ET3
ADVANCED POWER TRANSDUCER

USER'S MANUAL

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

Limitation of Liability
Elkor Technologies Inc. ("Elkor") reserves the right to make changes to its products and/or their specifications without notice. Elkor strongly recommends obtaining the latest version of the device specifications to assure the most current information is available to the customer.

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

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

Installation Considerations
Installation and maintenance of the ET3 should only be performed by qualified, competent personnel who have appropriate training and experience with high voltage and current devices. The ET3 must be installed in accordance with all Local and National Electrical Safety Codes.

WARNING

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

- During normal operation of this device, hazardous voltages are present on the input terminal strips of the device and throughout the connected power lines, including the potential transformers (PTs) and the unit's power supply. With their primary circuit energized, current transformers (CTs) may generate high voltage when their secondary windings are open. Follow standard safety precautions while performing any installation or service work (i.e. remove line/ PT fuses, short CT secondaries, etc). The ET3 box cover should be secured in place after installation.

- The ET3 transducer is not intended for primary protection applications.

- Do not HIPOT and/or dielectric test any of the digital or analog outputs. Refer to this manual for the maximum voltage level the ET3 can withstand.

- Do not exceed rated input signals as it may permanently damage the ET3.

- The ET3 chassis ground must be properly connected to the switchgear earth ground.

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1. INTRODUCTION

1.1 General

1.1.1 Electrical Wiring

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

1.1.2 Documentation

This document was written and released in March 2005 (rev.2.4).

1.1.3 Disclosure

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1.1.4 Warranty

The ET3 Advanced Power Transducer is warranted to the original purchaser against defective material and workmanship for a period of two (2) years from the date of delivery. During the warranty period Elkor will repair or replace, at its option, all defective equipment that is returned freight prepaid. There will be no charge for repair provided there is no evidence that the equipment has been mishandled or abused.

1.2 Product Description

The Elkor ET3 Advanced Power Transducer is a true RMS, three phase device designed for Building Automation and Energy Management applications.

The unit measures true RMS value of voltages and currents and calculates other electrical parameters, including rolling window demand power (WD). The transducer accumulates energy consumption (Watt-hours), available as pulsed output, and generates four analog output signals (models 1200 & 1250) proportional to the following parameters:

- Instantaneous real power (Watts) - output A
- Instantaneous apparent power (Volt-Amperes) - output B
- Demand real power (Watts Demand) - output C
- Averaged Current, Averaged Voltage, System Power Factor or Frequency (factory set) - output D

All the ET3 analog output signals meet the control industry standards:

- Energy pulses (Wh) can be slow (change-of-state with 50% duty cycle) or short - 100 ms.

- Four analog signals are available as 0-5 VDC or 4-20 mA (sourcing)

The ET3 digital output transmits all the parameters via an RS-485 port using Modbus RTU protocol.

The transducer is housed in a conduit-ready metal box intended for surface mounting, close to the electrical equipment. As an option a remote LCD display, the ET3-RDM, may by placed close to the main unit or installed remotely in a convenient and safe location.

Fig.1 illustrates the ET3 functional diagram.

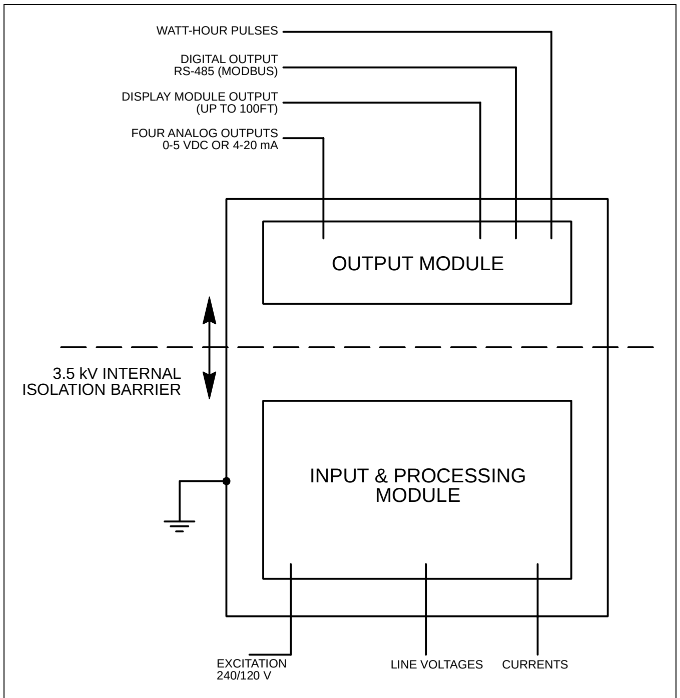


Fig 1. ET3 Functional Diagram

1.3 Features

The ET3 transducer accepts line voltages up to 600 V directly, without the need for Potential Transformers (PTs). The line input circuitry is optically isolated from the outputs. The following table summarizes the output features offered by various ET3 models:

	ET3-1100	ET3-1200	ET3-1250
Wh Pulses	✓	✓	✓
RS485 Communications	✓	✓	✓
Remote Display Output	✓	✓	
0-5VDC Analog Outputs		✓	
4-20mA Analog Outputs			✓

** Display output port not available on ET3-1250 (4-20mA) output versions

2.0 SPECIFICATIONS

2.1 Operating Specifications

Environmental:

Indoor Installation
Temperature: 0 to 60 °C (industrial grade –40 to 60°C available on special request)
Humidity: 10 to 90% non-condensing

Electrical:

Power Supply Requirements:

120 V or 240 V (factory selected), 50/60 Hz, 6 VA

Monitored Power System Parameters:

Note: All line inputs are electrically isolated from the outputs and the chassis. Isolation test 3500 V RMS , 1 min.

Direct Input Voltage Max. Rated 600 VRMS (phase-to-phase), 347 VRMS phase to ground for 4 wire systems (PTs are required for systems over 600 V);

Input Impedance: ≥ 1 MΩ

Supported Voltage Systems: 120/208 delta, wye
277/480 delta, wye
347/600 delta, wye

Frequency: 45 to 65 Hz

Current Inputs: Standard CTs, 0-5 A, 20% continued overload, 10 A absolute maximum; burden 0.01 VA @ 5 A,
-OR-
ELKOR MCT*xx* current sensors (may be wired off 5A CTs)

Absolute Maximum Ratings:
Voltage: 450 V (Line-to-Neutral) = 780V (Line-to-Line) (*)
Current: 10 A via CTs (*)

(*) Note: *These are the absolute maximum values that the unit can withstand without damage. They are not intended as operating values. See Product Name Tag on the enclosure for the Rated Operating Line Parameters.*

2.2 Output Specifications

Output Signals: **Watt-hours** - solid state relay; 300V, 0.4A maximum load;
configurable as 50% duty cycle (change of state) or 100 ms pulses.
Watts, Volt-Amperes, Watts Demand - available as 0-5 VDC or 4-20 mA on outputs A, B and C (4-20 mA is sourcing, max. loop impedance 600 Ohm)
Averaged Current / Averaged Voltage / System Power Factor / Frequency - available on output D (this parameter is factory set at the time of ordering)

Digital Communication: one RS-485 port, 9600 baud, 8, N, 1; Modbus RTU protocol, over 20 parameters available (see section 4.4 for details);

Information Update Frequency: All outputs are updated every second.

