



**User Manual for the
*HE200ACM500***

Dual AC Power Monitor

MAN0482-06

PREFACE

This manual explains how to use the Dual AC Power Monitor.

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Note: The programming examples shown in this manual are for illustrative purposes only. Proper machine operation is the sole responsibility of the system integrator.

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CHAPTER 1: INTRODUCTION

1.1 Overview

The HE200ACM500 (ACM) is a stand alone module that monitors voltage and current on two separate circuits of 3-phase AC lines and provides indications of voltage, current, real power, reactive power, apparent power, power factor, power usage, frequency and phase difference. The ACM provides this information over the CsCAN network as global data, which can be monitored by devices such as a Horner APG Operator Control Station (OCS). In addition, the ACM is user configurable to allow either 'Delta' or 'Wye' connections and different Potential Transformer (PT) and Current Transformer (CT) ratios can be selected based on the application. Loading of these configuration parameters is accomplished over the CsCAN network by a selected master (OCS) which allows these modules to be simply 'plugged in' or replaced with little or no user intervention.

The ACM also provides eight sourcing inputs and eight 1/2 amp protected sinking outputs, which are read and controlled respectively by a network master. Network heartbeat functionality is supported in both directions to provide fail-safe operation of this discrete I/O.

The ACM uses a Digital Signal Processor for data capture, true power and true RMS processing, and I/O. An internal watchdog circuit is used to improve reliability. Firmware and calibration constants are stored in FLASH memory.

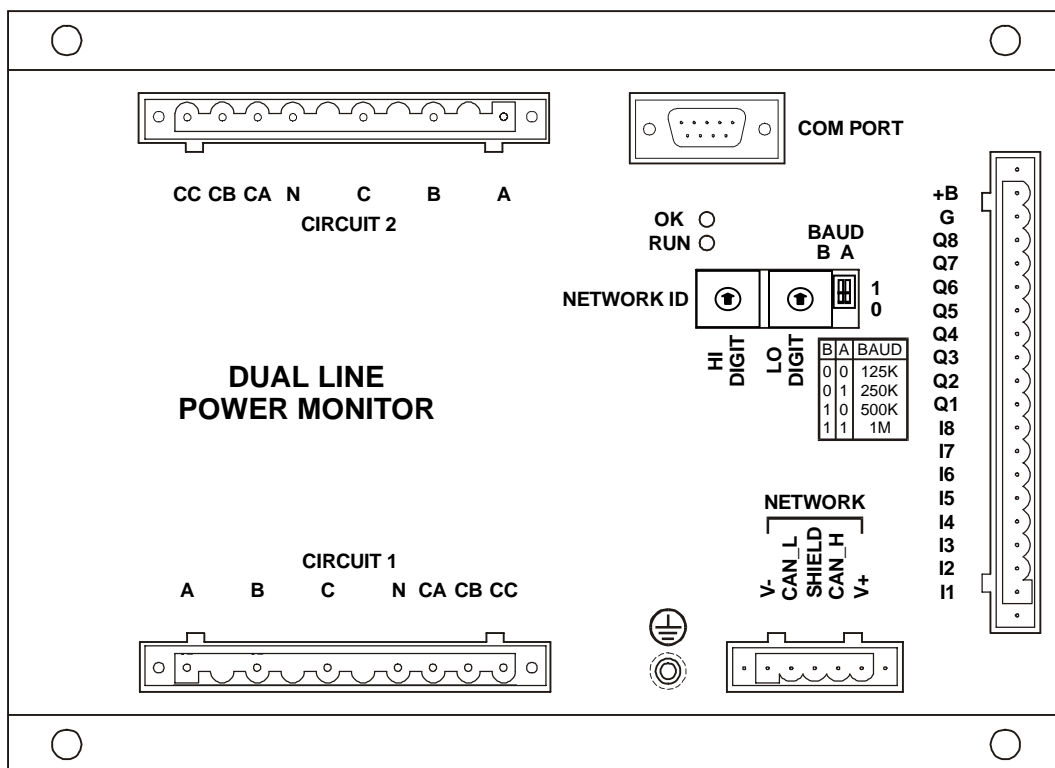


Figure 1.1 – ACM500 Dual AC Power Monitor

1.2 Specifications

Table 1.1 – ACM500 Specifications			
VOLTAGE INPUTS			
Input Range	90-600Vac	Input Frequency	40 to 70Hz
Conversion Time	0.18 Sec ¹	Voltage Measurement	True RMS
Accuracy	1%	Voltage Resolution	0.1Vac
Differential Phase Accuracy	0.5°	Frequency	Referenced to Line A
Differential Phase	Circuit 1A to Circuit 2A	Frequency Resolution	0.01Hz
Differential Phase Resolution	0.1°	Frequency Accuracy	0.1%
Input Impedance	> 2 Megohm to neutral;		
CURRENT INPUTS			
AC Current	Three-phase 5A, External Current Transformers (CTs) required	Common Mode	CTs returned to neutral
Overrange	50%	Input Frequency	40 to 70Hz
Accuracy	1%	Current Measurement	True RMS
Conversion Time	0.18 Sec ¹	Resolution	0.001A
DIGITAL INPUTS			
Inputs per Module	8	ON Voltage Level	40% of V Supply
Commons per Module	1	OFF Voltage Level	60% of V Supply
Input Voltage Range	6-36 VDC	Input Characteristics	Sourcing
Peak Voltage	36VDC Max.	Input Impedance	10K Ohms – Pull up to V Supply
DIGITAL OUTPUTS			
Outputs per Module	8	ON Voltage Level	1.5VDC Max.
Commons per Module	1	Maximum Load Current per channel	0.5A Max.
Operating Voltage	6 - 36VDC	Output Protection	Short Circuit
Output Type	Sinking / 10K Pull-Up	Maximum Leakage Current	100µA
Peak Voltage	36VDC Max.	Maximum Inrush Current	600mA.
Output Characteristics	Current Sinking	Minimum Load	None
GENERAL SPECIFICATIONS			
Required Power (Steady State)	12-24VDC nominal; 6-36VDC Maximum; Approximately 7 Watts	Recommended Number of ACM400's per Network	8 or less
Current (Inrush)	< 3 Amp for 10mSec	Network Bandwidth	80 messages per second (8%)
Connectors	Front access	Relative Humidity	5 to 95% Non-condensing
Terminal Type	Screw Clamp, Removable	Operating Temperature	0° to 60° Celsius
Protocol Supported	CsCAN	Weight	9 oz. (256 g)
¹ Differential phase conversion time = 90mSec.			

