Model 6444 *Portable Transducer Calibrator*

Operating Instructions
& Maintenance Manual

YD-09230-001
Revision E
November, 1999

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Specifications

Function	AC Watt, Var, Current and Voltage Transducer Tester and Calibrator
Ranges	0-150 V, RMS — Average Sensing 0-5A/0-10A, RMS 0-750/0-1500 Watt 0-750/0-1500 Var
Voltage Output	VA Rating 15 VA
Current Output	VA Rating HI-24 VA @ 1.0 PF 22 VA @ 0.5 PF LO-6 VA @ 1.0 PF 3 VA @ 0.5 PF
Load Power Factor	Unity and 0.5 Lag (Approximately)
Transducer Signal Load	1 Ω to 99,999 Ω and Infinity; selected by thumbwheel digital read-out switches
Standard Output Signal	0-10 V dc for zero to full scale of test quantity (V, A, W, Var)
Meters **(All meters are 3.5-digit liquid-crystal display (LCD) readout)**	Volts 0-150 Amperes 0-5/0-10 Watts/Vars 0-750/0-1500 Error -20%/0/+20%

Accuracy of Internal Standard Transducers	±0.1%
Accuracy (Indicating Meters)	Volt, Amp, and Watt/Var Indicators ±0.15% of reading (±1 Digit)
Accuracy (Standard Output)	±0.1% (Maximum)
Temperature Range	+25°C ±10°C
Power to Operate Unit	108 - 132 V, 60 Hz Approximately 40-130 VA (Dependentt upon loading on voltage and current output circuits.
Terminations	Five-way binding posts are mounted on the front panel of the instrument.
Packaging	Wood-formica portable instrument case with carrying handle
Dimensions	13" High X 22" Wide X 9" Deep (330 X 560 X 230 mm)
Weight	Approximately 45 pounds (20.4 kG)
Available Accessories	6242B offset adapter for calibrating transducers with 1-5/1-3-5 mA dc, 4-20/4-12-20 mA dc or 10-50/10-30-50 mA dc process control outputs.

General Information

1.1 Introduction

The Model 6444 Portable Transducer Calibrator checks and calibrates watt, var, current, and voltage transducers with output voltage ratings of 25 mV to 10 V. See Figure 1-1. The self-contained unit is enclosed in a portable carrying case. It requires no external loads or accessory equipment other then a Model 6242B Offset Adapter for testing transducers with process-control outputs (1-5/1-3-5 mAdc, 4-20/4-12-20 mAdc, or 10-50/10-30-50 mAdc outputs).

Three large 3.5-digit liquid crystal displays indicate the test voltage, current, and watts or vars to the test transducer. A fourth meter indicates error in percent of full scale of the transducer under test as compared against one of the internal high-accuracy standard transducers. Test voltage and current are independently adjustable from near zero to full range, and are continuously indicated on the volt and ampere meters.

Interlocking push button switches make it easy to select operating modes and ranges. Thumbwheel switches provide a fast and accurate means for setting up the proper load resistance and setting the calibrator to the proper voltage levels to calibrate the transducer under test.

A front-panel circuit breaker protects the instrument against inadvertent faults and overloads.

Isolating transformers are provided in each output circuit to protect the operator from dangerous potentials to ground.

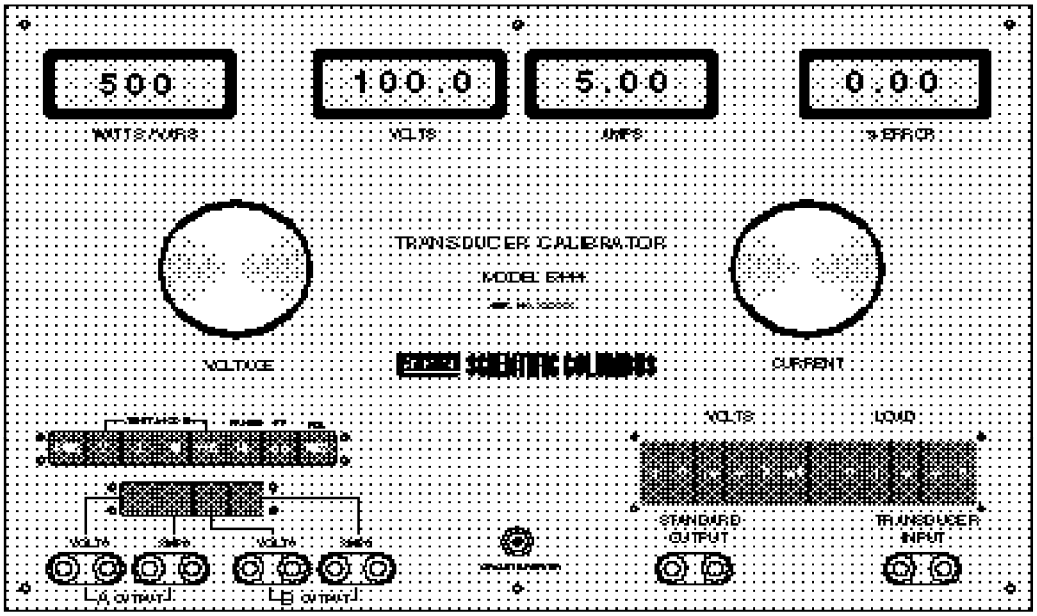

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Figure 1-1
Model 6444 Transducer Calibrator Front Panel Layout

1.2 Accessories

Each instrument is shipped with a detachable ac power cord. Interconnecting leads are required to completely test and calibrate transducers. An external digital voltmeter can be connected to the standard output terminals if desired. For more information, see Section 2.8.

Operating Instructions

2.1 Introduction

This section describes the basic operating procedures of the Model 6444 Transducer Calibrator. Refer to Figure 1-1 to become familiar with the equipment.

2.2 Activatng the Model 6444

Note: The transducer calibrator takes about 30 minutes to warm up.

1. Place the Model 6444 Transducer Calibrator on a workbench or table with the meters in a horizontal plane.

2. Plug the calibrator into a 120 V, 60 Hz power source using the power cord provided.

3. Rotate both voltage and current controls completely counterclockwise and put the four output push buttons in the "up" (off) position. The push buttons are located directly below the test-mode range switches. Every other push on each button restores the switch to the starting position (down--on, up--off).

4. Press the PWR push button.

2.3 Setting the Switches

Test Mode

Press the test-mode push button that corresponds to the type of transducer under test: V-voltage, A-current, W-watt, VAR-var.

Range

See Section 2.9 to use HI-range for overload tests.
Select the proper range for the current, watt, or var transducer under test. A sample setting would be:

HI Button		HI Button
UP (off)= 0-5A	OR	DOWN (on)=0-10A
0-750W or var		0-1500 W or var

When testing voltage transducers, the range switch has no effect.

Power Factor

Press the "1.0 PF" push button when testing watt or var transducers.

Polarity

The "REV" push button should be in the “up” position for normal operation of watt and var transducers. The position of the REV switch is not needed for current and voltage transducers.

Volt/Amps Output

All volts and amps push buttons should be in the “up” position until the transducer has been connected to the output terminals. In the “up” position, the amps push button completes the internal current circuit.

