PTB CALIBRATION

REQUIRED EQUIPMENT

BEST

Watt Calibrator	Rotek 800, 8000 or equivalent
DC Voltmeter	
DC Milliammeter	For output options B or E
Frequency Counter	For output option W

SECOND CHOICE

Wattmeter Standard	
AC Voltage Source	
AC Current Source	
AC Voltmeter	Must be true RMS Measuring
AC Ammeter	Must be true RMS Measuring
DC Voltmeter	
DC Milliammeter	For output options B or E
Frequency Counter	

All meters used for calibrating the PTB board must have an accuracy of ±0.06% or better to ensure precision of the PTB calibration.

GENERAL INFORMATION

1. **Table #1** lists all terminal connections and trimpot adjustment identifications. Page 2
2. **Table #2** shows inputs for "cal watt."
3. Drawing #1 identifies the zero and calibration trimpot locations on the main PTB board. Page 3
4. **Drawings 2 through 4A** show the connections to the PTB circuit board for calibrations from a single-phase source. Pages 5 through 7
5. **Drawings 5 and 6** show the wattmeter or watt calibrator connections. Page 8
6. PTB models that are supplied with current transformers are calibrated with the current transformers as part of the system.

CALIBRATION

A. Consult the tables and drawings for all necessary information before starting the calibration.

B. Connect 115 volts AC (or 230 volts AC if this PTB has option 2 for 220 volts instrument power) to the input terminals labeled "INSTRUMENT POWER" L1 and L2.

C. Turn instrument power on and allow 15 minutes for the circuits to stabilize the zero offsets.

D. **Zero Adjust:**
- With all voltage and current inputs at zero, adjust all zero trimpots listed in Table 1 for zero output at the output terminals.
- Set the outputs on boards with option E at 4 mADC.

E. Voltage Calibration:
- Using table 1, the Input Connections column shows each combination of voltage inputs and the corresponding output terminals.
- Apply the full scale rated voltage to each set of input terminals.
- Adjust the associated trimpot for full-scale voltage or current at the output terminals. Option B is 1 mADC, option D is 10 volts DC, option, X5 is 5 volts DC, and option E is 20 mADC.

F. Current Calibration:
- Refer to drawings 2 through 4A on pages 5, 6, & 7 for the current connections for the PTB model being calibrated.
- Connect all the current inputs in series and apply the full scale rated current to the input terminals.
- Adjust all current trimpots (see table 1) for full-scale voltage or current at the output terminals. Option B is 1 mADC, option D is 10 volts DC, option, X5 is 5 volts DC, and option E is 20 mADC.

G. Balance: Refer to drawings 2 through 4A for the PTB being calibrated. Use the drawing for the PTB models you are calibrating.
- **Single-phase** – Factory set and not required on single-phase models.
- **Three-phase, three-wire balance**. Reverse the current input L2 (X1and X2) so that L1 X2 is connected to X2 of L2. Apply the rated power listed in the "cal watt" column. Adjust trimpot P2 for a zero output at the output terminal 10 and common terminal 7. For output option E the zero is offset to 4 mADC.

- **Three-phase, four-wire balance.** Reverse current input terminals L2 (X1 & X2) and disconnect L3 terminals from the loop. Apply the rated power listed in the "cal watt" column. Adjust trimpot P2 for a zero output ate the output terminals 10 and the common 7. For output option E the zero is offset to 4 mADC.
- **Three-phase, four-wire balance continued.** Next disconnect current terminals L2 (X1 & X2) and reconnect terminals L3 (X1 & X2) but in reverse order. This will put terminal L1(X2) connected to L3(X2). Apply the rated power listed in the "cal watt" column. Adjust P1 trimpot for a zero output at terminals 10 and the common 7. For output option E the zero is offset to 4 mADC.

H. Final Watt Calibration.

- Make the connections to the wattmeter standard or the watt calibrator as shown in drawings 2 through 6 as shown on pages 5, 6, & 7.
- Consult Table 2 for the required inputs and power required (Cal watts).
- Calibrations is done using a single-phase power sources so that drawing 3 through 4A show the voltage inputs in parallel and the current inputs are in series.
- For three-phase, three-wire or four-wire models each element will measure the same load. The cal watts will be the same as the total or 2 times that read on the standard wattmeter or watt calibrator for three-phase, three-wire models, and 3 times that read on the standard wattmeter or watt calibrator for three-phase, four-wire models.
- Apply the "cal watts" power reading and adjust the watt trimpot P10 for full-scale output at terminals 10 and the common 7. Option B is 1 mADC, option D is 10 volts DC, option, X5 is 5 volts DC, and option E is 20 mADC.
- Check linearity over the range of voltage, current and power factor if you have the equipment available.

TABLE 1

MODEL	PHASE	INPUT CONNECTIONS	ZERO ADJUST TRIMPOT	CAL. ADJUST TRIMPOT	PARAMETER	OUTPUT TERMINAL TO COMMON
PTB-1	1Ø 2W	L1 - N	P4	P5	VOLTAGE	18
PTB-1	1Ø 2W	L1 (X1 – X2)	P12	P13	CURRENT	14
PTB-1	1Ø 2W	SEE DWG #2	P8	P10	WATTS	10
PTB-2	3Ø 3W	L1 – L2	P23	P24	VOLTAGE	16
PTB-2	3Ø 3W	L2 – L3	P15	P16	VOLTAGE	17
PTB-2	3Ø 3W	L3 – L1	P4	P5	VOLTAGE	18
PTB-2	3Ø 3W	L1 (X1 – X2)	P12	P13	CURRENT	14
PTB-2	3Ø 3W	L2(X1 – X2)	P19	P20	CURRENT	13
PTB-2	3Ø 3W	L3(X1 – X2)	P27	P28	CURRENT	12
PTB-2	3Ø 3W	See DWG #3	P8	P10	WATTS	10
PTB-3	3Ø 4W	L1 - N	P4	P5	VOLTAGE	18
PTB-3	3Ø 4W	L2 - N	P15	P16	VOLTAGE	17
PTB-3	3Ø 4W	L3 - N	P23	P24	VOLTAGE	16
PTB-3	3Ø 4W	L1 (X1 – X2)	P12	P13	CURRENT	14
PTB-3	3Ø 4W	L2 (X1 – X2)	P19	P20	CURRENT	13
PTB-3	3Ø 4W	L3 (X1 – X2)	P27	P28	CURRENT	12
PTB-3	3Ø 4W	SEE DWG# 4	P8	P10	WATTS	10

