximum input wire gauge:..... AWG #12 / 2.5 mm²
 Fault withstand:..... Meets IEEE C37.90.1
 Reading:..... Programmable full-scale to any PT ratio

CURRENT INPUTS

Class 10:..... 5 A nominal, 10 A maximum
 Burden:..... 0.005 VA per phase maximum at 11 A
 Pickup current:..... 0.1% of nominal
 Connections:..... O or U lug;
 Pass-through wire, 0.177" / 4.5 mm maximum diameter
 Quick connect, 0.25" male tab
 Fault Withstand (at 23°C):..... 100 A / 10 seconds, 300 A / 3 seconds, 500 A / 1 second
 Reading:..... Programmable full-scale to any CT ratio

MEASUREMENT METHODS

Voltage and current:..... True RMS
 Power:..... Sampling at 400+ samples/cycle on all channels
 measured; readings simultaneously
 A/D conversion:..... 6 simultaneous 24-bit analog-to-digital converters

UPDATE RATE

All parameters:..... Up to 1 second

ACCURACY

For 23⁰ C, 3 Phase balanced Wye or Delta load.

Parameter	Accuracy	Accuracy Input Range
Voltage L-N [V]	0.2% of reading ²	(69 to 480)V
Voltage L-L [V]	0.4% of reading	(120 to 600)V
Current Phase [A]	0.2% of reading ¹	(0.15 to 5)A
Current Neutral (calculated) [A]	2% of Full Scale ¹	(0.15 to 5)A @ (45 to 65)Hz
Active Power Total [W]	0.5% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Active Energy Total [Wh]	0.5% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Reactive Power Total [VAR]	1.0% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0 to 0.8) lag/lead PF
Reactive Energy Total [VARh]	1.0% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0 to 0.8) lag/lead PF
Apparent Power Total [VA]	1.0% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Apparent Energy Total [VAh]	1.0% of reading ^{1,2}	(0.15 to 5)A @ (69 to 480)V @ +/- (0.5 to 1) lag/lead PF
Power Factor	1.0% 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
Load Bar	+/- 1 segment	(0.005 to 6)A

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

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%.

EPM 2200 accuracy meets the IEC62053-22 Accuracy Standards for 0.5% Class Meters. This standard is shown in the table below.

Value of Current	Power Factor	Percentage Error Limits for Meters of Class 0.5 S
$0.01 I_n \leq I < 0.05 I_n$	1	±1.0
$0.05 I_n \leq I \leq I_{max}$	1	±0.5
$0.02 I_n \leq I < 0.1 I_n$	0.5 inductive 0.8 capacitive	±1.0 ±1.0
$0.1 I_n \leq I \leq I_{max}$	0.5 inductive 0.8 capacitive	±0.6 ±0.6
When specially requested by the user, from: $0.1 I_n \leq I \leq I_{max}$	0.25 inductive 0.8 capacitive	±1.0 ±1.0



In the table above:

I_n = Nominal (5A)

I_{max} = Full Scale

ISOLATION

All Inputs and Outputs are galvanically isolated to 2500 V AC

ENVIRONMENTAL

Storage:.....-20 to 70°C

Operating:.....-10 to 60°C

Humidity:.....up to 95% RH, non-condensing

Faceplate rating:NEMA 12 (water resistant), mounting gasket included

COMMUNICATIONS FORMAT

Types:.....RS485P - RS485 port through back plate plus KYZ Pulse

KYZ/RS485 PORT SPECIFICATIONS

RS485 Transceiver; meets or exceeds EIA/TIA-485 Standard:

Type:Two-wire, half duplex

Min. Input Impedance:96kΩ

Max. Output Current:±60mA

Wh PULSE

KYZ output contacts (and infrared LED light pulses through face plate):

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

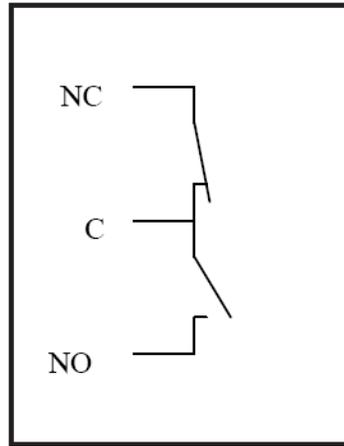


FIGURE 2-1: Internal Schematic (De-energized State)

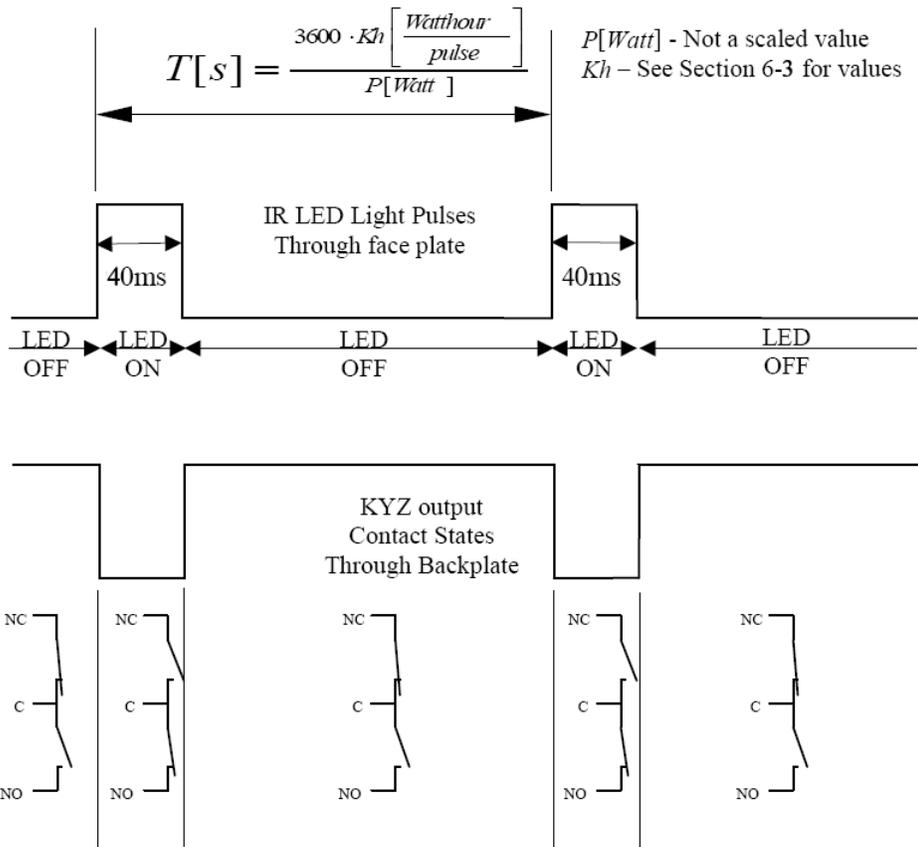


FIGURE 2-2: Output Timing



EPM 2200 Multi-function Power Metering System

Chapter 3: Mechanical Installation

3.1 Introduction

The EPM2200 meter can be installed using a standard ANSI C39.1 (4" Round) or an IEC 92mm DIN (Square) form. In new installations, simply use existing DIN or ANSI punches. For existing panels, pull out old analog meters and replace with the EPM2200 meter. The various models use the same installation. See Chapter 4 for wiring diagrams.

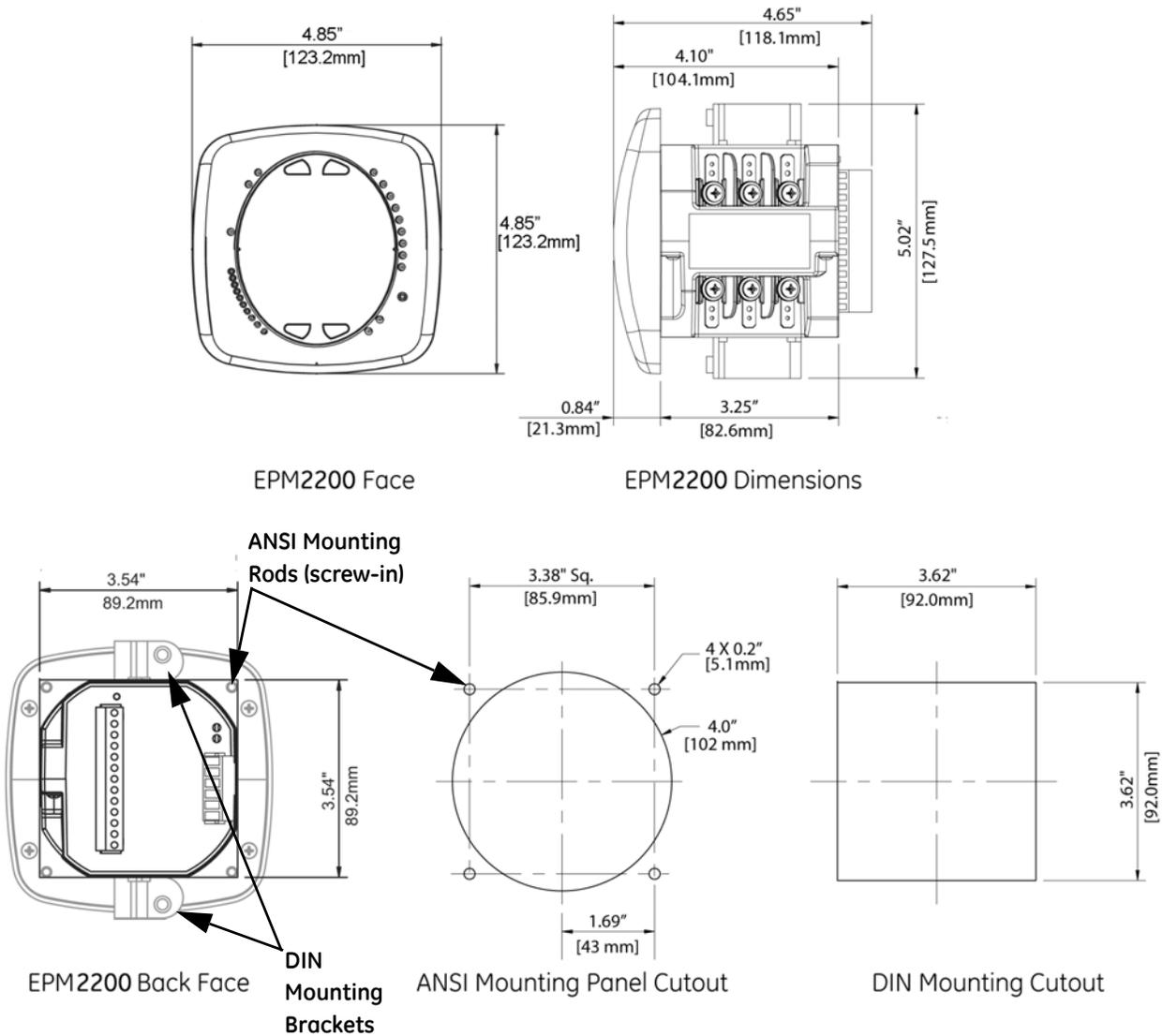


FIGURE 3-1: EPM2200 Mounting Information

Recommended Tools for EPM2200 Meter Installation:

- #2 Phillips screwdriver, small wrench and wire cutters.
- Mount the meter in a dry location free from dirt and corrosive substances. The meter is designed to withstand harsh environmental conditions. (See Environmental Specifications in Chapter 2.)

3.2 ANSI Installation Steps

1. Insert 4 threaded rods by hand into the back of meter. Twist until secure.
2. Slide ANSI 12 Mounting Gasket onto back of meter with rods in place.
3. Slide meter into panel.
4. Secure from back of panel with lock washer and nut on each threaded rod. Use a small wrench to tighten. Do not overtighten. The maximum installation torque is 0.4 Newton-Meter.

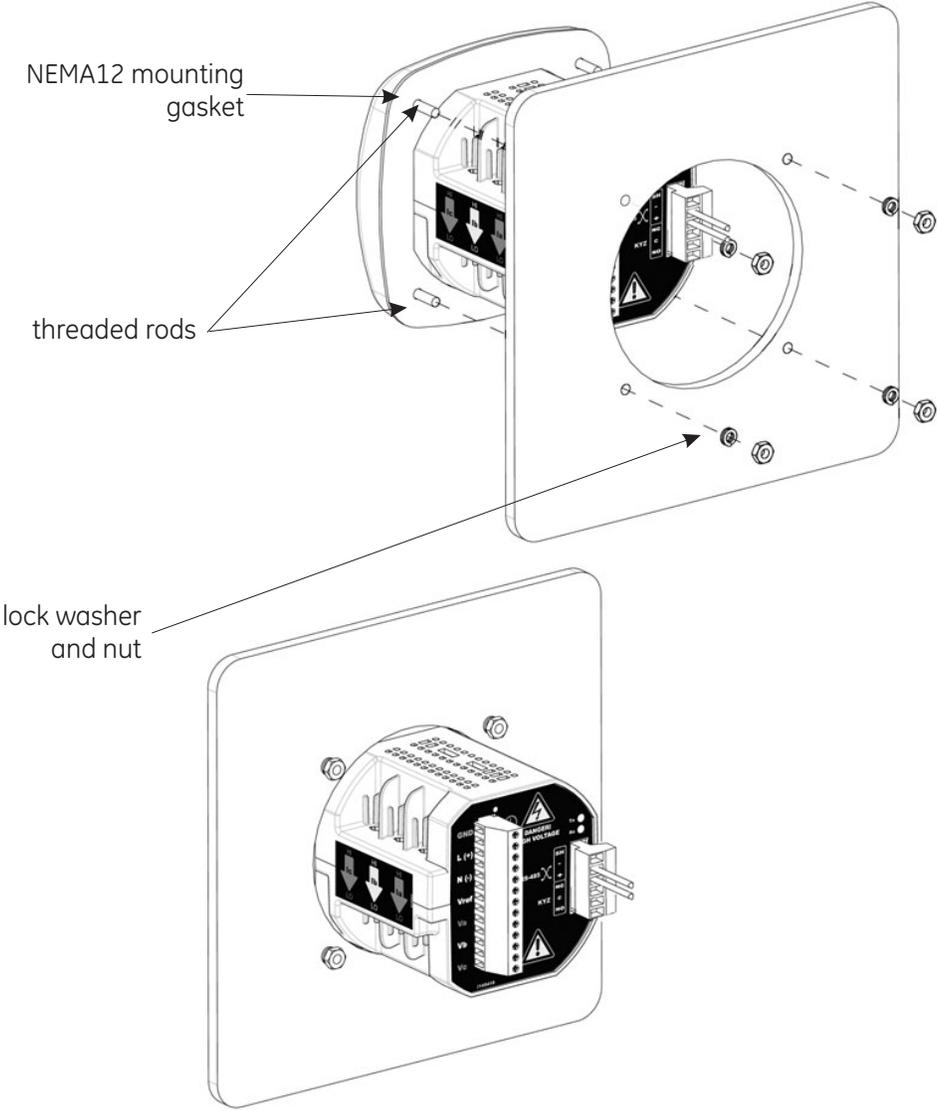


FIGURE 3-2: ANSI Mounting Procedure

3.3 DIN Installation Steps

1. Slide meter with NEMA 12 Mounting Gasket into panel. (Remove ANSI Studs, if in place.)
2. From back of panel, slide 2 DIN Mounting Brackets into grooves in top and bottom of meter housing. Snap into place.
3. Secure meter to panel with lock washer and a #8 screw through each of the 2 mounting brackets. Tighten with a #2 Phillips screwdriver. Do not overtighten. The maximum installation torque is 0.4 Newton-Meter.

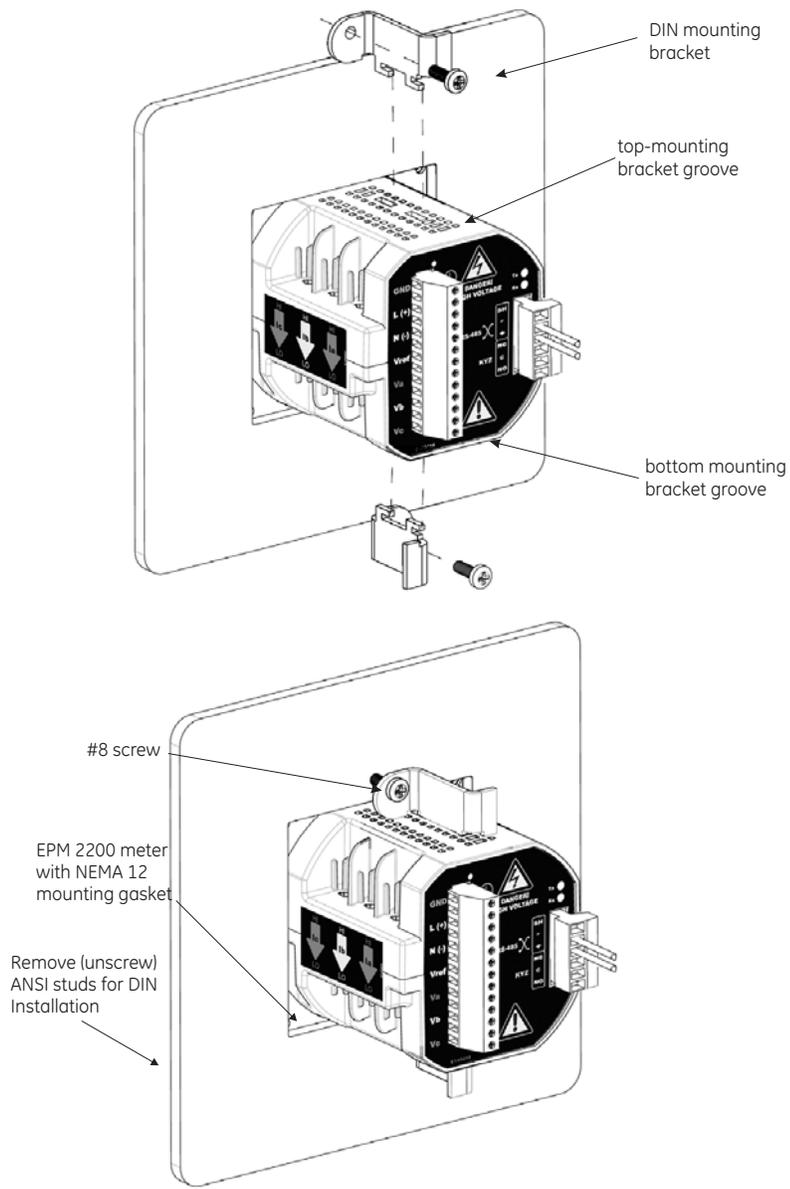


FIGURE 3-3: DIN Mounting Procedure



EPM 2200 Multi-function Power Metering System

Chapter 4: Electrical Installation

4.1 Considerations When Installing Meters

- Installation of the EPM2200 Meter must be performed by only 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.
- During normal operation of the EPM2200 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.
- 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. Do not HIPOT/Dielectric test any Outputs, Inputs or Communications terminals.
- GE recommends the use of **Shorting Blocks** and **Fuses** for voltage leads and power supply to prevent hazardous voltage conditions or damage to CTs, if the meter needs to be removed from service. **CT grounding is optional.**



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.