2.4 Setting the Transducer Load Resistance

Use the thumbwheel switches marked "load" to set the transducer's normal operating load resistance. Any desired resistance value from 1 through 99,999 Ω plus infinity can be selected. For best accuracy, avoid settings below 500 Ω, since the decade switches and leads contribute an approximate 0.25 Ω residual. For improved accuracy below 500 Ω, set the load to infinity and connect an external-load resistor (0.05-percent accuracy or better) to the transducer-input terminals.

Caution

When testing transducers that are capable of delivering 0.5W or more, set the load switch to infinity and connect an external load resistor of adequate power rating across transducer input terminals.

2.5 Setting the Transducer Volts Selector

Use the "volts" thumbwheel switches to set the transducer's full-scale output voltage level for the selected load resistance. If the test transducers' input ratings differ from the ratings of the standard transducers in the transducer calibrator, modify the volts setting by the appropriate ratio explained in the following sections. Settings of 00.00 to 19.99 are possible with multipliers of 0.01, 0.1, and 1.0. Do not attempt a volts setting in excess of 11.11 V. For best accuracy, use the lowest-possible multiplier. Do not exceed settings of 07.00 when checking 150 percent over-range capability of watt and var transducers.

2.6 Connecting the Test Transducer

Caution

Make certain that the four output push buttons are in the “up” position (output terminals are not energized) before connecting or disconnecting transducers.

For the current connections, use AWG 14 or larger wire size. Keep the wire length as short as practical.

1. Connect the voltage and/or current terminals of the transducer under test to the appropriate terminal pairs labeled “volts” and “amps”. Two sets of voltage and current terminals are provided for convenience. The calibrator's voltage output terminals are in parallel and the current output terminals are in series.

2. Observe the polarity of input and output terminals. Refer to the appropriate connection diagram.

3. Connect the transducer-polarity terminals to the red terminals on the Model 6444 Transducer Calibrator. Note only the output polarity has to be observed on the current and voltage transducers.

4. Connect the transducer's (under test) positive output terminal to the red transducer-input terminal, and the transducer's negative output terminal to the black transducer input terminal.

2.7 Testing and Calibrating the Transducer

The transducer is now ready to be tested according to the procedures outlined in the following chapters.

2.8 Using the 6444 Standard Output Signal

The output of each of the internal-standard transducers is available at the terminals marked "standard output". The standard transducers provide 10 V into 10 kΩ or greater loads at their respective full-scale calibration values as shown in Table 2-1.

Standard Transducer (Internal)	Range	Full Scale	Standard
Voltage	LO or HI	150V	10Vdc
Current	LO HI	5A 10A	10Vdc 10Vdc
Watt	LO HI	750W 1500W	10Vdc 10Vdc
Var	LO HI	750 VAR 1500 VAR	10Vdc 10Vdc

Table 2-1
Table for Calibrating Internal Standards

Use the standard-output signal to check signal conditioners and data transmission systems. The signal is a precision source of voltage proportional to whichever transducer input is pre-selected by the mode push buttons. For example, if a 0-10 Vdc is needed, the mode push button can be set in the "watts" position. Voltage and current adjustments can be made such that the watt indicator reads 750 W. Then, 10 Vdc appears across the standard output terminals.

If higher accuracy than the furnished indicating meters is required, connect an accurate digital voltmeter with higher than 10 kΩ input impedance across the standard output terminals to monitor the selected transducer output. Refer to Table 2-1 for the scaling factors. The digital meter indicates voltages proportional to watt, var, volt, or ampere outputs within ±0.25 percent. Therefore, the calibrator can be used for an accurate source of watts, vars, voltage, or current for a complete telemetering channel, or for calibrating, indicating average reading instruments or rms devices under conditions explained in later chapters.

2.9 HI Range Testing

Sometimes you may want to observe the calibration of transducers with extreme overloads. Press the "HI-range" push button to set up the calibrator for the higher outputs (although the unit under test may be rated at only 5 A, 500 W, or 500 vars). To use the calibrator-error meter properly, double the "volts" setting determined in all of your nominal volts calibrations. Follow the instructions for normal operation of the calibrator. Do not exceed a setting of 11.11 V. If necessary, lower the load resistance or use an external resistor to create a voltage-divider network. For more information, refer to Section 2.4.

Example

Assume that doubling the volts setting requires an adjustment of 20.0 V, and the load resistance is 10 kΩ. Because this volts setting cannot be made on the calibrator, you must lower the volts setting to 10 V and the load setting to 5 kΩ for constant current-type transducer units. If a voltage-output type transducer is under test, follow the same procedure, but place an accurate 5-kΩ resistor in series with the transducer input terminals so that half of the voltage is dropped across the external resistor.

Notes

Test & Calibration

Voltage Transducers

3.1 Introduction

This section explains how to test and calibrate average sensing voltage transducers calibrated in rms units using the Model 6444 Transducer Calibrator.

3.2 Setting Up the Model 6444

Set up the Model 6444 Transducer Calibrator according to the instructions outlined in Chapter 2.

3.3 Connecting the Transducer

1. Check to see that the "voltage" and "current" knobs are fully counterclockwise, and the "volts" and "amps" push buttons are in the “up” position.

2. Connect the voltage transducer to the Model 6444 Transducer Calibrator. See Figure 3-1.

3. Observe polarity of the transducer output, connecting the positive (+) output to the red transducer input terminal. Polarity of the volts input to the transducer is insignificant.

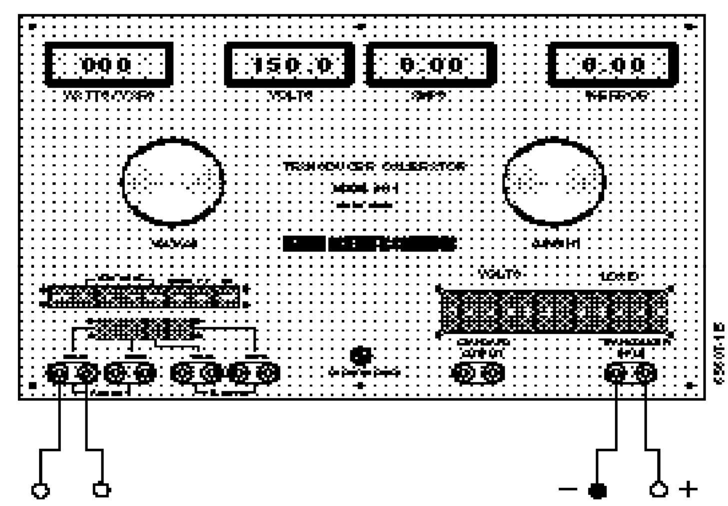


Figure 3-1
Connections for Voltage Transducers

3.4 Setting the Load Selector

Set the load thumbwheel dials to read the required load-resistance value for the transducer under test. Refer to Section 2.4.

3.5 Setting the Volts Selector

Determine the transducer-voltage output for a transducer with a constant current output, with the load selected using the following formula:

$$\text{VOLTS} = \text{LOAD} \times [\text{full-scale output current in amperes}] \times \frac{150\text{ V}}{\text{calibrating volts}}$$

Set the "volts" thumbwheel to a setting determined in the following manner:

Example

Assume that a transducer with 150 V input full-scale calibration and 1 mA constant current-type output is connected to a 1.5 kΩ load. The proper load setting is 01500. The volts setting is calculated in the following manner:

$$\text{VOLTS} = 01500 \times 0.001\text{A} \times \frac{150}{150}$$

VOLTS = 1.5 V

Possible volts settings are 01.50 X 1.0 and 15.00 X 0.1. Use 01.50 X 1.0 for best accuracy. (1.0) is the lower multiplier without exceeding a setting of 11.11.

