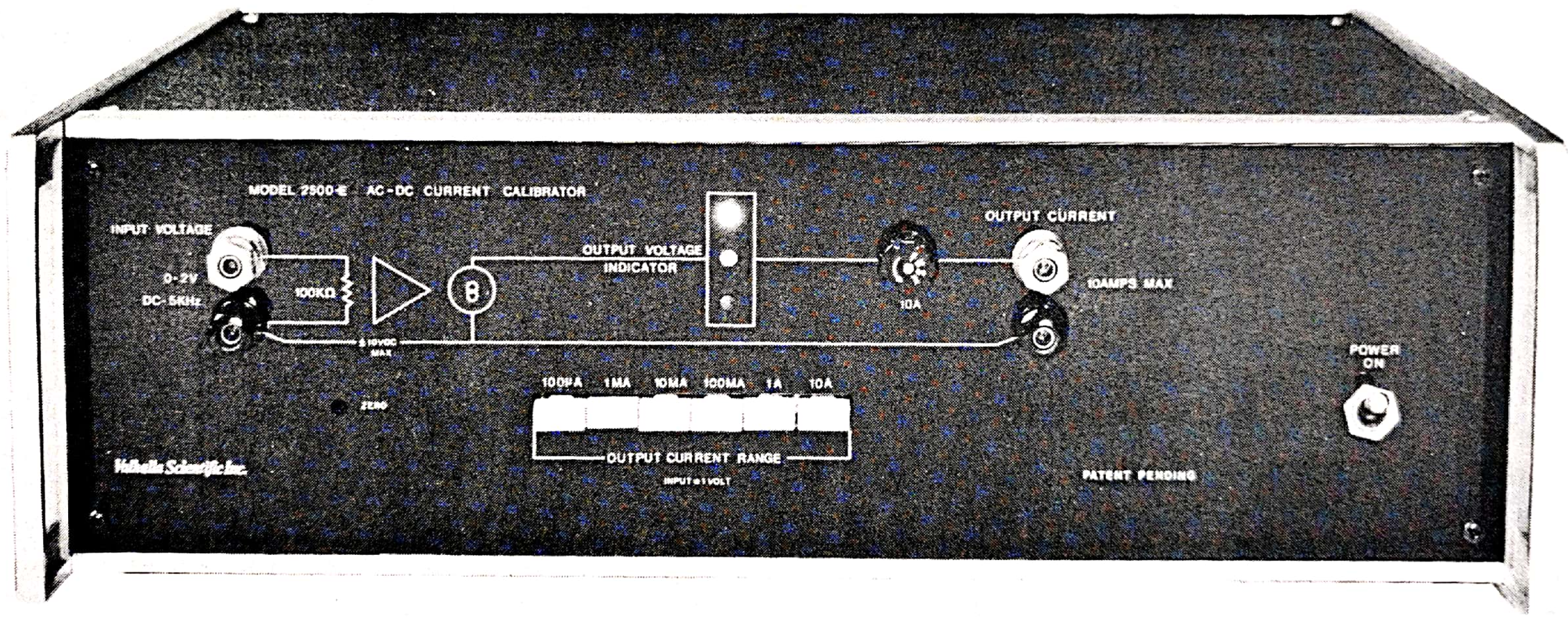
INSTRUCTION MANUAL MODELS 2500-E/2500-EP

CERTIFICATION

Valhalla Scientific Inc. certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. Valhalla Scientific Inc. further certifies that its calibration measurements are traceable to the National Bureau of Standards to the extent allowed by NBS's calibration facility.

WARRANTY

Vallhalla Scientific, Inc. warrants this instrument against defects in material and workmanship for one year from date of shipment. We will repair or replace the instrument during the warranty period provided it is returned to Valhalla Scientific Inc. No other warranty is expressed or implied. We are not liable for consequential damages. Permission must be obtained directly from the factory for warranty repair returns. No liability will be accepted if returned without such permission.