PTB MODEL NUMBER IDENTIFICATION

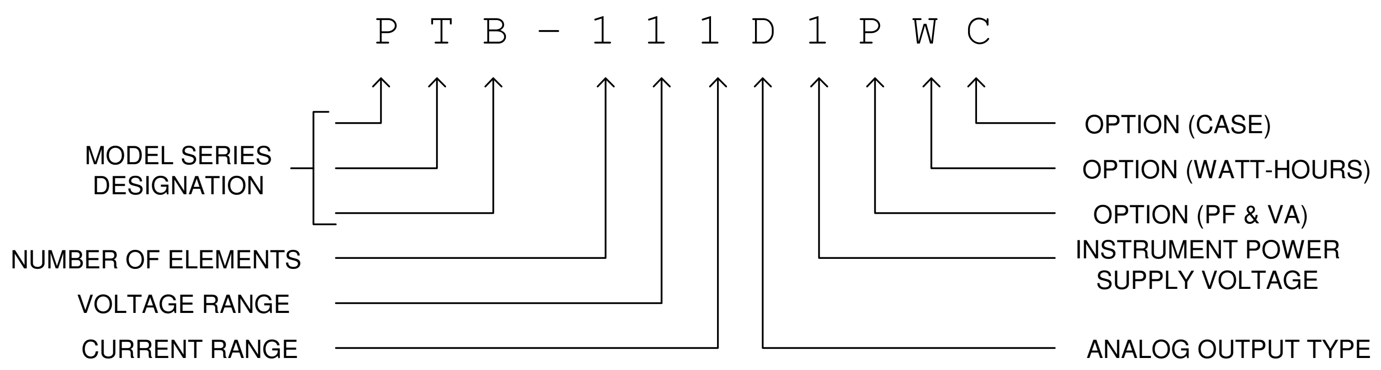


TABLE 2

PHASE	INPUT VOLTAGE	FULL SCALE CURRENT	*WATT CALIBRATOR SETTING	*TOTAL FULL SCALE FOR PTB
1Ø 2W	150 VOLTS	5 AMPERES	600 WATTS	600 WATTS
1Ø 2W	300 VOLTS	5 AMPERES	1200 WATTS	1200 WATTS
1Ø 2W	600 VOLTS	5 AMPERES	2400 WATTS	2400 WATTS
3Ø 3W	150 VOLTS	5 AMPERES	600 WATTS	1200 WATTS
3Ø 3W	300 VOLTS	5 AMPERES	1200 WATTS	2400 WATTS
3Ø 3W	600 VOLTS	5 AMPERES	2400 WATTS	4800 WATTS
3Ø 4W	150 VOLTS	5 AMPERES	600 WATTS	1800 WATTS
3Ø 4W	300 VOLTS	5 AMPERES	1200 WATTS	3600 WATTS
3Ø 4W	600 VOLTS	5 AMPERES	2400 WATTS	7200 WATTS

*For models supplied with current transformers, multiply the calibrator setting and the total full-scale watts by the current transformer ratio.