4.1.1 CT Leads Terminated to Meter

The EPM 2200 is designed to have Current Inputs wired in one of three ways. *Figure 4-1:* below, shows the most typical connection where CT Leads are terminated to the meter at the Current Gills.

This connection uses Nickel-Plated Brass Studs (Current Gills) with screws at each end. This connection allows the CT wires to be terminated using either an "O" or a "U" lug. Tighten the screws with a #2 Phillips screwdriver. The maximum installation torque is 1 Newton-Meter.

Other current connections are shown in Figures 3.6 and 3.7. A Voltage and RS-485 Connection is shown in Figure 3.8..

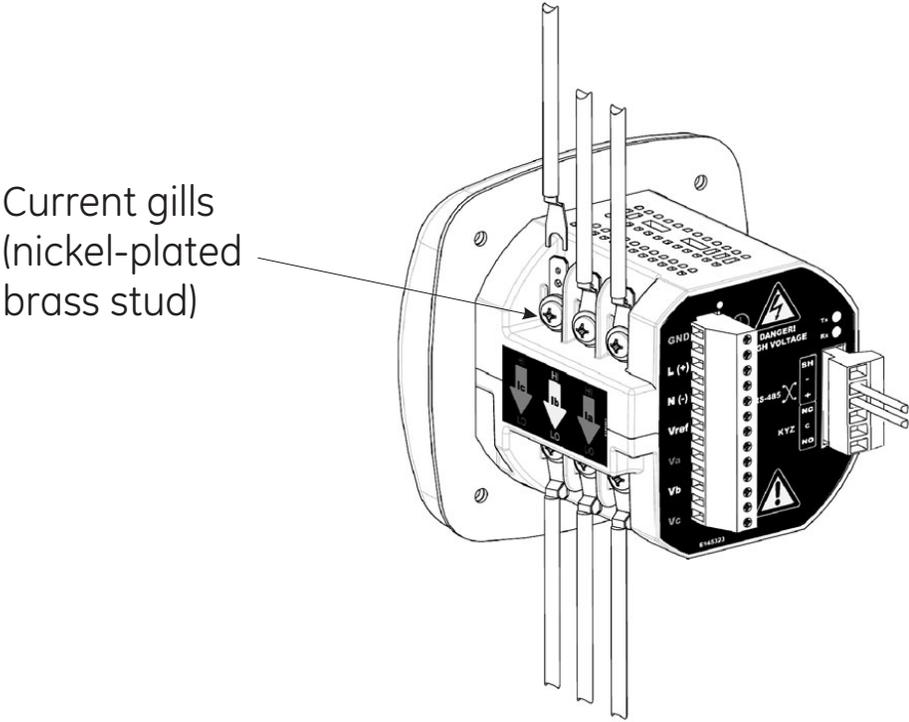


FIGURE 4-1: CT leads terminated to meter, #8 screw for lug connection

Wiring diagrams are detailed in the diagrams shown below in this chapter. Communications connections are detailed in *Chapter 5*.

4.1.2 CT Leads Pass-Through (No Meter Termination)

The second method allows the CT wires to pass through the CT Inputs without terminating at the meter. In this case, remove the current gills and place the CT wire directly through the CT opening. The opening will accommodate up to 0.177" / 4.5 mm maximum diameter CT wire.

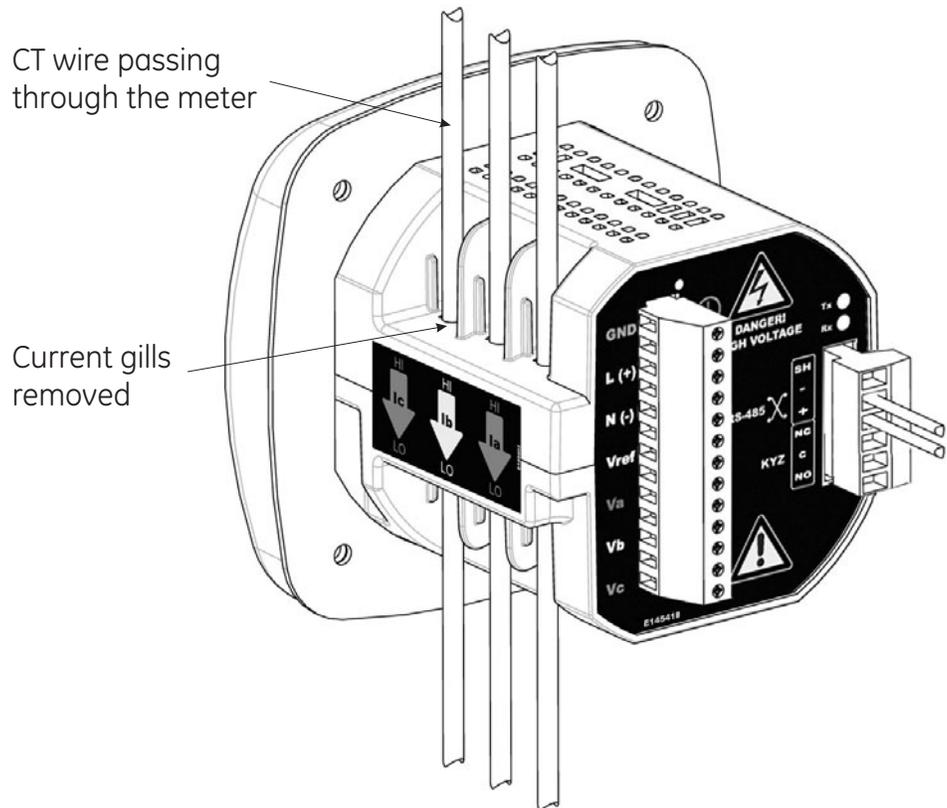


FIGURE 4–2: Pass-Through Wire Electrical Connection

4.1.3 Quick Connect Crimp CT Terminations

For quick termination or for portable applications, a quick connect crimp CT connection can also be used.

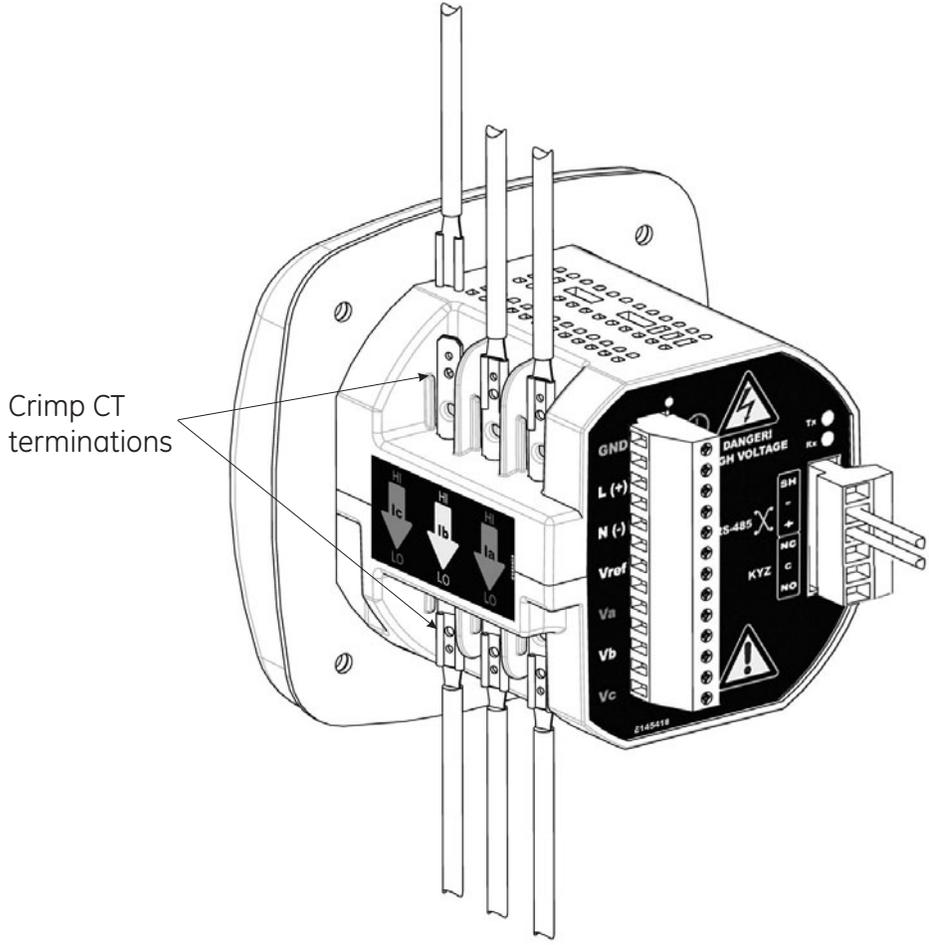


FIGURE 4-3: Quick Connect Electrical Connection

4.1.4 Voltage and Power Supply Connections

Voltage Inputs are connected to the back of the unit via a optional wire connectors. The connectors accommodate up to AWG#12 / 2.5 mm wire.

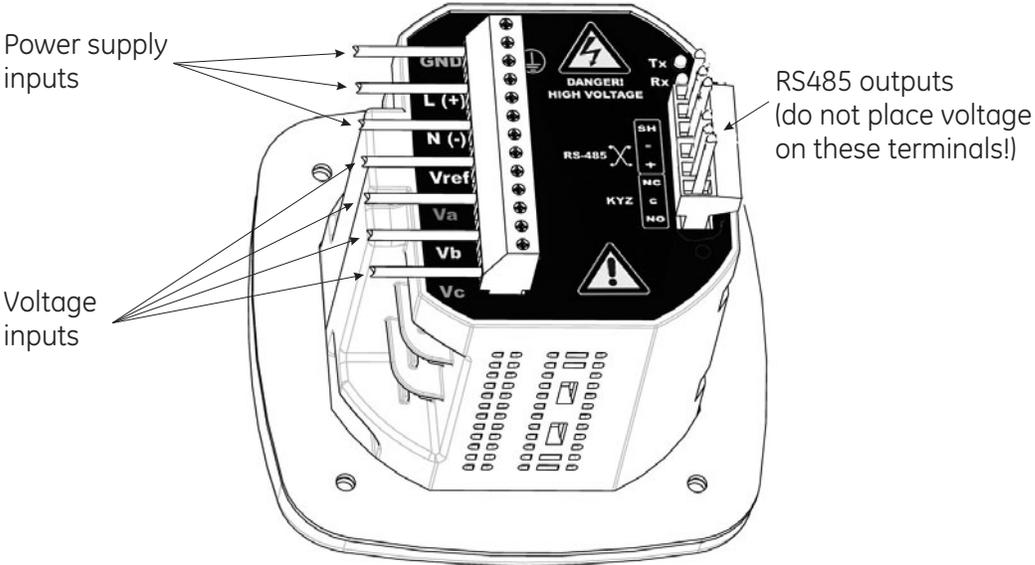


FIGURE 4-4: Voltage Connection

4.1.5 Ground Connections

The EPM 2200 ground terminals (⊕) should be connected directly to the installation's protective earth ground. Use 2.5 mm wire for this connection.

4.1.6 Voltage Fuses

GE Multilin 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 3.0 Amp fuse on the Power Supply.

4.2 Electrical Connection Diagrams

4.2.1 Description

Choose the diagram that best suits your application and maintains the CT polarity.

1. Three-phase, four-wire system Wye with no PTs (direct voltage), 3 CTs, 3 element.
 - 1a. Dual Phase Hookup
 - 1b. Single Phase Hookup
2. Three-phase, four-wire system Wye with no PTs (direct voltage), 3 CTs, 2.5 element.
3. Three-phase, four-wire Wye with 3 PTs, 3 CTs, 3 element.
4. Three-phase, four-wire Wye with 2 PTs, 3 CTs, 2.5 element.
5. Three-phase, three-wire Delta with no PTs (direct voltage), 2 CTs.
6. Three-phase, three-wire Delta with 2 PTs, 2 CTs.
7. Three-phase, three-wire Delta with 2 PTs, 3 CTs.
8. Current-only measurement (three-phase).
9. Current-only measurement (dual-phase).
10. Current-only measurement (single-phase).

These diagrams are indicated in the sections following.

4.2.2 (1) Wye, 4-Wire with no PTs and 3 CTs, no PTs, 3 Element

For this wiring type, select 3 **EL WYE** (3-element Wye) in the meter programming setup.

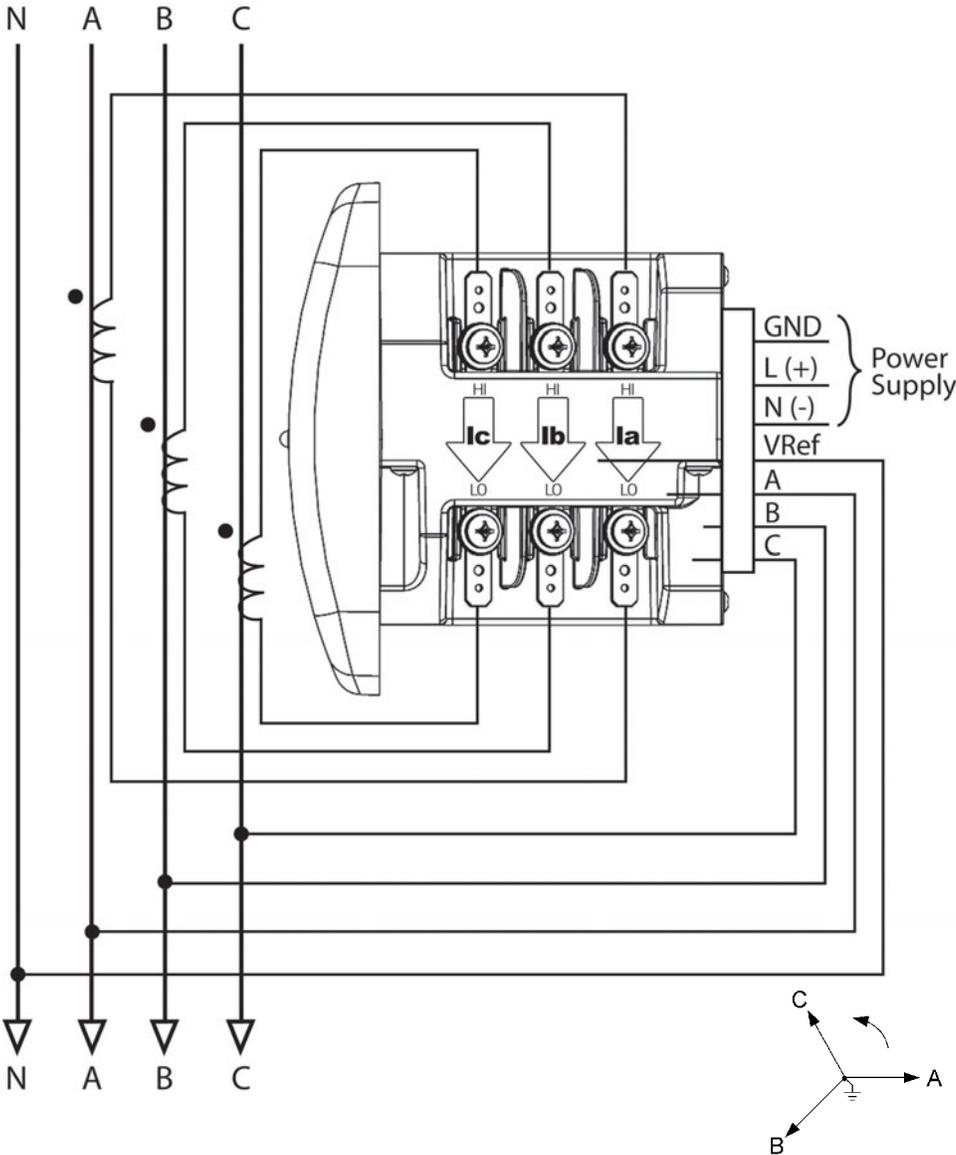
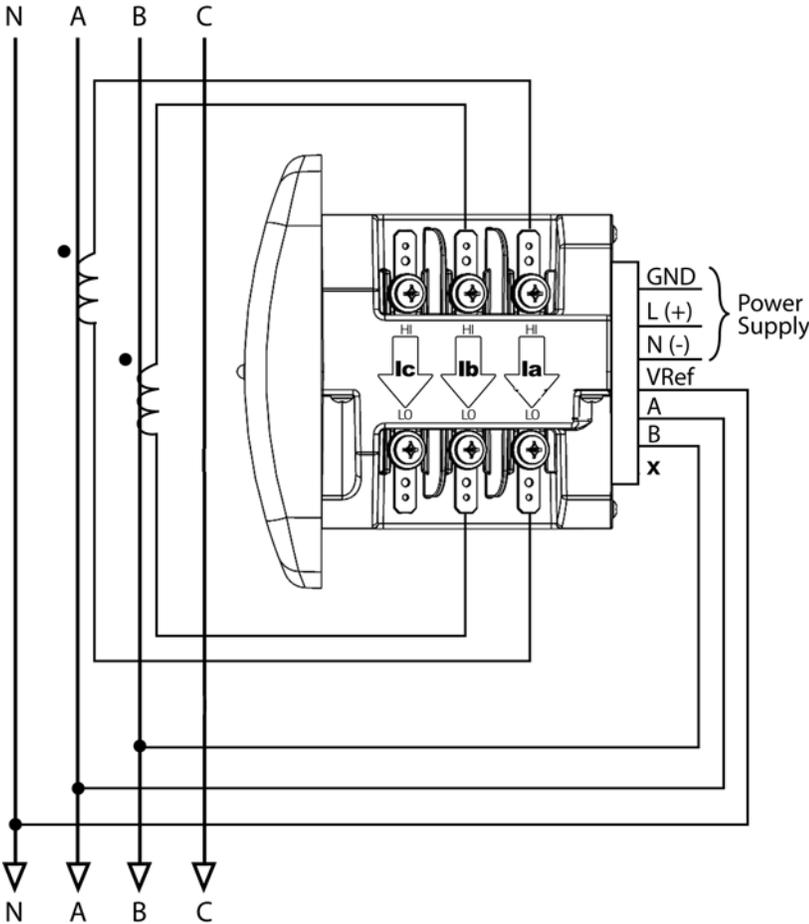
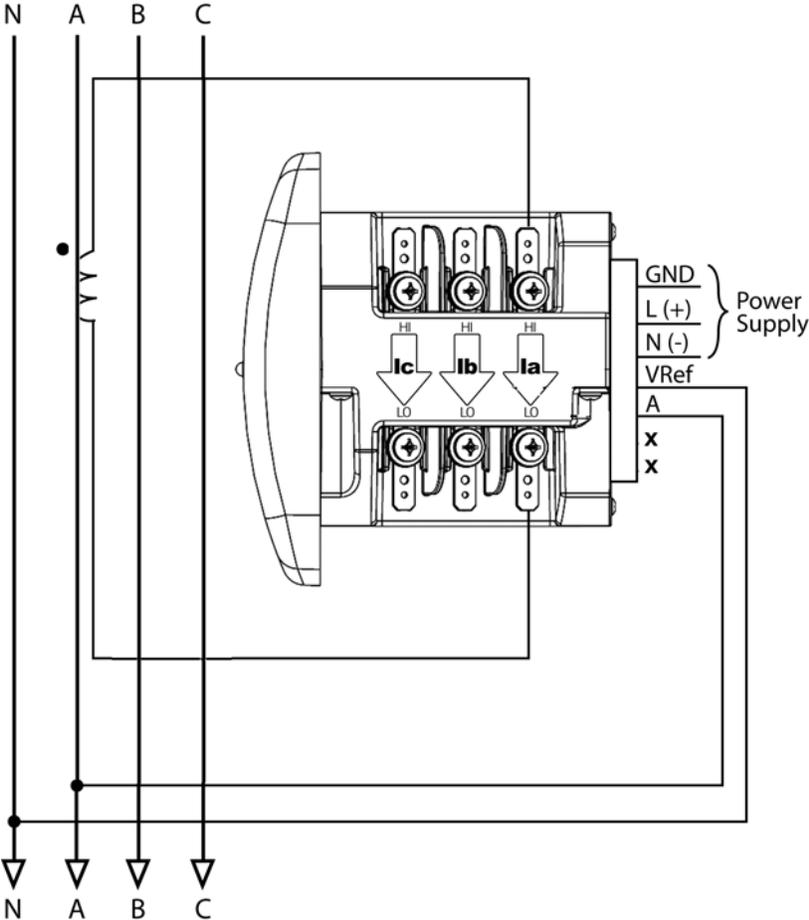