Display (Optional ET3-RDM unit available): LCD graphical with back-light (see section 4.3 for details)

2.3 Accuracy Specification

Class 0.5 device:	All parameters: 0.5 % of readings (at 25°C, within 10 to 100 % of nominal inputs, PF ≥ 0.5, 5 A Input)
Current:	0.3% (@ 25°C, 10 to 100% of rated load)

Note: Metering grade CTs and PTs are recommended for high accuracy applications.

3.0 INSTALLATION

3.1 Grounding Considerations

The ET3 transmitter's enclosure and the input instrument transformers should be grounded to earth ground in accordance with the applicable electrical safety code. The grounding post on the bottom of the enclosure can be utilized in some wiring installations (i.e. if a non-metallic conduit or cable is used).

Output signal ground is usually provided by the controller (RTU, DDC, PLC etc). The output common (GND) **IS ISOLATED** from the chassis ground (earth ground) and the input common (Ref).

3.2 Power Supply Wiring

A dedicated 120 VAC (or 230-240 VAC) 50 or 60 Hz properly fused circuit is recommended for the ET3 transducer. The power supply wires should be wired through a dedicated conduit or raceway, separately from the line input wires, if the metered system voltage is different then the power supply voltage.

The power input to the ET3 is fused by a fast acting 0.5 A pico-fuse located on the PC board. This fuse is not intended for user servicing.

3.3 Line Circuits Wiring

The ET3 is a true 'three element' meter that can be used in any electrical system. For a four wire system ('wye', with distributed neutral) the transducer requires current and voltage information from each phase which means that three current transformers (CTs) and three line voltages plus the neutral have to be wired to the unit.

The ET3 can be used in three wire systems ('delta', without distributed neutral) as a 'three element' meter (three CTs required) or it may be wired as a 'two element' meter utilizing only two CTs (and two PTs).

The wiring diagrams for various power system configurations are shown in Figs. 2 & 3. They are also located on the inside of the ET3 enclosure.

Standard wiring principles for electricity meters apply to the ET3 transducer, as for any other '3 element' electricity meter. The polarity of interfacing transformers should be observed. The left terminal of each current input connector is always associated with the 'X1' wire of the responding CT. Please refer to Appendix 3 for details on CT wiring.

The use of a 3/4" metallic conduit with 600V, AWG #14 wires is recommended for power line connections. **This connection has to be performed by qualified personnel in the accordance with the applicable electrical codes and standards.**

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

3.4 Enclosure Mounting

The ET3 is housed in a metal box intended for surface installation. The box can be installed on a wall, plywood or attached directly to other electrical enclosures. The ET3 enclosure is conduit ready with two 3/4” knock-outs located at the bottom and one 1/2” knock-out located on the top and intended for output wiring only.

Note: While drilling and punching additional holes into the enclosure, extreme care must be taken to prevent damage to the electronics and to avoid metal fillings inside of the enclosure.

3.5 Indicators and Jumpers

The ET3 has three indicating LEDs located on top of the PCB. They may be helpful for wiring/operation diagnostics.

- ***LED1*** - Green ‘power ON’ LED indicates the presence of power supply to the transducer.
- ***LED2*** - Red Wiring Diagnostic LED, will flash if input wiring polarity is incorrect.
- ***LED3*** - Yellow Wh LED indicates the energy pulse relay operation.

There are two user selectable jumpers located on the ET3 PCB, under the metal cover:

- **Address DIP** switch allows device address selection (1 to 63) to be used in Modbus communication. (1 is the LSB, 6 is the MSB)

  “UP” means switch in the up position (towards outputs). “Down” means switch in the down position (towards inputs).

	DIP1-1	DIP1-2	DIP1-3	DIP1-4	DIP1-5	DIP1-6
Bit	“1”	“2”	“4”	“8”	“16”	“32”
Examples:						
1	UP	DOWN	DOWN	DOWN	DOWN	DOWN
5	UP	DOWN	UP	DOWN	DOWN	DOWN
30	DOWN	UP	UP	UP	UP	DOWN

3.6 kWh Reset Procedure

Jumper J2 (kWh RESET) is used to RESET the device accumulators.
Note: The reset action will erase the accumulated Watt-hour total !!!

The reset procedure for the meter is as follows:

1. *Turn power to the meter off.*
2. *Remove the front panel.*
3. *Apply the shunt to short J2.*
4. *Apply power to the meter. At this point accumulated kWh and Clicks will be reset.*
5. *Remove the shunt (open J2).*
6. *Re-install the front panel.*

kWh values will automatically roll over to 0 when the kWh register reaches 99,999,999.9 kWh (0x3B9AC9FE). See chapter 4.4.1 for details

*NOTE: The jumper labeled **J1-CONFIG.** is not a user jumper.*

4. TRANSDUCER OPERATION

4.1 General

The transducer is ready in a few seconds after the excitation power supply is applied. The green LED indicates power ON. Flashing red LED indicates an input wiring problem.

4.2 Output Signals

4.2.1 Energy (kWh) Pulses

As a standard the ET3 offers an open collector opto-isolator that will change state (flip) as a predefined amount of energy (Wh) is measured. These slow pulses have a duty cycle of 50% and can be easily monitored by any standard EMS digital input. On request, a short 100 milli-second pulse is available for an external electronic pulse counter.

The amount of Watt-hours per one pulse is factory set but can be user selected (via Modbus) from 16 standard values offered by the ET3. The maximum pulsing speed is 1 Hz (3600 pulses in one hour) and the desired pulse value should be carefully chosen not to exceed this number. The Wh/pulse value depends on the nominal voltage and the current specified for the unit. i.e. a 3~120 V, 5A transducer with 500:5A CTs the nominal power will be:

3 (phase) x 120 (volts) x 5 (amps) x 100 (CT Ratio) = 180 kW.