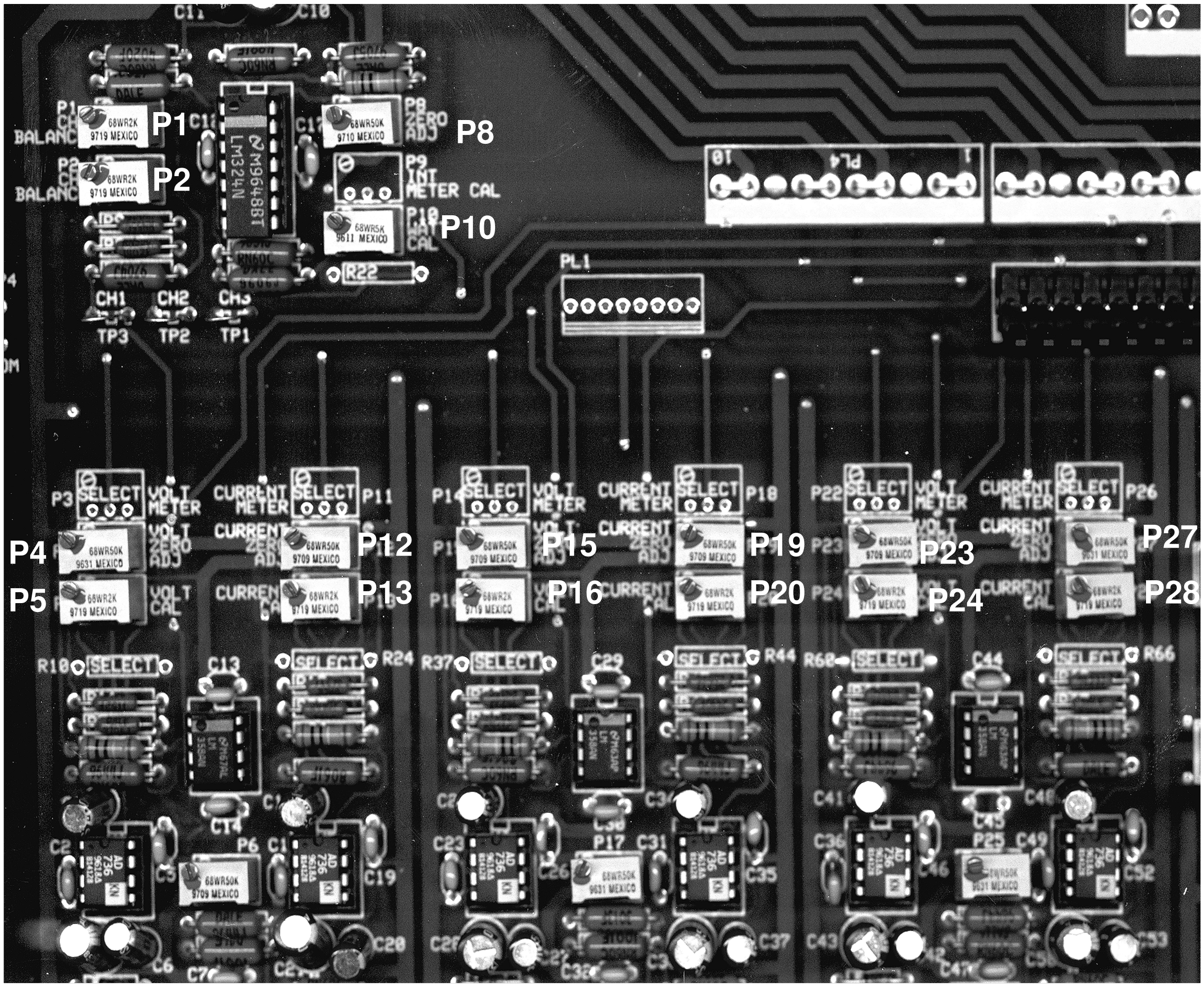
Trouble Shooting

1. **No outputs from any of the output terminals:** Check instrument power at the terminals marked instrument power L1 and L2.
2. **Low outputs on current and watts:** Check wires between the PTB terminals and the current transformers. If they have been extended this may cause low readings. Please see bulletin 101 on page 14.
3. **Low or no output on watts only.** Look for incorrect phasing between the voltage and current inputs. Look for reversed current transformers. Review the PTB connection diagram for correct phasing and polarities on the current transformers.
4. **Negative Output for watts and for optional power factor:** Current transformers are either connected with reversed polarity or are on the current conductors backwards. Check the polarity marks and review the PTB connection diagram.

The voltage connections and the current transformers must reference the current carrying lines as shown in our connection diagrams. Polarities on the current transformers must be observed and correctly positioned and connected. Power measuring equipment is polarity sensitive.

PTB MAIN BOARD TRIMPOT LOCATIONS

P2 L3 BALANCE P8 WATT ZERO
P1 L2 BALANCE P10 WATT CAL.

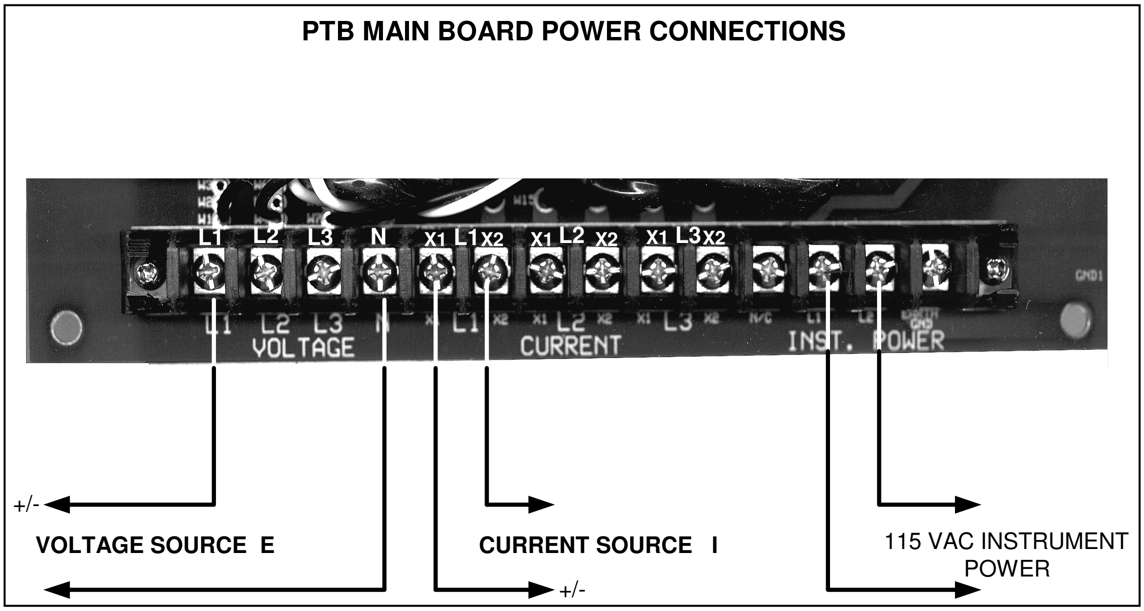


P4 L1 VOLTAGE ZERO
P5 L1 VOLTAGE CAL.
P12 L1 CURRENT ZERO
P13 L1 CURRENT CAL.

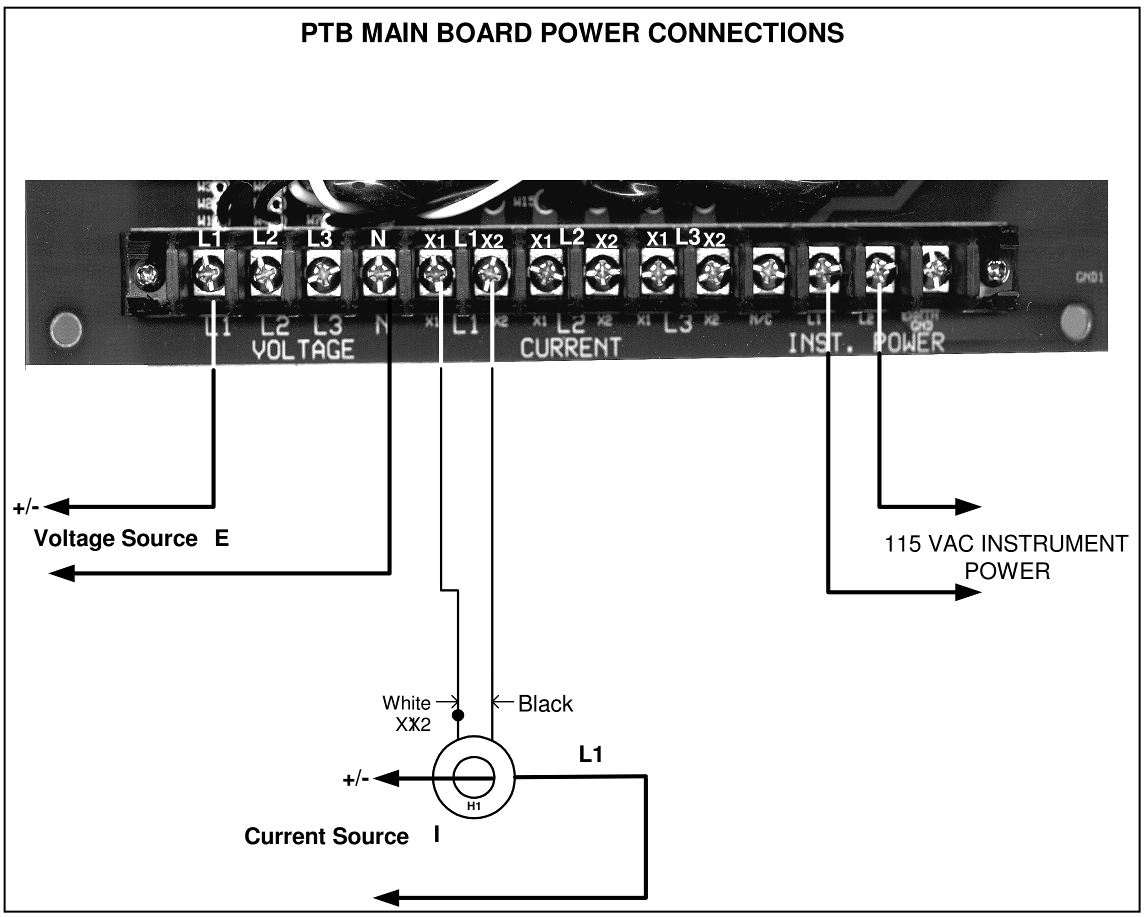
P15 L2 VOLTAGE ZERO
P16 L2 VOLTAGE CAL.
P19 L2 CURRENT ZERO
P20 L2 CURRENT CAL.