FIGURE 4-5: 4-Wire Wye with no PTs and 3 CTs, 3 Element

4.2.3 (1a) Dual Phase Hookup



4.2.4 (1b) Single Phase Hookup



4.2.5 (2) Wye, 4-Wire with no PTs and 3 CTs, 2.5 Element

For this wiring type, select **2.5EL WYE** (2.5-element Wye) in the meter programming setup.

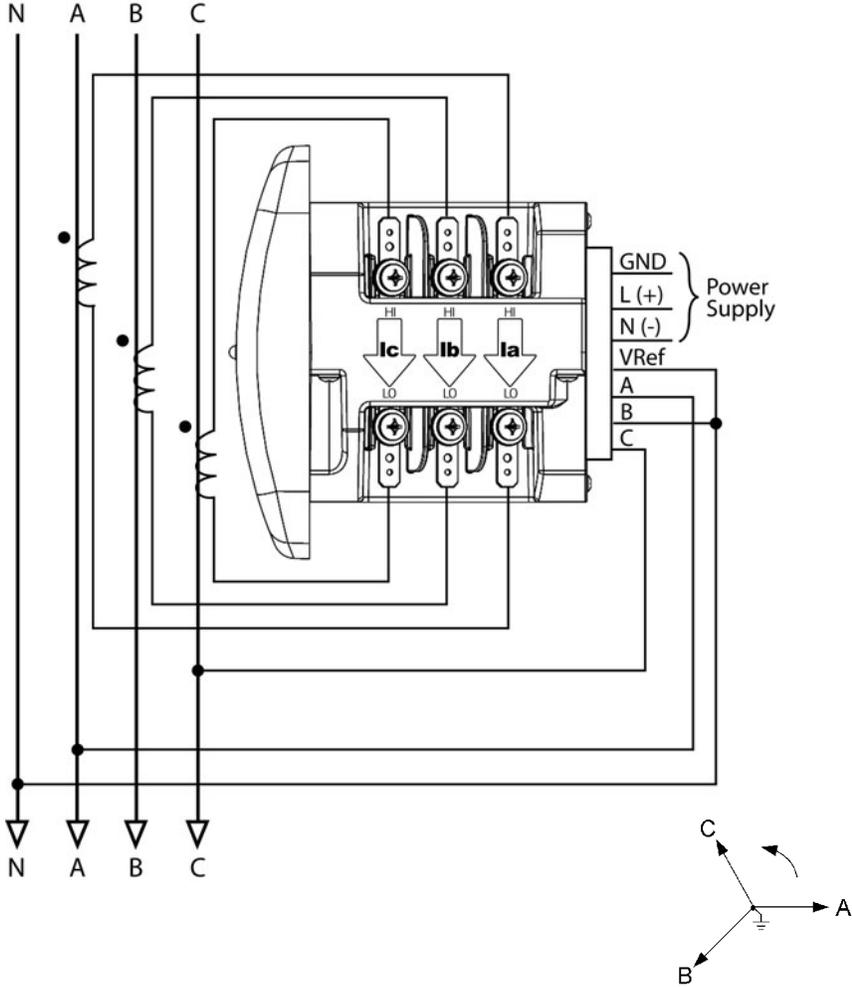


FIGURE 4-6: 4-Wire Wye with no PTs and 3 CTs, 2.5 Element

4.2.6 (3) Wye, 4-Wire with 3 PTs and 3 CTs, 3 Element

For this wiring type, select 3 **EL WYE** (3-element Wye) in the meter programming setup.

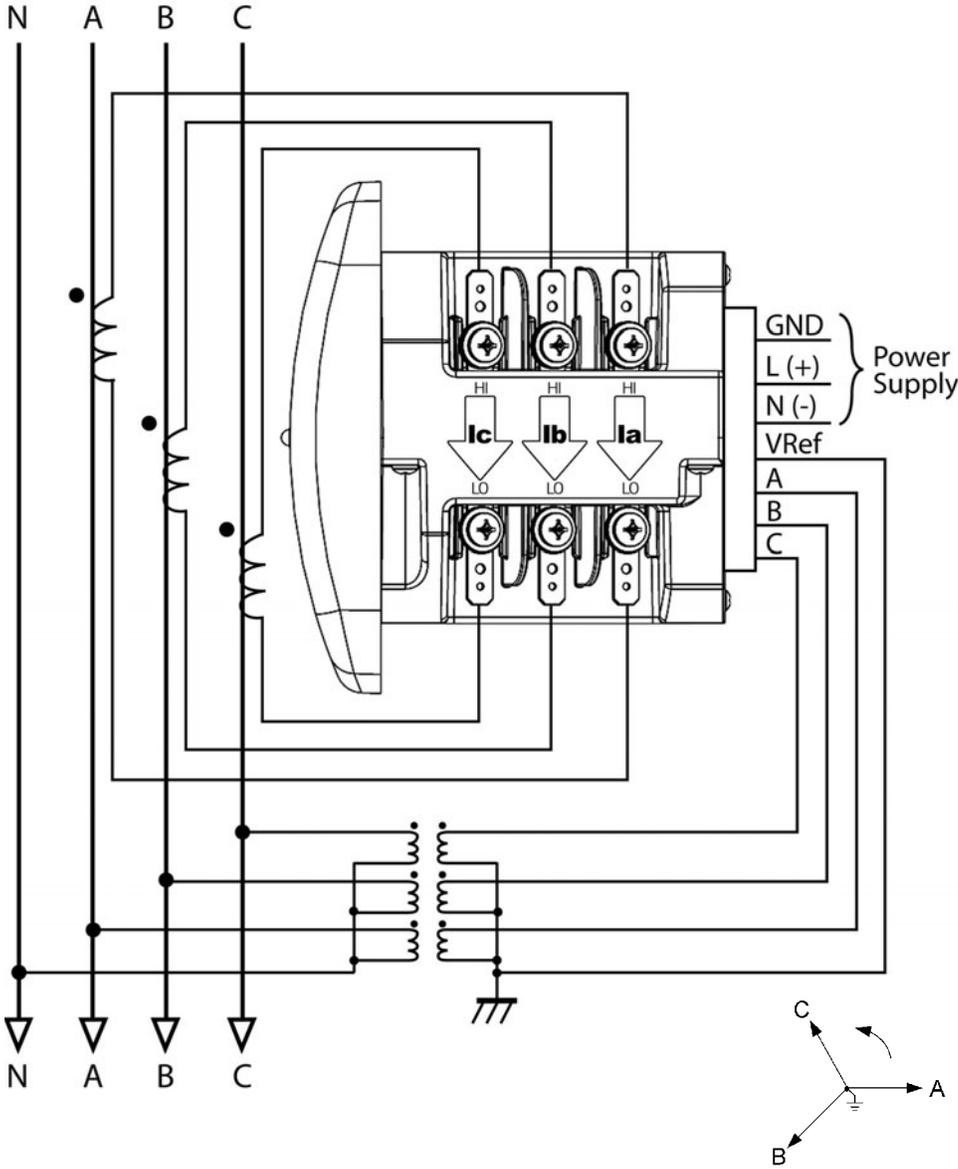


FIGURE 4-7: 4-Wire Wye with 3 PTs and 3 CTs, 3 Element

4.2.7 (4) Wye, 4-Wire with 2 PTs and 3 CTs, 2.5 Element

For this wiring type, select **2.5EL WYE** (2.5-element Wye) in the meter programming setup.

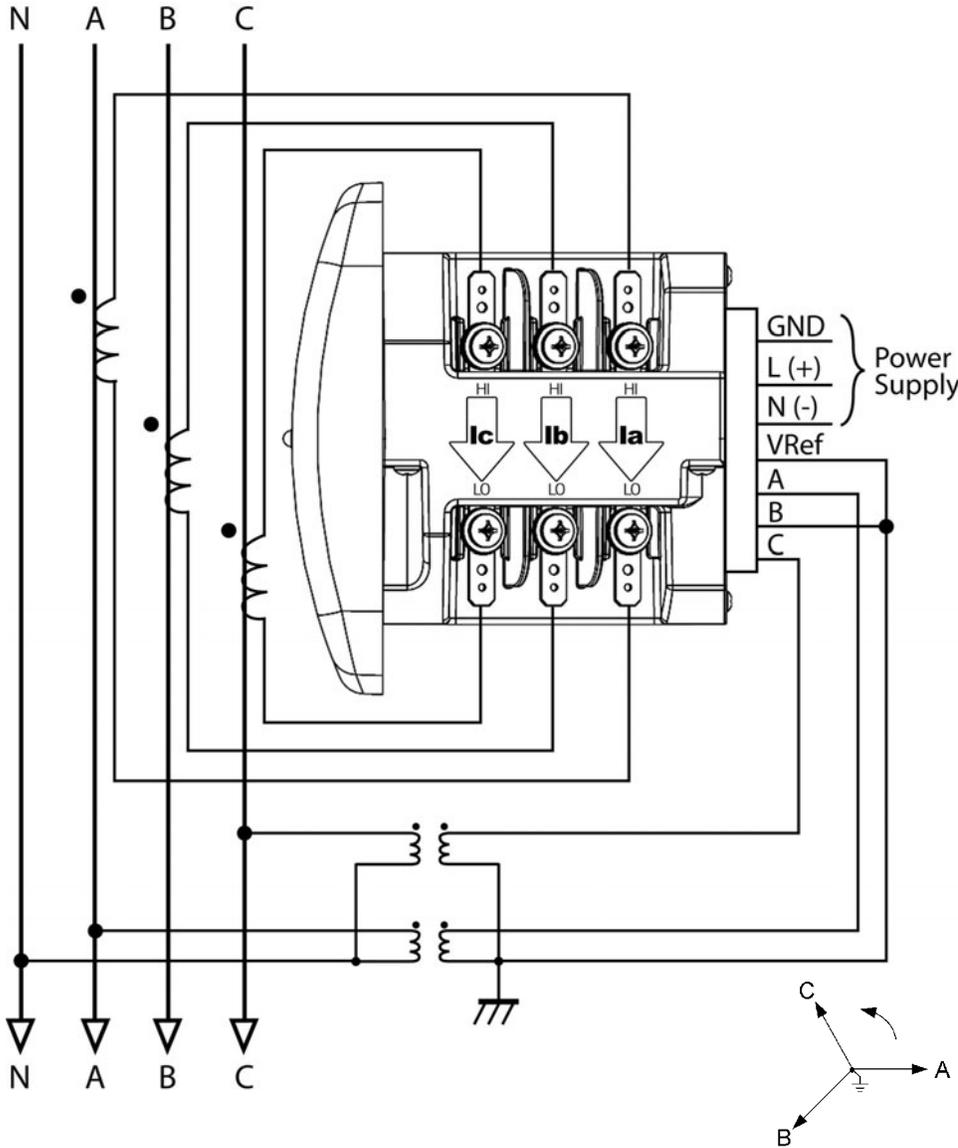


FIGURE 4-8: 4-Wire Wye with 2 PTs and 3 CTs, 2.5 Element

4.2.8 (5) Delta, 3-Wire with no PTs, 2 CTs

For this wiring type, select 2 ct DEL (2 CT Delta) in the meter programming setup.

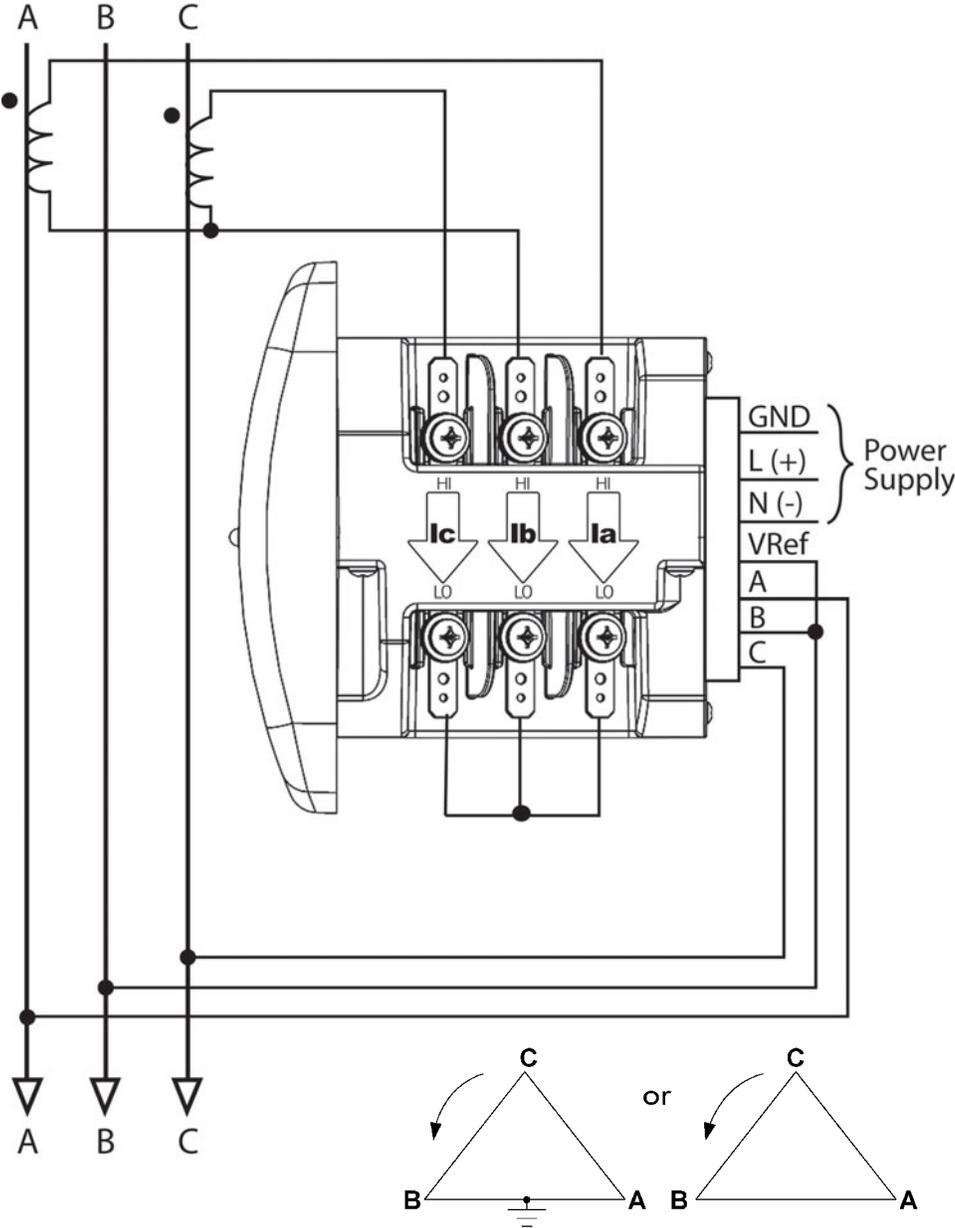


FIGURE 4-9: 3-Wire Delta with no PTs and 2 CTs

4.2.9 (6) Delta, 3-Wire with 2 PTs, 2 CTs

For this wiring type, select 2 ct DEL (2 CT Delta) in the meter programming setup.