1.3 Technical Assistance

For manual updates and assistance, contact Technical Support at the following locations:

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NOTES

CHAPTER 2: INSTALLATION



ATTENTION: Only qualified electrical personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life.

ATTENTION: The ACM is directly connected to incoming AC power. Disconnect, lock out, and tag all incoming power to the ACM before performing the following procedure. Failure to observe this precaution could result in severe bodily injury or loss of life.

ATTENTION: For ease of installation and replacement, plug-in connectors are provided for the AC inputs. These connectors **MUST NOT BE UNPLUGGED** if any current is flowing through the CT primaries. Failure to observe this precaution will result in damage to the connector and an electrical shock hazard. Screw locks are provided on all I/O connectors to prevent accidental circuit interruption. Installation personnel must verify that the connectors are properly secured.

ATTENTION: All applicable codes and standards should be followed in the installation of this product.

2.1 Mounting

Physical dimensions for the ACM are shown in Figure 2.1

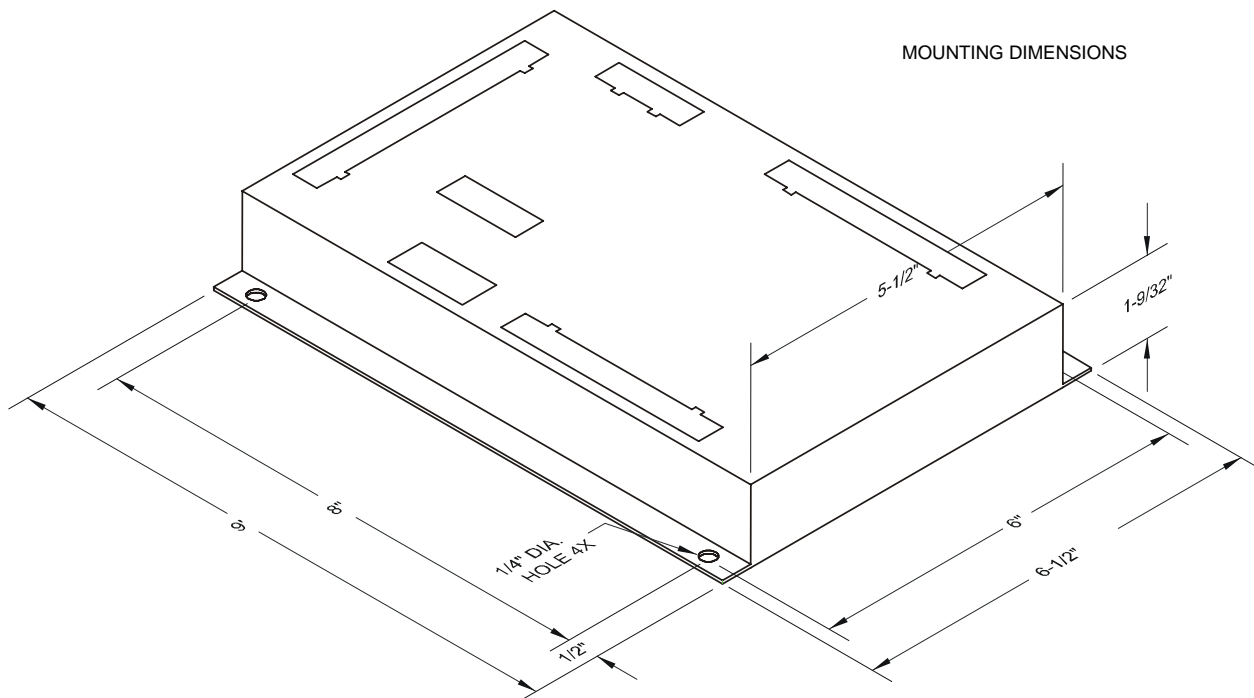


Figure 2.1 – ACM Dimensions

2.2 Isolation

The AC monitoring circuits are isolated from the input power and from each other to at least 1500VAC. The CAN interface (network) is also isolated and powered from its connector (meets DeviceNet specifications). The RS-232 port is NOT isolated and is powered from the main input supply.

2.3 Power Connection

The ACM is powered from a DC source between 6 and 36 volts and draws approximately 7 watts. Refer to figure 2.2 below for wiring.

2.4 Discrete I/O Connection

The eight DC sourcing inputs are provided with internal 10K ohm pull-ups to V+ power and are intended for switch contact to VC. The input threshold is approximately $\frac{1}{2}$ VC. The eight $\frac{1}{2}$ Amp DC sinking outputs, sink current to power common (VC) and are protected against over-current and over-voltage spikes.