MODEL 2500-E

AC-DC CURRENT CALIBRATOR

SECTION I

GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The Model 2500-E and Model 2500-EP AC-DC Current Calibrators are complete wide-range voltage-to-current converters. These instruments convert a precision input voltage to a proportional output current. The full scale current ranges are selectable in decade increments from 100 microamperes full scale to 10 amperes full scale. The Model 2500-E range selection is by means of a six-station push button switch mounted on the front panel. The Model 2500-EP range selection is remotely programmable through a rear panel connector. Both units are housed in a heavy-duty aluminum case which is ideally suited to the most rugged requirements.

1-3 ACCESSORIES

1-4 The Model 2500-E is shipped from the factory with a detachable power cord and an instruction manual. The Model 2500-EP is shipped with a power cord, instruction manual and a mating plug for the rear panel range selector program input receptacle.

1-5 Rackmount - Option R

1-6 The Model 2500-E and Model 2500-EP may be purchased with an Option R rackmount adaptor that fits a standard 19 inch equipment enclosure.

1-7 Cable - Option C

1-8 The Option C Input Cable Set may be purchased with the Models 2500-E and 2500-EP or may be obtained on separate order.

SECTION II

INSTALLATION

2-1 INTRODUCTION

2-2 This section contains information for the inspection and installation of the Model 2500-E and Model 2500-EP AC-DC Current Calibrators.

2-3 INITIAL INSPECTION

2-4 If the external shipping container shows evidence of in-transit damage, such damage should be immediately brought to the attention of the carrier and such damage noted on the bill of lading.

2-5 Unpack the instrument and retain the shipping container until the instrument has been inspected for possible damage in shipment. If in-shipment damage is observed, notify the carrier and obtain his authorization for repairs before returning the instrument to the factory. Where the external shipping container shows evidence of damage in transit, but the instrument shows no external damage, it may be advisable to perform the calibration procedue of Section V to determine that the instrument has not incurred hidden damage.

2-6 POWER REQUIREMENTS

2-7 The Model 2500-E and Model 2500-EP AC-DC Current Calibrators are normally shipped from the factory for operation from 105 to 125 volts AC at 50 to 60 Hz. The current required is 5 amperes.

NOTE

The Model 2500-E and Model 2500-EP may be purchased from the factory with provisions for operation from 220 volts AC, 50 to 60 Hz.

2-8 INSTALLATION

2-9 If the Model 2500-E AC-DC Current Calibrator is to be in use in a bench top application, installation requires only that the power cord be inserted in the mating connector on the rear panel of the instrument and the other end of the cord be inserted into the wall receptacle. The Model 2500-EP will require, in addition, connection of the rear panel mounted range programming input connector to a suitable source of control signals. Information for these connections is provided in 2-11.

2-10 The Models 2500-E and 2500-EP AC-DC Current Calibrators use wind tunnel type heatsinks. Air is forced through the heatsink radiators by an internally mounted fan. Restriction of the air flow through the heatsink will result in excessive heating and possible failure of the power transistors. Caution should be taken to insure that neither the air inlet nor the outlet are obstructed in any way. In rack mount applications, the maximum ambient temperature within the rack should not exceed 50 degrees Centigrade. If total power dissipation of equipment in the rack causes the internal rack temperatures to exceed the 50 degrees Centigrade limit, forced air cooling of the entire rack should be employed.

CAUTION

Do not restrict the airflow of the unit cooling system. Maintain the internal temperature of equipment racks at or below 50 degrees Centigrade.

2-11 MODEL 2500-EP REMOTE PROGRAMMING

2-12 The Model 2500-EP has provisions for remote control of range selection and indication of output voltage range. Range selection requires an external 5 volt DC source. The 5 volt source negative is connected to pin 7 of J6 on the rear panel of the unit. The 5 volt source positive is then connected to one of the pins of J6, in accordance with the information listed in Table 1, to select the desired range. Only one pin is to be connected to the source positive at any time. These connections power relay coils which require 30 milliamperes. Surge limiting diodes are internally connected across the coil of each relay. External surge limiting devices are, therefore, not required.