In one hour there will be 180 kWh used. At 50 Wh/pulse selected there would be 3600 pulses (180,000/50) thus the output would pulse every second. It is recommended to select higher Wh/pulse ratio so that at full load the output could pulse every few seconds. At 100 Wh/pulse the pulse rate would be 2 seconds.

Note: *Please refer to the Calibration Sheet for scaling of output parameters.*

4.2.2 Analog Output Signals

The ET3-1200 offers four 0-5VDC analog signals. Model ET3-1250 offers four 4-20 mA sourcing signals. In either case, three first outputs always represent: (a) Watts, (b) Volt-Amperes, (c) Watts-Demand. The fourth signal may be ordered as averaged current (factory default), averaged L-N voltage, system frequency or system power factor. The WD output has a user definable (via Modbus) ‘rolling window’ time interval from 1 to 45 minutes. (Factory default is 15 minutes).

4.2.3 Digital Outputs

The RS-485 digital communication port allows for remote viewing of all the measured parameters via any Modbus RTU Master device. The communication port is configured for 9600, N,8,1. The details of this output are described in chapter 4.4.

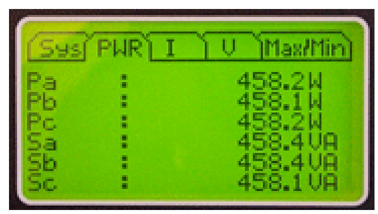
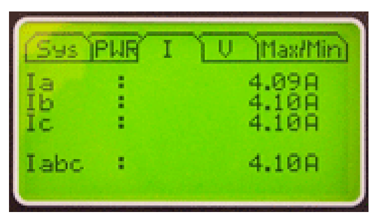
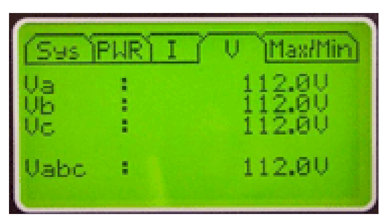
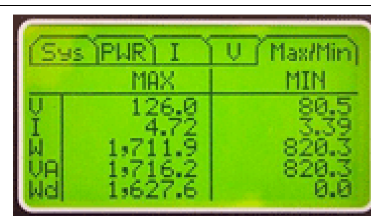
The Display (DSPL) port is custom designed to provide digital communications to an optional remote display described in chapter 4.3.

4.3 Remote LCD Display Module (optional)

The ET3-RDM is an optional module which connects to a designated digital output of the ET3. The module displays all of the relevant information made available by the ET3. The module is powered by the ET3 and requires only three wires to operate. It may be installed up to 100 ft (30 m) from the ET3 unit.

** NOTE: The ET3-RDM module is not available for ET3-1250 (4-20mA) output versions.

The ET3-RDM simple user interface is divided into screens represented by "file-folder" style tabs. Each screen displays parameters relevant to the tab selected. The available tabs are:

System: (Sys) • System Power Factor • Frequency (Hz) • Total Real Power (W) • Total Apparent Power (VA) • Demand (Wd) • Energy (kWh)	
Power (PWR): • Real Power, Phase A (W) • Real Power, Phase B (W) • Real Power, Phase C (W) • Apparent Power, Phase A (VA) • Apparent Power, Phase B (VA) • Apparent Power, Phase C (VA)	
Current (I): • Current, Phase A (A) • Current, Phase B (A) • Current, Phase C (A) • Average Current in Three Phases (A)	
Voltage (V): • Voltage, Phase A (V) • Voltage, Phase B (V) • Voltage, Phase C (V) • Voltage, Line-to-Line AB (V) • Voltage, Line-to-Line BC (V) • Voltage, Line-to-Line CA (V)	
MAX/MIN: • Maximum and Minimum Voltage (V) • Maximum and Minimum Current (A) • Maximum and Minimum Real Power (W) • Maximum and Minimum Apparent Power (VA) • Maximum and Minimum Demand (Wd)	

The ET3-RDM is controlled using the arrow keys. Selection of screens is done by the ◀ and ▶ keys. The tabs scroll in the order which they appear on the screen. To move to a tab right of the currently selected tab simply press the ▶ key. The tabs “wrap around” so that to get to the “System” tab from the “Max/Min” tab simply press ▶ once, or press ◀ four times.

When viewing the Max/Min parameters (calculated and stored by the ET3-RTM), pressing and holding the ■ key for 3 seconds will clear the MAX/MIN values.

Every parameter (with the exception of the Max/Min parameters) may be viewed using a Large Display. The parameter is selected using the ▲ and ▼ keys. As these keys are pressed a block will display which parameter is to be selected. To select the parameter, press the ■ key.

When in the large display mode, pressing ■ will return to the regular display mode.

The built in backlight is triggered every time any key is pressed. The backlight will remain lit for 20 seconds after any button has been pressed.

An information screen is made available by pressing and holding the ◀ and ▶ keys for three seconds. This information screen will display the CT and PT ratios configured in the meter. This screen will also allow contrast adjustment by using the ▲ and ▼ keys. To exit the information screen, press the ■ key.

Large Display View

Key Functions for various modes:

Key	*Normal View*	*Large Display View*	*Information View*
◀ and ▶	Selects Tab Pressing and holding both for three seconds brings up the information view.	No action	No action
▲ and ▼	Selects parameter for Large Display view	No action	Change Contrast Level
■	Initializes Large Display view on selected parameter. Does nothing if no parameter is selected If view is MAX/MIN, pressing and holding ■ will reset the MAX/MIN values	Return back to Normal View	Return back to Normal View.

Note: The display does *NOT* allow resetting of kWh, nor the setup of any parameters.

4.4 Digital Communications

ET3 versions equipped with digital communications (versions 1100, 1200 and 1250) feature a digital output port suitable for Modbus communications.

Communications Protocol: The ET3 utilizes a subset of Modicon's "Modbus™" standard protocol. There must be a repeater installed if more than 30 units are on the communications chain.

