MOORE INDUSTRIES

PPA

Phase Angle Transducer

USER'S MANUAL

April 2016

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Introduction

Moore Industries' Phase Angle Transducer (PPA) measures the phase angle of single- or three-phase ac power circuits by monitoring two voltage or a combination of voltage and current inputs and produces a proportional process variable current output.

This manual contains descriptive, calibration, and installation information for the PPA. Notes and Warnings are provided in this manual to help the user avoid minor inconveniences (Notes) and personal injury (Warnings) while calibrating or installing the PPA.

Description

The PPA accepts two voltage inputs or a voltage and a current input and produces a proportional current output that is linear with the phase angle of the inputs. The PPA will drive the output to zero percent should the voltage input (Va input for dual voltage inputs) be lost or removed while the current or the other voltage input is still applied. If the current input or both voltage inputs are removed from the unit, the output will be either plus or minus maximum — no certainty as to which, but it will be one extreme or the other.

The input, output, and operating power requirements for the PPA are all factory-configured to user specifications, selected from the available settings listed in table 1.

The PPA is packaged in an aluminum housing that can be either surface mounted (SM Housing) or DIN-rail mounted (DM Housing). Electrical connections are made to terminal strips located on the front panel of each unit. An optional safety cover is available for each terminal strip. This optional safety cover is made of a non-conductive material and is easily removed to access the terminals.

Every PPA is equipped with zero and span adjustments for setting the zero- and 100-percent output levels. Both of these adjustments are accessible at the front panel of the PPA.

A single internal jumper is provided for field-configuration of the unit for single- or three-phase input operation. Units equipped with the MG Option have additional jumpers for configuring the unit for single- or three-phase operation.

An optional liquid crystal display (LCD), which provides readouts of the phase angle of the input in degrees, is available for the PPA. Other useful options are also available, and some of the more popular are described in the following subsection (Options).

Table 1 contains the operational and performance specifications for the PPA. Table 2 is a supplemental table containing the PPA's overload current ratings.

Options

The PPA is available with some user-friendly and application-specific options. The following paragraphs contain brief descriptions of some of the more popular options for the PPA. For information on availability of options not described here, contact your local sales representative or Moore Industries directly.

DSP Option — Provides a 3.5-digit, front-panel LCD that displays the input phase angle in degrees.

MG Option — Provides a motor or generator contact-closure (relay) output and front-panel LED's to indicate the direction of current flow. This option requires one voltage input and one current input; this option will not work with two voltage inputs.

RO Option — Provides a reverse output that is proportional to the input. In cases where the input would produce a zero-percent output, with this option the output would be the full-scale (100-percent) output rating of the unit. Where the output would normally be 100-percent, it would be zero-percent with this option.

Table 1. *PPA Operational and Performance Specifications*

Characteristic	Specifications
Input	Factory-configured. **Voltage-Voltage** or **Voltage-Current** **Voltages:** 69 Vac (50-90 Vac) 120 Vac (85-150 Vac) 240 Vac (170-300 Vac) 460 Vac (300-575 Vac) 600 Vac (425-750 Vac) **Current:** 1 A (0.05-1 A) 2 A (0.1-2 A) 5 A (0.2-5 A) 10 A (0.3-10 A) 25 A (1-25 A) (Single- or three-phase operation is user-configurable.)
Output	Factory-configured. **–1 to 1 mA** (–1 mA = full lead, 0 mA = 0 deg., 1 mA = full lag) **0-1 mA**, bidirectional (0 mA = full lead, 0.5 mA = 0 deg., 1 mA = full lag) **4-20 mA** (4 mA = 0 deg., 20 mA = full lag) **4-20 mA** , bidirectional (4 mA = full lead, 12 mA = 0 deg., 20 mA = full lag) **4-20 mA**, lead (20 mA = full lead, 4 mA = 0 deg.)
Power	Factory-configured. **Self-powered** (from voltage input) **120 or 240 Vac** (external power) **12-42 Vdc** (loop-powered; 4-20 mA output units ONLY)
Controls	**Adjustments:** Two front-panel, multiturn potentiometers **Zero:** Adjusts zero-percent output to within ±2% of span **Span:** Adjusts 100-percent output to within ±10% of span **Jumpers:** A single internal jumper for configuring unit for single- or three-phase operation; with MG Option, two additional jumpers for this same setting
Indicators	**LCD:** With DSP Option; 3.5-digit liquid crystal display; displays the input phase angle in degrees from –180.0° to 180.0° **LED:** With MG Option; two red LED's indicate if the input represents a motor or a generator
Performance	**Accuracy:** ±0.5°, maximum; or ±0.01 power factor **Stability:** ±0.1% of reading per year **Dielectric Test:** 2000 Vrms for 1 min between input-output-power-case; 1500 Vrms with any RSxxx Option **Ripple:** 1% peak of full-scale at maximum span and load **Response:** 400 msec to 99% of output **Overload Voltage:** 1.5 times nominal input voltage **Overload Current:** SEE TABLE 2 **Ambient Temperature Effect:** ±0.01% of span per °C
Environmental Ratings	**Ambient Operating Temperature:** –40 to 80 °C (–40 to 176 °F) **Relative Humitity (operating):** 0 to 95%, non-condensing
Weight	0.85 kg (1 lb, 14 oz)
NOTE: Refer to the Installation Section for the PPA's outline dimensions.	

Table 2. *Overload Current Ratings (from table 1)*

Input	Continuous	10 sec/hr	3 sec/hr	1 sec/hr	0.5 sec/hr
1	10	15	20	50	100
2	15	25	50	100	250
5	20	50	100	250	400
10	20	50	100	250	400
25	30	75	100	250	400
NOTE: All values are rated in amps (A).					

RS232C & RS485 Options — Provides a front-panel, 9-pin, RS-232 connector for output to computers for communications in RS-232C or RS-485 protocols. Each has a different internal circuit.

TJ Option — Provides a front-panel test jack for monitoring the output. Does not interrupt output loop.

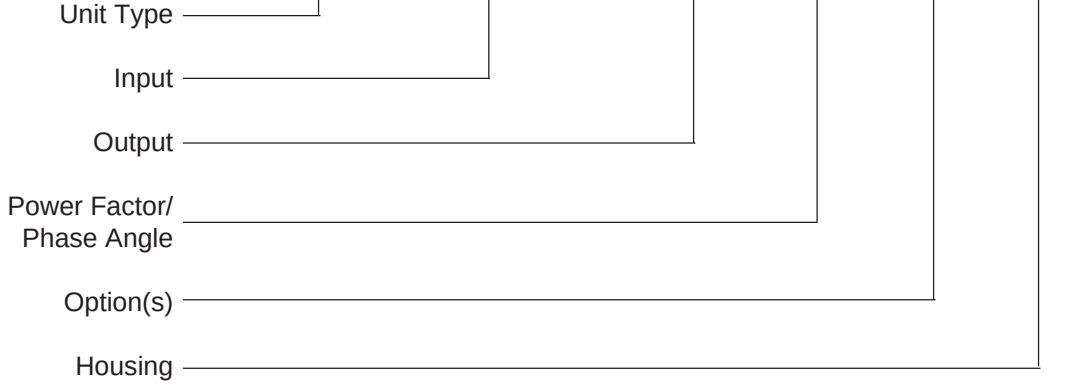
Serial/Model Number. A historical record is maintained on every PPA sold and serviced by Moore Industries. The historical information is keyed to the units serial number. To obtain historical information, or for technical assistance by phone, you must provide both the serial number and model number of the unit in question to a Moore Industries' representative.