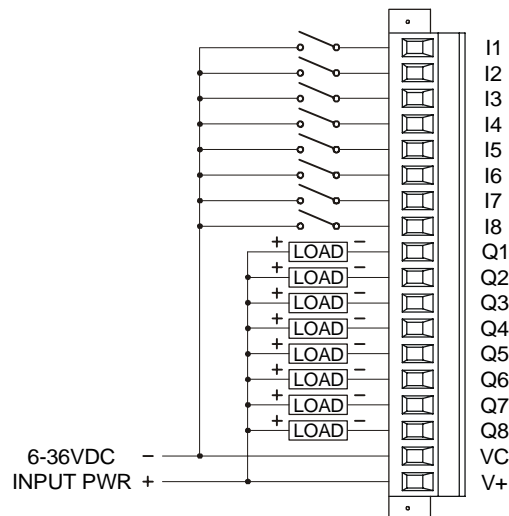


Figure 2.2 - Power and Discrete I/O wiring diagram

2.5 CsCAN (network) Connection

Can Wiring rules (Refer to Figure 2.3.)

1. Wire the CAN network in a daisy-chained fashion such that there are exactly two physical end-points on the network.
2. The two nodes at the physical end-points need to have 121 ohm 1% terminating resistors connected across the CAN_L and CAN_H terminals
3. Use data conductors (CAN_L and CAN_H) that are 24 AWG shielded twisted pair for 'thin cable' and 22 AWG shielded twisted pair for 'thick cable'. They must also have 120-ohm characteristic impedance. In typical industrial environments, use a Belden wire #3084A ("thin"). Use #3082A ("Thick") for network cable lengths greater than 100 meters in environments where noise is a concern.
4. Use power conductors (V- and V+) that are 18 AWG twisted-pair for 'thin cable' and 15 AWG twisted-pair for 'thick cable'.
5. Connect the V- power conductor to a good earth ground **at one place only** on the network, preferably at a physical endpoint.

CH. 2

6. For a section of cable between two nodes, the cable shield is connected to the cable shield input at **one end of the cable only**.
7. A CAN network (without repeaters) is limited to 64 nodes (with 63 cable segments) with a maximum combined cable length of 1500 ft. at 125Kbaud.
8. Up to four CAN network segments, which adhere to the above rules, may be connected together using three CAN repeaters. In this manner, a CAN network may be extended to 253 nodes with a total cable distance of 6000 ft. at 125Kbaud.

For more information on wiring the CsCAN network, refer to an OCS users manual.

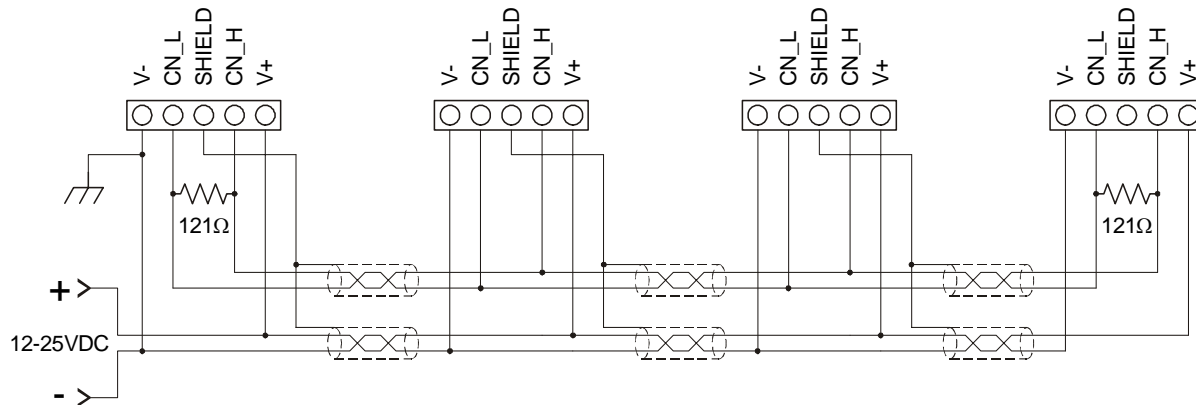


Figure 2.3 – CsCAN wiring diagram

2.6 Serial Port Connection

Currently, the serial port is not available for field applications.

2.7 AC Voltage and Current input Connection

The AC inputs are divided into two circuits (Refer to figure 1.1 for circuit connector location). Each circuit has three voltage signals (A, B, C), which accept input voltages from 0 – 600VAC with respect to neutral (N). These inputs can be directly connected or passed through external potential transformers (PTs). If voltages greater than 600VAC are to be measured, external PTs are required.

Each circuit also has three current signals (CA, CB, CC), which are designed for standard 5 amp secondary current transformers (CTs) with their commons tied to the neutral (N) pin. Correct polarity as indicated in the wiring diagram is essential for valid power measurements.

For three phase Wye hookups, the Wye neutral is connected to the ACM neutral pin (refer to figure 2.4 and 2.6). For Delta hookups, line C is connected to the ACM neutral pin and the C input pin is not connected (refer to figure 2.5).

Note: The mode (Wye or Delta) and PT and CT ratios must be provided to the ACM as configuration data and must match the physical configuration for proper operation. Ratios are used to scale voltage and current input measurements to match those on the primary side of the PTs and CTs for internal power calculations. ACM accuracy specification assumes no error is contributed from the external PTs and CTs.

