EIG DNP V3.0 Protocol Assignments

For Futura+ and DM Series Power Monitors

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1. DNP Implementation

1.1 PHYSICAL LAYER

Electro Industries meters are capable of using either RS-232C or RS-485 as the physical layer. This is supplied through the use of the appropriate optional communication module, which can be ordered with the meter or separately.

1.1.1 RS-232C

RS-232C is used for point-to-point communication only. Electro Industries meters are DCE devices; they transmit on Pin 2 and receive on Pin 3. To connect to a DTE device, like the COM port of a computer, a direct connection cable may be used. To connect to another DCE, a Null Modem cable (one which flips pins 2 and pin 3) must be used.

1.1.2 RS-485

RS-485 provides multi-drop network communication capabilities. Multiple meters may be placed on the same bus, allowing for a Master device to communicate with any of the other devices. Appropriate network configuration and termination should be evaluated for each installation to insure optimal performance.

1.1.3 Communication Parameters

Electro Industries meters communicate in DNP V3.0 using the following communication settings:

- 8 Data Bits
- No Parity
- 1 Stop Bit

1.1.4 Baud Rates

Electro Industries meters are programmable to use several standard baud rates, including:

- 1200 Baud
- 2400 Baud
- 4800 Baud
- 9600 Baud

1.2 DATA LINK LAYER

The Data Link Layer as implemented on Electro Industries meters is subject to the following considerations:

1.2.1 Length Field / Buffer Size

The internal buffers are limited to 256 bytes. After removing checksums and the headers for the Data Link, Transport and Application Layers, this leaves 212 bytes for application data. Thus, the largest Length allowable is 222 (0xDE). Messages should be constructed with this limitation in mind.

1.2.2 Control Field

The Control Byte contains several bits and a Function Code. Specific notes follow.

1.2.2.1 Control Bits

Communication directed to the meter should be Primary Master messages (DIR = 1, PRM = 1). Response will be primary Non-Master messages (DIR = 0, PRM = 1). Acknowledgment will be Secondary Non-Master messages (DIR = 0, PRM = 0).

1.2.2.2 Function Codes

Electro Industries meters support all of the Function Codes for DNP V3.0. Specific notes follow.

1.2.2.2.1 Reset of Data Link (Function 0)

Before confirmed communication with a master device, the Data Link Layer must be reset. This is necessary after a meter has been restarted, either by applying power to the meter or reprogramming the meter. The meter must receive a RESET command before confirmed communication may take place. Unconfirmed communication is always possible and does not require a RESET.

1.2.2.2.2 User Data (Function 3)

After receiving a request for USER DATA, the meter will generate a Data Link CONFIRMATION, signaling the reception of that request, before the actual request is processed. If a response is required, it will also be sent as UNCONFIRMED USER DATA.

1.2.2.2.3 Unconfirmed User Data (Function 4)

After receiving a request for UNCONFIRMED USER DATA, if a response is required, it will be sent as UNCONFIRMED USER DATA.

1.2.3 Address

DNP 3.0 allows for addresses from 0 - 65534 (0x0000 - 0xFFFE) for individual device identification, with the address 65535 (0xFFFF) defined as an all stations address. Electro Industries meters' addresses are programmable from 0 - 9999 (0x0000 - 0x270F), and will recognize address 65535 (0xFFFF) as the all stations address.

1.3 TRANSPORT LAYER

The Transport Layer as implemented on Electro Industries meters is subject to the following considerations:

1.3.1 Transport Header

Multiple-frame messages are not allowed for Electro Industries meters. Each Transport Header should indicate it is both the first frame (FIR = 1) as well as the final frame (FIN = 1).

1.4 APPLICATION LAYER

The Application Layer contains a header (Request or Response Header, depending on direction) and data. Specific notes follow.

1.4.1 Application Headers

Application Headers contain the Application Control Field and the Function Code.

1.4.1.1 Application Control Field

Multiple-fragment messages are not allowed for Electro Industries meters. Each Application Header should indicate it is both the first fragment (FIR = 1) as well as the final fragment (FIN = 1). Application-Level confirmation is not used for Electro Industries meters.