Example

Assume a non constant current output-type transducer with full-scale calibration of 120 V input and 1 mA output operating into a load of exactly 2.2 kΩ. The proper load setting is 02200, and the volts setting is calculated in the following manner:

$$\text{VOLTS} = 02200 \times 0.001 \times \frac{150}{120}$$

VOLTS = 2.75

The proper volts setting is 02.75 X 1.0.

Example

Assume a transducer with full-scale calibration of 110 V input and 50 mV output into a load of 10 kΩ. The proper load setting is 10000 and the volts setting is calculated in the following manner:

$$\text{VOLTS} = 10000 \times \frac{0.050}{10000} \times \frac{150}{110}$$

VOLTS = 0.0681

The proper volts setting is 06.81 X 0.01.

3.6 Energizing the Transducer

Make sure that the "V" test-mode push button is pressed.

Press the "A" output/volts push button.

Rotate the "voltage" knob clockwise until the full-scale calibration voltage for the transducer is indicated on the voltmeter.

3.7 Measuring Transducer Error

Read the error in percent-of-full scale on the error meter. If the transducer full-scale calibration is 150 V, the error meter is direct reading. For calibrations other than 150 V see Section 3.9.

3.8 Error Meter Off-Scale Indication

If the error meter display goes blank, check for possible incorrect volts or load settings. Also check for incorrect polarity on the transducer connections to the transducer calibrator. If these conditions are correct, adjust the "volts" thumbwheels so that the meter indicates a "zero" reading. The error is calculated in the following manner:

$$\text{Error} = \frac{\text{(new volts setting - original volts setting)}}{\text{original volts setting}} \times 100$$

Example

Assume a transducer with nominal volts setting of 1.00 V. When standard input is applied, the error meter reads off-scale on the positive (+) side. Setting the "volts" selector to 1.045 gives a zero-error reading.

$$\text{Error} = \frac{1.045 - 1.000}{1.000} \times 100$$

Error = +4.5%

3.9 Correcting Error Reading

For voltage transducers with other than 150 V full-scale calibration, the error reading must be corrected in the following manner:

$$\text{Actual error} = \text{indicated error} \times \frac{150\text{ V}}{\text{calibrating volts}}$$

Example

If a transducer with full-scale calibration of 120 V gives an indicated error of 0.2 percent, the actual error is calculated in the following manner:

$$\text{Actual error} = 0.2\% \times \frac{150}{120}$$

Actual error = 0.25%

3.10 Calibration

If the transducer requires calibration adjustment, do the following:

1. Restore the volts dials to the original setting if they have been changed because of an off-scale meter reading.

2. Set the voltage control to the full-scale calibration input voltage of the unit under test.

3. Adjust calibration control of the transducer to give zero reading on the error meter.

3.11 Testing Linearity

To measure the transducer-linearity error, set the input to the desired levels, and read the error at each level. Apply the correction factor as described in Section 3.9, if required. Full-scale error is indicated at each setting.

3.12 Testing Load Sensitivity

Load sensitivity of constant-current output transducers may be measured by varying the load setting over the desired resistance range, keeping the input set at full-scale value. For each load setting, a new volts setting must be made as outlined in Section 3.5. Do not exceed 11.11V.

3.13 Disconnecting the Transducer

When all tests are complete, do the following:

1. Return the voltage knob to the extreme counterclockwise position.

2. Return the "volts" push button to the “up” position.

3. Disconnect the transducer.

(Optional)

3.14 Calibrating Expanded-Scale Volt Transducers

A calibrator has the expanded-scale option if it has an "X" in the model number. It is possible to calibrate expanded-scale voltage transducers of one specific input range and for an output of 5 V.

If a transducer with an input range of 75 to 150 V must be calibrated for an output of 0-5 Vdc, the user need only position the toggle switch on the front panel of the calibrator to the expanded-scale setting, and adjust the "volts" thumbwheel to 5 kΩ . The error meter reads directly in percent of full scale referred to the output. To refer the error to the input range, divide the error indicated on the error meter by a factor derived from the span and the center of the span. Thus, in the present example, a 1.0-percent-of-full-scale error at 150 V input referred to the output (and read directly on the calibrator error meter) would be an error of 1.0 percent, divided by 112.5 (center of span)/75 (total span) equal to 0.667 percent referred to the input.

Notes

Test & Calibration

Current Transducers

4.1 Introduction

This section explains how to test and calibrate average-sensing current transducers calibrated in rms units using the Model 6444 Transducer Calibrator.

4.2 Setting Up the Model 6444

Set up the Model 6444 transducer calibrator according to the instructions in Chapter 2.

4.3 Connecting the Transducer

1. Connect the current transducer to the transducer calibrator as shown in Figure 4-1. Make certain that the voltage and current knobs are fully counterclockwise, and the "volts" and "amps" push buttons are in the “up” position. Use AWG 14 or larger wire for the input leads to the transducer.

2. Observe polarity of the transducer output connecting the (+) output to the red transducer input terminal. Polarity of the amps input to the transducer is not significant.

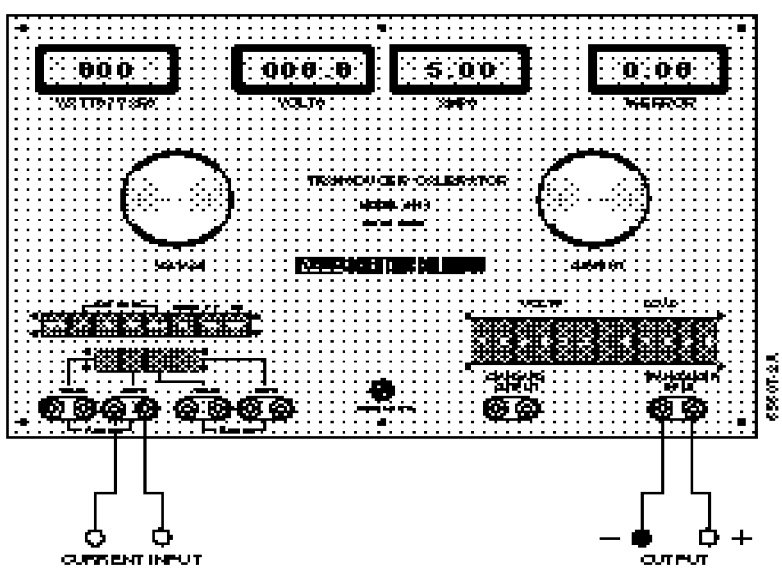


Figure 4-1
Connections for Current Transducers

4.4 Setting the Load Selector

Set the load thumbwheel dials to read the load-resistance value required for the transducer under test.

4.5 Setting the Volts Selector

For a transducer with a constant current or voltage output, the transducer output voltage can be determined in the following manner:

$$\text{LO Range Setting, VOLTS} = \text{LOAD} \times \text{(full-scale output) (current in amperes)} \times \frac{5A}{\text{calibrating amperes}}$$

$$\text{HI Range Setting, VOLTS} = \text{LOAD} \times \text{(full-scale output) (current in amperes)} \times \frac{10A}{\text{calibrating amperes}}$$

4.6 Energizing the Transducer

1. Determine that the "A" test-mode push button is pressed.
2. Determine that that HI range push button is in the proper position.
3. Press the "A" output/amps push button.