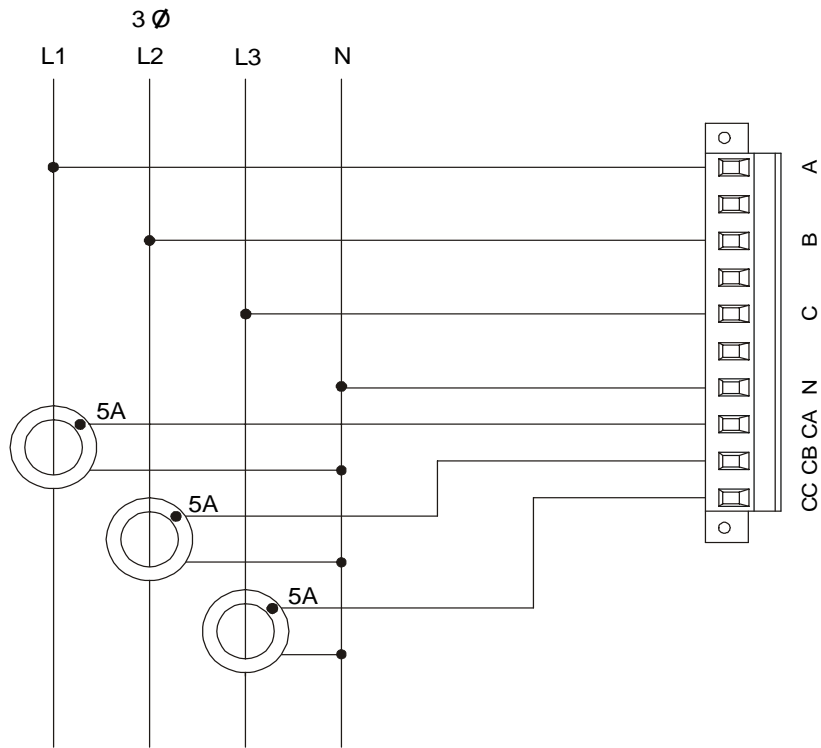


Figure 2.4 - Four-wire 'Wye' with direct voltage connection wiring diagram

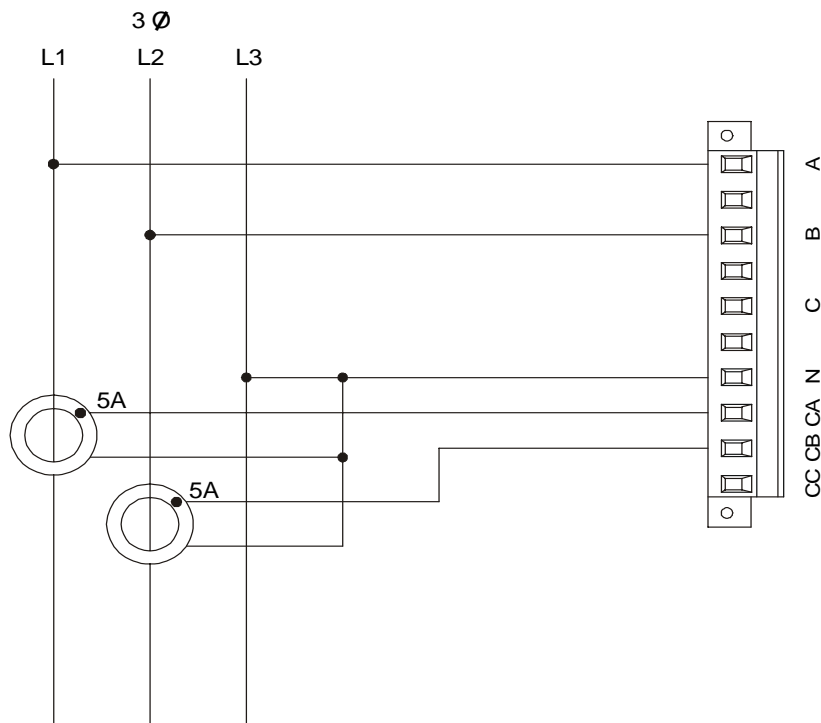


Figure 2.5 - Three-wire 'Delta' with direct voltage connection wiring diagram

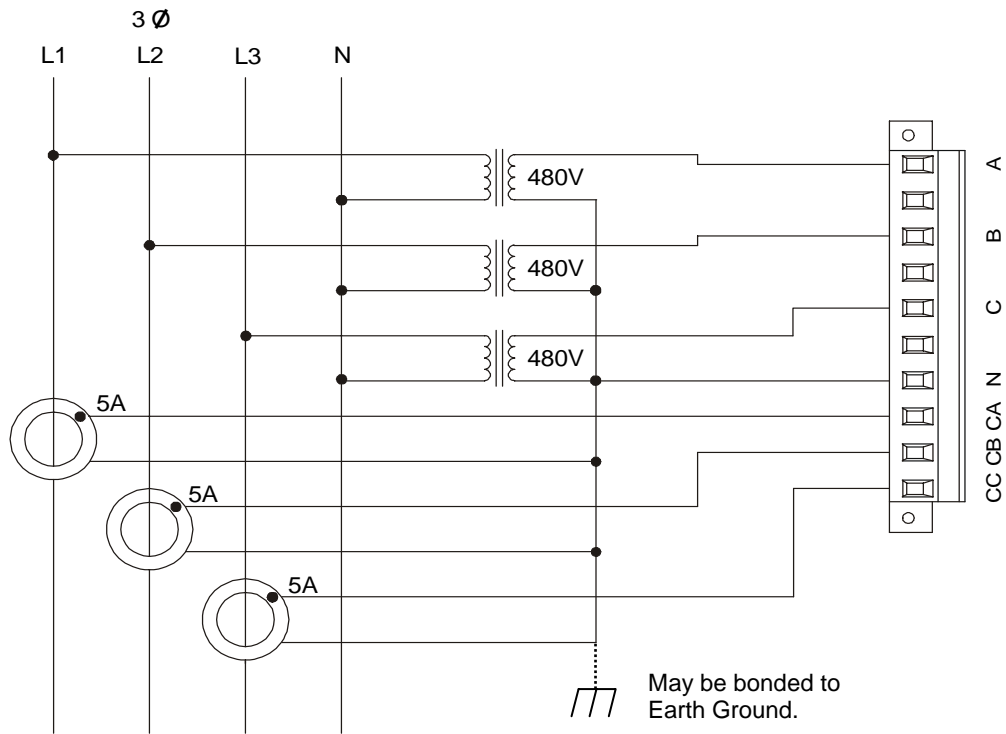


Figure 2.6 – Four-wire ‘Wye’ with Potential Transforms (PTs) wiring diagram

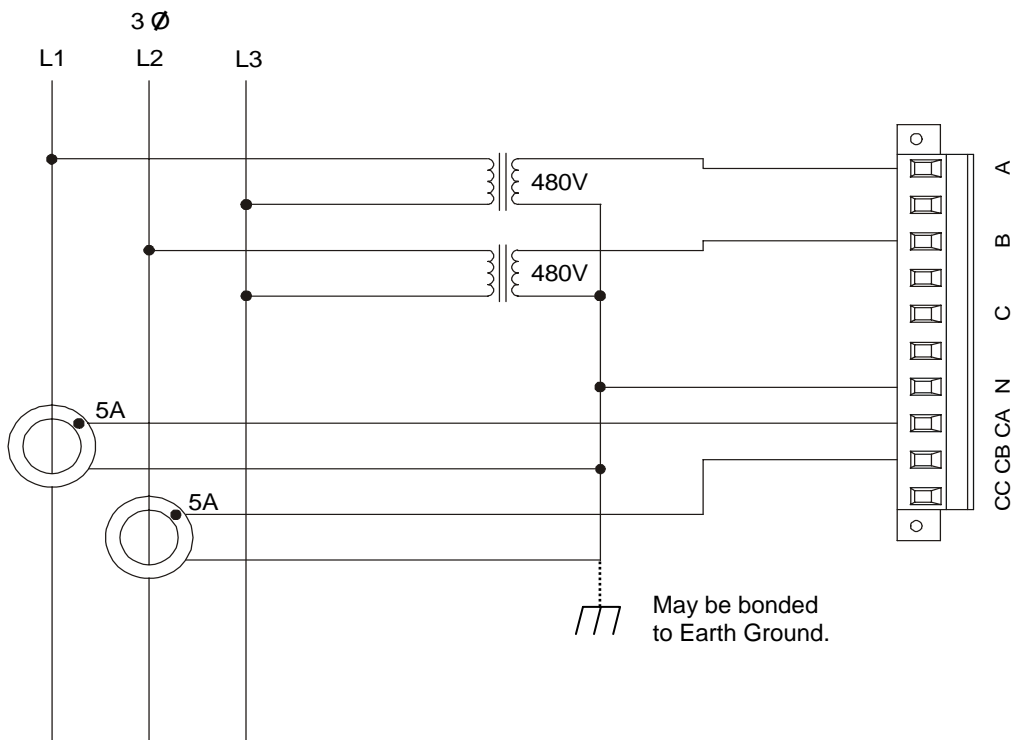


Figure 2.7 – Three-wire ‘Delta’ with Potential Transforms (PTs) wiring diagram

NOTES

CHAPTER 3: CONFIGURATION

3.1 Network Baud Rate

Select the appropriate CsCAN baud rate [125, 250, 500 or 1000Kbaud] using with the front panel DIP switches. (See Figure 3.1. for location of switches.)

B	A	Baud
0	0	125K
0	1	250K
1	0	500K
1	1	1M

Note: The user should verify that this Network Baud Rate matches that of the other devices on the CsCAN network. Failure to observe this precaution could disable network communications.

3.2 Network Address

3.2.1 Network Address Switches

The ACM Network ID is configured with the two multi-position rotary switches on the face surface of the ACM. (See Figure 3.1.) These are 16 position switches that require the ID to be entered as a hexadecimal number. While the maximum address on a CsCAN network is 253 (FDh), the maximum address accepted from the switch is 152 (98h). Attempting to enter an address greater than 152 merely generates