1.4.1.2 Function Codes

The following Function codes are implemented on Electro Industries meters.

1.4.1.2.1 Read (Function 1)

Objects supporting the READ function are:

- Binary Inputs (Object 1) (Futura Only)
- Binary Outputs (Object 10)
- Counters (Object 20)
- Analog Inputs (Object 30)
- Time & Date (Object 50) (Futura Only)
- Class (Object 60)

These Objects may be read either by requesting a specific Variation available as listed in this document, or by requesting Variation 0. READ request for Variation 0 of an Object will be fulfilled with the Variation listed in this document.

1.4.1.2.2 Write (Function 2)

Objects supporting the WRITE function are:

- Internal Indications (Object 80)

1.4.1.2.3 Select (Function 3) (Futura Only)

Objects supporting the SELECT function are:

- Control Relay Output Block (Object 12)

Use of this function starts a 1 second timer for a legal use of the Operate (Function 4) function.

1.4.1.2.4 Operate (Function 4) (Futura Only)

Objects supporting the OPERATE function are:

- Control Relay Output Block (Object 12)

Use of this function can legally be performed only within 1 second of reception of the appropriate Select (Function 3) function.

1.4.1.2.5 Direct Operate (Function 5)

Objects supporting the DIRECT OPERATE function are:

- Control Relay Output Block (Object 12)

1.4.1.2.6 Direct Operate - No Acknowledgment (Function 6)

Objects supporting the DIRECT OPERATE - NO ACKNOWLEDGMENT function are:

- Control Relay Output Block (Object 12)

1.4.1.2.7 Response (Function 129)

Application responses from Electro Industries meters use the RESPONSE function.

1.4.2 Application Data

Application Data contains information about the Object and Variation, as well as the Qualifier and Range.

1.4.2.1 Object and Variation

The following Objects and Variations are supported on Electro Industries meters:

- Binary Input Status (Object 1, Variation 2) † (Futura Only)
- Binary Output Status (Object 10, Variation 2) †
- Control Relay Output Block (Object 12, Variation 1)
- 32-Bit Binary Counter Without Flag (Object 20, Variation 5) †
- 16-Bit Analog Input Without Flag (Object 30, Variation 4) †
- Time & Date (Object 50, Variation 1) † (Futura Only)
- Class 0 Data (Object 60, Variation 1) †
- Internal Indications (Object 80, Variation 1)

† READ requests for Variation 0 will be honored with the above Variations.

1.4.2.1.1 Binary Input Status (Obj. 1, Var. 2) (Futura Only)

Binary Input Statuses support the following functions:

- Read (Function 1)

  A READ request for Variation 0 will be responded to with Variation 2.

  Binary Input Statuses may be indexed with Qualifier Codes 0, 1, 2 or 6.

  Binary Input Statuses are used to communicate the following data measured by Electro Industries meters:

- Digital Inputs

1.4.2.1.1.1 Digital Inputs (Points 0-3)

Some Electro Industries meters are optionally capable of monitoring digital inputs. Binary Input Status points report the state of these inputs. If the feature is not present on this device, the point is reported as being off-line. If the feature is present, the point is reported as being on line.

1.4.2.1.2 Binary Output Status (Obj. 10, Var. 2)

Binary Output Statuses support the following functions:

- Read (Function 1)
  A READ request for Variation 0 will be responded to with Variation 2.

  Binary Output Statuses may be indexed with Qualifier Codes 0, 1, 2 or 6.

  Binary Output Statuses are used to communicate the following data measured by Electro Industries meters:

- Energy Reset State
- Demand Reset State (Futura Only)
- Relay States (Futura Only)

1.4.2.1.2.1 Energy Reset State (Point 0)

Electro Industries meters accumulate power generated or consumed over time as Hour Readings, which measure positive VA Hours and positive and negative W Hours and VAR Hours. These readings may be reset using a Control Relay Output Block object (Obj. 12). This Binary Output Status point reports whether the Energy Readings are in the process of being reset, or if they are accumulating. Normally, readings are being accumulated and the state of this point is read as '0'. If the readings are in the process of being reset, the state of this point is read as '1'.