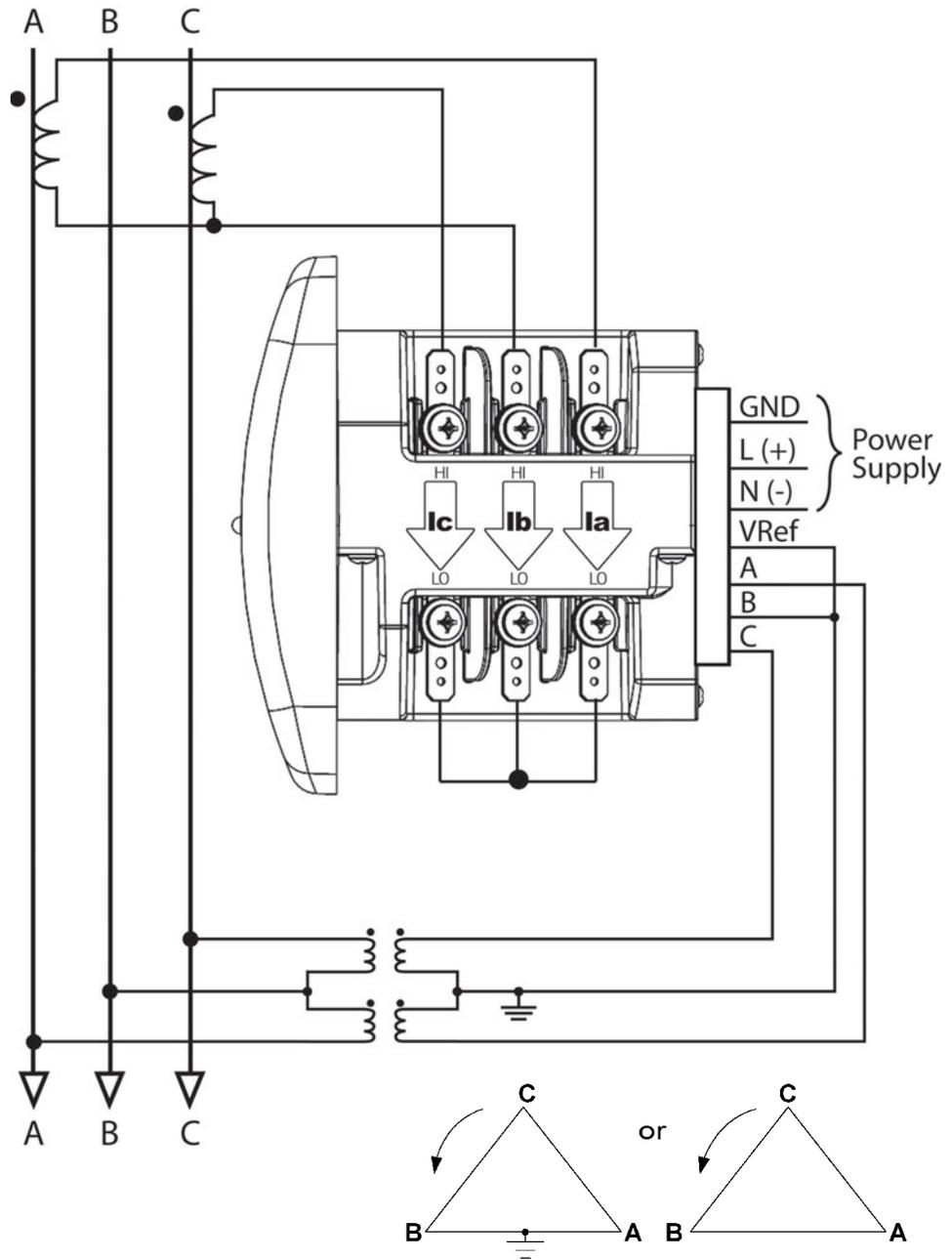


FIGURE 4-10: 3-Wire Delta with 2 PTs and 2 CTs

4.2.10 (7) Delta, 3-Wire with 2 PTs, 3 CTs

For this wiring type, select 2 ct DEL (2 CT Delta) in the meter programming setup.

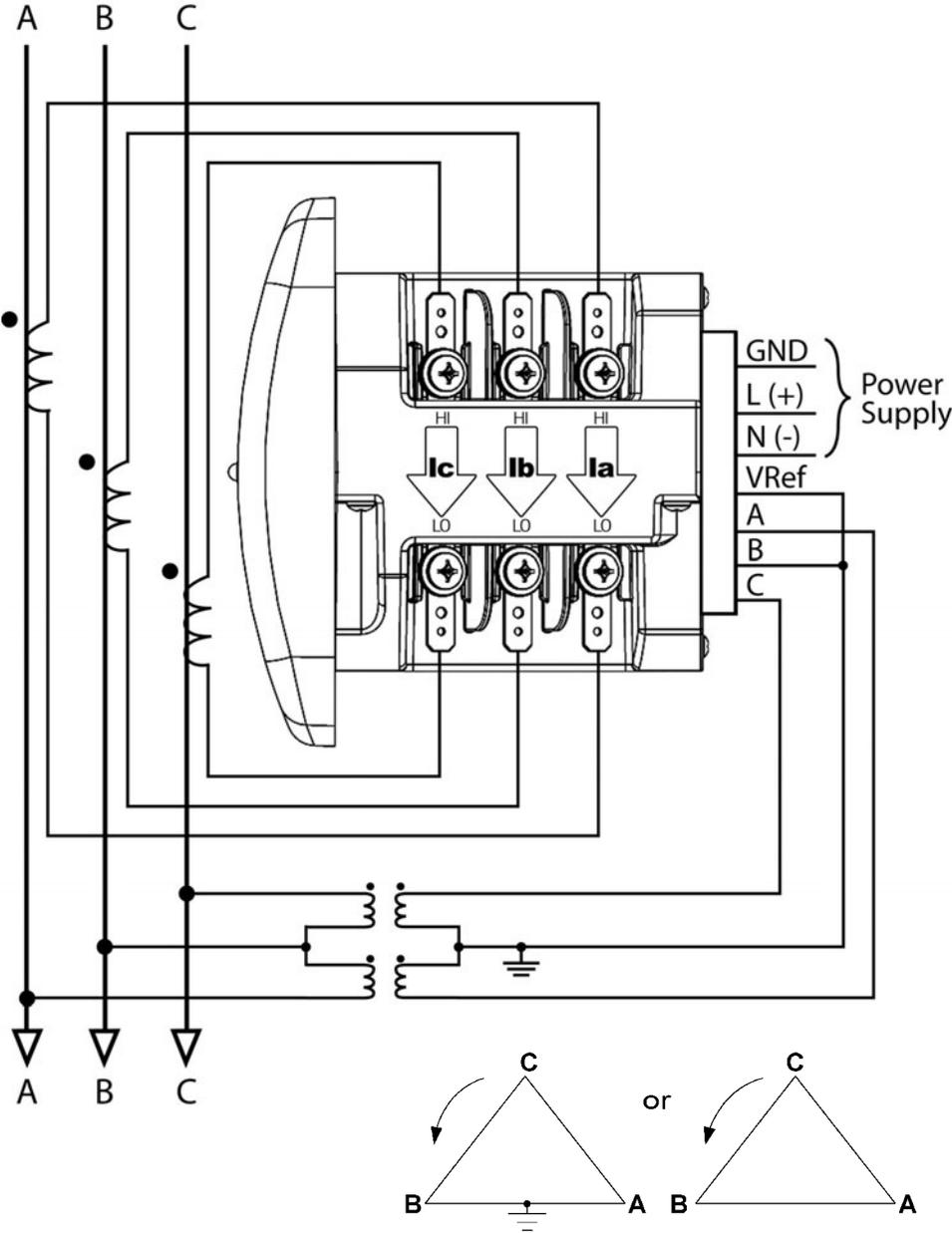


FIGURE 4-11: 3-Wire Delta with 2 PTs and 3 CTs

4.2.11 (8) Current-Only Measurement (Three-Phase)

For this wiring type, select 3 **EL WYE** (3 Element Wye) in the meter programming setup.

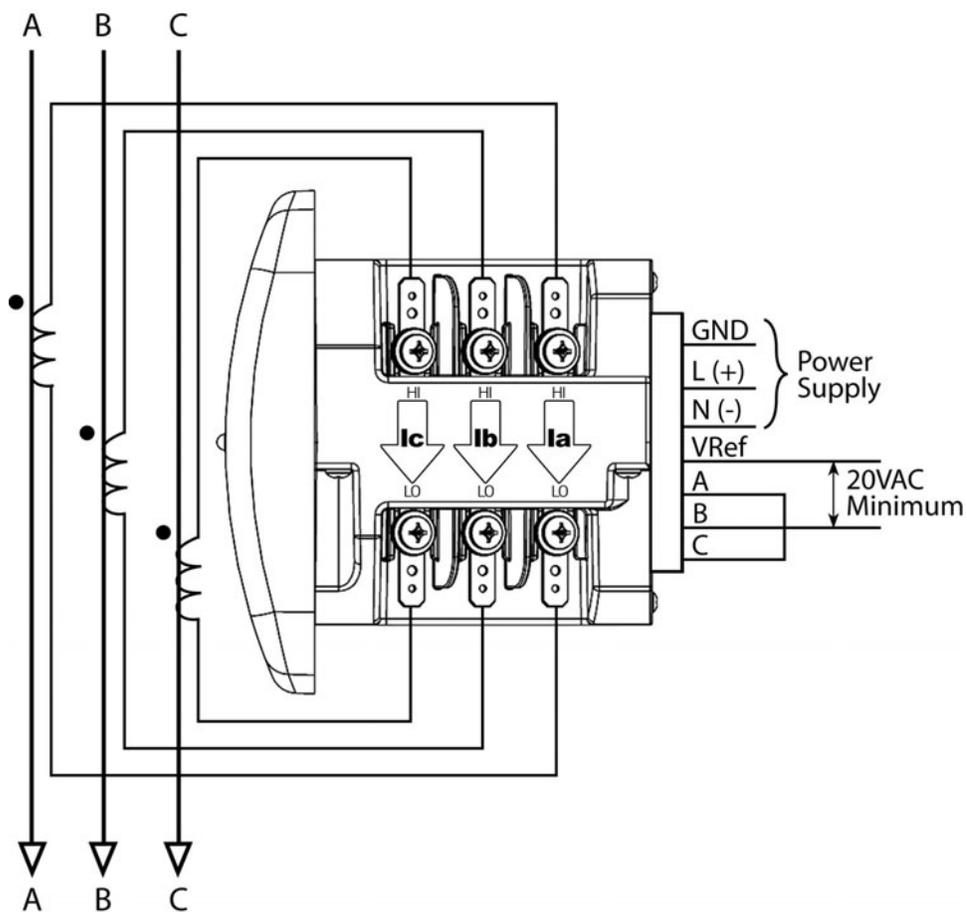


FIGURE 4-12: Current-Only Measurement (Three-Phase)



Even if the meter is used only for current measurement, the unit requires a 20VAC reference. Please ensure that the voltage input is attached to the meter. AC control power can be used to provide the reference signal.

4.2.12 (9) Current-Only Measurement (Dual-Phase)

For this wiring type, select 3 **EL WYE** (3 Element Wye) in the meter programming setup.

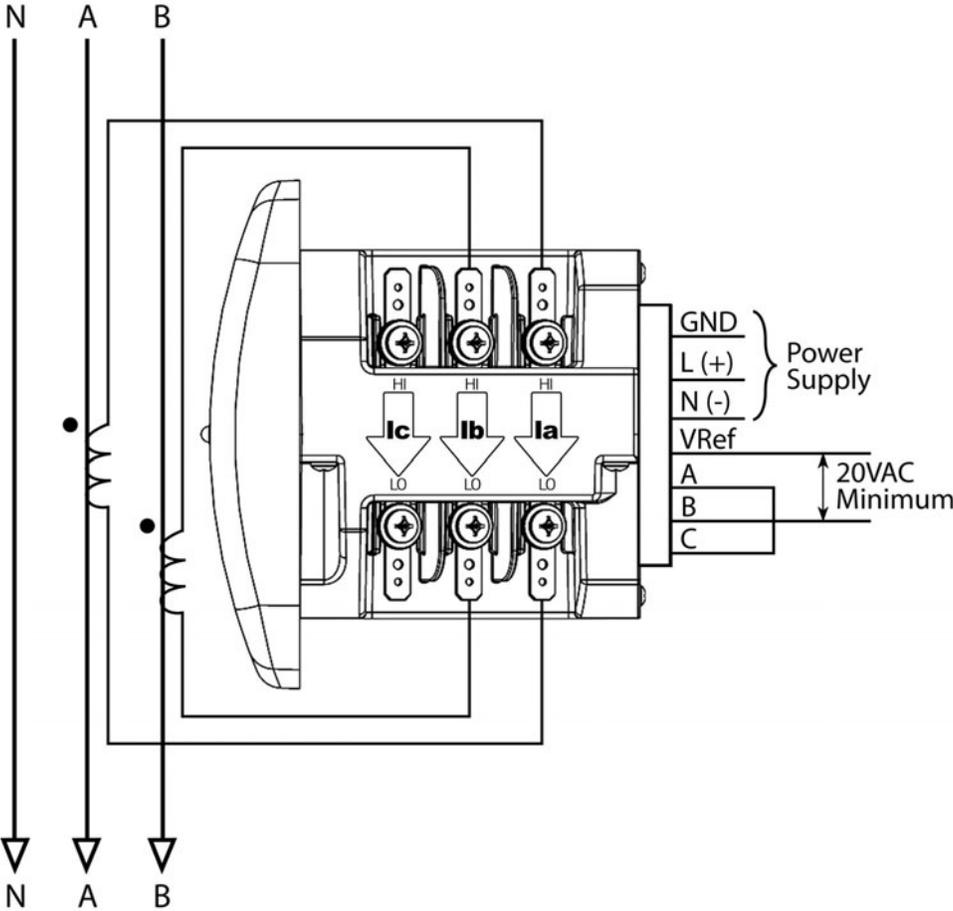


FIGURE 4-13: Current-Only Measurement (Dual-Phase)



NOTE

Even if the meter is used only for current measurement, the unit requires a AN volts reference. Please ensure that the voltage input is attached to the meter. AC control power can be used to provide the reference signal.

4.2.13 (10) Current-Only Measurement (Single-Phase)

For this wiring type, select 3 **EL WYE** (3 Element Wye) in the meter programming setup.

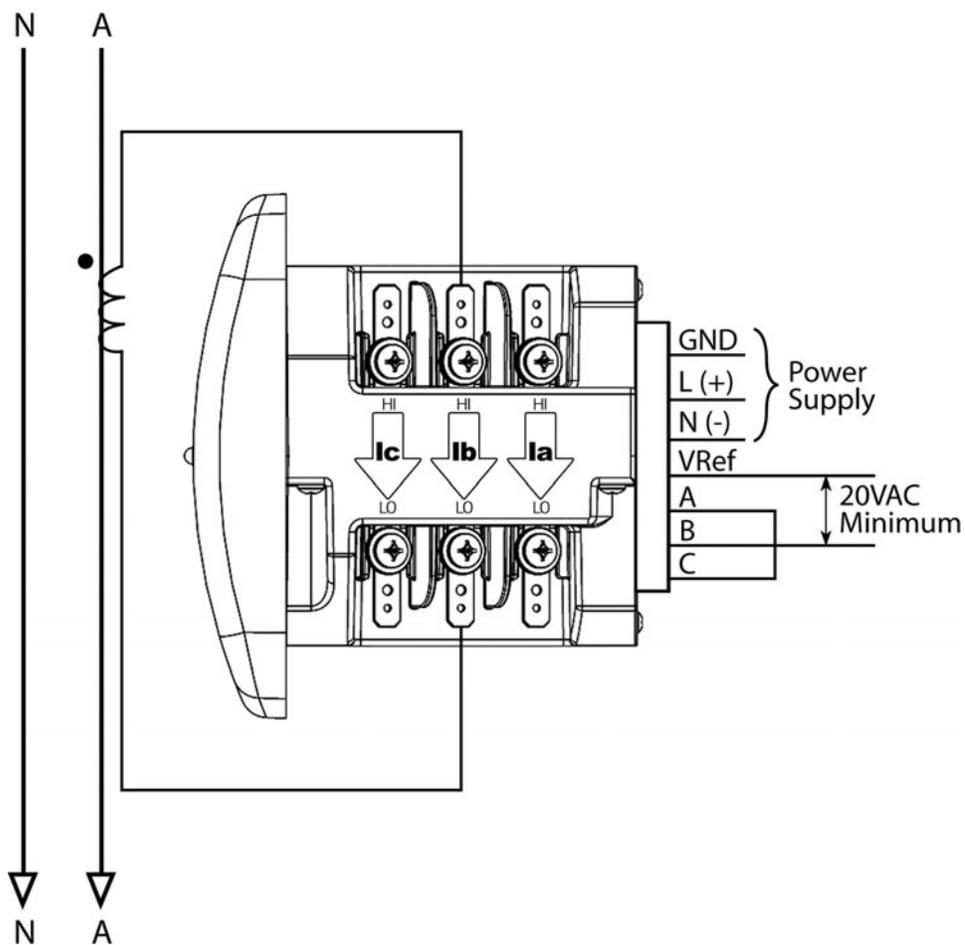


FIGURE 4-14: Current-Only Measurement (Single-Phase)



Even if the meter is used only for current measurement, the unit requires a AN volts reference. Please ensure that the voltage input is attached to the meter. AC control power can be used to provide the reference signal.