4. Use the LO range if the test transducer calibration is 5 A or less, and the HI range if the test transducer calibration is between 5 and 10 A. The "B" output/amps push button must be in the “up” position to complete the circuit, unless an external circuit is jumpered across the "B" output/amps terminals. Refer to Section 2.9 if the HI-current push button is used.

5. Rotate the "current" knob clockwise until the full-scale calibration current is indicated on the meter.

4.7 Measuring Transducer Error

Read the error in percent of full scale on the error meter. If the transducer under test has a full-scale calibration of 5 or 10 A and the "HI range" push button has been selected accordingly, the error meter is direct reading. If the error meter goes off-scale, refer to Section 3.8, "Error Meter Off-Scale Indication", to substitute amperes in place of volts in the formulas.

4.8 Correcting Error Reading

For current transducers with other than 5 or 10 A full-scale calibration, the error reading must be corrected in the following manner:

$$\text{LO range actual error} = \text{indicated error} \times \frac{5A}{\text{calibrating amperes}}$$

$$\text{HI range actual error} = \text{indicated error} \times \frac{10A}{\text{calibrating amperes}}$$

Refer to the example for error reading correction in Chapter 3.

4.9 Calibration

Restore the "volts" dials to their original setting if they have been changed because of an off-scale meter reading. If the transducer requires a calibration adjustment, set the current control to the full-scale calibration input current of the unit under test and adjust the calibration control of the transducer to give zero reading on the error meter.

4.10 Testing Linearity

Transducer linearity error can be measured by following the procedure covered in the "Linearity Test" section of Chapter 3.

4.11 Testing Load Sensitivity

Load sensitivity may be measured by following the procedure outlined in Section 3.12.

4.12 Disconnecting the Transducer

When all tests are complete, return the "current" knob to the extreme counterclockwise position, return the amps push button to the "up" position, and disconnect the transducer.

Notes

Test & Calibration

Watt Transducers

5.1 Introduction

This section explains how to test and calibrate 1-, 1-1/2-, 2-, 2-1/2-, and 3-element watt transducers using the Model 6444 Transducer Calibrator.

5.2 Connecting the Transducer

Before connecting the transducer, set up the transducer calibrator according to the instructions outlined in Chapter 2. Use AWG 14 or larger wire for the current input connections.

1. Make sure that the "voltage" and "current" knobs are fully counterclockwise and the "volts" and "amps" push buttons are in the "up" (off) position.

2. Connect the transducer to the transducer calibrator as shown in the appropriate connection diagram of Figure 5-1.

3. Observe polarity of the current, voltage, and output connections as shown. Note that the polarity of one current coil on the 1-1/2- and 2-1/2-element units is reversed when compared to the manufacturer's wiring diagrams. This is necessary as the calibrator is providing single-phase power on all tests instead of three-phase power.

5.3 Setting the Load Selector

Set the "load" thumbwheel dials to read the load resistance value (in ohms) required for the transducer under test. For more information, refer to Section 2.4.

5.4 Setting the Volts Selector (Std. Calibration)

For transducers (except 2-1/2 element) calibrated with standard 500 calibrating watts per element, the "volts" thumbwheel dials are set to indicate directly the full-scale output calibrating voltage of the transducer. Table 5-1 gives the standard calibrating watts for the various transducer configurations.

Transducer Type (Elements)	Standard Calibrating Watts
1	500
1-1/2	1000
2	1000
2-1/2	1500
3	1500

Table 5-1
Standard Calibrating Watt

Note: For 2-1/2-element transducers, the calculated volts setting must be multiplied by a factor of 1-1/3 or by 2/3 if using the alternate connection Figure 5-1E. Also see Section 5.6.

For a voltage (or millivolt) output-type transducer, the proper volts setting is the full-scale calibrating output voltage of the unit under test.

VOLTS = full-scale calibration in volts

If the transducer is a constant-current output type, the volts selector setting is calculated by multiplying the load setting times the full-scale calibrating output current of the unit under test:

VOLTS = LOAD X [full-scale output current in amperes]

Example

Assume a 1-element transducer with full-scale calibration of 1 mA output at 500 W input is to be tested. If it normally operates into a 2.5 kΩ load, set the load selector to 02500 and calculate the volts setting in the following manner:

VOLTS = 2500 X 0.001
VOLTS = 02.50 X 1.0

5.5 Setting the Volts Selector (Special Calibration)

To obtain the proper volts selector setting, a correction factor must be applied to a transducer with full-scale calibration different from the values in Table 5-1. The correcting factor is the ratio of the standard calibrating watts (Table 5-1) to the actual calibrating watts of the transducer.

The corrected volts setting for a voltage-output type transducer is:

$$\text{VOLTS} = [\text{full-scale output calibrating in volts}] \times \left[\frac{\text{standard calibrating watts}}{\text{actual calibrating watts}}\right]$$

Example

Assume that the transducer under test is a three-element millivolt type with full-scale calibration of 120 mV output at 1200 W input (400 W/element).

Set the load selector to the load-resistance value specified, or to infinity if none is given.

The volts-selector setting is calculated in the following manner:

$$\text{VOLTS} = 0.120 \times \frac{1500}{1200} \text{ OR } \frac{500}{400}$$

VOLTS = 0.15

The proper setting is 01.50 X 0.1 because the setting with the lowest-possible multiplier should be used without exceeding a setting of 11.11.

Example

The corrected volts setting for a constant-current output type transducer is:

$$\text{VOLTS} = \text{LOAD} \times [\text{full-scale output current in amperes}] \times \left[\frac{\text{standard calibrating watts}}{\text{actual calibrating watts}}\right]$$

Assume that the transducer under test is a two-element unit calibrated for 1 mA output at 800 W input (400 W/element), and uses a load of 800 Ω.

Set the load selector to 00800 and calculate the volts setting in the following manner:

$$\text{VOLTS} = 800 \times 0.001 \times \frac{1000}{800} \text{ OR } \frac{500}{400}$$

VOLTS = 1.00

The proper volts setting is 10.00 X 0.1.

5.6 2-1/2-Element Transducers (Special Considerations)

In a single-phase test where the potential coils are in parallel and the current coils are in series, 2-1/2-element transducers produce one-third higher output than in normal three-phase operation. For this reason, the calculations performed in Sections 5.4 and 5.5 must be multiplied by 1-1/3 to obtain the proper volts selector settings.

In Figure 5-1D, the B-phase current coil is connected in series with the A- and C-phase coils with reverse polarity. Failure to reverse the B-phase coil will result in zero output. See Section 5.2.

5.7 Zero Adjustment (Amplified Units Only)

Apply amplifier power to the transducer for a minimum of one minute. If the amplifier is powered from a potential input of the transducer, press the appropriate output "volts" push button and adjust the "voltage" knob until the nominal input voltage is indicated on the voltmeter.

Temporarily disconnect the current leads to the transducer and depress the "A" output amps push button to eliminate any possibility of current flow in both the test transducer and in the internal standard.

If required, adjust the test transducer zero control for zero indication on the error meter.

With the voltage and current control fully counterclockwise, return the "volts" and "amps" push buttons to the “up” position and reconnect the current loads.