Transmission Mode: RS-485 Half-Duplex RTU, 9600 bps, N,8,1

Command Framing (functions 3 & 4, read N words):
Query (8 bytes)

Address Field	Function Code	Starting Register	Number of Registers	CRC
1~63	3 or 4	0~M	1~N	
(1 byte)	(1 byte)	(2 byte)	(2 byte)	(2 byte)

Response

Address Field	Function Code	Byte Count	Data Field... (register M)		...Data Field (register M+N)		CRC
1~63	3 or 4	0~N	Hi Byte	Lo Byte	Hi Byte	Lo Byte	
(1 byte)	(1 byte)	(1 byte)	(2 bytes per register)				(2 bytes)

Command Framing (function 6, write single word):
Query (8 bytes)

Address Field	Function Code	Starting Register	Data Field		CRC
1~63	6	0~N	Hi Byte	Lo Byte	
(1 byte)	(1 byte)	(2 byte)	(2 byte)		(2 byte)

Response

Address Field	Function Code	Starting Register	Data Field		CRC
1~63	6	0~N	Hi Byte	Lo Byte	
(1 byte)	(1 byte)	(2 byte)	(2 byte)		(2 byte)

- Start of frame: No transmission for at least a 3.5 bit period (3.5ms at 9600bps)
- Address Field: Applicable addresses are 1~63. The address must match the one defined on the units DIP switch.
- Function Code: 3 = Configuration Registers; 4 = Data Registers; 6 = Write to Configuration Registers (note: many of the configuration registers are factory adjustable only. See table 4.3.1 for details)
- Starting Register = Contains the number of the first register requested (functions 3 and 4), or the register to write to (function 6).
- Data Field: Contains the number of registers requested (functions 3 and 4), or the value to write into the appropriate register (function 6).
- CRC: 16 bit CRC

4.4.1 Modbus Function 3 Registers

Register Offset	***Name***	***Comments***
0x0000h (40001)	PT Ratio	Defines the PT ratio. This number is used to calculate the energy (Clicks and kWh readings), but does *not* influence the voltage output registers. *Use this register to with function 4 registers to obtain engineering units.*
0x0001h (40002)	CT Ratio	Defines the CT ratio. This number is used to calculate the energy (Clicks and kWh readings), but does *not* influence the current output registers. *Use this register to with function 4 registers to obtain engineering units.*
0x0002h (40003)	Demand Time	Sets the time (in minutes) for the rolling demand window A time period of 1 to 45 minutes may be defined. Default factory setting is 15 minutes.
0x0003h (40004)	Pulse Configuration	Sets the 'click' type and value. The high byte specifies click type (0 = Change of state type, 1 = 100ms pulse type). The low byte specifies the click value as per the setting below: 0x00h = 0.5 [Wh/Click] 0x08h = 200 [Wh/Click] 0x01h = 1 [Wh/Click] 0x09h = 500 [Wh/Click] 0x02h = 2 [Wh/Click] 0x0Ah = 1 [kWh/Click] 0x03h = 5 [Wh/Click] 0x0Bh = 2 [kWh/Click] 0x04h = 10 [Wh/Click] 0x0Ch = 5 [kWh/Click] 0x05h = 20 [Wh/Click] 0x0Dh = 10 [kWh/Click] 0x06h = 50 [Wh/Click] 0x0Eh = 20 [kWh/Click] 0x07h = 100 [Wh/Click] >0x0Eh = Invalid Example 1: to set a pulse type of change of state with a 1 kWh/Click value, set the register to 0x000Ah Example 2: to set a pulse type of 100ms per click with a 20 Wh/Click value, set the register to 0x0105h
0x0004h (40005)	Pulse Count	Accumulator of how many 'clicks' have occurred. This register may only be reset by the on-board reset jumper.
0x0005h (40006)	kWh Total (High)	Holds a running total of energy used. These two 16-bit registers form one 32-bit long integer. Presented as the kWh value x10. Example: kWh Total (High) = 0x1234 kWh Total (Low) = 0xABCD The 32-bit register should be 0x1234ABCD, which translates to 305,441,741 (decimal). Therefore the value should be interpreted as: 30,544,174.1 kWh. **kWh values will roll over at 99,999,999.9 kWh (0x3B9AC9FE)** See chapter 3.5 for reset details.
0x0006h (40007)	kWh Total (Low)	

4.4.1 Modbus Function 3 Registers (continued)

0x0007h (40008)	*Click Accumulator*	*Factory adjustable only*
0x0008h (40009)	*Click Accumulator*	*Factory adjustable only*
0x0009h (40010)	*Va Offset*	*Factory adjustable only*
0x000Ah (40011)	*Vb Offset*	*Factory adjustable only*
0x000Bh (40012)	*Vc Offset*	*Factory adjustable only*
0x000Ch (40013)	*Va Scale Factor*	*Factory adjustable only*
0x000Dh (40014)	*Vb Scale Factor*	*Factory adjustable only*
0x000Eh (40015)	*Vc Scale Factor*	*Factory adjustable only*
0x000Fh (40016)	*Ia Offset*	*Factory adjustable only*
0x0010h (40017)	*Ib Offset*	*Factory adjustable only*
0x0011h (40018)	*Ic Offset*	*Factory adjustable only*
0x0012h (40019)	*Ia Scale Factor*	*Factory adjustable only*
0x0013h (40020)	*Ib Scale Factor*	*Factory adjustable only*
0x0014h (40021)	*Ic Scale Factor*	*Factory adjustable only*
0x0015h (40022)	*Analog Cal. Factor*	*Factory adjustable only*
0x0016h (40023)	*Analog Config.*	*Factory adjustable only*
0x0017h (40024)	*Analog Scale 1*	*Factory adjustable only*
0x0018h (40025)	*Analog Scale 2*	*Factory adjustable only*
0x0019h (40026)	*Analog Scale 3*	*Factory adjustable only*
0x001Ah (40027)	*Analog Scale 4*	*Factory adjustable only*

4.4.2 Modbus Function 4 Registers

Register Offset	***Name [units]***	***Comments***
0x0000h (30001)	Device Version	Specifies the device version. The high byte is the major revision, the low byte is the minor revision.
0x0001h (30002)	Average Voltage [V]	Averaged voltage (line-to-neutral) in three phases. Presented as the value x10 Example: 1205 = 120.5 V (*x PT Ratio*)
0x0002h (30003)	Average Current [A]	Averaged current in three phases. Presented as the value x1,000 (5A versions only) *** Example: 3425 = 3.425 A (*x CT Ratio*)
0x0003h (30004)	Pf (A) [cos Ø]	Power Factor in respective phase. Presented as the value x10,000 Example: 8645 = pf 0.8645
0x0004h (30005)	Pf (B) [cos Ø]	
0x0005h (30006)	Pf (C) [cos Ø]	