P23 L3 VOLTAGE ZERO
P24 L3 VOLTAGE CAL.
P27 L3 CURRENT ZERO
P28 L3 CURRENT CAL.

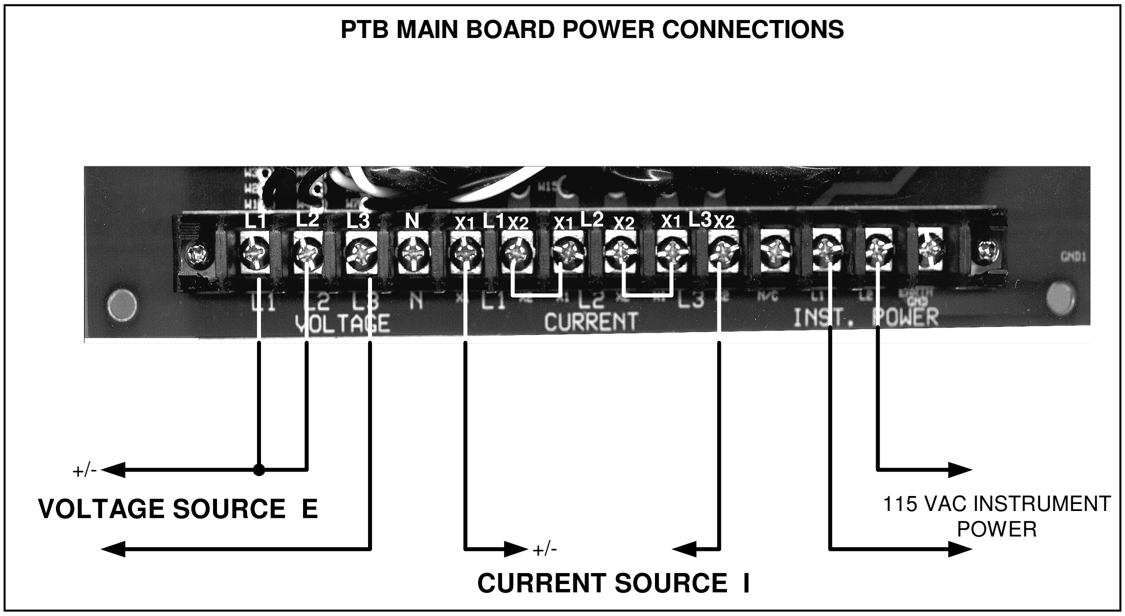
Drawing 1 The PTB Main Board Showing Trimpot Location