The serial and model numbers for the PPA are located on a label that is affixed to the right side panel of the unit.

The following example identifies the significance of each field of the PPA model number:

EXAMPLE

PPA / 120AC,1A,1P / 4-20MA / 90 / -120AC [SM]



Calibration

Every PPA is calibrated and tested at the factory prior to shipment. Before placing a PPA into service, we recommend that you first bench check each unit, if possible, and then field calibrate each unit, if necessary. By performing a bench check, you can verify that each unit is configured properly for the intended application and determine if adjustments to the output are required.

The factory-calibration is performed using highly accurate test equipment to verify that each PPA meets customer specifications. This equipment may be unavailable at some facilities. The Calibration Setup subsection describes the calibration equipment required.

PPA Controls

The PPA has two types of controls; the Zero and Span potentiometers (pots), and the single- or three-phase jumper. Units factory-configured with the MG Option are equipped with two additional jumpers, which are also used to configure the unit for single- or three-phase input operation.

Zero and Span Adjustments. The zero and span adjustments are multiturn pots that are located on the front panel of the PPA, and are labeled “ZERO” and “SPAN”.

The ZERO pot is used to set the zero-percent output to within ±2% of span. The SPAN pot is used to set the full-scale (100-percent) output (1 or 20 mA), to within ±10% of span.

Each of these pots is equipped with a slip-clutch at each end of the wiper blade travel. If either pot is turned to its extreme, in either direction, you will feel a slipping sensation and in some cases you will hear a clicking sound as the potentiometer shaft is rotated. Turning either pot clockwise increases the value of the respective output. Turning them counterclockwise decreases the respective output value.

Jumpers. The basic PPA has one jumper whose position is user-selectable for single- or three-phase input operation (not on voltage-voltage input units). This jumper is located on PC1. To access it, the unit must be disassembled. Figure 1 illustrates the disassembly required to access this jumper. Figure 2 shows the jumper location and positioning options for selecting single- of three-phase operation.

Units equipped with the MG Option have two additional jumpers. These jumpers are also located on PC1, and are also used to configure the PPA for single- or three-phase operation. Figure 2 shows the jumper setting options for units with the MG Option.

PPA Indicators

The basic PPA has no visual indicators, but the DSP Option provides an LCD. This LCD is a 3.5-digit display (with fixed decimal point, xxx.x) that provides readouts of the phase angle of the inputs with readings ranging from –180.0 to 180.0. (For values greater than zero (0.0), no positive sign (+) is displayed.)

Units configured with the MG Option have two red LED’s to indicate that the input is either from a motor or a generator. To use the MG Option, the inputs must be a combination of a voltage and a current source. Based on the phase relationship of the inputs, the PPA will indicate if the input is representative of a motor or a generator. If the phase angle between the voltage and current inputs is greater than ±90°, its a generator; if less than ±90°, its a motor.