4.4.2 Modbus Function 4 Registers (continued)

0x0006h (30007)	V (A) [V]	Voltage (line-to-neutral) in respective phase. Presented as the value x10 Example: 1205 = 120.5 V (*x PT Ratio*)
0x0007h (30008)	V (B) [V]	
0x0008h (30009)	V (C) [V]	
0x0009h (30010)	I (A) [A]	Current in respective phase. Presented as the value x1,000 ***(see note below) Example: 3425 = 3.425 A (*x CT Ratio*)
0x000Ah (30011)	I (B) [A]	
0x000Bh (30012)	I (C) [A]	
0x000Ch (30013)	Real Power (A) [W]	Real Power in respective phase. Presented as the value x10 Example 3425 = 342.5 W (*x PT Ratio x CT Ratio*)
0x000Dh (30014)	Real Power (B) [W]	
0x000Eh (30015)	Real Power (C) [W]	
0x000Fh (30016)	Appr Power (A) [VA]	Apparent Power in respective phase. Presented as the value x10 Example 3425 = 342.5 VA (*x PT Ratio x CT Ratio*)
0x0010h (30017)	Appr Power (B) [VA]	
0x0011h (30018)	Appr Power (C) [VA]	
0x0012h (30019)	Power Demand [W]	Watts Demand calculated by the sliding window defined by the Demand Time parameter. Presented as the value x10 Example 3425 = 342.5 W (*x PT Ratio x CT Ratio*)
0x0013h (30020)	Total Real Power [W]	Total Real Power in three phases. Presented as the value x10 Example 10275 = 1,027.5 W (*x PT Ratio x CT Ratio*)
0x0014h (30021)	Total Appr Power [VA]	Total Apparent Power in three phases. Presented as the value x10 Example 10275 = 1,027.5 VA (*x PT Ratio x CT Ratio*)
0x0015h (30022)	System Power Factor [cos Ø]	Total Power Factor in the system. Presented as the value x10,000 Example 8645 = 0.8645
0x0016h (30023)	Frequency [Hz]	System frequency Presented as the value x100 Example 5999 = 59.99 Hz

***NOTE: All data (with the exception of kWh) is represented without CT and PT ratio scaling (ie: as if CT Ratio and PT Ratio = 1). CT and PT ratios are only applied to kWh data (registers 0x0017, 0x0018, function 3) and output kWh pulses (Click Count).*

To obtain engineering units, the RTU master must scale each register as specified above and apply CT and PT ratios. The CT and PT ratios should be obtained from the function 3 registers (page 15).

The optional ET3-RDM module will display data in Engineering Units (proper scaling applied), provided the CT and PT ratios have been properly configured in the meter.

5. OUTPUT INTERPRETATION

5.1 General

Only energy (Wh) outputs include CT and PT multipliers. All other outputs, both analog and digital, are represented without CT and PT ratio scaling (both multipliers = 1).

When programmed, the CT and PT multipliers are only applied to kWh pulses and kWh data (sent via RS-485). The ET3-RDM module (optional) will display all output data with proper scaling, providing that the CT and PT ratios have been programmed in the meter (see chapter 4.4).

If only analog outputs are used, the ET3 transducer does not require any programming. To obtain Engineering Units (EGU) the generic output signals must be multiplied by the CT and PT ratios.

CT and PT ratios, as well as the desired Wh/pulse value (*refer to chapter 4.2.1*) may be programmed via the RS-485 Modbus interface. If the CT/PT ratios are set as 'one', the RTU master must retain the CT/PT ratio information to perform calculations on the output data. In this case, the conversion of all generic output signals to EGU may be performed by the RTU unit (EMS panel, PLC, data logger etc., or manually).

5.2 Unit Calibration Sheet

Each ET3 transducer is shipped with its Unit Calibration Sheet (*see sample in Appendix 1)* that provides generic, factory defined, full scale (FS) values for all outputs. These FS values are dependent on the nominal voltage/current input and the electrical system configuration (programmed at the factory based on order specifications). The FS output calibration values are also shown on the PCB cover, inside the ET3 enclosure. As with digital outputs the FS values must be multiplied by the respective CT/PT ratios to show EGU.

5.2.1 Watt-hour Pulse Interpretation

If the ET3 transducer was not programmed by the user for specific CT/PT ratios (and the Wh/pulse ratio) both multipliers must be used for the EGU energy output interpretation. The generic, factory default pulse value depends on system voltage and is calculated not to exceed the maximum pulsing frequency (*as discussed in chapter 4.2.1, the Wh/pulse ratio must not exceed the maximum rate of one pulse per second*).

For a 208/120 V transducer this value is 1 Wh/pulse (*see paragraph 5.2.3*). For a 480/277 V unit it is 2 Wh/pulse and for 600/347 V it is 5 Wh/pulse. To obtain EGU Watt-hour value, the accumulated number of pulses (clicks) must be multiplied by the generic pulse value and both the CT and PT ratio.

5.2.2 Analog Output Interpretation

The generic full scale analog output values depend on system voltage and configuration. They are chosen to allow for system overload conditions and rounded to be easily scaled down as being dividable by 5 (5 VDC represents full scale output). *Please refer to sample calculations in paragraph 5.2.3).*

If both, CTs and PTs are used in the system the product of their ratio multiplication should be used for scaling of real power (W), apparent power (VA), demand power (WD). The CT ratio alone (and the PT ratio respectively) would be used for current and voltage scaling.

5.2.3 Generic Output Scaling Calculations (example)

The generic output values of an ET3 unit purchased for a 208/120 V system and 5 A current input will have its Full Scale outputs calibrated as follows:

(A) Power FS= 2500 W (120 V x 5 A x 3 phases = 2160 W; 2500 W is chosen to allow for overload conditions and as a number easily dividable by 5).
(B) Apparent Power FS = 2500 VA (calculated as above)
(C) Demand Power FS = 2500 WD (calculated as above)

(D) Current FS = 6.00 A (5 A nominal + 20% overload)
Voltage FS = 150 V (L-N), (120 nominal + 20% over-voltage = 144 V, rounded to 150 V)
Power Factor FS = 1.000
Frequency FS = 65 Hz

This sample 208/120 V ET3 transducer will have energy pulse value factory set at 5 Wh/pulse thus one pulse will be generated every:

$$\frac{3600 \text{ seconds/hour} \times 5 \text{ Wh/pulse}}{2160 \text{ W}} = 8.3 \text{ seconds}$$

if the nominal load of 2160 W is present. Note that the ET3 generates pulses on even one-second intervals so that a number of pulses should be counted to obtain accurate readings.

6. TYPICAL ENERGY MANAGEMENT APPLICATIONS

There are many potential applications for Elkor power transducers in Energy Management Systems. Experience has shown that at least 1% drop in electrical energy cost can be expected just from the fact that the loads are metered. Additional, far more significant, savings can be achieved by a systematic electrical system monitoring and implementation of load management measures. Some examples are listed below:

Load Shedding:

By continuously monitoring the plant/facility electrical load the peak demand charges can be significantly reduced by staggering the electrical equipment use during peak periods. The daily demand profile can be established and, in some cases the energy consuming processes may be shifted outside the peak hours. The Watt Demand output offered by the ET3 may be very helpful in this application.