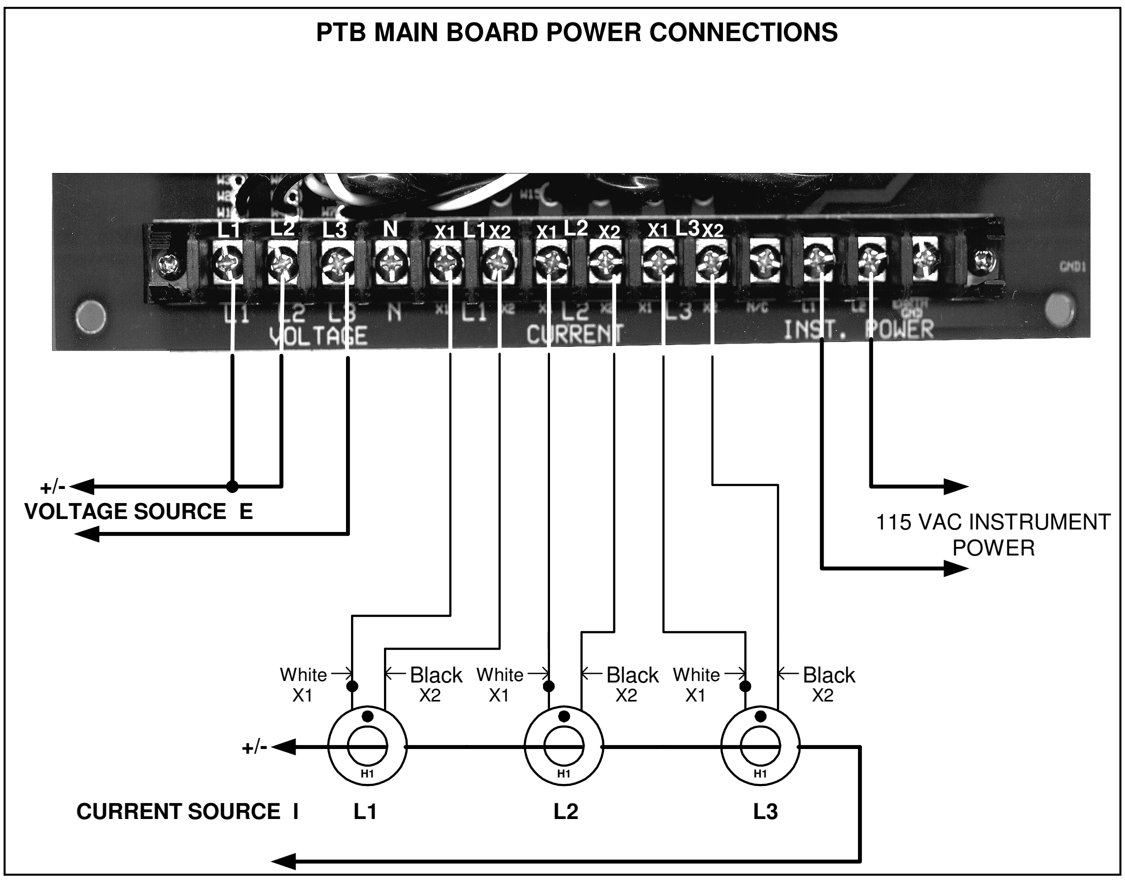
Drawing 2 Single Phase Connections



Drawing 2A Single Phase with Current Transformer

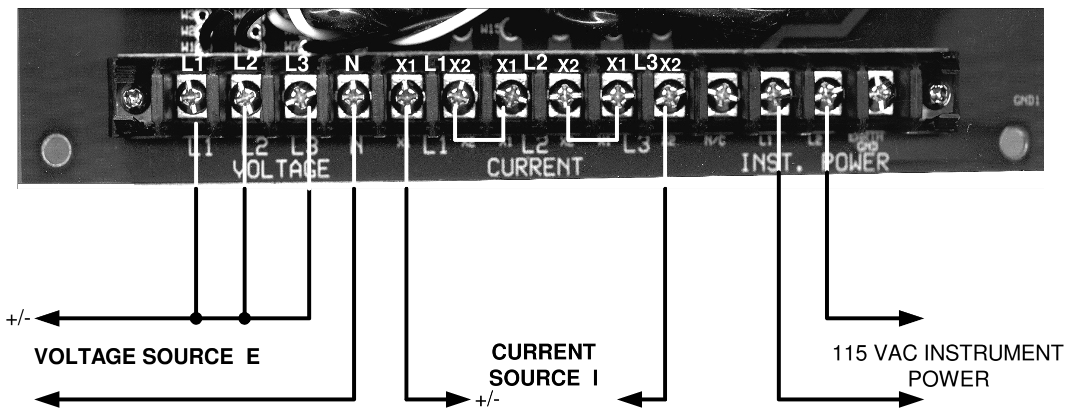


Drawing 3 Three-Phase, Three-Wire Connections



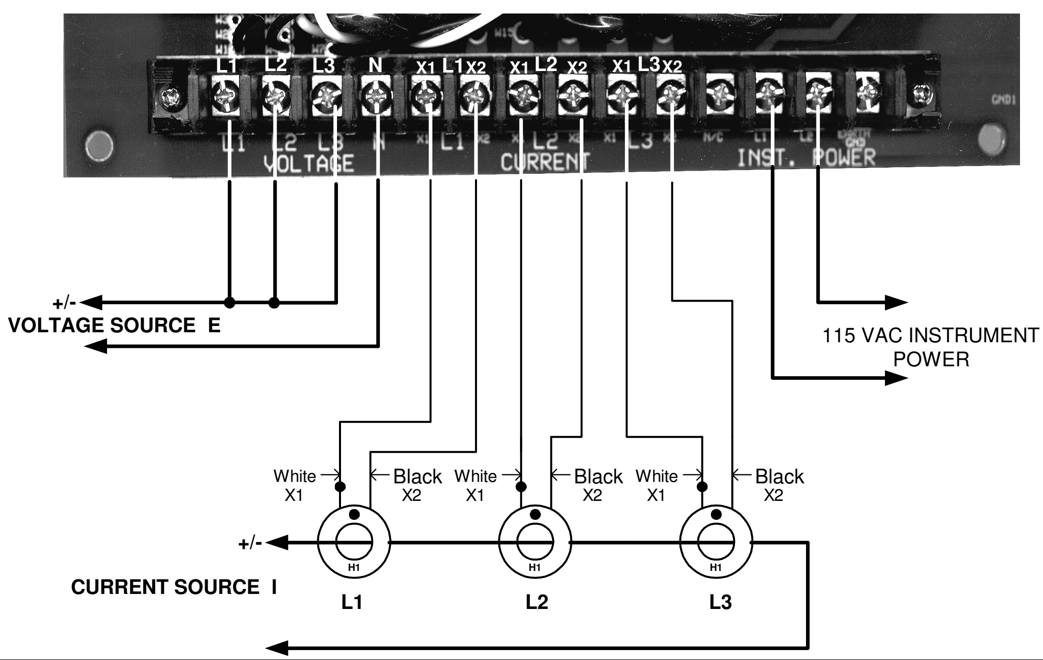
Drawing 3A Three-Phase, Three-Wire Connections with Current Transformers