EPM 2200 Multi-function Power Metering System

Chapter 5: Communication Installation

5.1 EPM2200 Communication

Through the 485P option, the EPM 2200 meter provides RS485 communication speaking Modbus ASCII and Modbus RTU protocols.

5.1.1 RS-485 / KYZ Output COM 2 (485P Option)

The 485P Option provides a combination RS485 and a KYZ Pulse Output for pulsing energy values. The RS485 / KYZ Combo is located on the terminal section of the meter.

The EPM2200 meter's RS485 port can be programmed with the buttons on the face of the meter or by using GE Communicator EXT 3.0 software.

The standard RS485 Port Settings are as follows:

- Address: 001 to 247
- Baud Rate: 9600, 19200, 38400 or 57600
- Protocol: Modbus RTU, Modbus ASCII

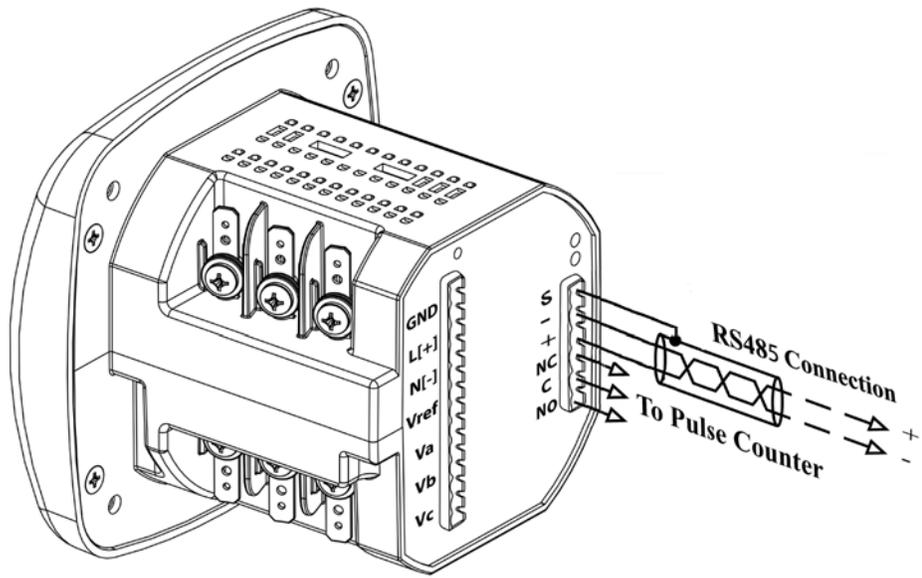


FIGURE 5-1: 485P Option with RS-485 Communication Installation

RS485 allows you to connect one or multiple EPM2200 meters to a PC or other device, at either a local or remote site. All RS485 connections are viable for up to 4000 feet (1219.20 meters).

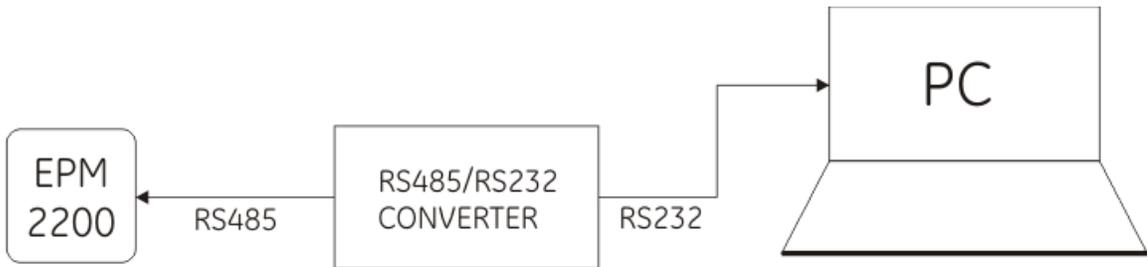


FIGURE 5-2: EPM2200 Connected to PC via RS485

As shown in Figure 5-2, to connect a EPM2200 to a PC, you need to use an RS485 to RS232 converter.

Figure 5-3 below, shows the detail of a 2-wire RS485 connection.

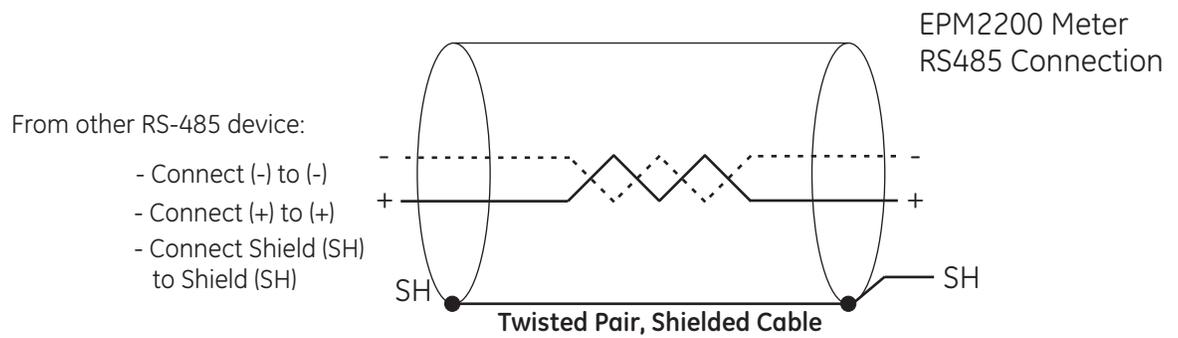


FIGURE 5-3: 2-wire RS485 Connection



NOTE

For All RS485 Connections:

- Use a shielded twisted pair cable 22 AWG (0.33 mm²) or larger, grounding the shield at one end only.
- Establish point-to-point configurations for each device on a RS485 bus: connect '+' terminals to '+' terminals; connect '-' terminals to '-' terminals.
- You may connect up to 31 meters on a single bus using RS485. Before assembling the bus, each meter must be assigned a unique address: refer to Chapter 5 of the GE Communicator EXT User's Manual for instructions.
- Protect cables from sources of electrical noise.
- Avoid both "Star" and "Tee" connections (see Figure 5.7).
- No more than two cables should be connected at any one point on an RS485 network, whether the connections are for devices, converters, or terminal strips.
- Include all segments when calculating the total cable length of a network. If you are not using an RS485 repeater, the maximum length for cable connecting all devices is 4000 feet (1219.20 meters).
- Connect shield to RS485 Master and individual devices as shown in Figure 5.6. You may also connect the shield to earth-ground at one point.
- Termination Resistors (RT) may be needed on both ends of longer length transmission lines. However, since the meter has some level of termination internally, Termination Resistors may not be needed. When they are used, the value of the Termination Resistors is determined by the electrical parameters of the cable.

Figure 5-4 shows a representation of an RS485 Daisy Chain connection.

5.2 EPM2200 Communication and Programming Overview

The EPM2200 meter can be programmed either through the buttons on the faceplate or through software. Software programming and communication utilize the RS485 connection on the back of the meter, as shown in fig 5-3. Once a connection is established, GE Communicator EXT 3.0 software can be used both to program the meter and to communicate with EPM2200 slave devices.

Meter Connection

To provide power to the meter, use one of the wiring diagrams in Chapter 4 or attach an Aux cable to GND, L('+') and N('-').

The RS-485 cable attaches to SH, '-' and '+' as shown above.

5.2.1 Factory Initial Default Settings

You can connect to the EPM2200 using the Factory Initial Default Settings. This feature is useful in debugging or in any situation where you do not know the meter's programmed settings and want to find them.

When the EPM2200 is powered up, you have up to 5 seconds to poll the Name Register as shown in the example below: "How to Connect." You will be connected to the meter with the Factory Initial Default Settings. The meter continues to operate with these default settings for 5 minutes. During this time, you can access the meter's Device Profile to ascertain/change meter information. After the 5 minutes have passed, the meter reverts to the programmed Device Profile settings.



Factory Initial Default Settings:

- Baud Rate: 9600
- Port: COM1
- Protocol: Modbus RTU

How to Connect

1. Open GE Communicator EXT software.
2. Click the Connect button on the tool bar.



FIGURE 5-6: Connect Button

The Connect screen appears, showing the Default settings. Make sure your settings are the same as shown here. Use the pull-down windows to make changes, if necessary.

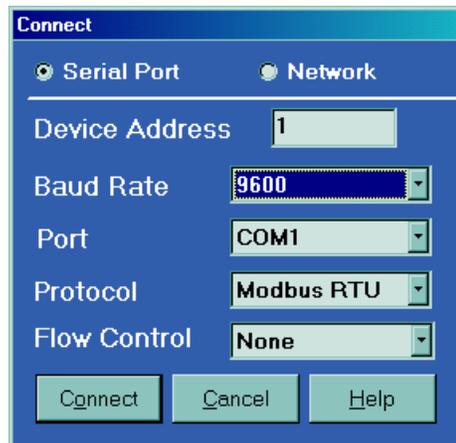


FIGURE 5-7: Serial Port settings

3. Click the Connect button on the screen.



NOTE

If you do not connect with the Factory Initial Default Settings within 5 seconds after powering on the meter, the Device Profile reverts to the programmed Device Profile. In that case, disconnect and reconnect power before clicking the Connect button.

The Device Status screen appears, confirming a connection.

Device Status - Network - IP Address: 3.94.246.209:502

List of Currently Connected Devices

Device	Device Type	Boot	Run-time	DSP Boot	DSP Run-time	Comm State	DSP State	On Time	Serial #	NVRAM	Pro
121689	EPM 2200	601	618	600	628	Healthy	Healthy	9/15/2006 20:10:37.33	00121689	4 MB	Full

Polling Device Info 1

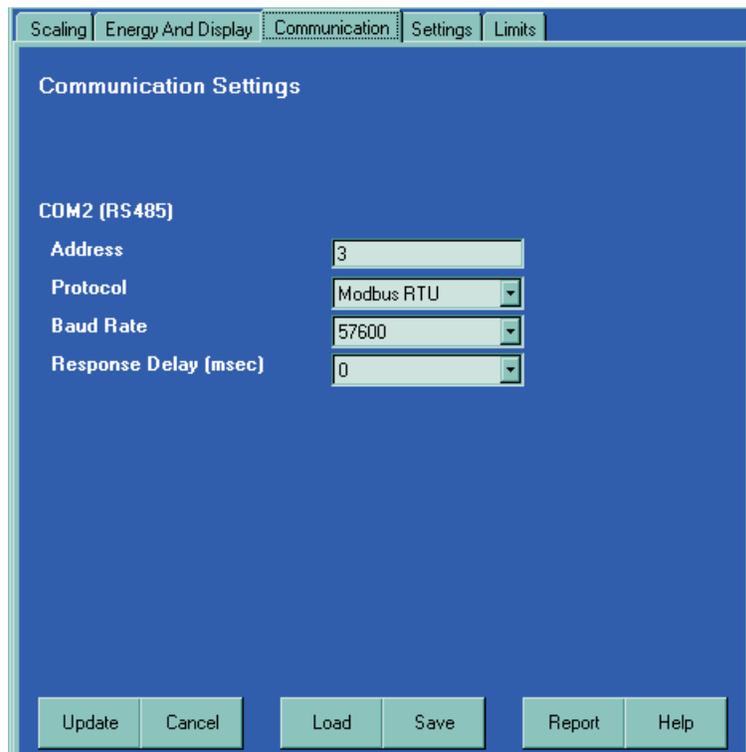
OK Help

FIGURE 5-8: Device Status screen

Click OK. The main screen of GE Communicator EXT software reappears.



- Click the Profile icon on the left of the toolbar. A set of EPM2200 Profile Programming Screens appears:



- Click the Communication tab. The Communication Settings appear. Use drop-down menus to change settings, if desired.

Communication Settings

- **COM2 (RS485)**
 - Address (1-247)
 - Protocol (Modbus RTU, ASCII)
 - Baud Rate (9600 to 57600)
 - Response Delay (0-750 msec)



COM1 is not used by the EPM2200 meter.

6. When changes are complete, click the Update button to send a new profile to the meter.
7. Click Cancel to Exit the Profile (or)
8. Click other tabs to update other aspects of the Profile (see section 5.2.2 below).

5.2.2 Additional EPM2200 Profile Settings

SCALING (CT, PT Ratios and System Wiring)

- CT Numerator (Primary):
- CT Denominator (Secondary): 5 (factory set)
- CT Multiplier:
- CT Fullscale: Calculation Based on Selections
- PT Numerator (Primary):

- PT Denominator (Secondary):
- PT Multiplier:
- PT Fullscale: Calculation Based on Selections

System Wiring: Number of Phases: One, Two or Three



NOTE

VOLTS FULL SCALE = PT Numerator x PT Multiplier



WARNING

You must specify Primary and Secondary Voltage in Full Scale. Do not use ratios! The PT Denominator should be the Secondary Voltage level.

Example:

A 14400/120 PT would be entered as:

PT Num: 1440

PT Denom: 120

Multiplier: 10

This example would display a 14.40kV.

Example CT Settings:

200/5 Amps: Set the Ct-n value for 200, Ct-Multiplier value for 1.

800/5 Amps: Set the Ct-n value for 800, Ct-Multiplier value for 1.

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

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

Example PT Settings:

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

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

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

345,000/115 Volts: Pt-n value is 3470, Pt-d value is 115, Pt-Multiplier value is 100

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



NOTE

Settings are the same for Wye and Delta configurations.

ENERGY AND DISPLAY POWER AND ENERGY FORMAT

The screenshot shows the 'Power and Energy Format' configuration window. The window has tabs for 'Scaling', 'Energy And Display', 'Communication', 'Settings', and 'Limits'. The 'Energy And Display' tab is active. The window contains several settings:

- Power Scale: auto
- Energy Digits: 8
- Energy Decimal Places: 0
- Energy Scale: unit
- Example: 12345678
- Power Direction: view as load
- Demand Averaging:
 - Averaging Method: block
 - Interval(Minutes): 15
 - Sub Interval: 2
- Auto Scroll Display: Off
- Display Configuration:
 - Volts L-N
 - Volts L-L
 - Amps
 - W/VAR/PF
 - VA/Hz
 - Wh
 - VARh
 - VAh

Buttons at the bottom include Update, Cancel, Load, Save, Report, and Help.

Power Scale
 Energy Digits
 Energy Decimal Places
 Energy Scale
 (Example Based on Selections)
 Power Direction: View as Load

Demand Averaging

Averaging Method: Block or Rolling
 Interval (Minutes)
 Sub Interval

Auto Scroll: Click to Activate

Display Configuration:

Click Values to be displayed.



You MUST have at least ONE selected.



If incorrect values are entered on this screen the following message appears:



Current, CT, PT and Energy Settings will cause invalid energy accumulator values. Change the inputted settings until the message disappears.

SETTINGS

Password (Meter is shipped with Password Disabled; there is NO DEFAULT PASSWORD)

Enable Password for Reset

Enable Password for Configuration

Change Password

Change VSwitch

(Call GE Multilin for Update Information.)

Change Device Designation

Enter a new Device label in the entry field.

1. Click **Update** to send a new Profile.

After programming the Device Profile, click:

- **Update** to send the new Profile to the connected meter.



If the Update fails, the software asks if you want to try again to Update.

- **Save** to save the Device Profile settings in a file.
- **Cancel** (once you have loaded or saved the Device Profile) to Exit the EPM2200 Profile screen.



If you click **Cancel** before **Save** or **Update**, you will lose any changes you have made to the Device Profile.

2. Use *GE Communicator EXT* to communicate with the device and perform required tasks. Refer to the *GE Communicator EXT User's Manual* for more details. You can access the manual online by clicking **Help > Contents** from the *GE Communicator EXT* Main screen.



EPM 2200 Multi-function Power Metering System

Chapter 6: Using the Meter

6.1 Introduction

The EPM2200 meter can be configured and a variety of functions can be accomplished simply by using the Elements and the Buttons on the meter face. This chapter will review Front Panel Navigation. Complete Navigation Maps can be found in Appendix A of this manual.



FIGURE 6-1: Faceplate of EPM2200 Meter with Elements

6.1.1 Meter Face Elements

- **Reading Type Indicator:**
Indicates Type of Reading

- **% of Load Bar:**
Graphic Display of Amps as % of the Load
- **Parameter Designator:**
Indicates Reading Displayed
- **Scale Selector:**
Kilo or Mega multiplier of Displayed Readings



FIGURE 6-2: EPM 2200 Faceplate Buttons

6.1.2 Meter Face Buttons

Using **Menu, Enter, Down and Right Buttons**, perform the following functions:

- View Meter Information
- Enter Display Modes
- Configure Parameters (Password Protected)
- Perform Resets
- Perform LED Checks
- Change Settings
- View Parameter Values
- Scroll Parameter Values

Enter Button: Press and release to enter one of four Display Modes

- Operating Mode (Default),
- Reset Mode (ENTER once, then Down)
- Settings Mode (ENTER twice, then Down)
- Configuration Mode (ENTER three times, then Down)

Menu Button: Press and release to navigate Config Menu, return to Main Menu

Right Button: Operating Mode - Max, Min, Del kW, Net kW, Total kW

Reset Mode - Yes, No

Settings Mode - On, Off, Settings

Config Mode - Password Digits, Available Values, Digits

Down Button: Scroll DOWN through Mode menus

Use Buttons in Modes of Operation:

- Operating Mode (default): View Parameter Values
- Reset Mode: Reset Stored Max and Min Values
- Settings Mode: View Meter Setting Parameters and Change Scroll Setting
- Configuration Mode: Change Meter Configuration (Can be Password Protected)



The above is a brief overview of the use of the Buttons.

For Programming, refer to Chapter 7.

For complete Navigation Maps, refer to Appendix A of this manual.

6.2 % of Load Bar

The 10-segment LED bargraph at the bottom of the EPM2200 unit's display provides a graphic representation of Amps. The segments light according to the load in the %Load Segment Table below.