1.4.2.1.2.2 Demand Reset State (Point 1) (Futura Only)

Electro Industries meters maintain maximum readings on most parameters. These readings may be reset using a Control Relay Output Block object (Obj. 12). This Binary Output Status point reports whether the Demand Readings are in the process of being reset or, if they are active. Normally, maximums are being monitored and the state of this point is read as '0'. If the readings are in the process of being reset, the state of this point is read as '1'.

1.4.2.1.2.3 Relay States (Points 2-4) (Futura Only)

Some Electro Industries meters are optionally capable of producing digital outputs using relays. These Binary Output Status points report the state of these relays. If the feature is not present on this device, the point is reported as being off-line. If the feature is present, the point is reported as being
on-line. A reading of '1' equals Open, or de-energized. A reading of '0' equals Closed, or energized.

1.4.2.1.3 Control Relay Output Block (Obj. 12, Var. 1)

Control Relay Output Blocks support the following functions:

- Select (Function 3) (Futura Only)
- Operate (Function 4) (Futura Only)
- Direct Operate (Function 5)
- Direct Operate - No Acknowledgment (Function 6)

Control Relay Output Blocks may be indexed with Qualifier Codes 7, 8 or 9 when used with the Select (Function 3) and Operate (Function 4) functions.

Control Relay Output Blocks may be indexed with Qualifier Codes 0, 1 or 2 when used with the Direct Operate (Function 5) and Direct Operate No Acknowledge (Function 6) functions.

Control Relay Output Blocks are used for the following purposes:

- Energy Reset
- Demand Reset (Futura Only)

1.4.2.1.3.1 Energy Reset (Point 0)

Electro Industries meters accumulate power generated or consumed over time as Hour Readings, which measure positive VA Hours and positive and negative W Hours and VAR Hours. These readings may be reset using Point 0.

Use of the SELECT (Function 3) and OPERATE (Function 4) functions will operate using any settings for the parameters of Control Code, Count, On Time, Off Time and Status.

Use of the DIRECT OPERATE (Function 5) or DIRECT OPERATE - NO ACKNOWLEDGE (Function 6) functions will operate only with the settings of Pulsed ON (Code = 1 of Control Code Field) once (Count = 0x01) for ON 1 millisecond and OFF 0 milliseconds.

1.4.2.1.3.2 Demand Reset (Point 1) (Futura Only)

Electro Industries meters maintain maximum readings on most parameters. These readings may be reset using Point 1.

Use of the SELECT (Function 3) and OPERATE (Function 4) functions will operate using any settings for the parameters of Control Code, Count, On Time, Off Time and Status.

Use of the DIRECT OPERATE (Function 5) or DIRECT OPERATE - NO ACKNOWLEDGE (Function 6) functions will operate only with the settings of Pulsed ON (Code = 1 of Control Code Field) once (Count = 0x01) for ON 1 millisecond and OFF 0 milliseconds.

1.4.2.1.4 32-Bit Binary Counter Without Flag (Obj. 20, Var. 5)

Counters support the following functions:

- Read (Function 1)

  A READ request for Variation 0 will be responded to with Variation 5.

  Counters may be indexed with Qualifiers Codes 0, 1, 2 or 6.

  Counters are used to communicate the following data measured by Electro Industries meters:
- Hour Readings

1.4.2.1.4.1 Hour Readings (Point 0 - 3)

Point	Readings	Unit
0	+kW Hour	kWH
1	-kW Hour	kWH
2	+kVAR Hour	kVARH
3	-kVAR Hour	kVARH

*These readings may be cleared by using the Control Relay Output Block.

1.4.2.1.5 16-Bit Analog Input Without Flag (Obj. 30, Var. 4)

Analog Inputs support the following functions:

- Read (Function 1)

  A READ request for Variation 0 will be responded to with Variation 4.

  Analog Inputs may be indexed with Qualifier Codes 0, 1, 2 or 6.