an address of 152. The limit of 152 is based on the requirements that an associated OCS must exist at Network ID space (ACM Network ID + 100) to provide control and configuration data to the ACM. Networking operation is covered in Chapter 4.

These Network ID switches are read at power-up and continuously thereafter allowing the user to change the Network ID on the fly. When a Network ID switch change is detected, a 5 sec delay occurs before the ACM attempts to re-connect to the network. This allows the user a little time to dial in both switches before the ACM attempts to reconnect to the network. See LED Indications in chapter 4 to determine the state of the network connection.

ACM Network ID of 255 (FFh) is reserved for factory use and stalls the unit (both LEDS flash in unison) if the ACM is powered up with that ID. To correct: power-down the ACM, change ID switches to valid address and re-apply power.

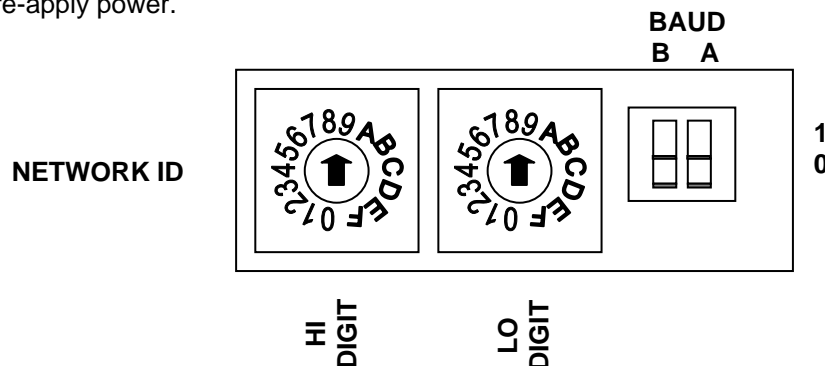


Figure 3.1 – Close-up of Network ID Switches and Baud Switches

To set a unique Network ID on the ACM400, insert a screwdriver into the two Network ID switches (HI Digit and LO Digit).

3.2.2 Network ID Table

Table 3.2 shows the decimal equivalent of hexadecimal numbers. HI Digit and LO Digit settings are also shown. Refer to the table when setting Network IDs for ACM100 modules used in CsCAN networks.