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

Table 6-1: % Load Segments

Segments	Load \leq % 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%

6.3 Watt-hour Accuracy Testing (Verification)

To be certified for revenue metering, power providers and utility companies have to verify that the billing energy meter will perform 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 EPM 2200 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.

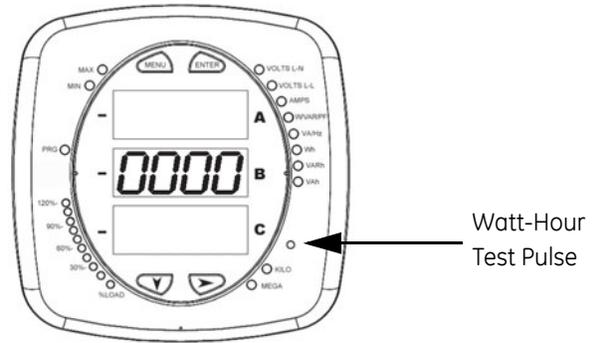


FIGURE 6-3: Watt-hour Test Pulse

Refer to the figure below for an example of how this test works.

Refer to Table 6-2 below for the Wh/Pulse Constant for Accuracy Testing.

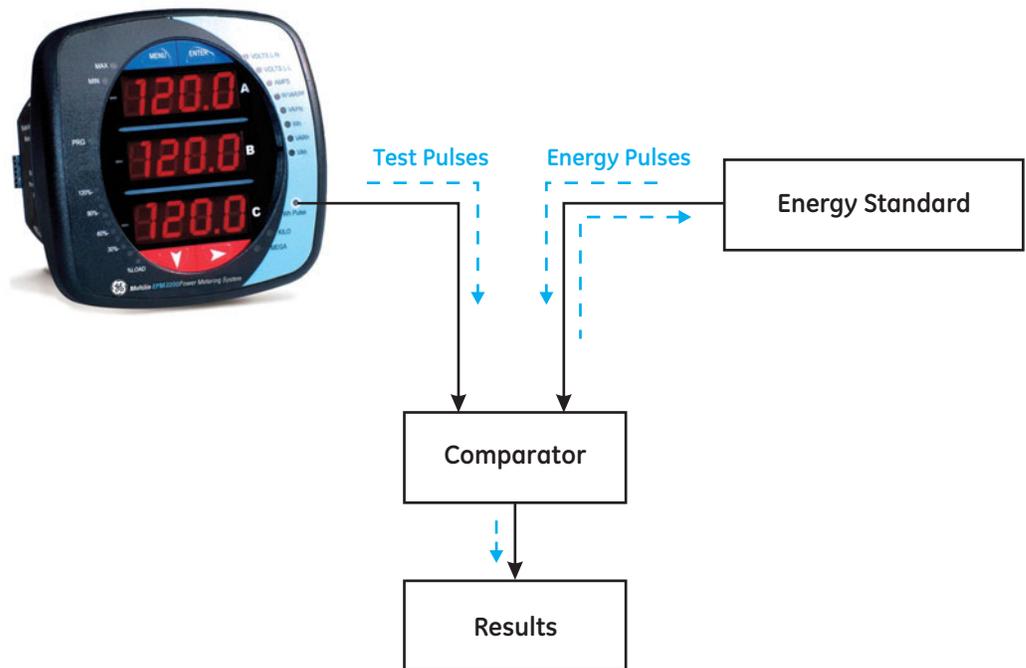


FIGURE 6-4: Using the Watt-hour Test Pulse

6.3.1 Infrared & KYZ Pulse Constants for Accuracy Testing

Table 6–2: Infrared & KYZ Pulse Constants for Accuracy Testing

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



- Minimum pulse width is 40 ms.
- Refer to section 2.2 for Wh Pulse specifications.



EPM 2200 Multi-function Power Metering System

Chapter 7: Configuring the Meter Using the Front Panel

7.1 Overview

The EPM2200 front panel can be used to configure the meter. The EPM2200 has three MODES:

- **Operating Mode** (Default)
- **Reset Mode**
- **Configuration Mode.**

The MENU, ENTER, DOWN and RIGHT buttons navigate through the modes and navigate through all the screens in each mode.

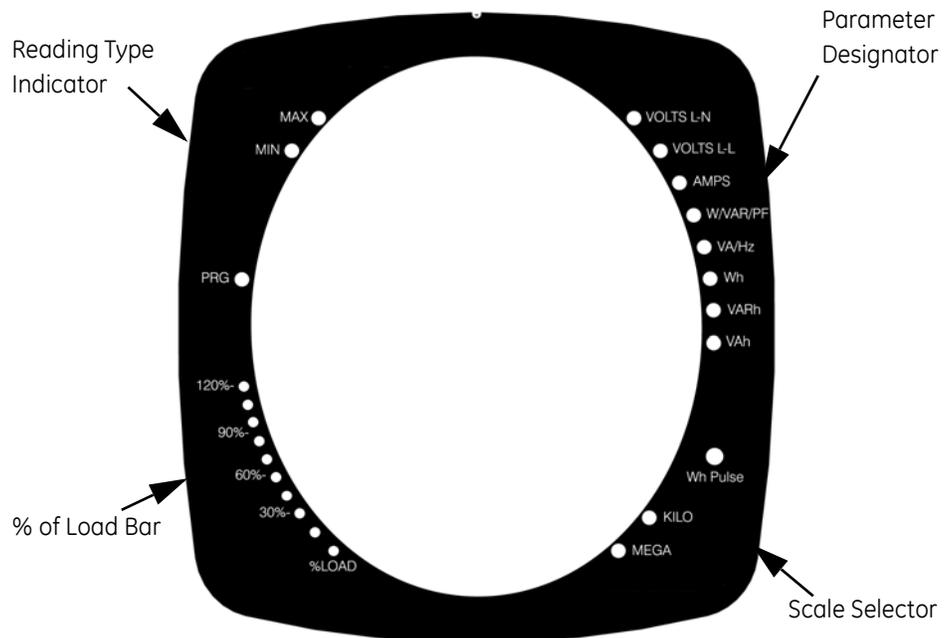


FIGURE 7-1: EPM2200 Label

In this chapter, a typical set up will be demonstrated. Other settings are possible. The complete Navigation Map for the Display Modes is in Appendix A of this manual. The meter can also be configured with software (see *GE Communicator EXT 3.0 Manual*).

7.2 Start Up

Upon Power Up, the meter will display a sequence of screens. The sequence includes the following screens:

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

EPM2200 will then automatically Auto-Scroll the Parameter Designators on the right side of the front panel. Values are displayed for each parameter.

The **KILO** or **MEGA LED** lights, showing the scale for the Wh, VARh and VAh readings.

An example of a Wh reading is shown here.

An example of a Wh reading is shown below.

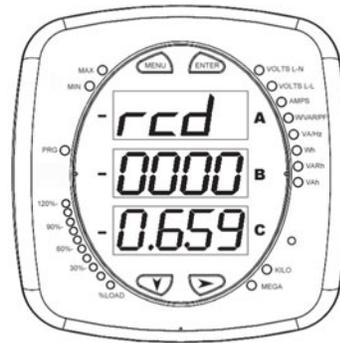


FIGURE 7-2: Typical Wh Reading

The EPM2200 will continue to scroll through the Parameter Designators, providing readings until one of the buttons on the front panel is pushed, causing the meter to enter one of the other MODES.

7.3 Configuration

7.3.1 Main Menu

Push **MENU** from any of the Auto-Scrolling Readings. The MAIN MENU Screens appear.

The String for **Reset Mode** (rSt) appears (blinking) in the A Screen.

If you push **DOWN**, the MENU scrolls and the String for **Configuration Mode** (CFG) appears

(blinking) in the A Screen.

If you push **DOWN** again, the String for **Operating Mode** (OPr) appears (blinking) in the A Screen.

If you push **DOWN** again, the MENU scrolls back to Reset Mode (rSt).

If you push **ENTER** from the Main Menu, the meter enters the Mode that is in the A Screen and is blinking. See *Appendix A* for Navigation Map.

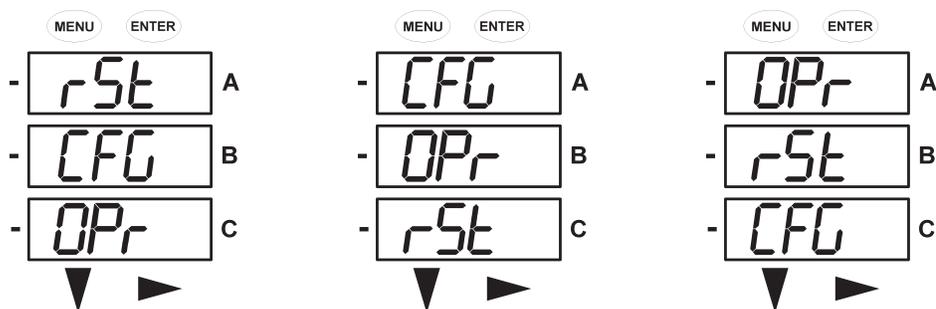
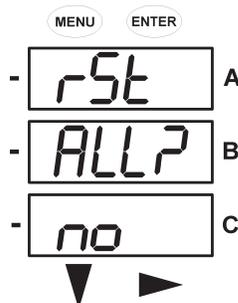


FIGURE 7-3: Main Menu Screens

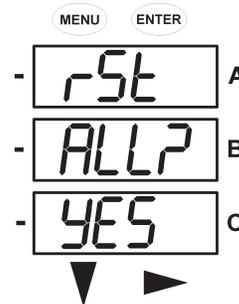
7.3.2 Reset Mode

If you push **ENTER** from the Main Menu, the meter enters the Mode that is in the A Screen and is blinking. Reset Mode is the first mode to appear on the Main Menu. Push **ENTER** while (rSt) is in the A Screen and the “RESETALL? no” screen appears. **Reset ALL resets all Max and Min values.** See *Appendix A* for Navigation Map.



- If you push **ENTER** again, the Main Menu continues to scroll.
- The **DOWN** button does not change the screen.

- If you push the **RIGHT** button, the RESET All? YES screen appears.



- To Reset All, you must enter a 4-digit Password, **if Enabled** in the software (see section 5.2.2).
- Push **ENTER**; the following Password screen appears.

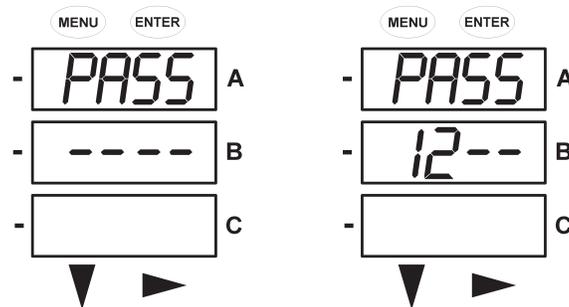
7.3.2.1 Enter Password (only if it has been enabled in software)

To enter a Password:

- **If PASSWORD is Enabled in the software** (see section 5.2.2 to Enable/Change Password), a screen appears requesting the Password. **PASS** appears in the A Screen and **4 dashes** in the B Screen. The **LEFT** digit is flashing.
- Use the **DOWN** button to scroll from 0 to 9 for the flashing digit. When the correct number appears for that digit, use the **RIGHT** button to move to the next digit.

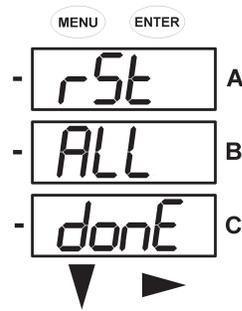
Example: On the Password screens below:

- On the left screen, four dashes appear and the left digit is flashing.
- On the right screen, 2 digits have been entered and the third digit is flashing.

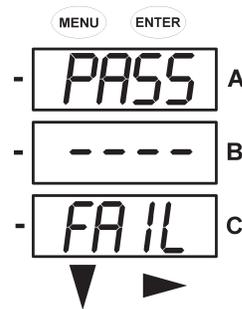


PASS or FAIL:

- When all 4 digits have been entered, push **ENTER**.
- If the **correct Password** has been entered, "rSt ALL done" appears and the screen returns to Auto-Scroll the Parameters. (In other Modes, the screen returns to the screen to be changed. The left digit of the setting is flashing and the Program (PRG) LED flashes on the left side of the meter face.)



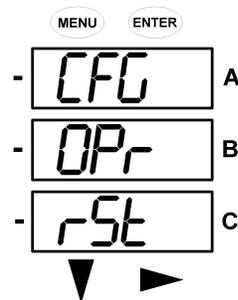
- If an **incorrect Password** has been entered, “PASS ---- FAIL” appears and the screen returns to Reset ALL? YES.



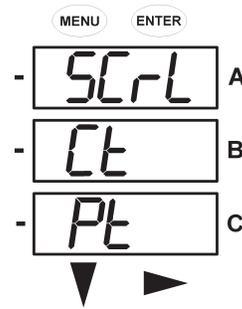
7.3.3 Configuration Mode

The following procedure describes how to navigate the configuration mode menu.

1. Press the **MENU** Button from any of the auto-scrolling readings.
2. Press **DOWN** to display the Configuration Mode (**CFG**) string in the “A” screen.



3. Press **ENTER** to scroll through the configuration parameters, starting at the **SCrL Ct Pt** screen.



4. Push the **DOWN** Button to scroll all the parameters: scroll, CT, PT, connection (**Cnct**) and port.
The active parameter is always flashing and displayed in the “A” screen.

7.3.4 Configuring the Scroll Feature

Use the following procedure to configure the scroll feature.

1. Press the **ENTER** button to display the **SCrL no** message.
2. Press the **RIGHT** button to change the display to **SCrL YES** as shown below.

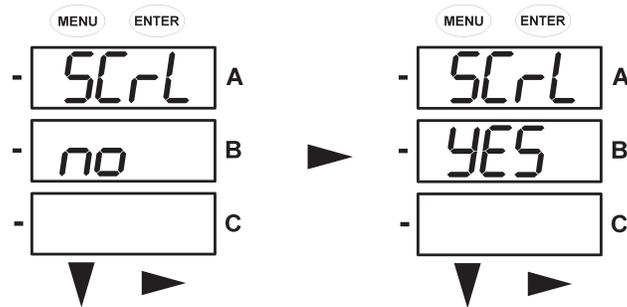


FIGURE 7-4: Scroll Mode Configuration

When in scroll mode, the unit scrolls each parameter for 7 seconds on and 1 second off. The meter can be configured through software to only display selected screens. In this case, it will only scroll the selected displays.

3. Push **ENTER** to select **YES** or **no**.

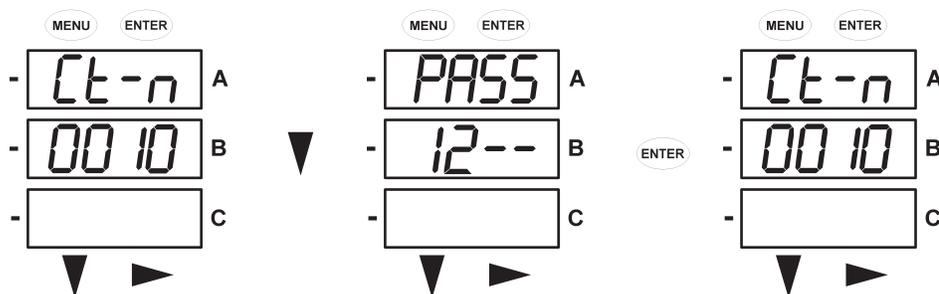
The screen scrolls to the CT parameters.

7.3.5 Programming the Configuration Mode Screens

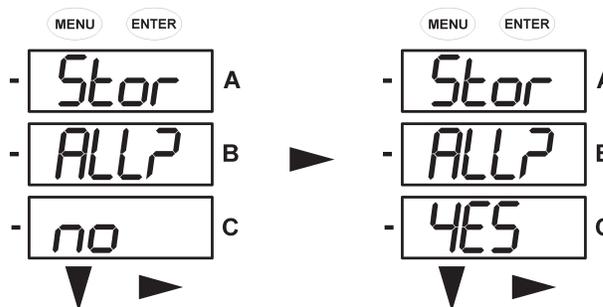
Use the following procedure to program the screen for configuration mode.

1. Press the **DOWN** or **RIGHT** button (for example, from the **Ct-n** message below) to display the password screen, if enabled in the software.
2. Use the **DOWN** and **RIGHT** buttons to enter the correct password (refer to *Reset Mode* on page 7-4 for steps on password entry).

- Once the correct password is entered, push **ENTER**.
The **Ct-n** message will reappear, the PRG faceplate LED will flash, and the first digit of the “B” screen will also flash.



- Use the **DOWN** button to change the first digit.
- Use the **RIGHT** button to select and change the successive digits.
- When the new value is entered, push **ENTER** twice.
This will display the **Stor ALL? no** screen.
- Use the **RIGHT** button to scroll to change the value from **no** to **YES**.



- When the **Stor ALL? YES** message is displayed, press **ENTER** to change the setting.

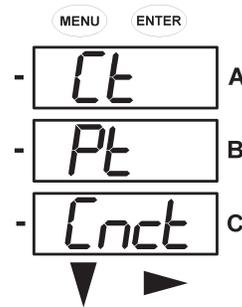
The **Stor ALL donE** message will appear and the meter will reset.



7.3.6 Configuring the CT Setting

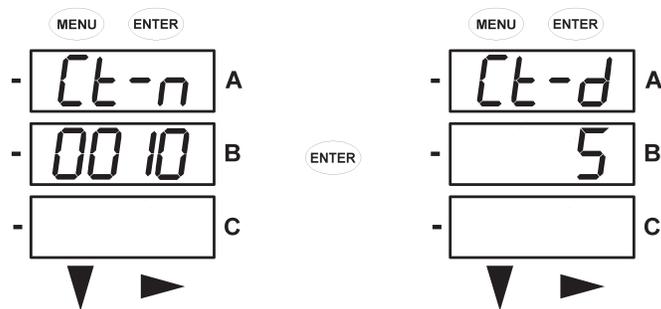
Use the following procedure to program the CT setting.

1. Push the **DOWN** Button to scroll through the configuration mode parameters. Press **ENTER** when **ct** is the active parameter (i.e. it is in the “A” screen and flashing).