5.8 Adjusting Balance (2- and 2-1/2-Element Transducers)

Caution

Balance adjustments are not required in Scientific Columbus transducers. A balance adjustment is sometimes provided on 2- and 2-1/2-element transducers for equalizing the outputs of the elements. The extra B-current coil of 2-1/2-element transducers is not used for this test and should be completely disconnected, as shown in Figure 5-1E.

If necessary, check the balance by temporarily reversing the polarity of either one voltage or one current coil (but not both).

1. Apply power to the transducer by pressing the appropriate push buttons (Section 5.9), rotating the "voltage" and "current" knobs to give the transducer’s nominal input values on the voltmeter and ammeter of the transducer calibrator.

2. Observe the output of the transducer on the external dc voltmeter connected across the calibrator input terminals. Ignore the error meter readings during this time.

3. The voltmeter should be capable of resolving 0.05 percent or less of the transducer’s full-scale output voltage (the voltage which has been set on the volts selector). If required, adjust the balance control of the transducer for zero $\pm$0.05 percent of the full-scale control voltage.

4. After completing the test, remove power from the transducer by rotating the "voltage" and "current" knobs counterclockwise and putting the "output" push buttons in the “up” position. Reconnect the transducer in its normal test configuration as shown in Figure 5-1.

5.9 Applying Power to the Transducer

1. Connect voltage and current inputs to the transducer by pressing the appropriate output push buttons. The push buttons corresponding to output terminals not in use should be in the “up” position.

2. Press the "W" push button (HI if current rating is over 5 A). See Section 2.9 for special instructions if the HI current push button is used. The "REV" and "0.5 PF" buttons should be up.

3. Rotate the "voltage" and "current" knobs clockwise until the approximate nominal-rated values of voltage and current for the transducer appear on the voltmeter and ammeter of the transducer calibrator. It is important to note the following at this point:

   - The calibrating watts input seen by the transducer in this test condition is equal to the product of the watts noted on the watts indicator, times the number of effective elements. See Table 5-2 for the number of effective elements for the various transducer types.

   - The calibrating watts level for most transducers is less than the effective watts level at nominal voltage and current ratings.

Example

A one-element watt transducer with calibrating watts of 500 W typically has nominal voltage and current ratings of 120 V and 5 A, respectively. To test the transducer at its full-scale calibrating level, reduce one or both of the input parameters so that their product is equal to 500. One-hundred volts at 5 A or 120 V at 4.17 A are possible values that can be used.

Transducer Type (Elements)	Number of Effective Elements	Standard Calibrating Watts	Model 6444 Watt Reading
1	1	500	500
1-1/2	2	1000	500
2	2	1000	500
2-1/2	3	1500	500
3	3	1500	500

Table 5-2
Effective Elements for Different 500 W/Element Transducer Types

The reading on the wattmeter of the Model 6444 Transducer Calibrator is equal to the watts/effective element applied to the transducer under test.

5.10 Measuring Transducer Error

Set the "voltage" and "current" controls to apply calibrating watts to the transducer under test. Keep both the voltage and current within the nominal ratings of the transducer. Refer to Section 5.9.

If the transducer is calibrated with standard calibrating watts (Table 5-2), read the error directly in percent of full scale on the error meter. For other calibrations, see Section 5.11.

5.11 Error Meter Off-Scale Indications

If the error meter goes off scale, follow the procedure outlined in Section 3.8.

5.12 Correcting Error Reading

For transducers calibrated with other than standard calibrating watts (Table 5-2), the reading on the error meter must be corrected in the following manner:

$$\text{Actual Error} = [\text{indicated error}] \times \frac{[\text{standard calibrating watts}]}{\text{actual calibrating watts}}$$

5.13 Adjusting Calibration

If the transducer requires calibration adjustment, set the voltage and current to the desired values to give full-scale calibrating watts. Refer to Section 5.9.

If the volts selector has been changed because of an off-scale meter reading, restore its nominal setting before making a calibration adjustment. Adjust the transducer's calibration control to give zero reading on the error meter.

5.14 Testing Linearity

Measure the transducer's voltage linearity by setting the current to the nominal-rated value and varying the voltage over the transducer's operating range. Observe percent of full scale error at desired current levels on the error meter.

Measure current linearity by setting the voltage to the nominal-rated value and varying the current over the transducer's operating range. Observe percent of full scale error at desired current levels on the error side.

5.15 Testing Load Sensitivity

Load sensitivity of constant current output transducers can be measured by following the procedure outlined in Section 3.12.

5.16 Testing Power Factor

To check the transducer performance at approximately 0.5 PF, press the "0.5 PF" push button and readjust the current control for full-scale current. The error meter indicates percent of full-scale error.

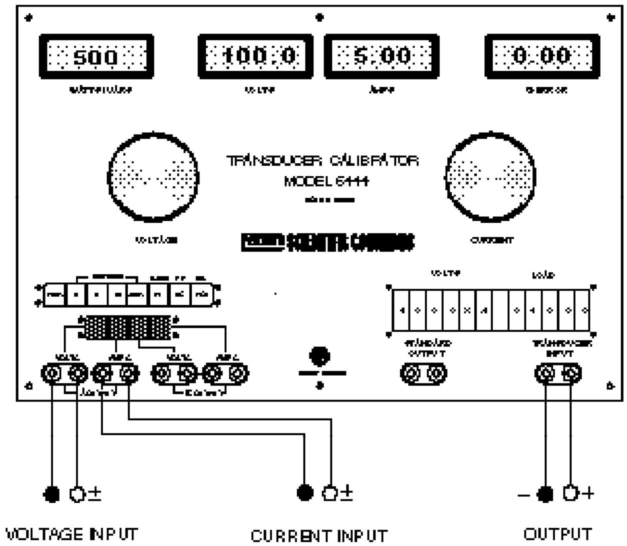
5.17 Testing Reverse Power

To test the transducer for reverse power performance, press the "POL REV" push button and observe the error under the desired operating conditions. Repeat Sections 5.10 through 5.16 if the error appears to increase significantly when the "POL REV" push button is activated.

5.18 Disconnecting the Transducer

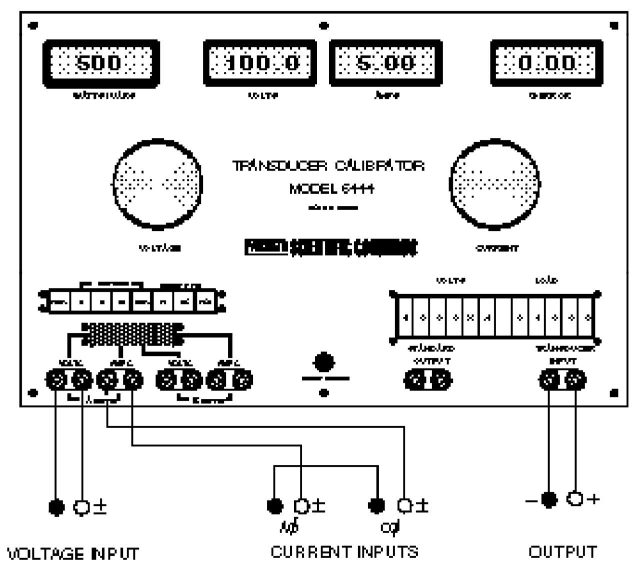
When all tests are complete, do the following:

1. Return the "voltage" and "current" knobs to the extreme counterclockwise position.
2. Return the "volts" and "amps" push buttons to the “up” position.
3. Disconnect the transducer.