2-13 In addition to the output voltage range indicators provided on the front panel, internal relay contacts provide for connection of remote output voltage indicators. The relay contacts are connected to pins of J6, as listed in Table 1. They are not connected to any internal voltage source nor is surge limiting provided. Therefore, a voltage source must be provided external to the Model 2500-EP to power the remote indicators. If inductive devices are connected to these relay contacts, surge limiting must be provided.

Table 2-1. Model 2500-EP Remote Range Selection Programming Connections.

J6 Pin No.	Function
1	Selects 10 Ampere Range.
2	Selects 1 Ampere Range.
3	Selects 100 Milliampere Range.
4	Selects 10 Milliampere Range.
5	Selects 1 Milliampere Range.
6	Selects 100 Microampere Range.
7	5 Volt Source Negative Connection.
8	N/C
9	Range Indicator Relay Contacts Common.
10	Green Output Voltage Range Relay Contact.
11	Orange Output Voltage Range Relay Contact.
12	Red Output Voltage Range Relay Contact.

SECTION III

OPERATION

3-1 INTRODUCTION

3-2 This section of the manual contains complete operating instructions for the Models 2500-E and 2500-EP AC-DC Current Calibrators.

3-3 INPUT VOLTAGE

3-4 The polarity and level of the output current of the Models 2500-E and 2500-EP AC-DC Calibrators is directly proportional to the input voltage polarity and level. A zero input voltage will produce a zero output current. As the input voltage is increased, the output current will increase within the selected range. With the 1 MA range selected, an input of 1.0000 volts DC will produce an output current of 1.0000 milliampere. If the input voltage is increased to 1.5000 volts, the output current will increase to 1.5000 milliamperes. Similarly, with the 10 MA range selected, 1.0000 volts input will produce a 10.000 milliampere current output. Increasing the input to 1.5000 volts will produce an output current of 15.000 milliamperes. A positive polarity input will produce an output current of positive polarity and a negative input will produce an output current of negative polarity. An AC input signal will produce an output current having the amplitude and phase characteristics of the applied input signal.

3-5 The maximum input voltage is ±3 volts DC or peak AC. Although the accuracy is not specified at inputs higher than ±2 volts DC or peak AC, the unit is usable with inputs up to ±3 volts DC or peak AC.

3-6 RANGE SWITCHING

3-7 Range switching is accomplished with a front panel 6-station push button switch on the Model 2500-E and with remote signal inputs, as described in paragraph 2-11, on the Model 2500-EP. These ranges are defined in decade increments of 100uA, 1MA, 10MA, 100MA, 1A and 10A based on a 1 volt input. For example, with the 1MA range selected, a 1.0000 volt input will produce 1.0000 milliampere of output current. If a 1.0000 volt AC input is applied, the output current will be 1.0000 milliampere RMS and it will have the frequency and phase characteristics of the input.

3-8 As previously stated, the output current is proportional to the input voltage. Therefore, a 2 volt input will produce an output current which is 200% of the selected range (e.g., if the 1 MA range is selected, the output current will be 2 milliamperes). The effective output impedance of the AC-DC Current Calibrator approaches infinity. Therefore, the output circuit will attempt to deliver the selected current into any load impedance applied to the output terminals. A 1 milliampere current output applied to a 1K ohm load impedance produces 1 volt across that load impedance. A 1 milliampere output current applied to a 2K ohm load impedance produces 2 volts, etc., until the output voltage reaches the ±10 volt DC or peak AC maximum compliance level (±7 volts DC or peak AC on the 10A range). The 10 volts DC maximum compliance voltage corresponds to 7.07 volts RMS maximum compliance voltage for sine wave output currents.