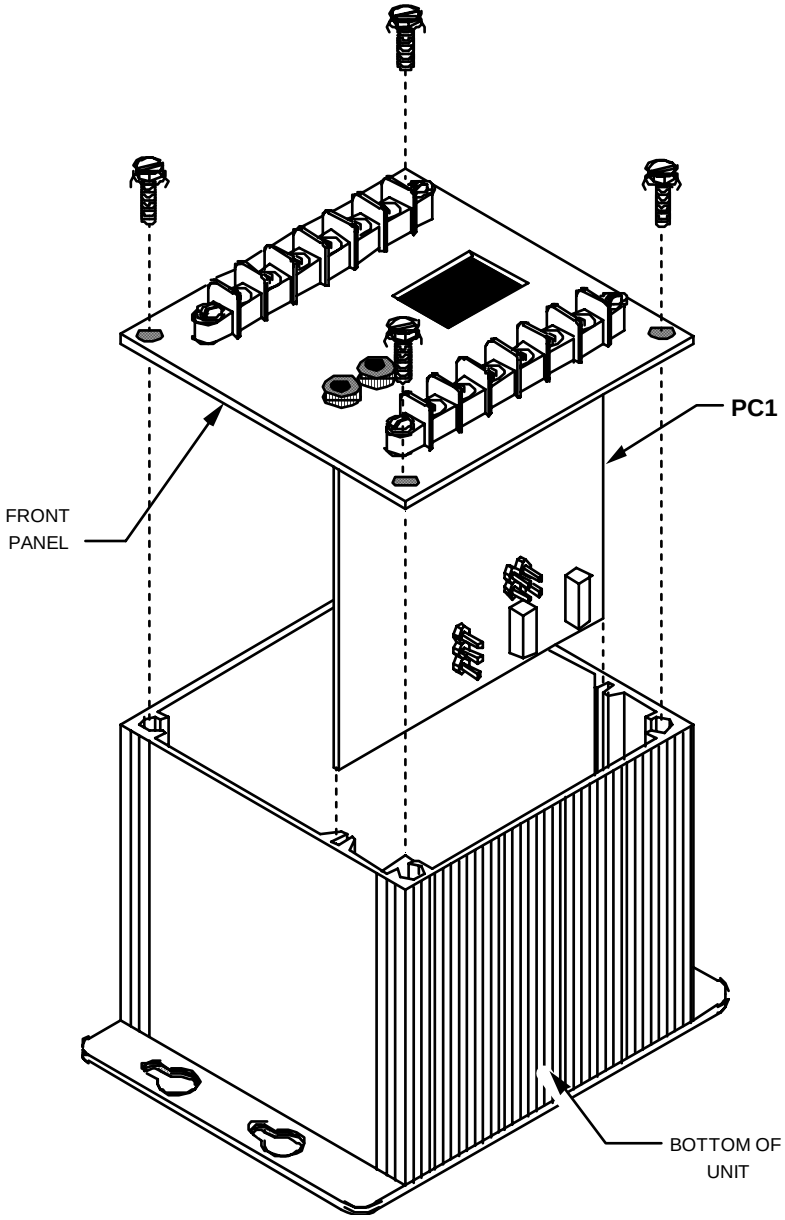


Figure 1. *PPA Disassembly – Accessing PC1*

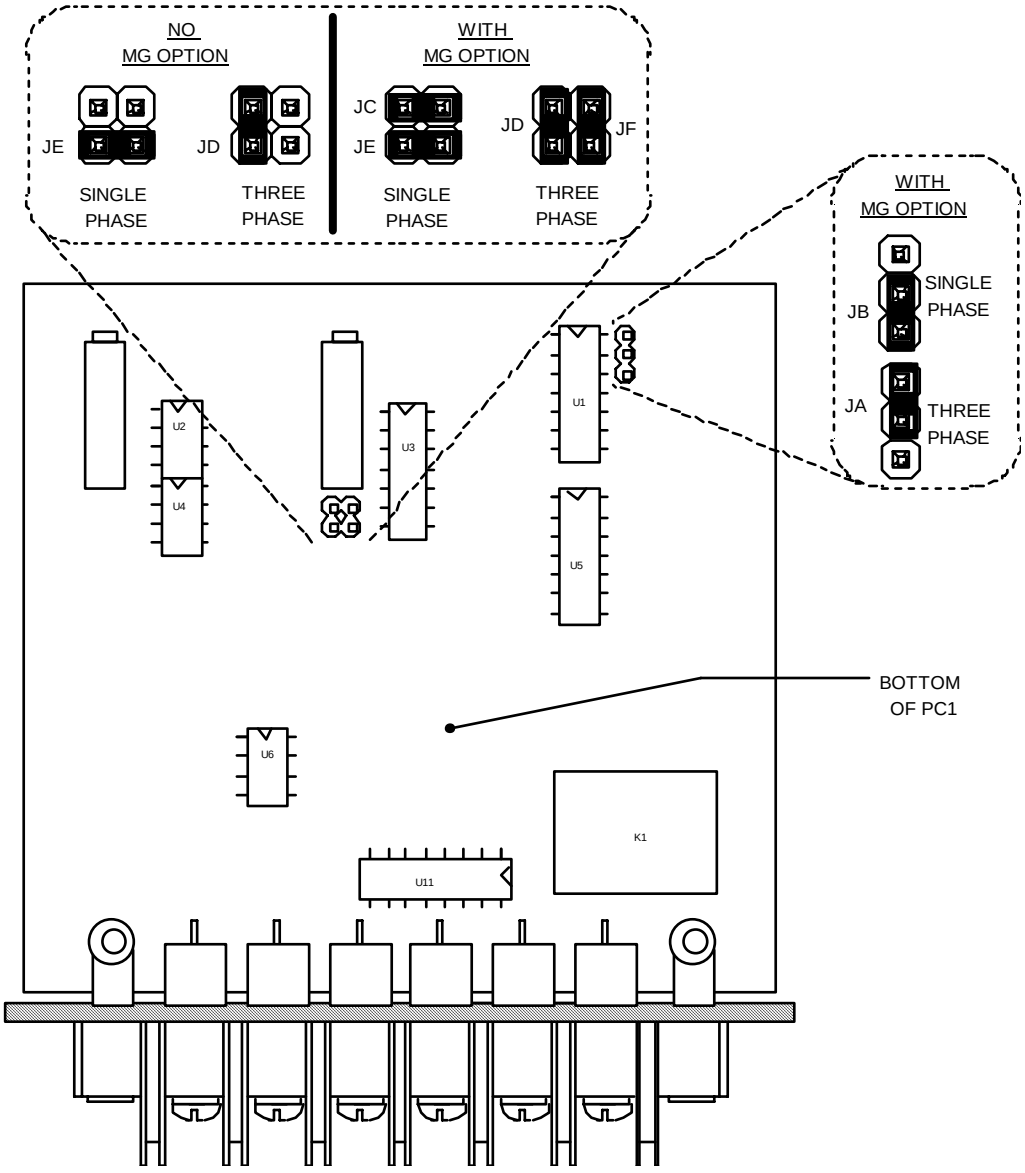


Figure 2. *PC1, Jumper Locations and Settings*

Calibration Setup

The equipment used to factory-calibrate the PPA may be unavailable at some facilities. But, to perform the field calibration procedure properly, you must use the equipment as describes in this section. Table 3 lists the calibration equipment required to bench check and calibrate the PPA.

Output Reading Conversions. Two load resistors are listed in table 4; a 250ý and a 5000ý. Units configured for a 4-20 mA output require the 250ý resistor. Units configured for a 0-1 mA or –1 to 1 mA output require the 5 ký resistor.

Readings taken with the voltmeter during calibration will be in volts when read across one of these load resistors. A 4-20 mA output loaded with a 250ý resistor will read 1-5 volts (1 V = 4 mA; 5 V = 20 mA). A 0-1 mA output loaded with a 5 ký resistor will read 0-5 volts (0 V = 0 mA; 5 V= 1 mA). A –1 to 1 mA output loaded with a 5 ký resistor will read –5 to 5 volts (–5 V = –1 mA; 5 V = 1 mA). Use Ohms Law to calculate other specific readings [I (current) = E (volts) ÷ R (resistance)].

Adjusting Bidirectional Units. When adjusting the zero-percent output for *bidirectional* units, the mid-point of the output range is the set point for the zero adjustment. Table 4 contains the mid-point (0 degrees) output settings by unit output configuration (refer to the unit's model number for its output configuration). For other output configurations, the ZERO pot is used to set the output to the minimum output value shown in the unit's model number. The SPAN pot is still used to set the full-scale output to the maximum output rating of the unit.

With bidirectional outputs, the total span of the output signal is divided equally into two portions; leading and lagging. For example, from zero degrees to full lag of a 4-20 mA bidirectional unit, the span is 8 mA instead of the total span of 16 mA. This is important to note when converting current output ratings to voltage for output readings, and for determining the output percentage that corresponds to the power factor settings required to adjust the full-scale output, as discussed in the next paragraph.

Table 3. *PPA Calibration Equipment*

Equipment	Specification
Input Source	ROTEK, Power/Energy Calibrator 811A
DC Voltmeter	Accuracy of 0.005%, or better
Load Resistor	250ý resistor for 4-20 mA outputs; 5 ký for 0-1 or -1 to 1 mA outputs; 0.01% tolerance
Ohmmeter	FOR UNITS WITH MG OPTION ONLY
Voltage Adaptor	FOR VOLTAGE-VOLTAGE UNITS ONLY; Moore Industries' Voltage Adapator module; to convert a current output from the ROTEK to a voltage input to the PPA
Screwdriver	Slotted-tip, head width no greater than 2.54 mm (0.1 in)
Technicians Tweezers	For setting jumpers, when required; needle-nose pliers may also be used

Table 4. *Mid-point Output Settings*

Output (in mA)	Full Lead	Mid-point (0°)	Full Lag
–1 to 1	–1	0	1
0-1 Bi.	0	0.5	1
4-20 Bi.	4	12	20
4-20	—	4	20
4-20 Lead	20	4	—

NOTE: The calibration procedure calls for a load resistor and voltmeter to take output readings. Refer to the Calibration Setup subsection for current-to-voltage conversion information.