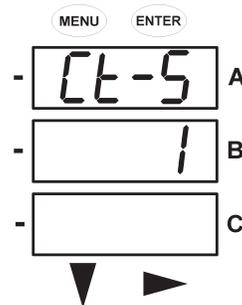
This will display the and the **ct-n** (CT numerator) screen.

2. Press **ENTER** again to change to display the **ct-d** (CT denominator) screen.



The **ct-d** value is preset to a 1 or 5 A at the factory and cannot be changed.

3. Press **ENTER** again to select the **ct-s** (CT scaling) value.



The **ct-s** value can be “1”, “10”, or “100”. Refer to *Programming the Configuration Mode Screens* on page 7-7 for instructions on changing values.

Example settings for the **ct-s** value are shown below:

200/5 A: set the **ct-n** value for "200" and the **ct-s** value for "1"

800/5 A: set the **ct-n** value for "800" and the **ct-s** value for "1"

2000/5 A: set the **ct-n** value for "2000" and the **ct-s** value for "1".

10000/5 A: set the **ct-n** value for "1000" and the **ct-s** value for "10".



The value for amps is a product of the **ct-n** and the **ct-s** values.

4. Press **ENTER** to scroll through the other **CFG** parameters. Pressing **DOWN** or **RIGHT** displays the password screen (see *Reset Mode* on page 7-4 for details).
5. Press **MENU** to return to the main configuration menu.



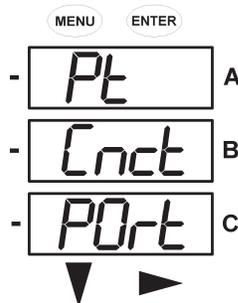
ct-n and **ct-s** are dictated by Primary Voltage.

ct-d is secondary Voltage.

7.3.7 Configuring the PT Setting

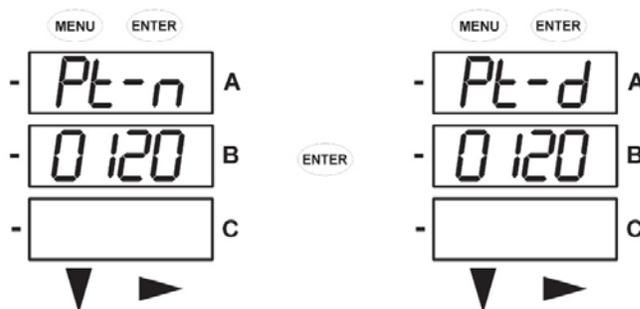
Use the following procedure to program the PT setting.

1. Push the **DOWN** Button to scroll through the configuration mode parameters.
2. Press **ENTER** when **Pt** is the "active" parameter (i.e. it is in the "A" screen and flashing) as shown below.

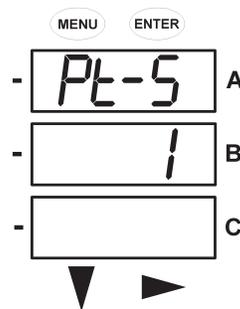


This will display the **Pt-n** (PT numerator) screen.

3. Press **ENTER** again to change to display the **Pt-d** (PT denominator) screen.



4. Press **ENTER** again to select the to **Pt-s** (PT scaling) value.



The **Pt-S** value can be “1”, “10”, or “100”. Refer to *Programming the Configuration Mode Screens* on page 7-7 for instructions on changing values.

Example settings for the **Pt-n**, **Pt-d**, and **Pt-S** values are shown below:

277/277 Volts:	Pt-n value is 277, Pt-d value is 277, Pt-Multiplier is 1
14400/120 Volts:	Pt-n value is 1440, Pt-d value is 120, Pt-S value is 10
138000/69 Volts:	Pt-n value is 1380, Pt-d value is 69, Pt-S value is 100
345000/115 Volts:	Pt-n value is 3450, Pt-d value is 115, Pt-S value is 100
345000/69 Volts:	Pt-n value is 345, Pt-d value is 69, Pt-S value is 1000

5. Press **ENTER** to scroll through the other **CFG** parameters.
6. Press **DOWN** or **RIGHT** to display the password screen (see *Reset Mode* on page 7-4 for details).
7. Press **MENU** to return to the Main Configuration Menu.



Pt-n and **Pt-S** are dictated by primary voltage.
Pt-d is secondary voltage.

7.3.8 Configuring the Connection (Cnct) Setting

Use the following procedure to program the connection (**Cnct**) setting.

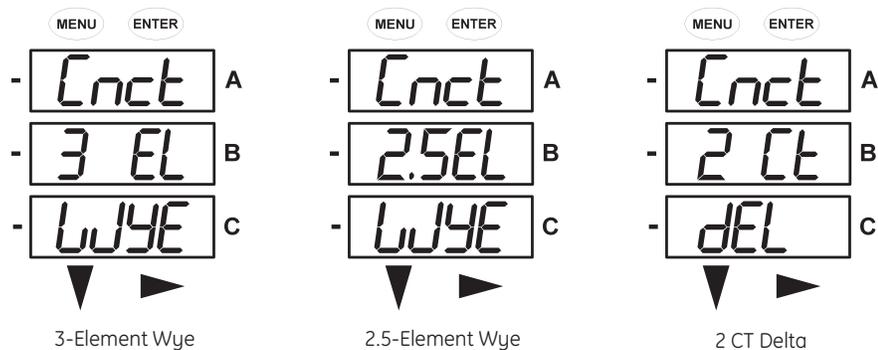
1. Push the **DOWN** Button to scroll through the Configuration Mode parameters: Scroll, CT, PT, Connection (Cnct), and Port. The “active” parameter is in the A screen and is flashing
2. Press **ENTER** when **Cnct** is the “active” parameter (i.e. it is in the “A” screen and flashing).

This will display the **Cnct** (Connection) screen. To change this setting, use the **RIGHT** button to scroll through the three settings. Select the setting that is right for your meter.

The possible Connection configurations are

- 3-element Wye (3 **EL WYE**)
- 2.5-element Wye (2.5**EL WYE**)
- 2 CT Delta (2 **ct deL**)

as shown below:

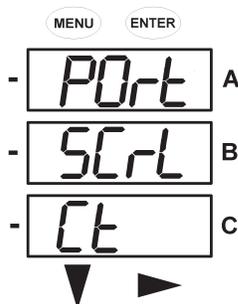


3. Press **ENTER** to scroll through the other **CFG** parameters.
4. Press **DOWN** or **RIGHT** to display the Password screen (see *Reset Mode* above for details).
5. Press **MENU** to return to the main Configuration menu.

7.3.9 Configuring the Communication Port Setting

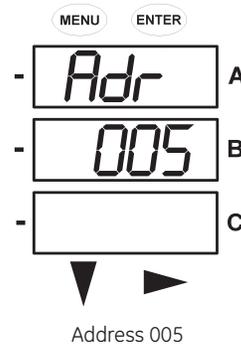
Use the following procedure to program the communication port (**Port**) settings.

1. Push the **DOWN** Button to scroll through the configuration mode parameters.
2. Press **ENTER** when **Port** is the active parameter (i.e. it is in the “A” screen and flashing) as shown below.



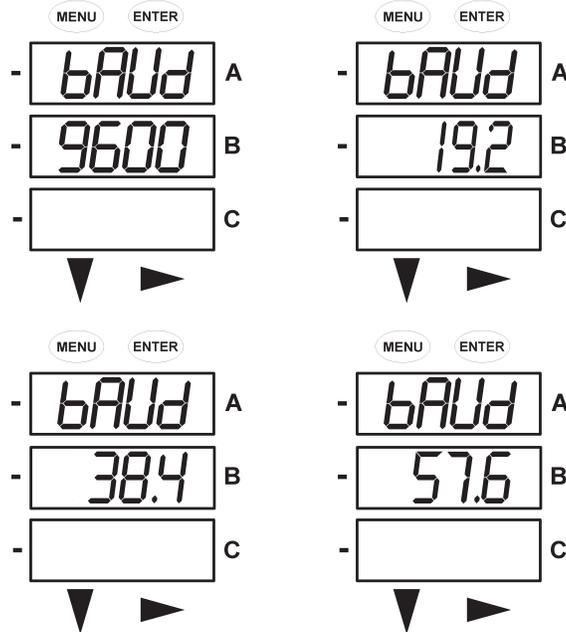
The following parameters can be configured through the **Port** menu

- The meter **Address (Adr)**, a 3-digit number.
 - The **Baud Rate (baud)**. Select from “9600”, “19.2”, “38.4”, and “57.6” for 9600, 19200, 38400, and 57600 kbps, respectively.
 - The **Communications Protocol (Prot)**. Select “rtU” for Modbus RTU, and “ASCI” for Modbus ASCII.
- The first **Port** screen is **Meter Address (Adr)**. The current address appears on the screen. Follow the programming steps in section 7.3.5. Select a three-digit number for the address.

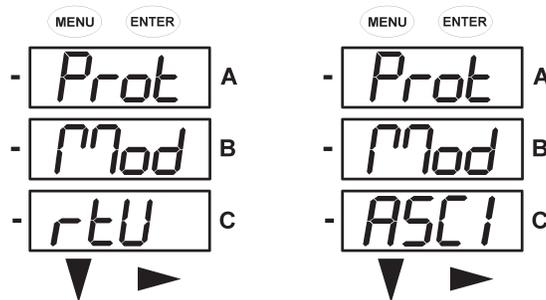


Refer to *Programming the Configuration Mode Screens* above for details on changing values.

- The next **Port** screen is the baud rate (**bAUD**). The current baud rate is displayed on the “B” screen. Refer to *Programming the Configuration Mode Screens* above for details on changing values. The possible baud rate screens are shown below.



- The final **Port** screen is the **Communications Protocol (Prot)**. The current protocol is displayed on the “B” screen.



Refer to *Programming the Configuration Mode Screens* above for details on changing values. The three protocol selections are shown below.

3. Press **ENTER** to scroll through the other **CFG** parameters.
4. Press **DOWN** or **RIGHT** to display the Password screen (see *Reset Mode* on page 7-4 for details).
5. Press **MENU** to return to the main Configuration menu.

7.3.10 Operating Mode

Operating mode is the EPM 2200 meter's default mode. If scrolling is enabled, the meter automatically scrolls through these parameter screens after startup. The screen changes every 7 seconds. Scrolling is suspended for 3 minutes after any button is pressed.

Push the **DOWN** button to scroll all the parameters in operating mode. The active parameter has the indicator light next to it on the right face of the meter.

Push the **RIGHT** button to view additional displays for that parameter. A table of the possible displays in the operating mode is below. Refer to *Appendix A* for a detailed navigation map of the operating mode.

Table 7-1: Operating Mode Parameter Readings

Parameter designator Available by Software Option (see Order Code table)		Possible Readings				
VOLTS L-N	A1, B1, C1	VOLTS_LN	VOLTS_LN_MAX	VOLTS_LN_MIN		
VOLTS L-L	A1, B1, C1	VOLTS_LL	VOLTS_LL_MAX	VOLTS_LL_MIN		
AMPS	A1, B1, C1	AMPS	AMPS_NEUTRAL	AMPS_MAX	AMPS_MIN	
W/VAR/PF	B1, C1	W_VAR_PF	W_VAR_PF_MAX_POS	W_VAR_PF_MIN_POS	W_VAR_PF_MAX_NEG	W_VAR_PF_MIN_NEG
VA/Hz	B1, C1	VA_FREQ	VA_FREQ_MAX	VA_FREQ_MIN		
Wh	C1	KWH_REC	KWH_DEL	KWH_NET	KWH_TOT	
VARh	C1	KVARH_POS	KVARH_NEG	KVARH_NET	KVARH_TOT	
VAh	C1	KVAH				



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



EPM 2200 Multi-function Power Metering System

Appendix A: EPM2200 Navigation Maps

Appendix A.1 Introduction

The EPM2200 meter can be configured and a variety of functions performed using the buttons on the meter face.

- An Overview of the Elements and Buttons on the meter face can be found in Chapter 6.
- An Overview of Programming using the buttons can be found in Chapter 7.
- The meter can also be programmed using software (see *GE Communicator EXT 3.0 Manual*).

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

The EPM2200 Navigation Maps begin on the next page.

They 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 will automatically return to Operating Mode after 10 minutes with no user activity.

Appendix A.2.1 EPM2200 Navigation Map Titles:

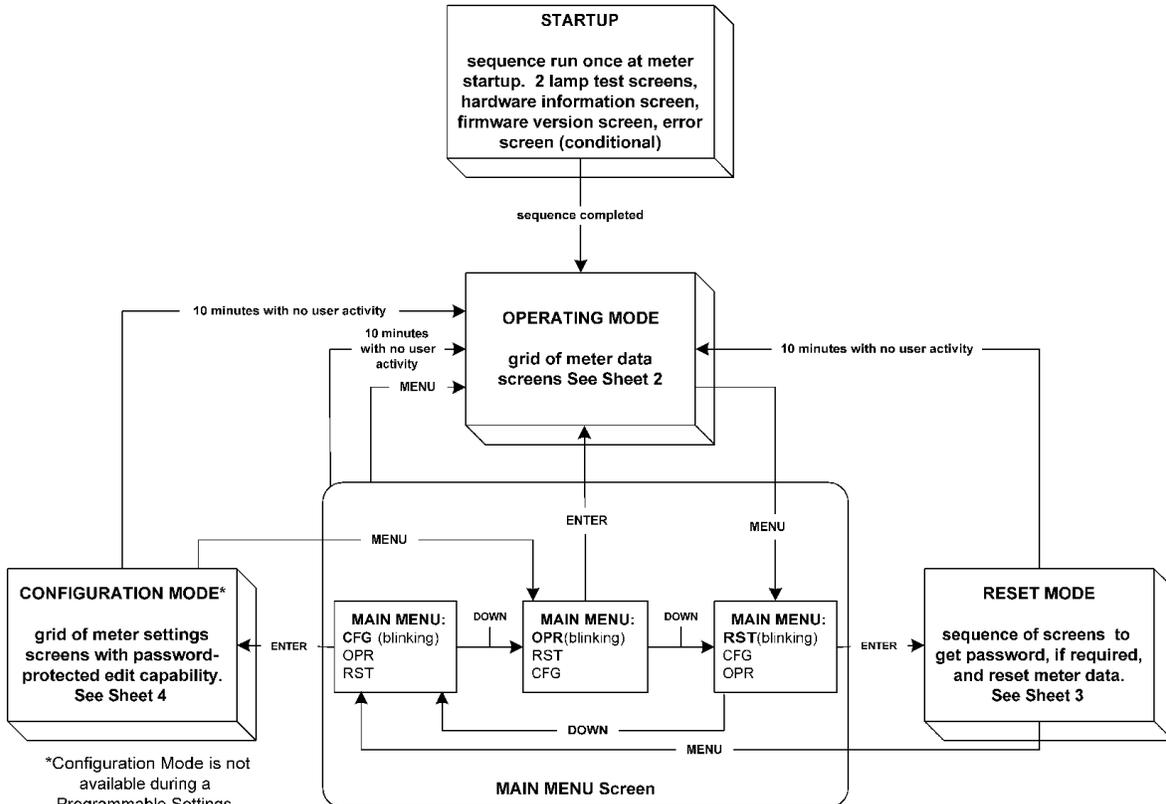
Main Menu Screens (Sheet 1)

Operating Mode Screens (Sheet 2)

Reset Mode Screens (Sheet 3)

Configuration Mode Screens (Sheet 4)

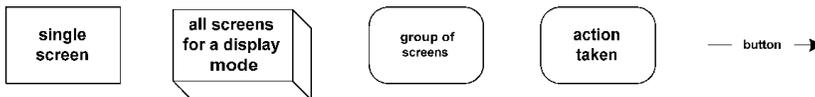
Main Menu Screens (Sheet 1)

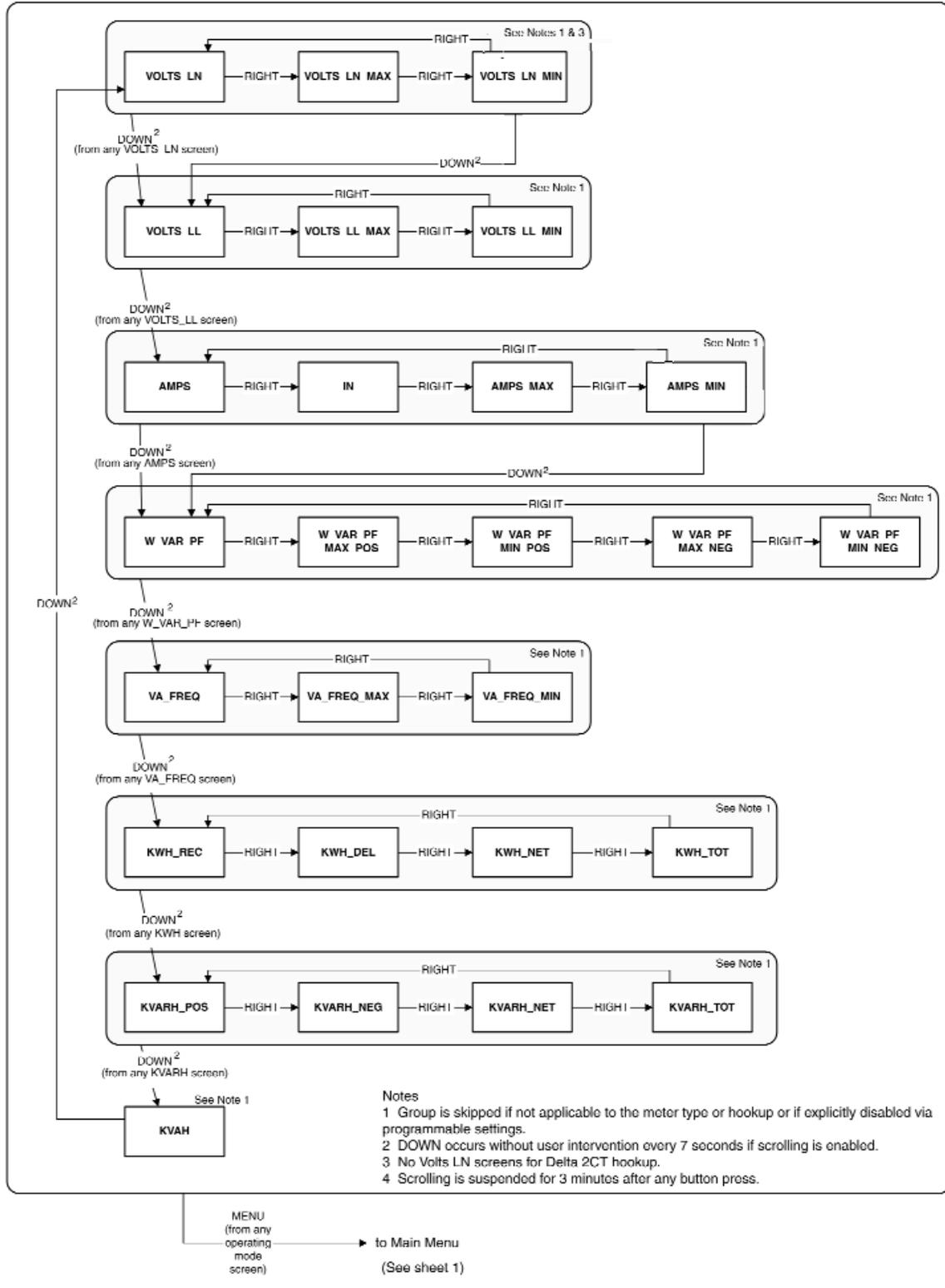


*Configuration Mode is not available during a Programmable Settings update via a COM Port.