Test Transducer Terminals

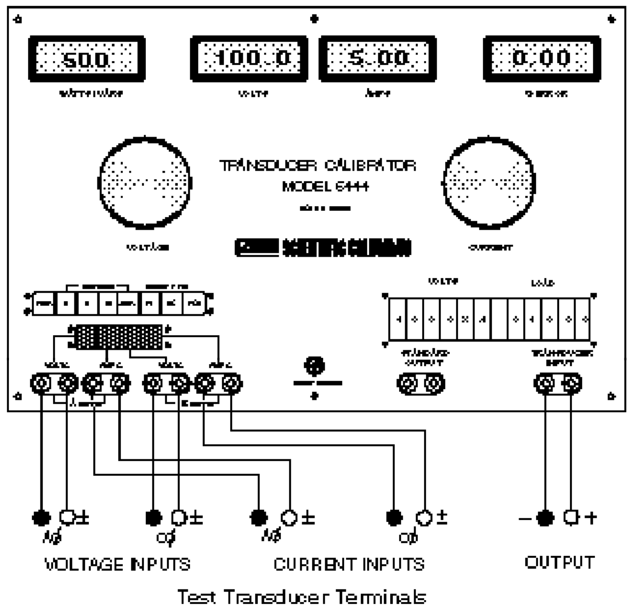
A) 1-Element Connection



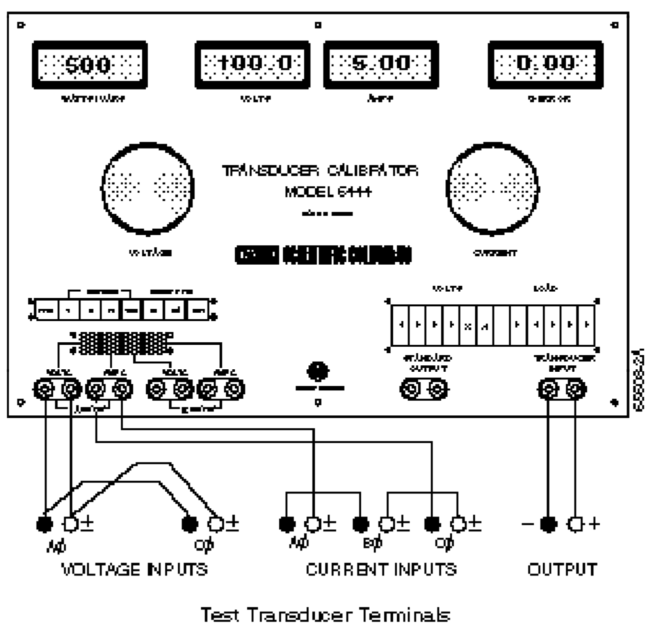
Test Transducer Terminals

B) 1-1/2-Element Connection

Figure 5-1a
Connection Diagrams for Watt and Var Transducers

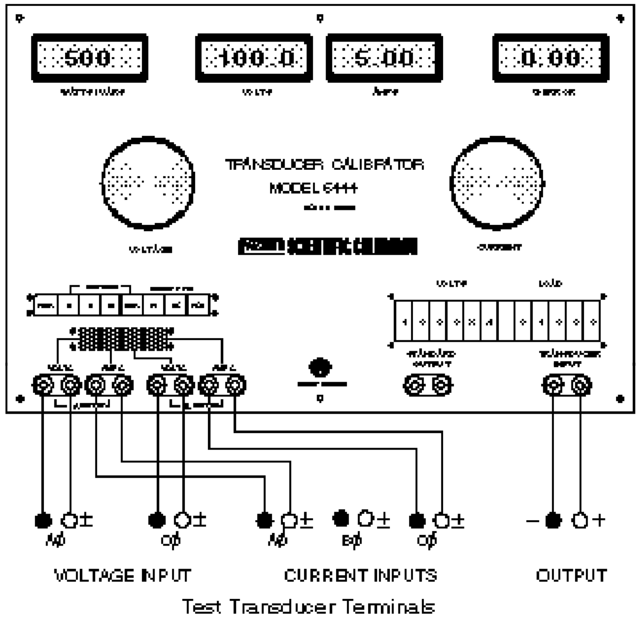


C) 2-Element Connection

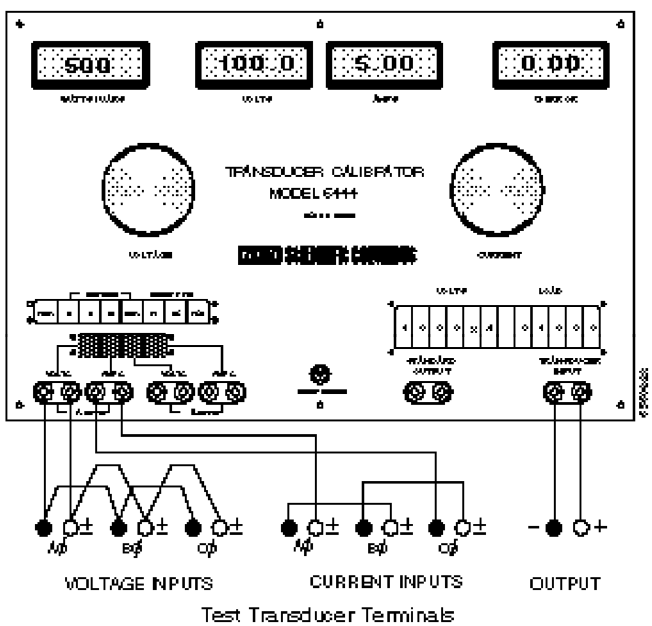


D) 2-1/2-Element Connection
Produces 1-1/3 Normal Output

Figure 5-1b
Connection Diagrams for Watt and Var Transducers



E) Alternate 2-1/2-Element Connection
Produces 2/3 Normal Output



F) 3-Element Connection

Figure 5-1c
Connection Diagrams for Watt and Var Transducers

Test & Calibration

Var Transducers

6.1 Introduction

This section covers testing and calibrating 1-, 1-1/2-, 2-, 2-1/2-, and 3-element var transducers using the Model 6444 Transducer Calibrator.

6.2 Connecting the Transducer

1. Before connecting the transducer, set up the transducer calibrator according to the instructions outlined in Chapter 2.

2. Connect the transducer to the transducer calibrator as shown in the appropriate connection diagram of Figure 5-1.

3. Make sure that the "voltage" and "current" knobs are fully counterclockwise and the "volts" and "amp"s push buttons are in the “up” (off) position. Observe polarity of the current, voltage, and output connections as shown.

Note: The polarity of one current coil on the 1-1/2 and 2-1/2-element units is reversed compared to the manufacturer’s wiring diagrams. The unit is reversed because the calibrator provides single-phase power on all tests instead of three-phase power. Use AWG 14 or larger wire for the current input connections.

6.3 Setting the Load Selector

Set the load thumbwheel dials to read the load-resistance value (in ohms) required for the transducer under test. Refer to Section 2.4.

6.4 Setting the Volts Selector (Std. Calibration)

For transducers (except 2-1/2-element) calibrated with standard 500-calibrating vars per element, the "volts" thumbwheel dials are set to indicate directly the full-scale output calibrating voltage of the transducer. Table 6-1 provides the standard calibrating vars for the various transducer configurations.