Power Factor Settings. When making the span adjustment, the POWER FACTOR setting of the ROTEK 811A varies depending on the power factor or phase angle configuration of the PPA being calibrated. Table 5 contains the power factor setting for the ROTEK 811A and the percentage of full-scale output to be achieved when making the span adjustment for specific unit configurations.

Setting Jumpers. To set jumpers, the PPA must be disassembled. Figure 1 illustrates the disassembly required to access the jumper(s) on PC1. Figure 2 shows the jumper location(s) and setting options. Units configured for voltage-voltage inputs do not require any jumper settings; therefore, disassembly of these units is not necessary. The PPA does not need to be opened to check or adjust the zero or span setting. For personal safety and ease of handling, re-assemble the PPA after jumper settings are complete or before making electrical connections to the unit.

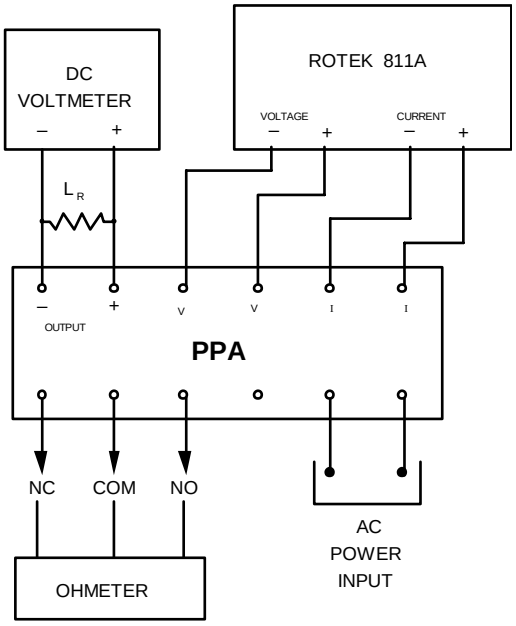
Figure 3 is a calibration hookup for a PPA configured for one voltage and one current input, with the MG Option.

Figure 4 is a calibration hookup for loop-powered units. These units require a 4-20 mA process loop to operate properly.

Figure 5 is a calibration hookup for a PPA configured for two voltage inputs. (The MG Option is not available for units with two voltage inputs.)

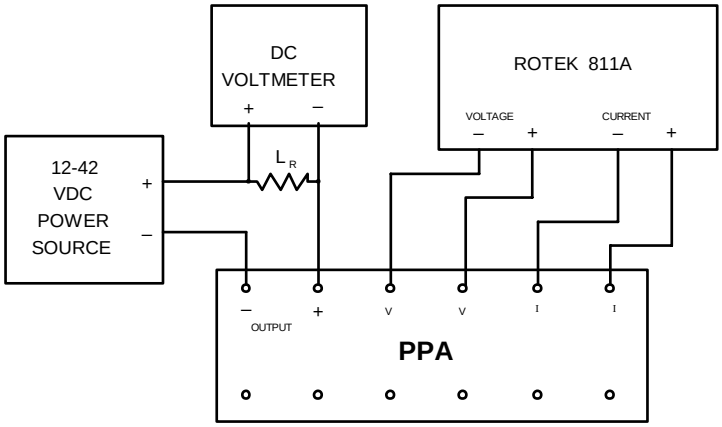
Table 5. *Full-scale Adjustment Power Factor Settings*

PPA Configuration		ROTEK 811A Power Factor Setting	Target Full-scale Output Percentage (%)
Power Factor	Phase Angle		
0		**0.1**	93.6
0.3		**0.3**	100
0.5		**0.5**	100
0.7		**0.7**	100
	30	**0.9**	86.14
	45	**0.7**	101.3
	60	**0.5**	100
	90	**0.1**	84.26
	180	**0**	50



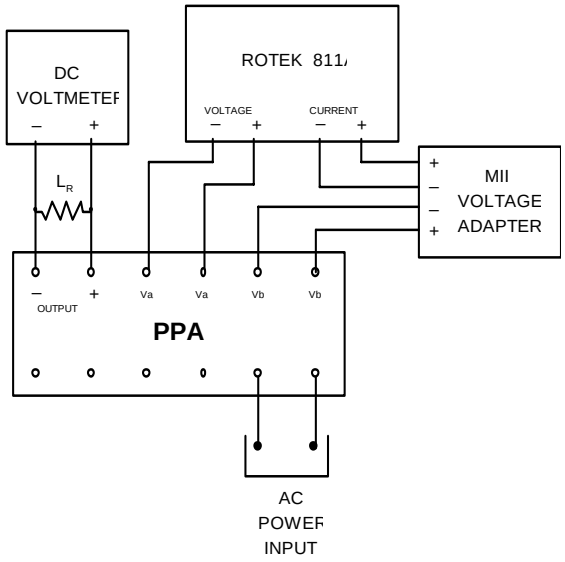
NOTE: L_R = 250 for 4-20 mA output or 5 k for 0-1 and -1 to 1 mA outputs.

Figure 3. *PPA Calibration Setup – Voltage-Current Input with MG Option*



NOTE: L_R = 250 for 4-20 mA output or 5 k for 0-1 and -1 to 1 mA outputs.

Figure 4. *PPA Calibration Setup – Loop-powered Units*



NOTE: L_R = 250 for 4-20 mA output or 5 k for 0-1 and -1 to 1 mA outputs.

Figure 5. *PPA Calibration Setup – Voltage-Voltage Input Units*

Calibration Procedure

Before beginning this procedure, check the units's model number for the configuration of the PPA to be calibrated. This information will be needed throughout this procedure for calibration setup, equipment settings, and output readings.

WARNING

Extremely high voltages are present at the current input terminals (I, •I) when either of the input wires is disconnected and current is still being applied. Ensure that the current input wires from the ROTEK Model 811A to the PPA terminals remain securely connected at all times while current is supplied to the PPA.

Zero and Span Adjustment

1. For voltage-current input units, disassemble PPA (see figure 1) and set internal jumper(s) for single-phase input (including three-phase units) as shown in figure 2. Slide electronics back into housing after jumper(s) is/are set.

2. Connect PPA to calibration equipment as shown in figure 3, 4, or 5, as appropriate.

3. With ROTEK 811A in STANDBY mode, set it for voltage and current input settings as required for PPA's configuration.

4. Apply external power to PPA, and depress OPERATE button on ROTEK 811A to apply input to PPA.

5. Set ROTEK 811A POWER FACTOR control to 1. Select lag by depressing LAG push button.

6. Adjust ZERO pot for a zero-percent output reading. Refer to table 4 for bidirectional output units; use zero degree (0°) values converted to volts.