Capacitor Switching:

By monitoring power factor the corrective capacitor banks can be switched to maintain the desired power factor to reduce I^2R transmission losses and to avoid possible low PF penalties imposed by the utility.

Energy Efficiency Monitoring:

By monitoring the power consumption and load profile the effectiveness of process or HVAC control strategies can be dynamically assessed. The performance of chillers, pumps, fans and VAV systems can be constantly monitored. True RMS measurements offered by Elkor's family of transducers may prove indispensable when Variable Speed Drives are used.

Phase Load Balancing

It is essential that the electrical loads within a building are equally spread among three phases (balanced). The use of ET3 for trending of load data will help to re-balance the feeders to avoid such problems as overheating, undervoltage and overload, as well as, unnecessary I^2R losses.

Voltage Monitoring:

Voltage monitoring is usually neglected in most large systems. It is important to know about voltage fluctuations and the seasonal changes to better manage the transformer tap changes and feeder loading.

7. GLOSSARY OF TERMS

Burden - available load handling capacity of CT or PT expressed in VA
(should be higher than input burden of a transducer)

CT - current transformer; scales down the primary load current;
usually in multiples of 100 A primary to 5 A secondary (i.e. 400:5)

CT Ratio - a multiplier to be used for scaling the transducer's output (i.e 400:5A CT has ratio of 80)

EGU - Engineering Unit (i.e the transducer's analog
mA Output Signal of 12 mA may represent 1000W
as a generic signal; after being scaled by CT and PT multipliers of, say, 800 this will become
800 kW in Engineering Units).

EMS - Energy Management System, computerized DDC system for control of building electrical and
mechanical systems.

kW - kilowatt (1000 W) unit of real power (a rate of energy consumption).

kWh - kilowatt-hour (1000 Wh) unit of electrical energy used and/or produced.

kVA - (1000 VA) a unit of apparent electrical power

PF - power factor; relation between real and apparent power (kW=kVA x PF)

PT - potential (voltage) transformer; to reduce primary line voltage to lower level acceptable by a
meter; usually 120 VAC output (in North America)

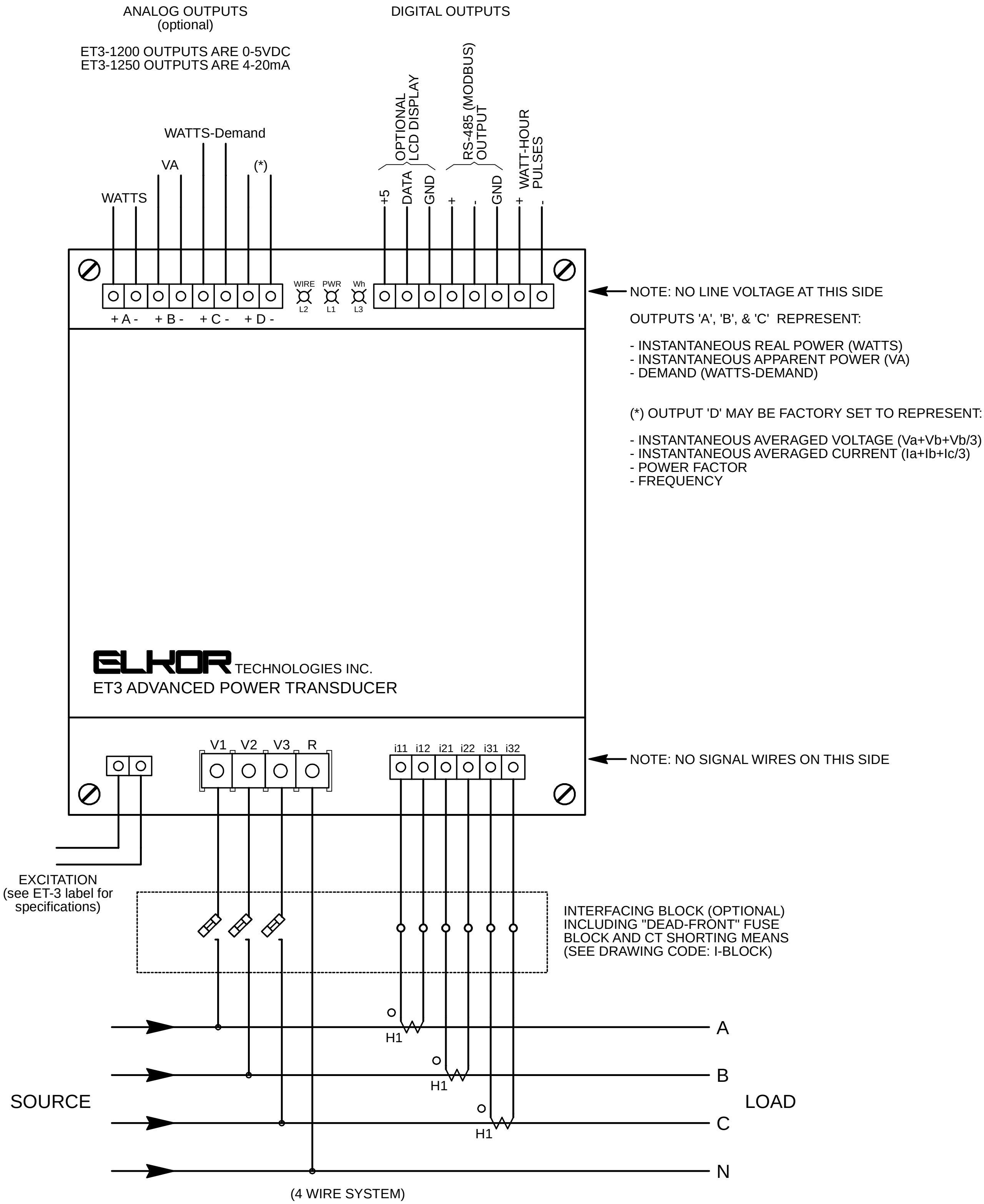
PT ratio - a multiplier to be used to scale the transducers voltage output if PTs are used (i.e a
4200:120 V PT has ratio of 35)

RMS - Root Mean Square, effective value of AC voltage and current
(the measure of AC effectiveness expressed in DC terms)