3-9 ZERO ADJUSTMENT

3-10 A zero adjustment has been provided and is accessible through a hole in the front panel located just below and to the right of the input terminals. The instrument should be allowed to warm up for a period of one hour prior to making the zero adjustment. To accomplish the zero adjustment, first short the input terminals together. Select the 1MA range and connect a precision 1K ohm resistor and a digital voltmeter (DVM) in parallel across the output terminals. If necessary, adjust the zero control until the DVM display reads ±100 microvolts DC, or less.

3-11 OUTPUT VOLTAGE INDICATOR

3-12 The output voltage indicator consists of three colored LED's, green, yellow and red. The green LED, when lit, indicates that the output compliance voltage is within specification limits. The yellow LED indicates a near over limit condition and the red LED indicates an over limit condition. The green indicator will be illumniated when the output compliance voltage is less than ±7 volts DC or peak AC. The green indicator is extinguished and the yellow indicator illuminated when the output compliance voltage is between ±7 and ±10 volts DC or peak AC. The yellow indicator will be extinguished and the red indicator illuminated when the output compliance voltage exceeds ±10 volts DC or peak AC.

NOTE

> The yellow indicator is the over-limit indicator in the 10A range because of the ±7V DC or peak AC maximum output compliance voltage limitation on that range.

3-13 The over limit indication occurs at a level below that where the specification limits are exceeded. When the over limit indicator is on (red LED except in the 10A range where

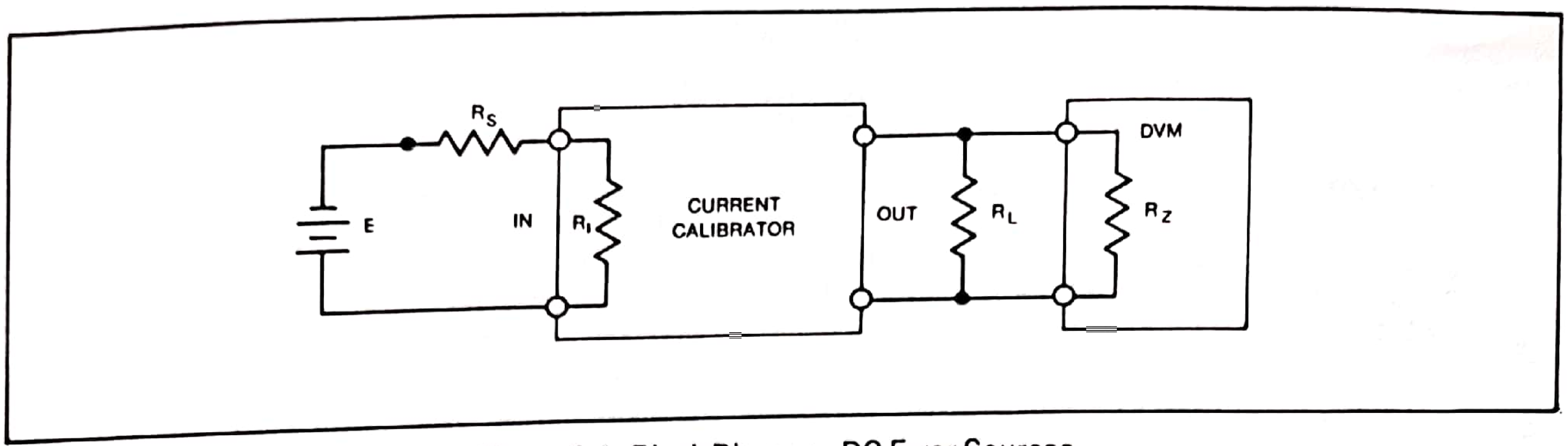


Figure 3-1. Block Diagram, DC Error Sources.

the yellow LED is the over limit indicator) the operator should make a careful check of the test setup to verify proper operating conditions. Although the output specifications may be exceeded, the over limit indication does not necessarily indicate non-linear operating conditions.

3-14 APPLICATION INFORMATION

3-15 The application of a precision constant current source, such as the Model 2500-E or 2500-EP AC-DC Current Calibrator, requires a knowledge of potential outside error sources.