7. Set ROTEK 811A POWER FACTOR control to appropriate setting for full-scale adjustment per unit configuration. Refer to table 5.

8. Adjust SPAN pot for a percentage output as listed in table 5 for power factor setting used in step 7. (NOTE: Not all settings are 100%.)

9. For single-phase input units, repeat steps 5 through 8 until zero and full-scale outputs are stable.

10. For any single-phase input and voltage-voltage input units, field calibration is complete. Turn ROTEK 811A off, or set to STANDBY, before disconnecting equipment.

NOTE
For MG Option check, refer to the following procedure before disconnecting equipment.

For three-phase input units, continue with step 11.

11. Turn ROTEK 811A off, or set to STANDBY, and set internal jumper(s) for three-phase input as shown in figures 2.

12. Set ROTEK 811A POWER FACTOR control to 0. Ensure LAG push button is still depressed.

13. Monitor output reading and adjust ZERO pot, as necessary for a zero-percent output reading. Refer to table 4 for bidirectional output units; use zero degree values converted to volts.

14. Span adjustment is not required.

15. For three-phase input units, field calibration is complete. Turn ROTEK 811A off, or set to STANDBY, before disconnecting equipment.

Checking the MG Option

NOTE
Complete the Zero and Span Adjustment procedure described previously before preceding with this check.

1. Remove input energy from PPA and set jumpers for single-phase input as shown in figure 2.

2. Set ROTEK 811A POWER FACTOR control to any setting except 0.

3. Connect an ohmmeter between terminals 7 and 8 at front panel of PPA. Verify a short exists across these normally-closed contacts and that only MOTOR LED is illuminated.

4. Reverse voltage polarity to PPA at ROTEK 811A voltage output connectors.

5. Verify that MOTOR LED extinguishes and only GENERATOR LED illuminates.

6. Connect an ohmmeter between terminals 7 and 8 and verify that these normally-closed contacts an open reading (Infinite) on ohmmeter.

7. Connect ohmmeter between terminals 8 and 9 and verify that a shorted condition exists across these relay contacts.

8. Reverse voltage input polarity again and note relay and LED states return to origin condition.

9. Turn ROTEK 811A off, or set to STANDBY, before disconnecting equipment.

Installation

Installation of the PPA is divided into two phases; physical mounting and completing the electrical connections. Generally, it is less cumbersome to physically mount a unit before completing the electrical connections.

Mounting the PPA

The PPA is available in two aluminum housing styles; a surface-mount (SM) a the DIN-rail mount (DM).

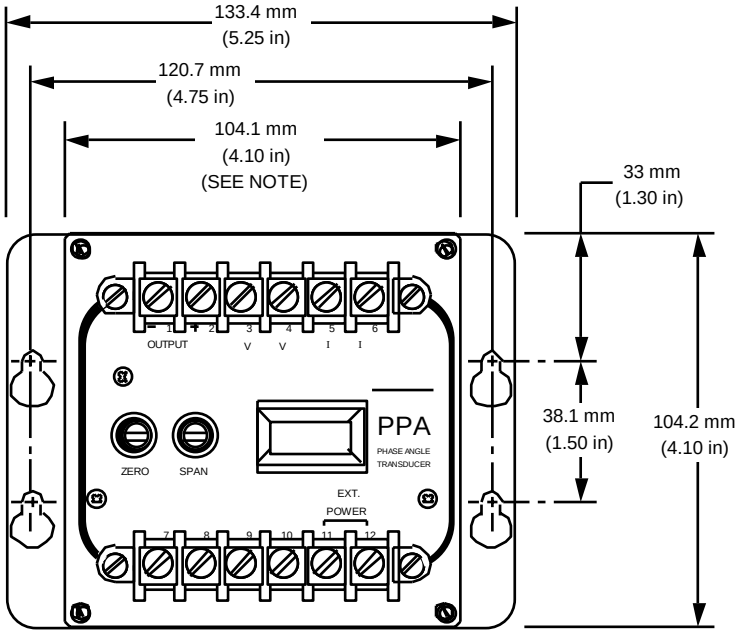
Surface-mount units may be mounted on any sturdy, flat surface. SM units have four keyhole cutouts (two on each side) of the rear mounting plate for easy mounting and removal.

DM units are designed to mount directly on standard DIN rails. These units are equipped with two mounting clips on the rear panel that are used to attach the unit to the rail. To complete the mounting of DM housed units, place the upper portion of the rear-panel clip under the upper lip of the DIN rail, then, pivot the unit down and back until the lower portion of the clip snaps on to the lower portion of the DIN rail.

For best performance, mount the PPA in an area free of excessive dust, moisture, and corrosive elements. Figure 6 contains the outline dimensions for the PPA.

Making the Electrical Connections

Every PPA is equipped with the same number of terminals. The configuration of the unit determines which terminals will be used. For example, if a unit is loop-powered, none of the lower terminals are used on a basic PPA.



NOTE: DIN rail-mount units have overall width of 104.1 mm (4.

Figure 6. *PPA Outline Dimensions*

Each terminal has a slotted-head screw that is used to make individual wiring connections.

PPA's configured with the MG Option provide a contact-closure output at terminals 7, 8, and 9. Terminals 7 and 8 are normally-closed (NC) and terminals 8 and 9 are normally-open (NO) — terminal 8 is common. These relay contacts can be used for external motor/generator indications or some other suitable contact-closure application. The MG Option relay is rated for 300 Vac, 6 A.

Figure 7 illustrates a typical hookup of a single-phase input, with MG Option. Figure 8 illustrates a typical hookup of a three-phase input, with MG Option.

Figure 9 and 10 illustrates loop-powered hookups for single- and three-phase inputs, respectively. Loop-powered units require a 4-20 mA loop.

Figure 11 illustrates a hookup for a PPA configured for two voltage inputs.

Operation

The basic PPA has no indicators. Unless the unit is configured with the DSP Option (an LCD) or the MG Option (two red LED's), the PPA will operate unattended once installed.

PPA's equipped with an LCD provide a readout of the phase angle of the inputs in degrees. These readouts range from –180.0° to (+)180.0°.