  Analog Inputs are used to communicate the following data measured by Electro Industries meters:

- Health Check
- Phase Current
- Phase-to-Neutral Voltage
- Total Power
- Phase Power
- CT & PT Ratios
- Neutral Current
- Frequency
- VA, Phase and Total
- Power Factor, Phase and Total
- Phase-to-Phase Voltage
- Total Harmonic Distortion
- Maximum Demands of Total Power

1.4.2.1.5.1 Health Check (Point 0)

The Health Check point is used to indicate problems detected by the meter. A value of zero (0x0000) indicates the meter does not detect a problem. Non-zero values indicate a detected anomaly.

1.4.2.1.5.2 Phase Current (Point 1 - 3)

Point	Reading
1	Phase A Current
2	Phase B Current
3	Phase C Current

These points are formatted as 2's complement fractions. They represent a fraction of a 10 A Secondary input. Inputs of above 10 A Secondary will be pinned at 10 A Secondary. For a further explanation of the format of these readings, see Appendix A.

1.4.2.1.5.3 Phase-to-Neutral Voltage (Point 4 - 6)

Point	Reading
4	Phase AN Voltage
5	Phase BN Voltage
6	Phase CN Voltage

These points are formatted as 2's complement fractions. For a standard back meter, they represent a fraction of a 150 V Secondary input. Inputs of above 150 V Secondary will be pinned at 150 V Secondary. For a further explanation of the format of these readings, see Appendix A. For units with back modules other than the standard back module, (G or 300 V, or L or 75 V), see Appendix B.

1.4.2.1.5.4 Total Power (Point 7 - 8)

Point	Reading
7	Total Watt
8	Total VAR

These points are formatted as 2's complement fractions. For a standard back meter, they represent a fraction of 4500 W Secondary in normal operation, or 3000 W Secondary in Open Delta operation. Inputs above/below +/-4500 or +/-3000 W Secondary will be pinned at +/-4500 or +/-3000 W Secondary, respectively. For a further explanation of the format of these readings, see Appendix A. For units with back modules other than the standard back module, (G or 300 V, or L or 75 V), see Appendix B.

1.4.2.1.5.5 Phase Power (Point 9 - 14)

Point	Reading
9	Phase A Watt
10	Phase B Watt
11	Phase C Watt
12	Phase A VAR
13	Phase B VAR
14	Phase C VAR

These points are formatted as 2's complement fractions. For a standard back meter, they represent a fraction of 1500 W Secondary. Inputs above/below +/-1500 W Secondary will be pinned at +/-1500 W Secondary. When in Open Delta operation, these points are always zero. For a further explanation of the format of these readings, see Appendix A. For units with back modules other than the standard back module, (G or 300 V, or L or 75 V), see Appendix B.

1.4.2.1.5.6 CT & PT Ratios (Point-15 - 18)

Point	Value
15	CT Ratio Numerator
16	CT Ratio Denominator
17	PT Ratio Numerator
18	PT Ratio Denominator

These points are formatted as 2's complement integers. They can be used to convert from units in terms of the Secondary of a CT or PT into units in terms of the Primary of a CT or PT. The ratio of Numerator divided by Denominator is the ratio of Primary to Secondary.

Electro Industries meters typically use Full Scales relating Primary Current to 5 Amps and Primary Voltage to 120 V. However, these Full scales can range from mA's to thousands of kA's, or mV's to thousands of kV's. The following rules apply:

- Full Scales containing fractions of Amps or Volts are truncated before being represented.
- Full Scales below 32,767 A : 5 A or 32,767 V : 120 V will be represented exactly, in that format. (Ex. 14.40 kV : 120 V (120 : 1) would be represented as PT Ratio Numerator = 14,400 (0x3840), PT Ratio Denominator = 120 (0x0078)).
- Full Scales above 32,767 A : 5 A or 32, 767 V : 120 V are represented as a Primary in terms of a Secondary which is a power of 2. This may produce a ratio that is not exact. (Ex. 50 kA : 5 A (10,000 : 1) would be represented as CT Ratio Numerator = 20,000 (0x4E20), CT Ratio Denominator = 2 (0x0002)).
- Full Scales which are above 32,767 A : 1 A or 32,767 V : 1 V get pinned at 32,767 A : 1 A or 32,767 V : 1 V.