PTB MAIN BOARD POWER CONNECTIONS

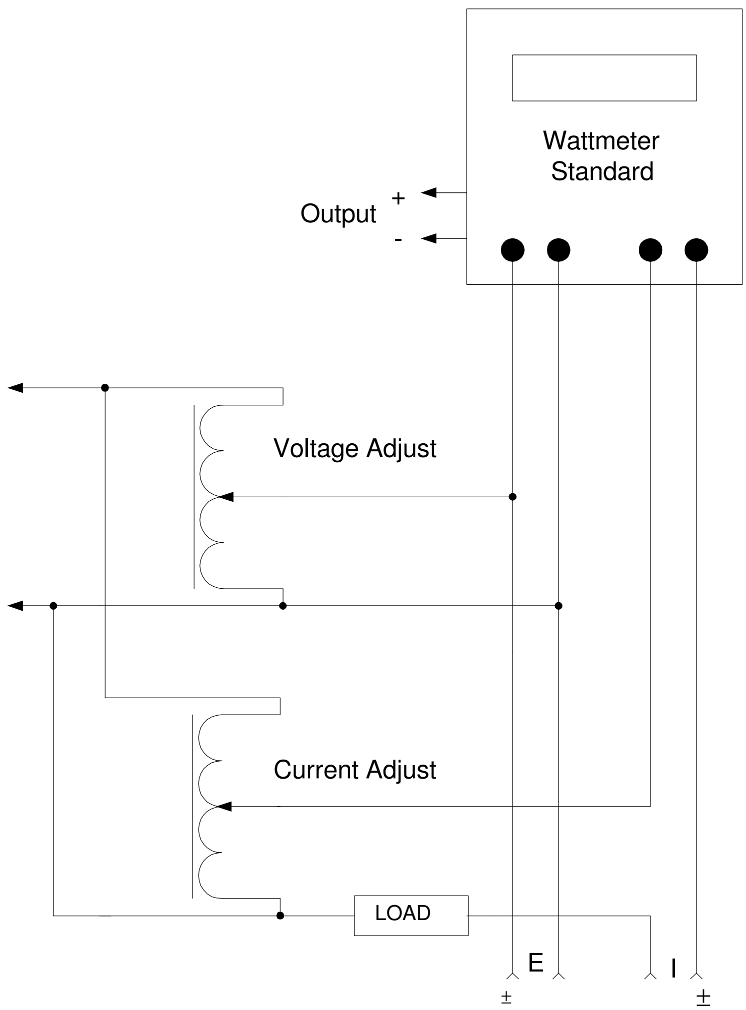


Drawing 4 Three-Phase, Four-Wire Connections

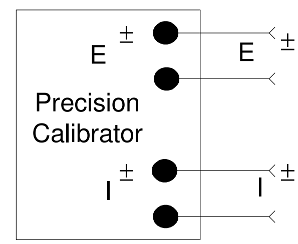
PTB MAIN BOARD POWER CONNECTIONS



Drawing 4A Three-Phase, Four-Wire Connections with Current Transformers.



Drawing 5



Using a precision Calibrator such as the Rotek 800A or 811A is the prefered method of calibration.

Rotek Instruments Corp.
390 Main St.
Waltham, MA 02254
781-899-4611

Drawing 6

Connection between PTB and the Calibrator

PTP ——►≻—— Calibrator

All calibrations must be done on the main PTB board before proceeding with calibration of the option P plug in board for volt-amperes and power factor or on the option W plug in board for watt-hours. The same test standards are required.

Option P VA (Volt-amperes) & Power Factor

Calibrating the option P plug in board requires the means of shifting the current ±90° out of phase from the voltage.

Drawing 7 on page 12 gives the option P location and the locations of the trimpots and amplifier test points.

Zeroing

VA (Volt-amperes) and Power Factor

Apply instrument power and allow 15 minutes for the circuits to stabilize.

1. Connect a voltmeter between pin 7 of each multiplier (633JN) A1, A2, & A3 and the output common, terminal 7, on the main PTB board.
   - Adjust the zero of each multiplier to zero using trimpots P7, P8 and P9 as shown in drawing 7.
   - Next connect the voltmeter to the output terminal 9 and the common terminal 7.
   - Adjust trimpot P5 (VA zero) for a zero output.
2. Compare the output at terminal 10 (watts) to the common terminal 7 and the output at terminal 8 (power factor) to the common terminal 7.
   - Adjust P4 (power factor zero) for the exact same reading as for watts at terminal 10 and power factor at terminal 8.
   - We want the power factor output and the watts output zeros to be the same.
   - Should the zero setting for watts have a slight offset, be sure to adjust the zero for power factor to the same offset.

VA CALIBRATION

1. Connect the voltmeter to terminal 9 and the common terminal 7 for the VA calibration.
2. Consult drawings 2 through 4A for standard calibration connections.
3. Consult Table 1 for the single phase input power requirement listed in this table.
4. Note Drawing 7 shows all multipliers plugged into the sockets.
   - A1 and A2 are not installed on single phase, single element models.
   - A1 is not installed on three-phase, three-wire, two element models.
5. Single-Phase, two-wire (1Ø 2W) models.
   - Make the connections shown in drawing 2 or 2A.
   - Apply the specified calibration watts for a 1Ø 2W model. See Table 2.
   - Adjust trimpot P6 (VA) for a full scale output (Option D – 10 volts DC, Option X5 – 5 volts DC, Option B 1 mADC, Option E – 20 mADC).
6. Three-phase, three-wire (3Ø 3W) models.
   - Connect **only** L1 to L3 voltage and L1 (X1-X2) current.
   - Apply the specified calibration watts for 3Ø 3W models as shown in table 2.
   - Change the jumper CN2 to position 1&2. See drawing 7. (Don't change this back to the original setting until the power factor section is calibrated.)
   - Adjust trimpot P2 (A3 cal) for ½ full scale. (Option D – 5 volts DC, Option X5 – 2.5 volts DC, Option B 0.5 mADC, Option E – 12 mADC.)
   - Next connect only L2 to L3 voltage and L2(X1-X2) current.
   - Adjust trimpot P1 (A2 cal) for ½ full scale. (Option D – 5 volts DC, Option X5 – 2.5 volts DC, Option B 0.5 mADC, Option E – 12 mADC.)

7. Three-phase, four-wire (3Ø 4W) models.
   - Connect only L3 to N (neutral) voltage and L1(X1-X2) current.
   - Apply the specified “cal watts” for 3Ø 4W models as shown in table 2.
   - Adjust trimpot P6 (VA cal) for 1/3 full scale. (Option D – 3.333 volts DC, Option X5 – 1.667 volts DC, Option B 0.333 mADC, Option E – 9.333 mADC.)
   - Repeat for L1 to N (neutral) and L1(X1-X2) current.
   - Apply the specified “cal watts” for 3Ø 4W models as shown in table 2.
   - Adjust trimpot P2 (A3 cal) for 1/3 full scale. (Option D – 3.333 volts DC, Option X5 – 1.667 volts DC, Option B 0.333 mADC, Option E – 9.333 mADC.)
   - Repeat for L2 to N (neutral) and L2(X1-X2) current.
   - Apply the specified “cal watts” for 3Ø 4W models as shown in table 2.
   - Adjust trimpot P1 (A2 cal) for 1/3 full scale. (Option D – 3.333 volts DC, Option X5 – 1.667 volts DC, Option B 0.333 mADC, Option E – 9.333 mADC.)