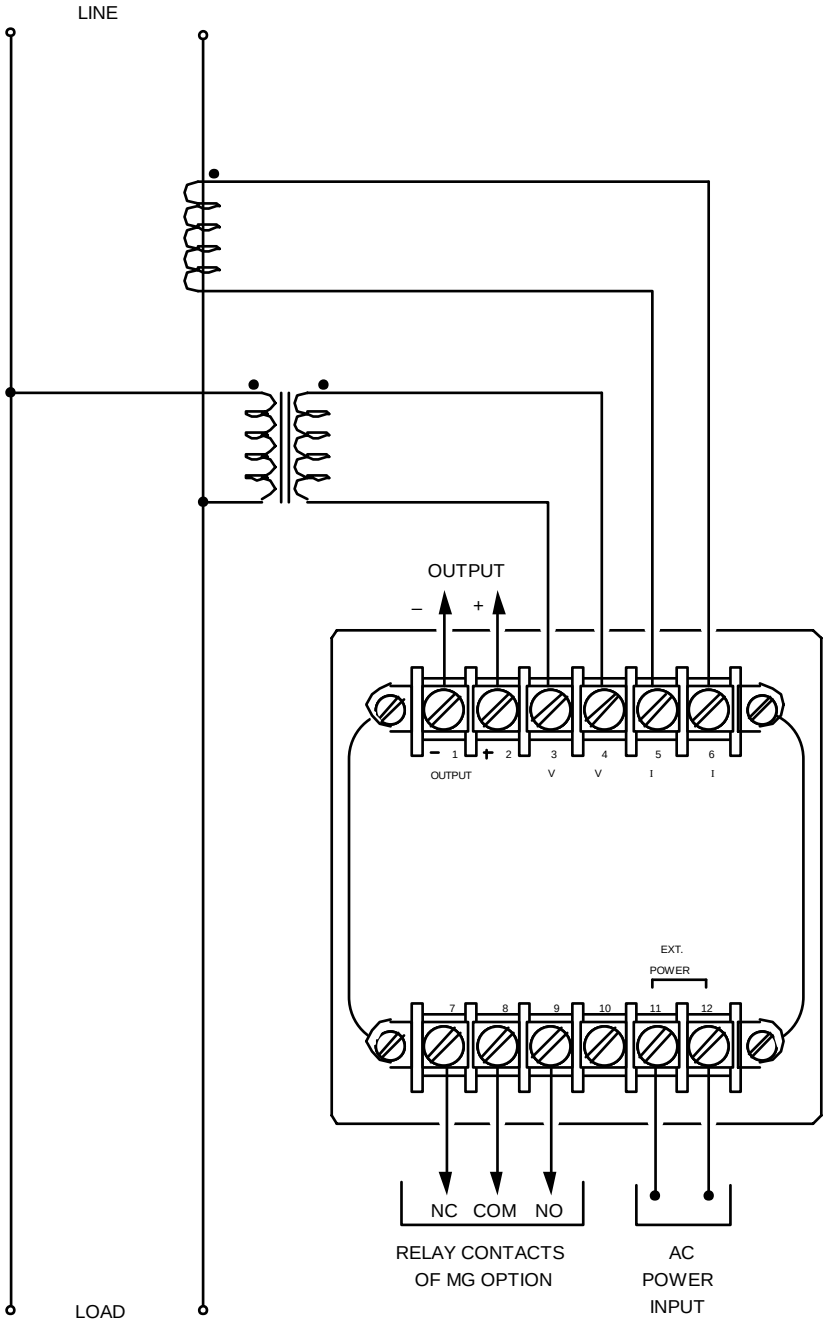
Units configured with the MG Option have two LED's to indicate that the input is either from a motor or a generator, based on the phase angle of the inputs. These LED's are on the front panel adjacent to the relay contact terminals. The MG Option relay changes state in conjunction with the LED's. The relay action can be used for external indications.

Maintenance

The PPA is built with highly reliable components, which allows it to operate unattended for extended periods of time. Because of this high reliability, field maintenance is limited to ensuring that wire terminals on the unit are clean and tight.

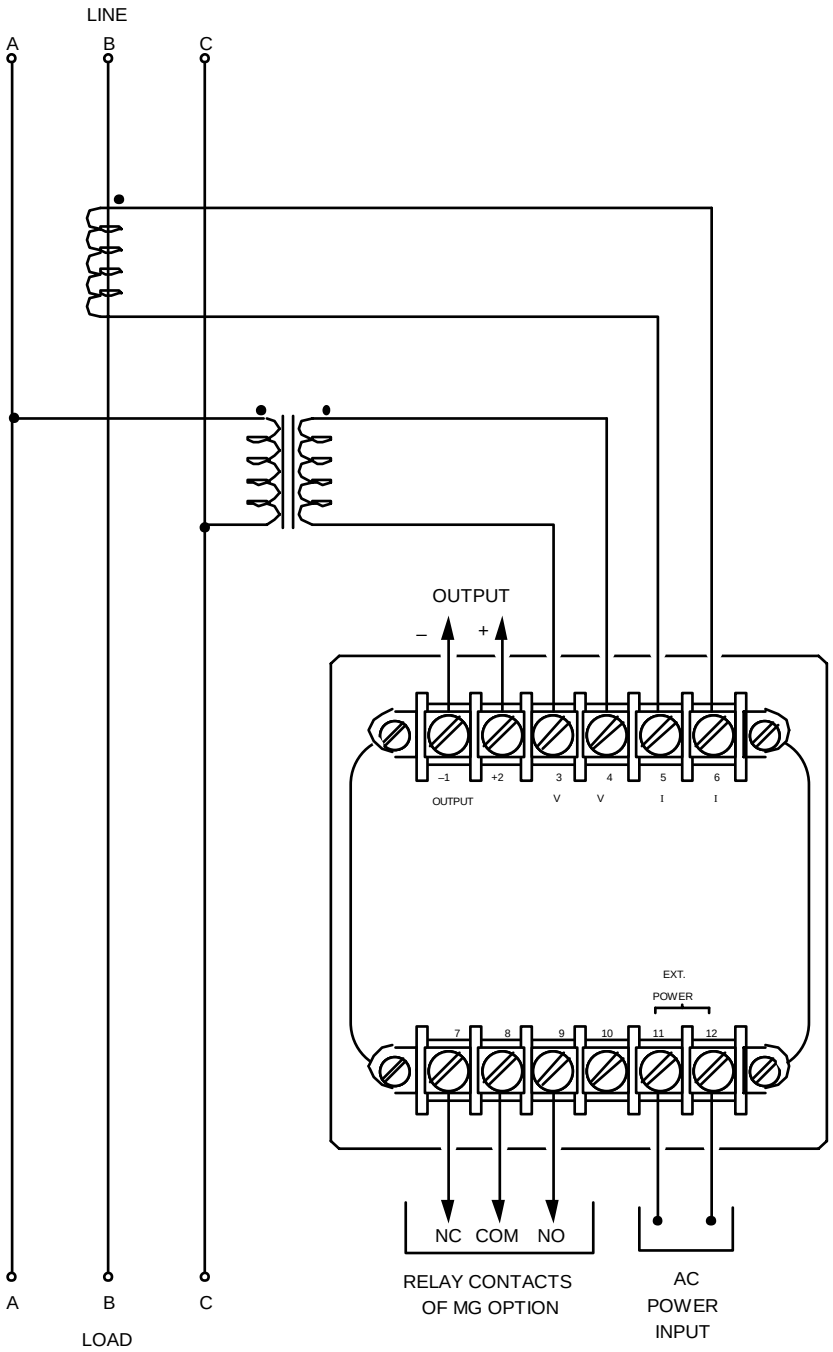
We recommend that the PPA be inspected for mounting security, terminal corrosion, and general cleanliness at least once every six months.