3-16 When measuring the DC current output of the AC-DC Calibrator, there are two primary potential error sources. The first occurs at the voltage input of the Current Calibrator. This error source is formed by the source impedance, R_S, of the input voltage source, shown in Figure 3-1, forming a resistor divider with the 100K ohm input impedance of the Current Calibrator, R_I. To maintain the error at 0.01% or less, the ratio of $R_I : R_S$ must be maintained at 10,000:1 or greater. Since R_I equals 100K ohms, the maximum impedance for R_S must be less than 10 ohms. The second potential error source occurs at the current output of the AC-DC Current Calibrator. This error source is the shunt impedance of the DVM, R_Z, shown in Figure 3-1, in parallel with the load impedance, R_L. To maintain the error at 0.01%, or less, the ratio of $R_L : R_Z$ must be maintained at 10,000:1 or greater. If the input impedance of the DVM is 10M ohms, the maximum shunt impedance, R_L, should not exceed 1K ohms. For a shunt impedance, R_L, of 1M ohm, the input impedance to the DVM, R_Z, must be at least 10,000M ohms.

3-17 Measuring AC current introduces several new potential error sources in addition to those outlined above. The most common error source is cable capacitance, C_C, shunted across the load as shown in Figure 3-2. If the output of the AC-DC Calibrator and the load are connected with five feet of RG58A/U cable, for example, the cable capacitance is 150 picofarads. If the output frequency is 5 KHz and the load resistance, R_L, is 10K ohms, the effective load impedance is:

$$Z = \frac{R_L\left(\frac{1}{2\pi \cdot 5\,\text{kHz} \cdot 150\,\text{pf}}\right)}{\sqrt{R_L^2 + \left(\frac{1}{2\pi \cdot 5\,\text{kHz} \cdot 150\,\text{pf}}\right)^2}} = 9.989 \text{ kilohms}$$

3-18 The effective error due to shunt capacitance, C_C, is, in this case, 0.11%. As shown in the above equation, shunt capacitance versus load impedance is a square law function. Reducing the load impedance by a factor of 10 (10K ohms to 1K ohms) reduces the error by a factor of 100 (0.11% to 0.0011%). Another potential error source is caused by