1.4.2.1.5.7 Neutral Current (Point 19)

This point is formatted as a 2's complement fraction. It represents a fraction of 15 A Secondary. Inputs above 15 A Secondary will be pinned at 15 A Secondary. When in Open Delta operation, this point is always zero. For a further explanation of the format of these readings, see Appendix A.

1.4.2.1.5.8 Frequency (Point 20)

This point is formatted as a 2's complement integer. It represents the Frequency as measured on Phase A Voltage in units of cHz (centiHertz, 1/100 Hz). Inputs below 45.00 Hz are pinned at 0 (0x0000), while inputs above 75.00 Hz are pinned at 9999 (0x270F).

1.4.2.1.5.9 VA, Phase and Total (Point 21 - 24)

Point	Reading
21	Phase A VA
22	Phase B VA
23	Phase C VA
24	Total VA

These points are formatted as 2's complement fractions. Points 21-23 represent a fraction of 1500 W Secondary. Inputs above/below +/-1500 w Secondary will be pinned at +/-1500 W Secondary. When in Open Delta, points 21-23 are always zero. Point 24 represents a fraction of 4500 W Secondary in normal operation, or 3000 W Secondary in Open Delta operation. Inputs above/below +/-4500 or +/-3000 W Secondary will be pinned at +/-4500 or +/-3000 W Secondary, respectively. For a further explanation of the format of these readings, see Appendix A. For units with back modules other than the standard back module, (G or 300 V, or L or 75 V), see Appendix B.

1.4.2.1.5.10 Power Factor, Phase and Total (Point 25 - 28)

Point	Reading
25	Phase A Power Factor
26	Phase B Power Factor
27	Phase C Power Factor
28	Total Power Factor

These points are formatted as 2's complement integers. They represent Power Factors from –1.000 (0x0FC18) to +1.000 (0x003E8). When in Open Delta operation, Phase Power Factor (Points 25-27) are always zero.

1.4.2.1.5.11 Phase-to-Phase Voltage (Point 29 - 31)

Point	Reading
29	Phase AB Voltage
30	Phase BC Voltage
31	Phase CA Voltage

These points are formatted as 2's complement fractions. For a standard back meter, they represent a fraction of a 300 V Secondary input. Inputs of above 300 V Secondary will be pinned at 300 V Secondary. For a further explanation of the format of these readings, see Appendix A. For units with back modules other than the standard back module, (G or 300 V, or L or 75 V), see Appendix B.

1.4.2.1.5.12 Total Harmonic Distortion (Point 32 - 37)

Point	Reading
32	Phase AN Voltage THD
33	Phase BN Voltage THD
34	Phase CN Voltage THD
35	Phase A Current THD
36	Phase B Current THD
37	Phase C Current THD

These points are formatted as 2's complement integers. They represent the percentage of Total Harmonic Distortion (THD) in units of hundredths of a percent (1 / 100 %) fractions.

1.4.2.1.5.13 Maximum Demands of Total Power (Point 38 - 41)

Point	Reading
38	Maximum Positive Demand Total Watts
39	Maximum Negative Demand Total Watts
40	Maximum Positive Demand Total VAR
41	Maximum Negative Demand Total VAR

These points are formatted as 2's complement fractions. For a standard back meter, they represent a fraction of 4500 W Secondary in normal operation, or 3000 W Secondary in Open Delta operation. Inputs above/below +/-4500 or +/-3000 W Secondary will be pinned at +/-4500 or +/-3000 W Secondary, respectively. For a further explanation of the format of these readings, see Appendix A. For units with back modules other than the standard back module, (G or 300 V, or L or 75 V), see Appendix B.

1.4.2.1.6 Time & Date (Obj. 50, Var. 1) (Futura Only)

Time & Dates support the following functions:

- Read (Function 1)

  A READ request for Variation 0 will be responded to with Variation 1.

  Time & Dates may be indexed by Qualifier Codes 0, 1, 2 or 6.

  Time & Dates are used to report the following information stored in an Electro Industries meter:

- Current Time
- Time of most recently stored Snapshot, Event and Waveform

  Meters that do not have real-time capability do not support the Time & Date Object.