Table 3.2 – Hexadecimal to Decimal Conversion (HI Digit and LO Digit Settings)															
Hex	Dec	HI	LO	Hex	Dec	HI	LO	Hex	Dec	HI	LO	Hex	Dec	HI	LO
00	0	0	0	29	41	2	9	53	83	5	3	7C	124	7	C
01	1	0	1	2A	42	2	A	54	84	5	4	7D	125	7	D
02	2	0	2	2B	43	2	B	55	85	5	5	7E	126	7	E
03	3	0	3	2C	44	2	C	56	86	5	6	7F	127	7	F
04	4	0	4	2D	45	2	D	57	87	5	7	80	128	8	0
05	5	0	5	2E	46	2	E	58	88	5	8	81	129	8	1
06	6	0	6	2F	47	2	F	59	89	5	9	82	130	8	2
07	7	0	7	30	48	3	0	5A	90	5	A	83	131	8	3
08	8	0	8	31	49	3	1	5B	91	5	B	84	132	8	4
09	9	0	9	32	50	3	2	5C	92	5	C	85	133	8	5
0A	10	0	A	33	51	3	3	5D	93	5	D	86	134	8	6
0B	11	0	B	34	52	3	4	5E	94	5	E	87	135	8	7
0C	12	0	C	35	53	3	5	5F	95	5	F	88	136	8	8
0D	13	0	D	36	54	3	6	60	96	6	0	89	137	8	9
0E	14	0	E	37	55	3	7	61	97	6	1	8A	138	8	A
0F	15	0	F	38	56	3	8	62	98	6	2	8B	139	8	B
10	16	1	0	39	57	3	9	63	99	6	3	8C	140	8	C
11	17	1	1	3A	58	3	A	64	100	6	4	8D	141	8	D
12	18	1	2	3B	59	3	B	65	101	6	5	8E	142	8	E
13	19	1	3	3C	60	3	C	66	102	6	6	8F	143	8	F
14	20	1	4	3D	61	3	D	67	103	6	7	90	144	9	0
15	21	1	5	3E	62	3	E	68	104	6	8	91	145	9	1
16	22	1	6	3F	63	3	F	69	105	6	9	92	146	9	2
17	23	1	7	40	64	4	0	6A	106	6	A	93	147	9	3
18	24	1	8	41	65	4	1	6B	107	6	B	94	148	9	4
19	25	1	9	42	66	4	2	6C	108	6	C	95	149	9	5
1A	26	1	A	43	67	4	3	6D	109	6	D	96	150	9	6
1B	27	1	B	44	68	4	4	6E	110	6	E	97	151	9	7
1C	28	1	C	45	69	4	5	6F	111	6	F	98	152	9	8
1D	29	1	D	46	70	4	6	70	112	7	0	FF*	255*	15	F
1E	30	1	E	47	71	4	7	71	113	7	1				
1F	31	1	F	48	72	4	8	72	114	7	2				
20	32	2	0	49	73	4	9	73	115	7	3				
21	33	2	1	4A	74	4	A	74	116	7	4				
22	34	2	2	4B	75	4	B	75	117	7	5				
23	35	2	3	4C	76	4	C	76	118	7	6				
24	36	2	4	4D	77	4	D	77	119	7	7				
25	37	2	5	4F	79	4	F	78	120	7	8				
26	38	2	6	50	80	5	0	79	121	7	9				
27	39	2	7	51	81	5	1	7A	122	7	A				
28	40	2	8	52	82	5	2	7B	123	7	B				

Note: ID Addresses 153 – 254 are not used.

* ID Address 255 is invalid. Reserved for Factory Use Only.

3.3 Operational mode and PT/CT Ratios

The mode and ratio configuration data for the ACM are provided by an associated OCS over the CSCAN network once the ACM powers up. This allows replacement of an ACM in the field without operator intervention in providing the configuration data. However, this also requires additional initial programming of the associated OCS to initialize and send that configuration data when the OCS powers-up. See Network operation in chapter 4.

3.4 Calibration

The ACM is calibrated at the factory and calibration data is not user accessible.

NOTES

CHAPTER 4: OPERATION

4.1 Power-up

At power-up, the ACM performs the necessary hardware checks, verifies the integrity of the factory calibration data and prepares to receive operational parameters from the network.

4.2 Network Operation

After power-up initialization, the ACM verifies the integrity of the network. If a valid network connection exists, the ACM issues a network request to its associated OCS for a global data update that contains the required configuration data. To issue this request, the ACM must know the Network ID of that associated OCS. The ACM determines that Network ID by adding 100 to its own Network ID. In addition, the ACM requires the associated OCS to consume 2 consecutive IDs starting at that OCS Network ID. That OCS's global data associated with the first Network ID is used to configure the first circuit and the global data associated with the second Network ID is used to configure the second circuit.

After issuing the request, the ACM then waits for the associated OCS's global data to be broadcast over the network. Should an OCS not exist at the appropriate Network IDs when the ACM powers-up, the ACM stalls until the OCS goes on-line and provides all of the required configuration data. While the ACM is stalled, no AC input sampling occurs, no indicators are calculated (including KWHs) and the discrete outputs are held at zero.

Note: Required configuration data includes *all* analog values and *all* digital values for *both* circuits of the ACM. This is required even if only one circuit or only analog or digital values are used in the application. Failure to provide valid configuration data for all parameters can cause the ACM not to work in any capacity.

Once the configuration information is received, the ACM begins sampling the inputs, calculating the provided indications and driving the discrete outputs. The ACM continues to monitor the associated OCS's global data after sampling begins which allows ratio configuration changes on the fly. However, to minimize network traffic, the associated OCS should be programmed to only send new global data during the first scan and thereafter ONLY if the data changes value.

The ACM is similar to its associated OCS in that it also consumes two Network IDs. The global data associated with the ACM's first Network ID is used to broadcast circuit 1's data while the global data associated with the second Network ID used to broadcast the circuit 2's data.