Transducer Type (Elements)	Standard Calibrating Vars
1	500
1-1/2	1000
2	1000
2-1/2	1500
3	1500

Table 6-1
Standard Calibrating Vars

Note: For 2-1/2-element transducers, the calculated volts setting must be multiplied by a factor of 1-1/3 or by 2/3 if using the alternate connection Figure 5-1E. Also see Section 6.6.

The proper volt setting for a voltage (or millivolt) output-type transducer is the full-scale calibrating output voltage of the unit under test.

VOLTS = full-scale output calibration in volts

If the transducer is a constant-current output type, the volts-selector setting is calculated by multiplying the load setting times the full-scale calibrating output current of the unit under test.

VOLTS = LOAD X [full-scale output current in amperes]

Example

Assume a one-element transducer with full-scale calibration of 1 mA output at 500 vars input is to be tested. If it normally operates into a 2.5 kΩ load, set the load selector to 02500 and calculate the volts setting in the following manner:

VOLTS = 2500 X 0.001
VOLTS = 02.50 X 1.0

6.5 Setting the Volts Selector (Special Calibration)

To obtain a proper volt-selector setting, a correction factor must be applied to transducers with full-scale calibration different from the values in Table 6-1. The correcting factor is the ratio of the standard calibrating vars (Table 6-1) to the actual calibrating vars of the transducer.

Example

For a voltage output-type transducer, the corrected volts setting is:

$$\text{VOLTS} = [\text{full-scale output calibration in volts}] \times \left[\frac{\text{standard calibrating vars}}{\text{actual calibrating vars}}\right]$$

Assume that the transducer under test is a three-element millivolt-type with full-scale calibration of 120 mV output at 1200 vars input (400 vars/element). Set the load selector to the load resistance value specified, or to infinity if none is given. The volts-selector setting is calculated in the following manner:

$$\text{VOLTS} = 0.120 \times \frac{1500}{1200}$$

VOLTS = 0.15

The proper setting is 01.50 X 0.1 since the setting with the lowest possible multiplier should always be used without exceeding a setting of 11.11.

Example

If the transducer is a constant-current output type, the corrected volts setting is:

$$\text{VOLTS} = \text{LOAD} \times [\text{full scale output current in amperes}] \times \left[\frac{\text{standard calibrating vars}}{\text{actual calibrating vars}}\right]$$

Assume that the transducer under test is a two-element unit calibrated for a 1 mA at 800 vars input (400 vars/element) and uses a load of 800 Ω. Set the load selector to 0800 and calculate the volts setting in the following manner:

$$\text{VOLTS} = 800 \times 0.001 \times \frac{1000}{800}$$

Volts = 1.00
The proper volts setting is 10.00 X .1

6.6 2-1/2-Element Transducers (Considerations)

In a single-phase test where the potential coils are in parallel and the current coils are in series, 2-1/2-element transducers produce one-third higher output than in normal three-phase operation. For this reason, the calculations in Sections 6.4 and 6.5 must be multiplied by 1-1/3 to obtain the proper volts selector settings.

Note on Figure 5-1D that the B-phase current coil is connected in series with the A- and C-phase coils with reverse polarity. Failure to reverse the B-phase coil results in zero output. For more information, see Section 6.2.

6.7 Zero Adjustment (Amplified Units Only)

1. Apply amplifier power to the transducer for a minimum of one minute. If the amplifier is powered from one of the transducer's potential inputs, press the appropriate output "volts" push button and adjust the "voltage" knob until the nominal input voltage is indicated on the voltmeter.

2. Temporarily disconnect the current leads to the transducer and press the "A" output amps push button to eliminate any possibility of current flow in both the test transducer and the internal standard.

3. If required, adjust the test transducer zero control for zero indication on the error meter.

4. With the voltage and current controls fully counterclockwise, return the "volts" and "amps" push buttons to the “up” position and reconnect the current leads.

6.8 Adjusting Balance (2- and 2-1/2-Element Transducers)

Caution

Balance adjustments are not required in Scientific Columbus transducers. A balance adjustment is sometimes provided on 2- and 2-1/2-element transducers for equalizing the outputs of the elements. The extra (B) current coil of 2-1/2-element transducers is not used for this test and should be completely disconnected as shown in Figure 5-1E.

Balance may be checked by temporarily reversing the polarity of either one voltage or one current coil (not both).

1. Apply power to the transducer by pressing the appropriate push buttons and rotating the "voltage" and "current" knobs to give the transducer's nominal input values on the voltmeter and ammeter to the transducer calibrator.

2. Observe the transducer's output on an external dc voltmeter connected across the calibrator input terminals. Ignore the error meter readings at this time. The voltmeter should be capable of resolving 0.05 percent or less of the transducer's full-scale output voltage (the voltage set on the volts selector). If required, adjust the balance control of the transducer for zero $\pm$0.05 percent of the full-scale output voltage.

3. After completing the test, remove power from the transducer by rotating the "voltage" and "current" knobs counterclockwise and putting the "output" push buttons in the "up" position. Reconnect the transducer in its normal test configuration as shown in Figure 5-1.

6.9 Applying Power to the Transducer

1. Connect voltage and current inputs to the transducer by pressing the appropriate "output" push buttons. The push buttons corresponding to the output terminals not in use should be in the "up" position.

2. Press the V, (HI if current rating is over 5 A), and 0.5 PF push buttons. The "REV" button should be up. See "Hi Range Testing" in Chapter 2 for special instructions if the "HI current" push button is used.

3. Rotate the "voltage" and "current" knobs clockwise until the approximate nominal-rated values of voltage and current for the transducer appear on the voltmeter and ammeter of the transducer calibrator. At this time, note the following items:

   - The calibrating-vars input seen by the transducer in this test condition is equal to the product of the vars noted on the var indicator times the number of effective elements. See Table 6-2 for the number of effective elements for the various transducer types.

   - The calibrating-vars level for most transducers is less than the effective var level and nominal voltage and current ratings.

   - The var meter indicates approximately 86 percent of full scale because the calibrator is not capable of applying 0.0 PF. The 0.5-PF setting outlined in 6.9 sets up an approximate 60-degree phase angle difference between voltage and current (sin 60^o EXI = vars) with 100 V 5 A the var/watt meter would indicate approximately 433 vars.

Example

An one-element var transducer with calibrating vars of 500 typically has nominal voltage and current ratings of 120 V and 5 A, respectively. To test the transducer at this 86-percent of full-scale calibrating level, reduce one or both of the input parameters so that their product is equal to 500. Possible values that can be used are 100 V at 5 A or 120 V at 4.17 A.

Transducer Type (Elements)	Number of Effective Elements	Standard Calibrating Vars	Model 6444 Var Reading
1	1	500	500
1-1/2	2	1000	500
2	2	1000	500
2-1/2	3	1500	500
3	3	1500	500

Table 6-2
Effective Elements for Different 500 Var/Element Transducer Types

The reading on the wattmeter of the transducer calibrator is equal to the vars per effective element applied to the transducer under test.

6.10 Measuring Transducer Error

Set the voltage and current controls to apply calibrating vars to the transducer under test, keeping both the voltage and current within the nominal ratings of the transducer. Refer to the Section 6.9.

If the transducer is calibrated with standard calibrating vars, read the error directly in percent of full scale on the error meter. For other calibrations see Section 6.12.