For technical assistance, or for more information about the PPA, contact Moore Industries' Customer Service Department by dialing 1-800-999-2900.



NOTE: Use ac power input only if unit is configured with 120AC or 240AC Option.

Figure 7. *Installation Hookup for Single-phase Inputs*



NOTE: Use ac power input only if unit is configured with 120AC or 240AC Option.

Figure 8. *Installation Hookup for Three-phase Inputs*

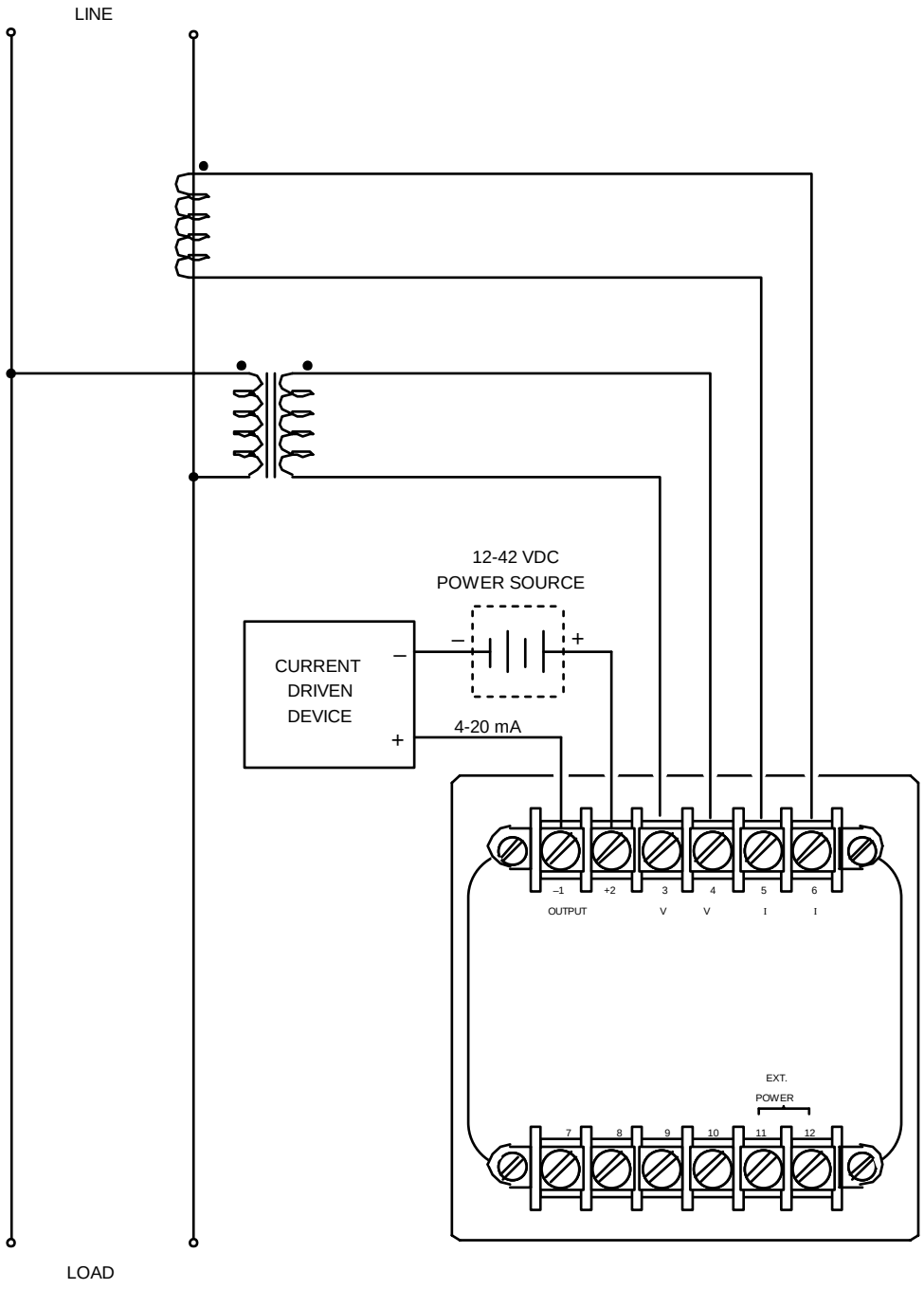


Figure 9. *Installation Hookup for Single-phase Inputs – Loop-powered*

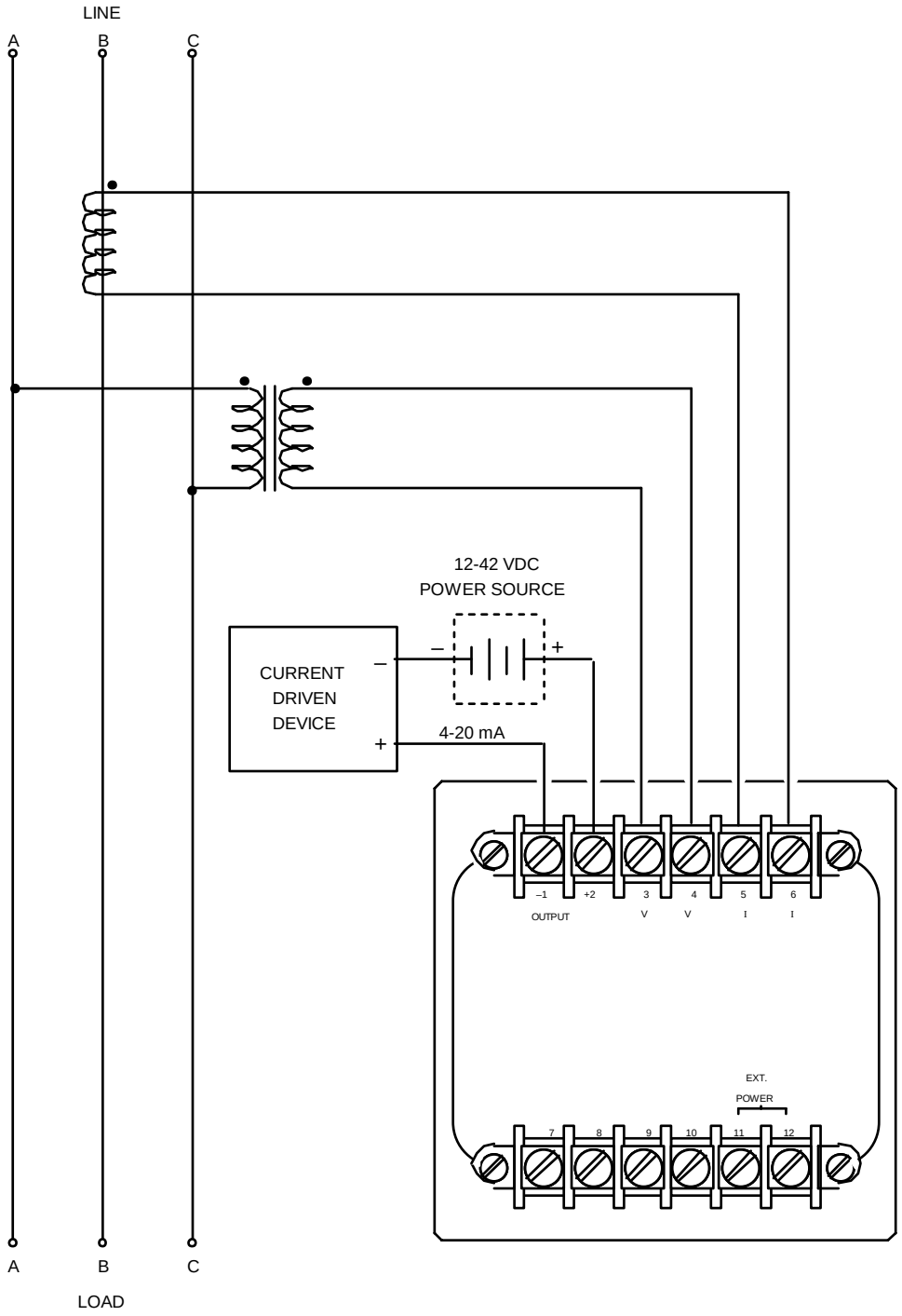
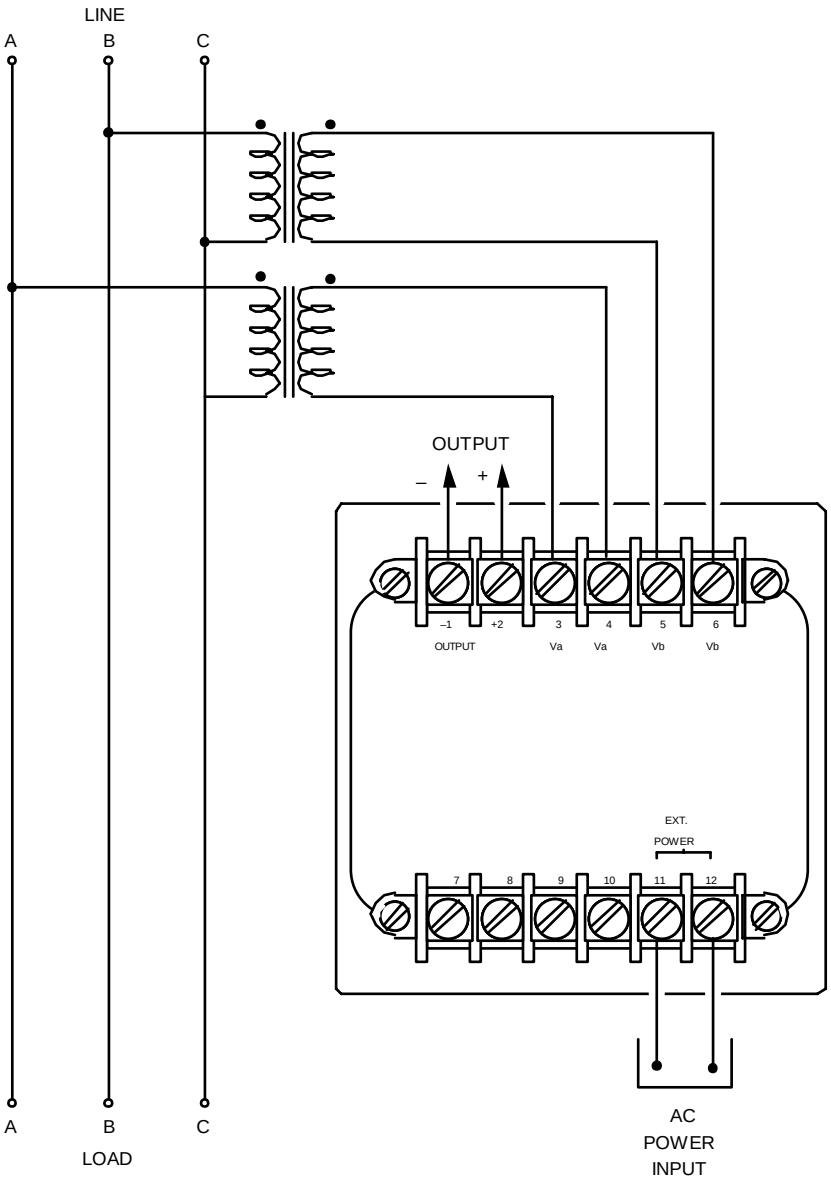


Figure 10. *Installation Hookup for Three-phase Inputs – Loop-powered*



NOTE: Use ac power input only if unit is configured with 120AC or 240AC Option.

Figure 11. *Installation Hookup for Voltage-Voltage Inputs*

NOTES

RETURN PROCEDURES

To return equipment to Moore Industries for repair, follow these four steps:

1. Call Moore Industries and request a Returned Material Authorization (RMA) number.

   Warranty Repair –
   If you are unsure if your unit is still under warranty, we can use the unit's serial number to verify the warranty status for you over the phone. Be sure to include the RMA number on all documentation.

   Non-Warranty Repair –
   If your unit is out of warranty, be prepared to give us a Purchase Order number when you call. In most cases, we will be able to quote you the repair costs at that time. The repair price you are quoted will be a "Not To Exceed" price, which means that the actual repair costs may be less than the quote. Be sure to include the RMA number on all documentation.

2. Provide us with the following documentation:
   a) A note listing the symptoms that indicate the unit needs repair
   b) Complete shipping information for return of the equipment after repair
   c) The name and phone number of the person to contact if questions arise at the factory

3. Use sufficient packing material and carefully pack the equipment in a sturdy shipping container.

4. Ship the equipment to the Moore Industries location nearest you.

The returned equipment will be inspected and tested at the factory. A Moore Industries representative will contact the person designated on your documentation if more information is needed. The repaired equipment, or its replacement, will be returned to you in accordance with the shipping instructions furnished in your documentation.

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