Note: Because the ACM broadcasts a large amount of global data on a continuous basis (every 200mSec.), it is recommend that the ACM not be used on a network that requires other device data to be passed in a time-critical manner.

4.2.1 Network Input Data

The ACM receives command and configuration data from its associated OCS 's global output (QG/AQG) data. More specifically, Circuit 1's control/configuration data is retrieved from the QG/AQG data associated with the OCS's first Network ID. Circuit 2's control/configuration data is retrieved from the QG/AQG data associated with the OCS's second Network ID. With a few exceptions, the format of the sent data is the same for both circuits and shown below in Table 4.1. For non-circuit specific data, such as discrete output commands, table 4.1 indicates which OCS Network ID's global data contains that information.

The associated OCS must initialize the configuration data before it sends it as global data (either through a ladder function block or through a remote request). This involves initializing the AQG data registers on the first scan. This removes the dependency on which device (OCS or ACM) powers-up first.

Digital (QG) – Control Registers (from OCS) [registers for circuit 2 duplicated at ID + 1]

Register(s)	Identifier
QG1-6	reserved
QG7	kWh Freeze
QG8	reserved
[First ID only]	
QG17	Digital Output 1
QG18	Digital Output 2
QG19	Digital Output 3
QG20	Digital Output 4
QG21	Digital Output 5
QG22	Digital Output 6
QG23	Digital Output 7
QG24	Digital Output 8

Analog (AQG) – Configuration Registers (from OCS) [registers for circuit 2 duplicated at ID + 1]

Register(s)	Identifier	Format
AQG1-2	VT1 ratio	32bit Float [multiplier]
AQG3-4	VT2 ratio	32bit Float [multiplier]
AQG5-6	VT3 ratio	32bit Float [multiplier]
AQG7-8	CT1 ratio	32bit Float [multiplier]
AQG9-10	CT2 ratio	32bit Float [multiplier]
AQG11-12	CT3 ratio	32bit Float [multiplier]
AQG13	Mode	16bit Unsigned (0=Wye, 1=Delta)
AQG14	factory reserved	[must be zero for proper operation]
[First ID only]		
AQG15	HB send time	16bit Unsigned [mSec]
AQG16	HB receive timeout	16bit Unsigned [mSec]

Table 4.1 – Network Input data (OCS QG/AQG) format

4.2.2 Network Output Data

The ACM broadcasts the monitored and calculated AC values and status indications through its global data. The ACM consumes two consecutive Network IDs. Circuit 1's output data is sent in the QG/AQGs associated with the ACM's first Network ID. Likewise, circuit 2's output data is sent in the QG/AQGs associated with the ACM's second Network ID. With a few exceptions, the format of the sent data is the same for both circuits and shown below in Table 4.2. For non-circuit specific data, such as discrete input status, table 4.2 indicates which ACM Network ID's global data contains that information.

Digital (QG) – Status registers (ACM outputs)

Register(s)	Identifier
QG1	Loss of phase (A)
QG2	Loss of phase (B)
QG3	Loss of phase (C)
QG4	Phase AB Phase Error [variation of greater than ± 3 degrees]
QG5	Phase AC Phase Error [variation of greater than ± 3 degrees]
QG6	reserved
QG7	kWh freeze acknowledge
QG9-QG16	reserved
[First ID only]	
QG17	Digital Input 1
QG18	Digital Input 2
QG19	Digital Input 3
QG20	Digital Input 4
QG21	Digital Input 5
QG22	Digital Input 6
QG23	Digital Input 7
QG24	Digital Input 8

Analog (AQQ) – Monitored and Calculated values (ACM outputs)

Register(s)	Identifier	Format
AQG1-2	Voltage A	32bit Float [Volts]
AQG3-4	Voltage B	32bit Float [Volts]
AQG5-6	Voltage C	32bit Float [Volts]
AQG7-8	Current A	32bit Float [Amps]
AQG9-10	Current B	32bit Float [Amps]
AQG11-12	Current C	32bit Float [Amps]
AQG13-14	Frequency	32bit Float [Hz]
AQG15-16	Watts	32bit Float [Watts]
AQG17-18	PF	32bit Float [ratio]
AQG19-20	VA	32bit Float [Volt-Amps]
AQG21-22	VAR	32bit Float [Volt-Amps Reactive]
AQG23-24	KWahr	32bit Float [Kilowatt-hours, See note]
AQG25-30	reserved	
[First ID only]		
AQG31 Model		16bit Unsigned [90h]
AQG32 Version		16bit Unsigned [high byte = major] [low byte = minor]
[Second ID only]		
AQG31-32	Diff. Phase	32bit Float [± 180.0 Degrees] (Both circuits Phase A voltage must be present)

Table 4.2 – Network Output data (ACM QG/AQG) format

4.2.3 Network Heartbeat (Network Connection Good)

The ACM supports the CsCAN heartbeat functionality. This feature is used to detect when either the associated OCS or the ACM fails or is disconnected from the network. The OCS may be programmed to use this feature to determine if the Discrete Input or AC monitoring information last received from the ACM is valid. Likewise, the ACM uses this feature to determine if the network data is valid for controlling the Discrete Outputs. Should the ACM lose the heartbeat from the OCS, the **discrete outputs are all set to OFF**.

To use the heartbeat functionality, a send and receive timeout must be configured at both the associated OCS and the ACM. For the OCS, heartbeat timeouts are controlled with the NetPut HB and the NetGet HB function blocks. For the ACM, timeout values are received as part of the configuration data sent from the OCS. From this data, the HB Send Timeout specifies the period at which the ACM broadcasts its heartbeat to the network. The HB Recv Timeout specifies the period at which the ACM expects a heartbeat from its associated OCS. Should this time expire without a heartbeat, the ACM enters a lost connection mode, which sets the discrete outputs to zero. Generally, the receive timeout must be greater than the send timeout to account for delays in either device or the network.