6.11 Error Meter Off-Scale Indications

Follow the procedure outlined in Section 3.8 if the error meter goes off scale.

6.12 Correcting Error Reading

For transducers calibrated with other than standard calibrating vars (Table 6-2), the reading on the error meter must be corrected in the following manner:

$$\text{Actual error} = [\text{indicated error}] \times \left[\frac{\text{standard calibrating vars}}{\text{actual calibrating vars}}\right]$$

6.13 Adjusting Calibration

If the transducer's calibration must be adjusted, set the voltage and current to the desired values to give full-scale calibrating vars. Refer to Section 6.9.

If the volts selector has been changed because of an off-scale meter reading, restore its nominal setting before adjusting the calibration. Adjust the transducer's calibration control to give a zero reading on the error meter.

6.14 Testing Linearity

The transducer's voltage linearity can be measured by setting the current to the nominal-rated value and varying the voltage over the transducer's operating range. Observe percent-of-full-scale error at desired voltage levels on the error meter.

Current linearity can be measured by setting the voltage to the nominal-rated value and varying the current over the transducer's operating range. Observe percent-of-full-scale error at desired current levels on the error meter.

6.15 Testing Load Sensitivity

Load sensitivity of constant current output transducers can be measured by following the procedure outlined in Section 3.12.

6.16 Testing Power Factor

To check the transducer performance at approximately 1.0 PF, press the 1.0 PF push button and readjust the current control for full-scale current. The error meter indicates percent of full-scale error.

Note: At this point, the var transducer under test should be producing zero output. Do not attempt to adjust zero with the zero adjust control (amplified units).

6.17 Testing Reverse Power

To test the transducer for reverse power performance, press the "POL REV" push button and observe the error under the desired operating conditions. If error appears to increase significantly when the "POL REV" push button is activated, repeat sections 6.10 through 6.16.

6.18 Disconnecting the Transducer

When all tests are complete, do the following:

1. Return the "voltage" and "current" knobs to the extreme counterclockwise position.
2. Return the "volts" and "amps" push buttons to the “up” position.
3. Disconnect the transducer.

Notes

Theory of Operation

7.1 Introduction

This section outlines the theory of operation of the Model 6444 Portable Transducer Calibrator.

7.2 Description

The Model 6444 Transducer Calibrator functions as a complete, portable test facility for testing and calibrating voltage, current, watt, and var transducers.

The heart of the instrument consists of accurate voltage, current, and watt/var standard transducers. See Figure 7-1. The transducer under test and the appropriate standard transducer are energized from the same voltage and/or current source and their outputs are compared on the sensitive error meter. This differential measurement technique has three advantages over direct-reading methods:

- Errors are greatly expanded for ease of reading and more accurate comparison against the standards.
- The influence of line voltage variations is essentially eliminated, giving stable error readings without requiring line-voltage conditioning.
- Load variations, power-factor variations, wave-form distortions, etc. are applied identically to the standard and unit under test.

High-stability dc amplifiers are used to normalize the outputs of the standard transducer and the test transducer at the 10 V level for comparison in the error meter circuit. The gain of the test-transducer amplifier is controlled by the volts-selector setting. Any test signal from 25 mV to 10 V may be standardized to the 10 V level. The standard signal is available at the standard output terminals. Refer to Section 2.8.

Accurate, terminating resistance is provided for the test-transducer output signal in the form of a five-decade, variable-load resistor made up of $\pm$0.025-percent resistors. The load resistance may be set in one-ohm steps from one to 99,999 Ω. An infinity setting is also provided. See Section 2.4.

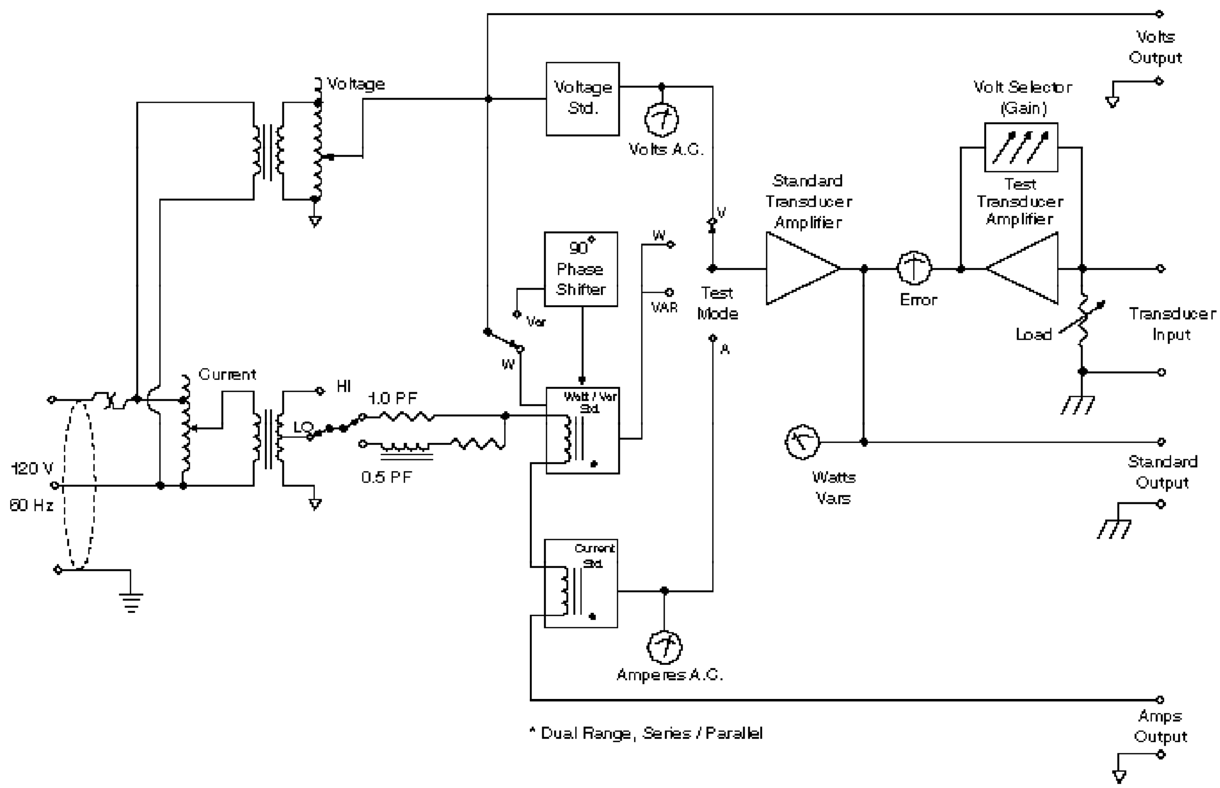


Figure 7.1 Model 6444 Block Diagram

Notes

Maintenance & Calibration

8.1 Introduction

This section outlines the maintenance and calibration of the Model 6444 Portable Transducer Calibrator.

8.2 Maintenance

The Model 6444 Portable Transducer Calibrator utilizes reliable, solid-state electronic components and rugged conservatively-rated power components and is virtually trouble free. No scheduled maintenance is required.

8.3 Calibration

Verification of calibration should be performed annually, or at more frequent intervals if severe environments (dusty, high humidity, high vibration, high temperature) are encountered. Scientific Columbus recommends that the Model 6444 Transducer Calibrator be returned to the manufacturer for this service.

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