MAIN MENU screen scrolls through 3 choices, showing all 3 at once. The top choice is always the "active" one, which is indicated by the blinking legend.

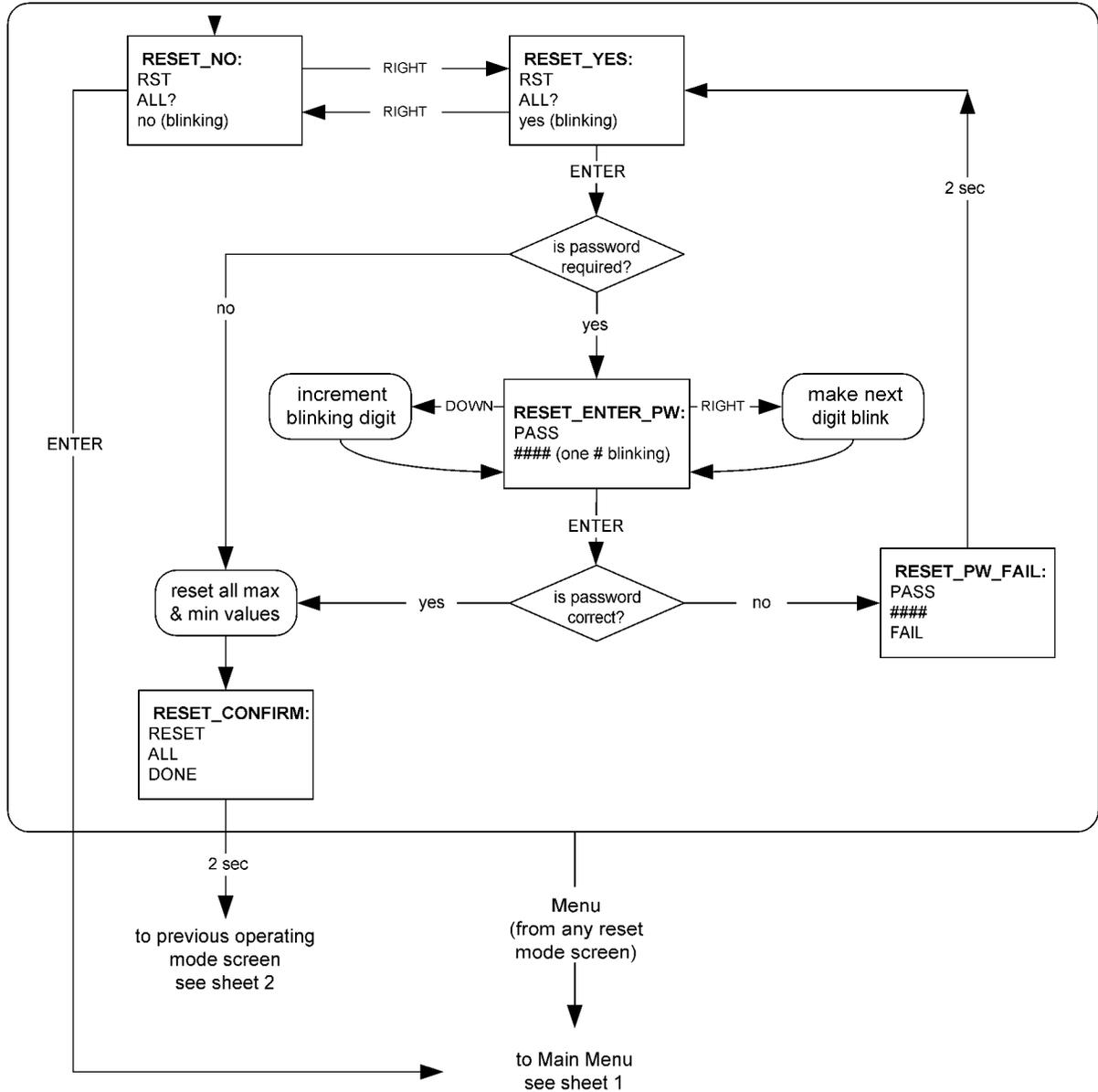
BUTTONS	
MENU	Returns to previous menu from any screen in any mode.
ENTER	Indicates acceptance of the current screen and advances to the next one.
DOWN, RIGHT	Navigation and Edit buttons
Navigation:	No digits or legends are blinking. On a menu, DOWN advances to the next menu selection, RIGHT does nothing. In a grid of screens, DOWN advances to the next row, RIGHT advances to the next column. Rows, columns and menus all navigate circularly.
Editing:	A digit or legend is blinking to indicate that it is eligible for change. When a digit is blinking, DOWN increases the digit value, RIGHT moves to the next digit. When a legend is blinking, either button advances to the next choice legend.



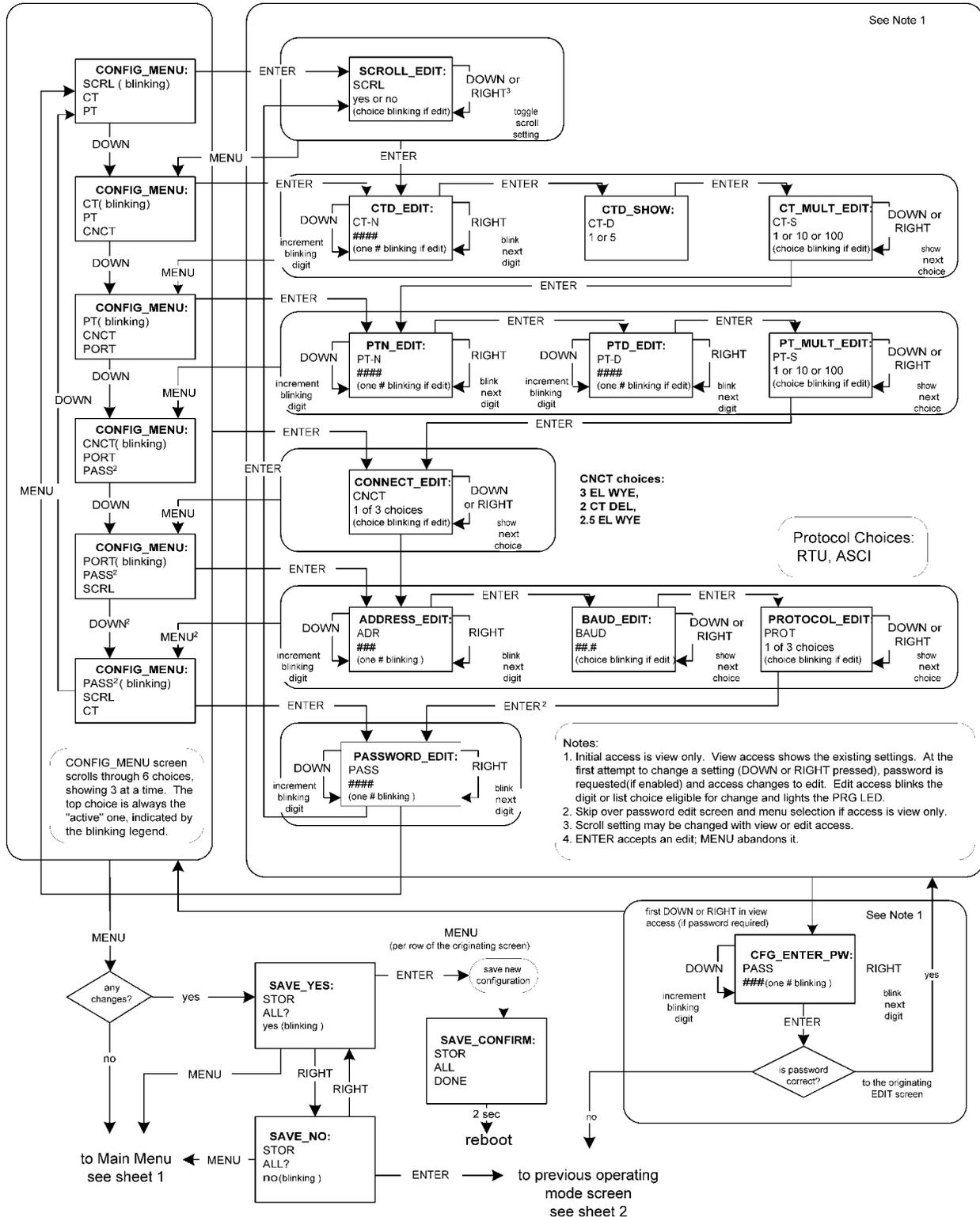


Reset Mode Screens (Sheet 3)

from MAIN MENU



Configuration Mode Screens (Sheet 4)





EPM 2200 Multi-function Power Metering System

Appendix B: Modbus Mapping for EPM2200

Appendix B.1 Introduction

The Modbus Map for the EPM2200 Meter gives details and information about the possible readings of the meter and about the programming of the meter. The EPM2200 can be programmed using the buttons on the face plate of the meter (Chapter 7). The meter can also be programmed using software. For a Programming Overview, see section 5.2 of this manual. For further details see the *GE Communicator EXT 3.0 Manual*.

Appendix B.2 Modbus Register Map Sections

The EPM2200 Modbus Register Map includes the following sections:

Fixed Data Section, Registers 1- 47, details the Meter's Fixed Information described in Section 7.2.

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 7.3.4.

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.

Appendix B.3 Data Formats

ASCII: ASCII characters packed 2 per register in high, low order and without any termination characters.

Example: "EPM2200" would be 4 registers containing 0x5378, 0x6172, 0x6B31, 0x3030.

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).

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

$$-1^{sign} \times 2^{137-127} \times 1.11000010001110111001$$

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

$$-1800.929$$

Register	0x0C4E1														0x01DB9																					
Byte	0x0C4							0x0E1							0x01D							0x0B9														
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	1				
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							0b11000010001110110111001																											

Formula Explanation

C4E11DB9 (hex) 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 of 127, so the Exponent value is 10.

The Mantissa is 11000010001110110111001 binary.

With the implied leading 1, the Mantissa is (1).C23B72 (hex).

The Floating Point Representation is therefore $-1.75871956 \times 2^{10}$

Decimal equivalent: -1800.929



Exponent = the whole number before the decimal point

Mantissa = the positive fraction after the decimal point

Appendix B.5 Modbus Register Map

Table Appendix B –1: Modbus Register Map (Sheet 1 of 7)

Hex	Decimal	Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Fixed Data Section							
Identification Block							read-only
0000 - 0007	1 - 8	Meter Name	ASCII	16 char	none		8
0008 - 000F	9 - 16	Meter Serial Number	ASCII	16 char	none		8
0010 - 0010	17 - 17	Meter Type	UINT16	bit-mapped	-----t -----vzv	t = 0 vzv = Software Option A1, B1, or C1	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	OEM Part Number					8
						Block Size:	47
Meter Data Section²							
Primary Readings Block, 6 cycles (IEEE Floating							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	VAs, 3-Ph total	FLOAT	-9999 M to +9999 M	VAs		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	VAs, 3-Ph total	FLOAT	-9999 M to +9999 M	VAs		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

Table Appendix B –1: Modbus Register Map (Sheet 2 of 7)

Hex	Decimal	Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
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	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	* decimal point implied, per energy format	2
0455 - 0456	1110 - 1111	VAR-hours, Negative	SINT32	0 to -99999999	VARh per energy format	* resolution of digit before decimal point = units, kilo, or mega, per energy format	2
0457 - 0458	1112 - 1113	VAR-hours, Net	SINT32	-99999999 to 99999999	VARh 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

Table Appendix B –1: Modbus Register Map (Sheet 3 of 7)

Hex	Decimal	Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
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
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	VAs, 3-Ph, Maximum Avg Demand	FLOAT	-9999 M to +9999 M	VAs		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
Phase Angle Block¹⁴							read-only
1003 - 1003	4100 - 4100	Phase A Current	SINT16	-1800 to +1800	0.1 degree		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

Table Appendix B –1: Modbus Register Map (Sheet 4 of 7)

Hex	Decimal	Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Register
Status Block							
1387 - 1387	5000 - 5000	Meter Status	UINT16	bit-mapped	--expnch sssssss	expnch = EEPROM block OK flags (e=energy, x=max, n=min, p=programmable settings, c=calibration, h=header), sssssss = state (1=Run, 2=Limp, 10=Prog Set Update via buttons, 12=Prog Set Update via communication port.)	1
1388 - 1388	5001 - 5001	Not Used	N/A				
1389 - 138A	5002 - 5003	Time Since Reset	UINT32	0 to 4294967294	4 msec	wraps around after max count	2
						Block Size:	4
Commands Section⁴							
Resets Block⁹							
4E1F - 4E1F	20000 - 20000	Reset Max/Min Blocks	UINT16	password ⁵			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		meter leaves PS update mode via reset	1
55F1 - 55F1	22002 - 22002	Calculate Programmable Settings Checksum ³	UINT16			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 ⁵	1
55F3 - 55F3	22004 - 22004	Write New Password ³	UINT16	0000 to 9999		write-only register; always reads zero	1
59D7 - 59D7	23000 - 23000	Initiate Meter Firmware Reprogramming	UINT16	password ⁵			1
						Block Size:	6
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

Table Appendix B –1: Modbus Register Map (Sheet 5 of 7)

Hex	Decimal	Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Reg
Programmable Settings Section (See note 15)							
Basic Setups Block							write only in PS update mode
752F - 752F	30000 - 30000	CT multiplier & denominator	UINT16	bit-mapped	dddddddd mmmmmmmm	high byte is denominator (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	mmmmmmmm MMMMhhhh	MMMMmmmmmmmm 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	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
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	Not Used					1

Table Appendix B –1: Modbus Register Map (Sheet 6 of 7)

Hex	Decimal	Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Register
7549 - 7549	30026 - 30026	COM2 setup	UINT16	bit-mapped	----dddd -ppp- bbb	dddd = reply delay (* 50 msec) ppp = protocol (1-Modbus RTU, 2-Modbus ASCII) 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	Not Used	N/A				1
754C - 754C	30029 - 30029	Not Used	N/A				1
754D - 754D	30030 - 30030	Not Used	N/A				1
754E - 754E	30031 - 30031	Not Used	N/A				1
754F - 754F	30032 - 30032	Not Used	N/A				1
7550 - 7554	30033 - 30037	Not Used	N/A				5
7555 - 7559	30038 - 30042	Not Used	N/A				5
755A - 755E	30043 - 30047	Not Used	N/A				5
755F - 7563	30048 - 30052	Not Used	N/A				5
7564 - 7568	30053 - 30057	Not Used	N/A				5
7569 - 756D	30058 - 30062	Not Used	N/A				5
756E - 7572	30063 - 30067	Not Used	N/A				5
						Block Size:	68
Secondary Readings Section							
12-Bit Block							read-only except as noted
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	volts = 150 * (register - 2047) / 2047	1
9C43 - 9C43	40004 - 40004	Volts C-N	UINT16	2047 to 4095	volts		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	amps = 10 * (register - 2047) / 2047	1
9C46 - 9C46	40007 - 40007	Amps C	UINT16	0 to 4095	amps		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) /	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

Table Appendix B –1: Modbus Register Map (Sheet 7 of 7)

Hex	Decimal	Description ¹	Format	Range ⁶	Units or Resolution	Comments	# Register
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	volts = 300 * (register - 2047) / 2047	1
9C4E - 9C4E	40015 - 40015	Volts C-A	UINT16	2047 to 4095	volts		1
9C4F - 9C4F	40016 - 40016	CT numerator	UINT16	1 to 9999	none	CT = numerator * multiplier / denominator	1
9C50 - 9C50	40017 - 40017	CT multiplier	UINT16	1, 10, 100	none		1
9C51 - 9C51	40018 - 40018	CT denominator	UINT16	1 or 5	none		1
9C52 - 9C52	40019 - 40019	PT numerator	UINT16	1 to 9999	none	PT = numerator * multiplier / denominator	1
9C53 - 9C53	40020 - 40020	PT multiplier	UINT16	1, 10, 100	none		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	* resolution of digit before decimal point = units, kilo, or mega, per 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

- ASCII ASCII characters packed 2 per register in high, low order and without any termination characters. For example, "EPM2200" would be 4 registers containing 0x5378, 0x6172, 0x6B31, 0x3030.
- 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).

- 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 EPM2200
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	N/A
13	N/A
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.
15	If any register in the programmable settings section is set to a value other than the acceptable value then the meter will stay in LIMP mode. Please read the comments section or the range for each register in programmable settings section for acceptable settings.
16	N/A