Sending a HB Recv Timeout value of zero in the configuration data disables the heartbeat-monitoring feature at the ACM. This allows the discrete outputs to remain at the last network commanded value if the associated OSC fails; however, if a network failure is detected, the discrete outputs are all set to off.

4.3 Discrete I/O

Eight sourcing DC inputs are provided which individually report a 1 (ON) when switched to common and are broadcasted on the network after the ACM receives the configuration data. Refer to Network Output data for format information.

Eight sinking DC outputs are also provided which activate when driven with a logic 1 or true register value. The associated OCS drives these outputs through its associated QG data. If the heartbeat function is enabled, the OCS must send consistent heartbeats (verifying its existence) or the outputs are set to a logic 0 or false state. Refer to Network Input Data for format information.

4.4 Configuration Data

The ACM receives its configuration data over the network from its associated OCS at power-up. Refer to Network Input Data above for format information.

4.4.1 Mode

This field specifies if the AC inputs are to be treated as 4-wire 'wye' or 3-wire 'delta' and must match what is physically wired.

0 – Wye 4-wire (3 PTs, 3 CTs)

1 – Delta 3-wire (2 PTs, 2 CTs)

4.4.2 Ratios

These fields specify the multiplier for each Voltage and Current input. This is a floating-point number used to scale the PT/CT secondary value to represent the true (primary) value.

For voltage direct connection, supply a ratio of 1.00

$$\begin{array}{rclcl} \text{input} & & \text{ratio} & & \text{displayed output} \\ 480 \text{ V} & * & 1.00 & = & 480 \text{ Volt} \end{array}$$

For CT with 500 Amp primary and 5 Amp secondary (500:5) use a ratio of 100.00

$$5 \text{ Amp} * 100.00 = 500 \text{ Amp}$$

4.5 AC Monitored and Calculated Data

AC Monitored and calculated data are broadcast continuously over the network. Refer to Network Output Data for format information.

4.5.1 RMS Voltage and Current

Voltage and current indications are true RMS values and are calculated by squaring each sample over one line cycle, averaging the resulting squares, and taking the square root of the result. User supplied configuration ratio (scaling) constants are then applied for the appropriate PT or CT attached to the input (direct attachment of voltage input requires a ratio of 1.00).

For delta mode, the third phase voltage and current are computed from the difference of the measurements of the other phases. Should the load on the third phase become open, the third phase values will not be correct.

4.5.2 Power Calculations

True power consists of a point-by-point product of the associated voltage and current values averaged over one line cycle. Volt-amperes (VA) is the sum of the product of the RMS voltage and current values. The VA value is absolute and contains no sign. Volt-amperes-reactive (VAR) is the vector difference of volt-amperes (VA) and true power. The VAR value is signed and may be used to determine if current is leading or lagging the voltage (negative when current is leading - capacitive load). Power factor is true power divided by volt-amperes (VA).

4.5.3 Power Usage (kWh)

Power usage (kWh) is calculated as the time integral of true power and is expressed in Kilowatt-hours. To prevent overflow and loss of this accumulated value over power-cycles, the associated OCS must periodically sample and reset this accumulation. Synchronization is provided for reading and resetting the power usage (kWh) accumulation such that an immediate calculation is not lost. To start this process, the OCS asserts the broadcasted 'kWh Freeze' (QG) bit. The ACM responds by making a copy of the kWh accumulator and queues that copied (frozen) value for transmission over the network (AQG). Next, the ACM resets the kWh accumulator and begins a new calculation. Finally, the ACM asserts the broadcasted 'kWh Freeze Acknowledge' (QG) bit once the frozen value is actually sent on the network. The associated OCS is then free to use the received kWh value for internal storage or accumulation.

Once the OCS has retrieved the 'frozen' copy, it releases the 'kWh Freeze' (QG) bit to allow the ACM's kWh network variable to revert to reflecting the real-time value of the kWh accumulator.

4.5.4 Circuit 1 and 2 Phase Difference

The phase difference is calculated by comparing the zero crossings of the voltage (A) input of each circuit. Each of the voltage (A) inputs must fall within the voltage and frequency limits of this device. If either circuit is providing a status of Loss-of-Phase (A), then the phase information is not calculated and displayed as zero.

4.6 Status

Status information is broadcasted over the network. See Network Output Data.

4.6.1 Loss of Phase (A, B, C) Bits

For each circuit, a minimal voltage and frequency must be applied to each voltage input to determine the AC values for proper indication and calculations. Should a signal on one of the voltage inputs fall out of the minimal range, its associated bit is asserted to warn the operator of the problem.

4.6.2 Circuit A/B and A/C Phase Error Bits

For each circuit, the phase difference of each voltage input zero crossing is continuously tested for a valid difference. In wye mode, if the phase varies more than ± 3 degrees from 120 and 240 degrees respectively, the appropriate bit is asserted to warn the operator of a phase imbalance. Likewise, in delta mode, if the phase varies more than ± 3 degrees from 60 degrees (between circuit A/B), the appropriate bit is asserted. In delta mode, the A/C phase error bit is inactive.

4.6.3 Freeze kWh Acknowledge

This value is asserted when the frozen kWh value is broadcasted on the network. See Power usage (kWh) above.

4.7 LED Indicators

OK	RUN	State

Both flash in continuous sequence		ACM500 is in monitor mode with the network ID set to FF. See section 3.2.
Both flash in numbered sequence		ACM500 failed power-up self-test. Contact technical support for assistance.
Fast Flash	Off	ID change delay
Slow Flash	Off	No network or Duplicate Network ID
On	Off	Waiting for configuration data
On	Fast Flash	Lost Factory calibration data
On	Slow Flash	Lost Network heartbeat
On	On	Run mode

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