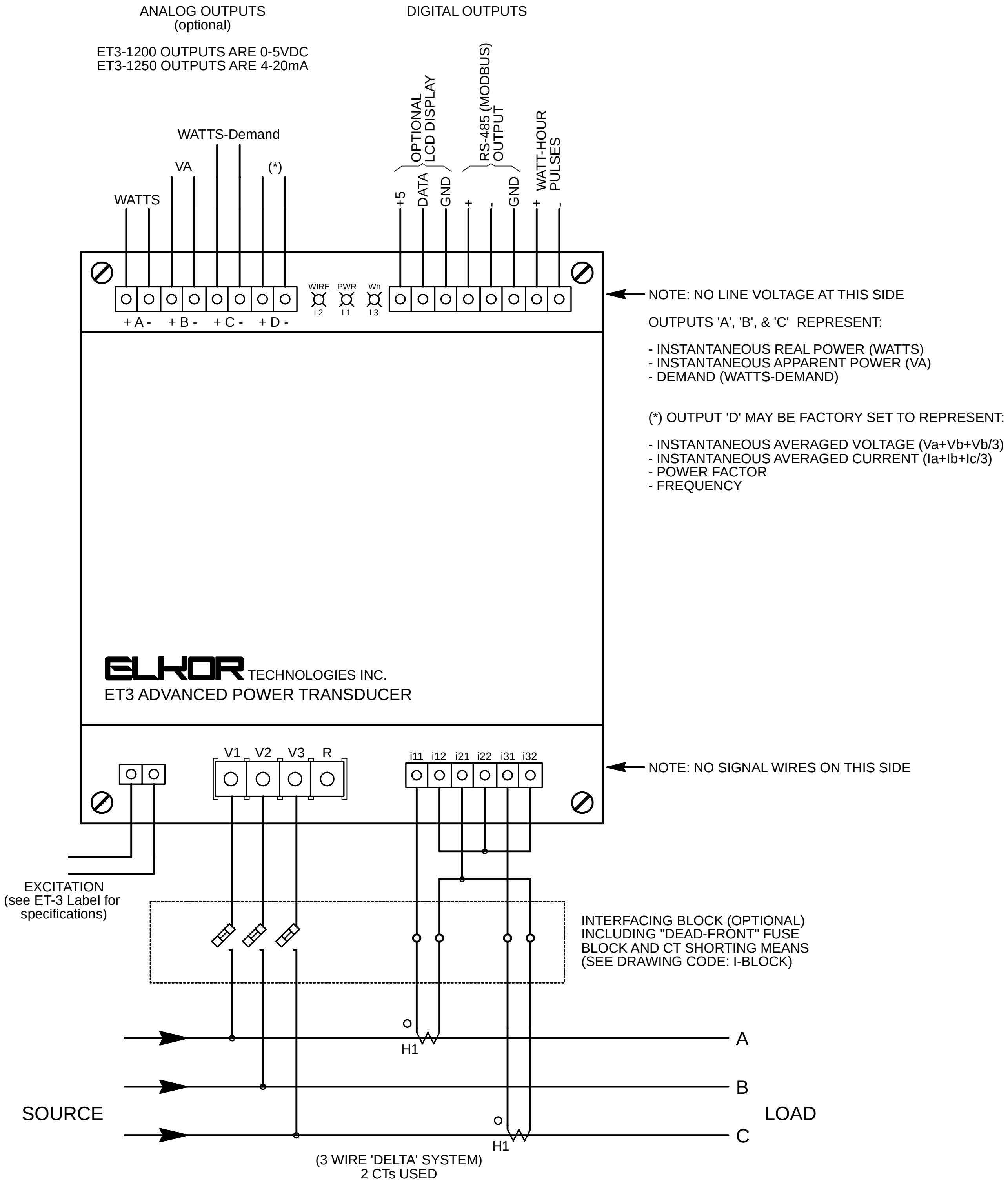
RTU - Remote Terminal Unit, central data collecting device (RTU is also used to describe the type of
Modbus communication protocol used by the device

Scan Period - the time it takes for multiple readings of all the line parameters, calculations and output
update.

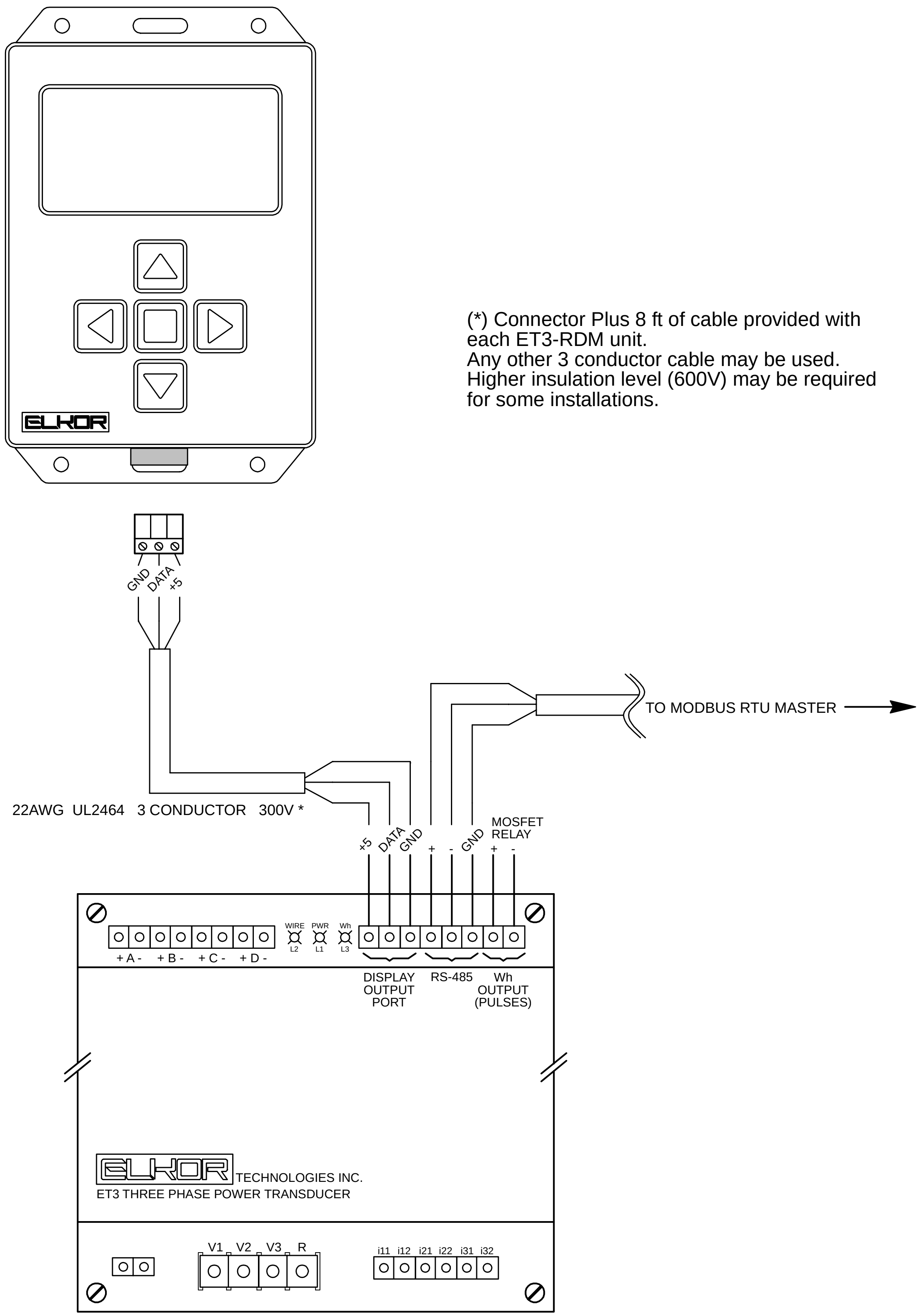
Appendix 1A: Four-Wire (Wye) Wiring Diagram