1.4.2.1.6.1 Current Time (Point 0) (Futura Only)

Meters that have real-time capability use this point to report the Current Time. Meters that could have real-time capability, but do not have it installed, return the default time of midnight, January 1, 1970.

1.4.2.1.6.2 Mass Memory Storage Timestamp (Point 1 - 3) (Futura Only)

Point	Reading
1	Most Recent Snapshot
2	Most Recent Event
3	Most Recent Waveform

Meters that have Mass Memory capability use these points to report the time of the most recent Snapshot, Event and Waveform. Should a log be empty or not present on a particular meter, it will return the default time of midnight, January 1, 1970.

1.4.2.1.7 Class 0 Data (Obj. 60, Var. 1)

Class Data support the following functions:

- Read (Function 1) for Futura Power Monitors

A request for Class 0 Data from an Electro Industries meter will return four Object Headers. Specifically, it will return 16-Bit Analog Input Without Flags (Object 30, Variation 4), Points 0 - 41, followed by 32-Bit Counters Without Flags (Object 20, Variation 5), Points 0 – 3, followed by Binary Output Status (Object 10, Variation 2), Points 0-4, followed by Binary Input Status (Object 1, Variation 2), Points 0-3.

- Read (Function 1) for DM Series Power Monitors

A request for Class 0 Data from an Electro Industries meter will return four Object Headers. Specifically, it will return 16-Bit Analog Input Without Flags (Object 30, Variation 4), Points 0 - 31, followed by 32-Bit Counters Without Flags (Object 20, Variation 5), Points 0 – 3, followed by Binary Output Status (Object 10, Variation 2), Point 0 - 0. (There is NO Object 1.)

A request for Object 60, Variation 0 will be treated as a request for Class 0 Data.

Class Data may be indexed with Qualifier Code 6.

1.4.2.1.8 Internal Indications (Obj. 80, Var. 1)

Internal Indications support the following functions:

- Write (Function 2)

Internal Indications may be indexed by Qualifier Codes 0, 1 or 2.

1.4.2.1.8.1 Device Restart (Point 7)

This bit is set whenever the meter has reset. The polling device may clear this bit by Writing (Function 2) to Object 80, Point 7.

1.4.2.2 Qualifier and Range

Electro Industries meters operate with Qualifier Codes 0, 1, 2 or 6. For codes 0, 1 and 2, the Range field contains 1 byte (Q-code = 0), 2 byte (Q-code = 1) or 4 byte (Q-code = 2) Start Range and Stop Range values, as Indices of data.

Qualifier Code 6 may also be used with the following objects:

- Counter (object 20)
- Analog Inputs (object 30)
- Time & Dates (object 50) (Futura Only)
- Class & Data (object 60)

Request with Qualifier Code 6 will return all of the points of the specified object.

Appendix A: Analog Input Secondary to Primary Conversion

Converting Fractional to Secondary

Most of the Analog Input (Object 30) points are formatted as 2's complement fractions. The Analog Input value varies from +32,767 to -32,768. Divided by 32,768, this produces the fraction. Multiplying the fraction by the Secondary scale of the particular Analog Input produces the Secondary value. The equation is therefore:

$$\text{Secondary Value} = \frac{\text{Analog Input}}{32768} \times \text{Secondary Scale}$$

Example 1:

Analog Input Point 4 (Phase AN Voltage) returns with the value of 16,384 (0x4000). The Secondary Scale for this point is 150 Volts Secondary. By the above equation, the Secondary Value is:

$$\frac{16384}{32768} \times 150 \text{ V Secondary} = 75 \text{ V Secondary}$$

CT and PT Ratios

To convert from Secondary to Primary, the CT and/or PT Ratio is needed. These ratios may be found by dividing the Ratio Numerator (Object 30, Point 15 or 17) by the corresponding Ratio Denominator (Object 30, Point 16 or 18). The equation is therefore:

$$\text{Ratio} = \frac{\text{Ratio Numerator}}{\text{Ratio Denominator}}$$

Example 2:

Analog Input Point 17 (PT Ratio Numerator) = 19,200 (0x4B00) and Point 18 (PT Ratio Denominator) = 16 (0x0010). By the above equation, the PT Ratio is:

$$\frac{19200}{16} = 1200:1$$

Converting Fractional to Primary

Combining the above two equations, the method of converting a 2's complement fraction representing a Secondary value into the equivalent Primary value would use the following equation:

$$\text{Primary Value} = \frac{\text{Analog Input}}{32768} \times \text{Secondary Scale} \times \frac{\text{Ratio Numerator}}{\text{Ratio Denominator}}$$

Example 3:

Analog Input Point 1 (Phase A Current) returns with a value of 9,871 (0x268F), Analog Input Point 15 (CT Ratio Numerator) with a value of 2,000 (0x07D0) and Analog Input Point 16 (CT Ratio Denominator) with a value of 5 (0x0005). The Secondary Scale for Point 1 is 10 A Secondary. By the above equation, the Primary Value is:

$$\frac{9871}{32768} \times 10 \text{ A Secondary} \times \frac{2000}{5} = 1205 \text{ A Primary}$$

Example 4:

The meter is in Open Delta operation. Analog Input Point 7 (Total Watt) returns with a value of -12,754 (0xCE2E), Analog Input Point 15 (CT Ratio Numerator) with a value of 1000 (0x03E8), Analog Input Point 16 (CT Ratio Denominator) with a value of 5 (0x0005), Analog Input Point 17 (PT Ratio Numerator) with a value of 12,000 (0x2EE0) and Analog Input Point 18 (Pt Ratio Denominator) with a value of 120 (0x0078). When operating in Open Delta, the Secondary Scale for Point 7 is 3000 W Secondary. By the above equation, the Primary Value is:

$$\frac{-12754}{32768} \times 3000 \text{ W Secondary} \times \frac{1000 \times 12000}{5 \times 120} = -23.35 \text{ MW Primary}$$

Appendix B: Analog Input Scaling for Alternate Back Modules

Standard Back Module (120 V)

Voltage readings are scaled relative to the range of the voltage back module. A standard back meter is capable of measuring voltages Phase-to-Neutral up to 150 Volts secondary, and Phase-to-Phase up to 300 Volts secondary. PT Ratios are entered relative to 120 Volts secondary. Voltage and Power readings are scaled as described in their respective sections.

G Back Module (300 V)

A G Back meter is capable of measuring voltages Phase-to-Neutral up to 300 Volts secondary and Phase-to-Phase up to 600 Volts secondary. PT Ratios are entered relative to 300 Volts secondary.

The difference in PT Ratios introduces a difference in scaling voltage and power readings. An extra factor of 300/120, or 2.5, is introduced when interpreting voltage and power readings on a G Back meter.

The scaling of phase-to-neutral voltages is to 375 Volts secondary, not 150 Volts secondary, phase-to-phase voltages is to 750 Volts secondary, not 300 Volts secondary. Watt, VAR and VA per phase values are scaled to 3750 Watt, VAR or VA secondary, and not to 1500. Total Watt, VAR and VA values are scaled to 7500 Watt, VAR or VA secondary in DELTA and 11,250 Watt, VAR or VA secondary WYE, instead of 3000 in DELTA or 4500 in WYE.

L Back Module (75 V)

An L Back meter is capable of measuring voltages Phase-to-Neutral up to 75 Volts secondary and Phase-to-Phase up to 150 Volts secondary. PT Ratios are entered relative to 75 Volts secondary.

The difference in PT Ratios introduces a difference in scaling voltage and power readings. An extra factor of 75/120, or 5/8 (0.625), is introduced when interpreting voltage and power readings on an L Back meter.

The scaling of phase-to-neutral voltages is to 93.75 Volts secondary, not 150 Volts secondary; phase-to-phase voltages is to 187.5 Volts secondary, not 300 Volts secondary. Watt, VAR and VA per phase values are scaled to 937.5 Watt, VAR or VA secondary, and not to 1500. Total Watt, VAR and VA values are scaled to 1875 Watt, VAR or VA secondary in DELTA and 2812.5 Watt, VAR or VA secondary WYE, instead of 3000 in DELTA or 4500 in WYE.