POWER FACTOR CALIBRATION

(The PTB should still be connected as shown in drawing 2 or 2A for the VA calibration.)

1. Connect the voltmeter to output terminal 8 and the common 7.

2. Single-phase, two–wire (1Ø 2W)
   - Apply the full rated “cal watts” to the input.
   - At a power factor of unity (1 or 100%), adjust trimpot P3 (PF Cal) for full-scale output. (Option D – 10 volts DC, Option X5 – 5 volts DC, Option B -- 1 mADC, Option E – 20 mADC).
   - Change the power factor from unity to 0 in steps of 0.1 PF. The output should change accordingly. (From full scale down to: Option D – 0 volts DC, Option X5 – 0 volts DC, Option B 0 mADC, Option E – 4 mADC at 0 power factor.)

3. Three-phase, three-wire (3Ø 3W)
   - The CN2 jumper is still in position 1&2.
   - The input connections are shown in drawing 3 or 3A.
   - Apply the full rated “cal watts” to the input at a power factor of unity (1 or 100%), adjust trimpot P3 (PF Cal) for full-scale output. (Option D – 10 volts DC, Option X5 – 5 volts DC, Option B -- 1 mADC, Option E – 20 mADC).
   - Change the power factor from unity to 0 in steps of 0.1 PF. The output should change accordingly. (From full scale down to: Option D – 0 volts DC, Option X5 – 0 volts DC, Option B 0 mADC, Option E – 4 mADC at 0 power factor.)
   - Return the CN2 jumper to position 2 & 3 once the 3Ø 3W power factor adjustments have been made.

4. Three-phase, four-wire (3Ø 4W)
   - The input connections are shown in drawing 4 or 4A.
   - Apply the full rated “cal watts” to the input at a power factor of unity (1 or 100%), adjust trimpot P3 (PF Cal) for full-scale output. (Option D – 10 volts DC, Option X5 – 5 volts DC, Option B -- 1 mADC, Option E – 20 mADC).
   - Change the power factor from unity to 0 in steps of 0.1 PF. The output should change accordingly. (From full scale down to: Option D – 0 volts DC, Option X5 – 0 volts DC, Option B 0 mADC, Option E – 4 mADC at 0 power factor.)

Option W Watt-hours

Consult table 3 and drawing 8 the W option board for information required for calibration. The same test standards are required plus a calibrated frequency counter capable of measuring 5 kilohertz within ±1 hertz.

Table 3 lists the required “cal watts” input, watt-hours per pulse (WH/C), counts per hour (C/Hr) and the output frequency from the voltage to frequency converter (VFC) used to calibrate option W.

CALIBRATION

1. Connect the frequency counter to the option W board at TP-1 and the Common 7. Adjust the counter for a 15-volt pulse.
2. Make the input connections as shown in drawings 2 through 4A for the PTB model being calibrated.
3. Apply the input “cal watts” and adjust the trimpot P2 (VFC CAL) for the frequency shown in the VFC FREQ column of table 3. (Either 5462 or 4096 hertz.)
4. Reduce the “Cal Watts” input to 10% of input and adjust trimpot P1 (VFC Zero) to read 10% of the frequency. (Either 546.2 or 409.6 hertz.)
5. Repeat step 3 if necessary to balance between 100% and 10%.

RELAY CLOSURE OUTPUT

1. Connect a counter to terminals 1 and 2.
2. Apply the input “cal watts” for the model being calibrated. Refer to table 3.
3. Count the relay contact closures for exactly 6 minutes.
4. The total count should be 10% of the rated C/HR given in table 3 ±1 count for the model being calibrated.
5. To check linearity, reduce the “cal watts” to 50%.
6. Count the relay contact closures for exactly 6 minutes.
7. The total count should be 5% of the rated C/Hr figure given in table 3 ±1 count for the model being calibrated.

This completes the calibration of the W option board.