Appendix 1B: Three-Wire (Delta) Wiring Diagram



Appendix 1C: Digital Output Wiring Diagram



Appendix 2: Sample Calibration Sheet

ELKOR ET3 ADVANCED THREE PHASE POWER TRANSDUCER
UNIT CALIBRATION SHEET

Model: **ET3-1200** Firmware Version: **1.0**

Serial No.: **SAMPLE**

Application: **Three phase, 4 Wire, 600/347 V, 60 Hz**

Current Transformers: **400:5 A,** (factory programmed **Ir = 80**)

Potential Transformers: **none,** (factory programmed **Vr = 1**)

Calibration Date: **November 01, 2002**

Analog Output Calibration (Full Scale Output = 5.000 VDC):

Output A - Real Power: **FS = 7500 W x 80 = 600 kW**

Output B - Apparent Power: **FS = 7500 VA x 80 = 600 kVA**

Output C - Demand: **FS = 7500 WD x 80 = 600 kWD**
Demand Interval: **T = 15 min** (factory programmed)

Output D - Averaged Current: **FS = 6.00 A x 80 = 480 A (avg)**

Watt-hour (Energy) Pulse Output:

One change of state: **200 Wh/pulse** (factory programmed)

Averaged Pulse Rate at Full Load: **1.2 seconds**

Digital Output (RS-485):

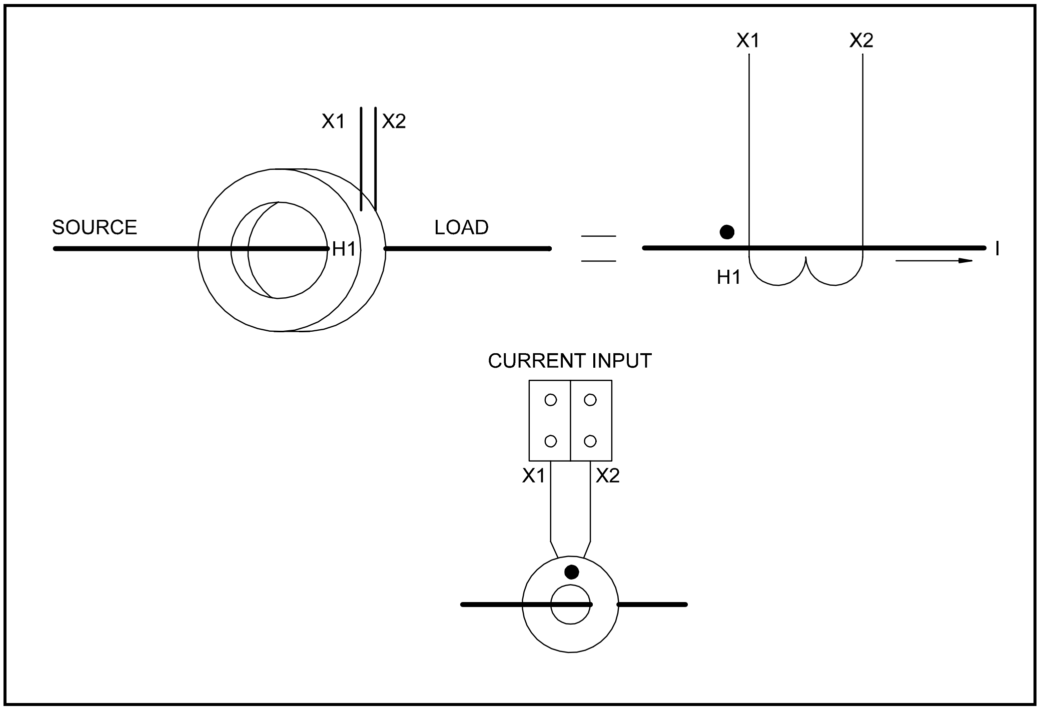
Device Address: **01** (DIP switch factory set)

Final Testing and Inspection:

- ❑ - **Serial number**
- ❑ - **Firmware version**
- ❑ - **CT/PT Calibration**
- ❑ - **Wh pulse value**
- ❑ - **Analog outputs**
- ❑ - **Counters cleared**
- ❑ - **Address set**
- ❑ - **Jumpers set**
- ❑ - **Final accuracy test**
- ❑ - **Connectors applied**

Tester ____________________ Date ____________________

Appendix 3: CT Wiring Notes



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

- While specifying CTs, one should consider both the electrical and mechanical parameters such as primary wire size, mounting arrangement, insulation level and the expected load current.
- If the maximum load current is known, select the closest standard CT value. If the load is unknown the bus rating, or better still, the transformer size may be used for the maximum current calculations. CTs can tolerate large over-correct condition without damage; the ET3 input accepts 6.0 A full scale input which assumes 20% continuos overload.
- CTs are designed to operate with their secondary winding (5A) in permanent short, or very close to the short condition. If the secondary winding is open while the primary current is present a very high EMF will be present on the disconnected wire. The effects of this EMF will depend on the primary current and the VA rating of the CT.
- **This EMF may create a hazard to the personnel and in some situations it may damage the CT insulation.** Provisions should be made to short the secondary winding before any re-wiring is performed. We recommend using a metering Test Switch or CT Shunting Blocks to be wired between CTs/PTs and ETM3 transducer.
- Usually, one of the secondary leads of each CT will be grounded. Since the ET3 has isolated inputs this does not create any problems in most applications. For two element systems (3 wires), grounding of CTs and PTs should be carefully observed.

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