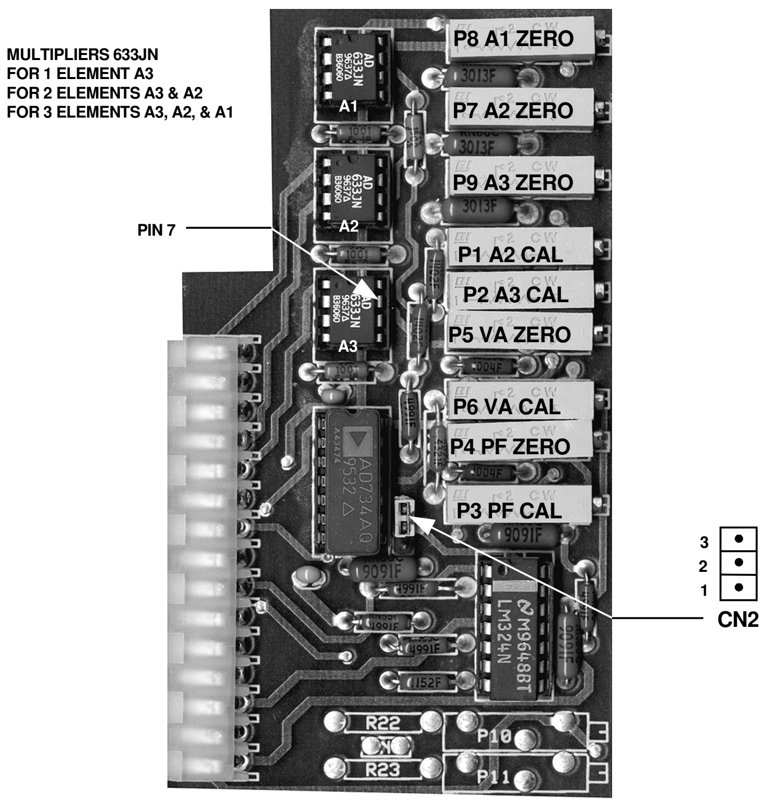
TABLE 3

TYPE	INPUT CAL WATTS	WH/C	C/HR	VFC FREQUENCY In Hertz
1Ø 2W				
150V-5A	600 W	1	600	5461
300V-5A	1200 W	1	1200	5461
600V-5A	2400 W	1	2400	5461
150V-100A	12 KW	20	600	5461
300V-100A	24 KW	20	1200	5461
600V-100A	48 KW	20	2400	5461
150V-200A	24 KW	40	600	5461
300V-200A	48 KW	40	1200	5461
600V-200A	96 KW	40	2400	5461
150V-400A	48 KW	80	600	5461
300V-400A	96 KW	80	1200	5461
600V-400A	192 KW	80	2400	5461
3Ø 3W	*			
150V-5A	600 W	1	1200	5461
300V-5A	1200 W	1	2400	5461
600V-5A	2400 W	1	4800	5461
150V-100A	12 KW	20	1200	5461
300V-100A	24 KW	20	2400	5461
600V-100A	48 KW	20	4800	5461
150V-200A	24 KW	40	1200	5461
300V-200A	48 KW	40	2400	5461
600V-200A	96 KW	40	4800	5461
150V-400A	48 KW	80	1200	5461
300V-400A	96 KW	80	2400	5461
600V-400A	192 KW	80	4800	5461
3Ø 4W	**			
150V-5A	1800 W	1	1800	4096
300V-5A	3600 W	1	3600	4096
600V-5A	7200 W	1	7200	4096
150V-100A	36 KW	20	1800	4096
300V-100A	72 KW	20	3600	4096
600V-100A	144 KW	20	7200	4096
150V-200A	72 KW	40	1800	4096
300V-200A	144 KW	40	3600	4096
600V-200A	288 KW	40	7200	4096
150V-400A	144 KW	80	1800	4096
300V-400A	288 KW	80	3600	4096
600V-400A	576 KW	80	7200	4096

* ½ Standard Input
** 1/3 Standard Input

Option P VA (Volt-amperes) & Power Factor Board

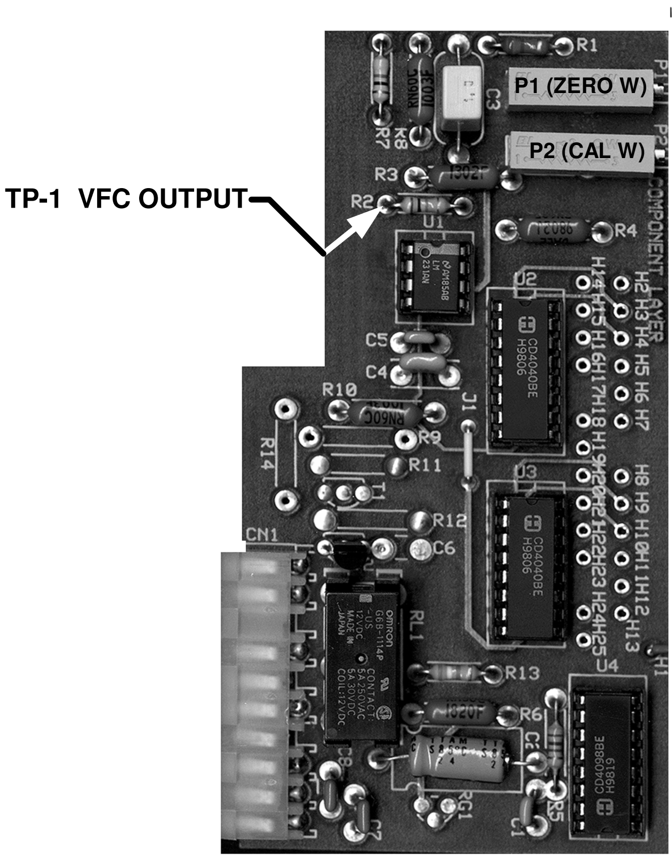
Drawing 7



Option W The Watt-Hour Board

Drawing 8

W OPTION BOARD



USING CURRENT AND POTENTIAL TRANSFORMERS WITH WATT TRANSDUCERS

TECHNICAL BULLETIN NO. 101

CONNECTIONS

One of the most commonly overlooked connections is that between the watt transducer and the current transformers. Power measuring transducers and meters are polarity sensitive.

Current transformers are marked with both primary and secondary polarity marks. The "H1" on the body of the current transformer is for the primary current through the opening. The "H1" must face the line or the source of the current. The secondary leads or terminals are labeled with an "X1" and an "X2." The "X1" corresponds to the polarity "H1" of the primary.

Current transformers supplied as part of OSI watt transducers have white and black secondary leads. The white lead is the X1 lead and the Black is the X2 lead.

In OSI connection diagrams the dots in the diagrams refer to the H1 for the primary and the X1 for the secondary.

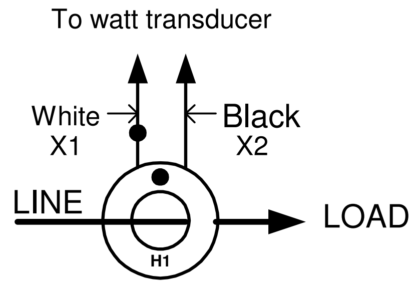


Figure 1 Current Transformer with Polarity Marks.

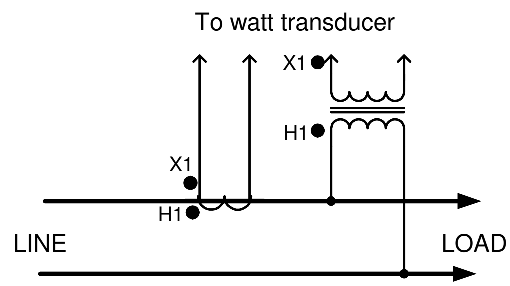


Figure 2 Current Transformer and Potential Transformer with Polarity Marks.

EXTENDING SECONDARY LEADS OF CURRENT TRANSFORMERS

It is very important to keep the electrical resistance in the secondary circuit of current transformers to a minimum. The following chart gives the maximum secondary lead length for typical current transformers.

CT CURRENT RATING	10 GAUGE WIRE	12 GAUGE WIRE	14 GAUGE WIRE
100:5	20 feet	15 feet	10 feet
200:5 though 400:5	40 feet	30 feet	20 feet
600:5 and higher ratios	80 feet	60 feet	40 feet

TB101.12.98