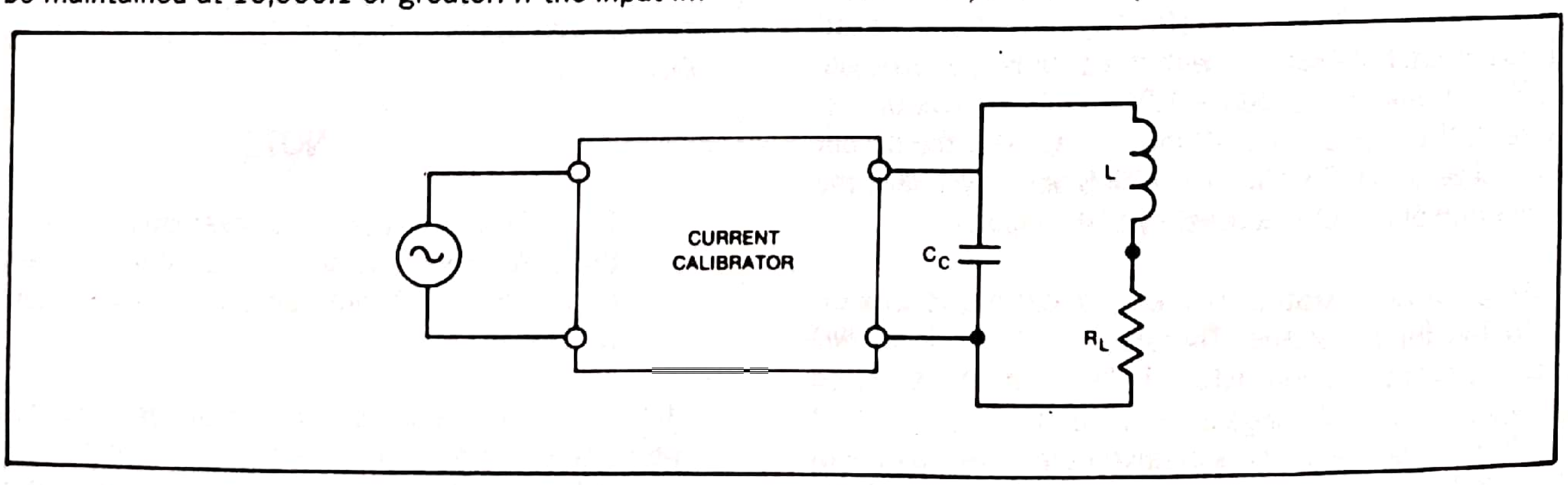


Figure 3-2. Block Diagram, AC Error Sources.

series inductance, L, in the load resistor, R_L. If the load resistance is 0.1 ohm at DC, and the series inductance is 0.5 microhenries, the effective load impedance at 5 KHz is:

$$Z = \sqrt{R_L^2 + (2\pi \cdot 5\,\text{kHz} \cdot 5\,\mu\text{H})^2} = 0.10123\ \text{ohm}$$

3-19 The effective error in load impedance caused by series inductance is, in this case, 1.23%. A precise 10.000 ampere RMS output current at 5 KHz from the AC-DC Calibrator applied to this load produces a voltage drop of 1.0123 volts RMS. In practice, series inductance only becomes a problem for shunt impedances of less than 3 ohms at frequencies of 5 KHz and above. Most of the commercially available, laboratory-standard 1 ohm resistors are not low enough in series inductance to be accurate at 1 ampere at 5 KHz. Special non-inductive precision current shunts are required to check the frequency response of the 1A and 10A ranges of this instrument.

SECTION IV

THEORY OF OPERATION

4-1 INTRODUCTION

4-2 The Model 2500-E and Model 2500-EP AC-DC Current Calibrators convert a precision input voltage to a precise output current with output polarity, or phase and frequency in the case of AC inputs, identical to the input. The paragraphs of this section provide a description of the circuits of the two units. Except as noted, all references are to the schematic diagram of Figure 5-5.

4-3 POWER SUPPLY

4-4 The circuits of the AC-DC Calibrator require positive and negative power sources. The ±20 volt sources are supplied by transformer T1, diode rectifiers CR5, CR6, CR7 and CR8, and filter capacitors C2 and C3. These provide the current source for transistors Q1 through Q8 and are regulated to ±15 volts by IC5 and IC6 to provide the necessary levels for the operational amplifiers, IC1, IC2 and IC7 and the level shifters, IC3 and IC4.

4-5 VOLTAGE TO CURRENT CONVERTER (TRANSCONDUCTANCE AMPLIFIER)*

4-6 A simplified diagram of the voltage-to-current converter is shown in Figure 4-1. The first amplifier, IC1, operates at unity gain by virtue of the operational feedback loop provided by R3. The output of the first amplifier drives the inverting input of IC2 which is the first section of the second amplifier, IC2/IC7. This amplifier operates open loop and, consequently, at very high gain. The output of the second amplifier provides a potentiometric feedback to the non-inverting input of the first amplifier. The system operates to maintain the output of the first amplifier, and the inverting input of the second amplifier, at approximately the same potential as that applied to the non-inverting input of the second amplifier. Very small inputs to the second amplifier are sufficient to drive it to full scale output.

*Protected by U.S. Patent No. 4,091,333.

4-7 Assume that the output terminals are shorted and 1 volt is applied to the input terminals with the RED input terminal positive. To equalize the inputs of the second amplifier, IC1 must be driven to zero. This is accomplished when the voltage drops across R1 and R2 are equal to those across R3 and R4. This condition will be obtained when the output of the second amplifier is at +1.0 volts. Since the output of IC1 must be zero, the drop across R3 must be 0.5 volts, making the inverting input +0.5 volts. The drops across R1 and R2 will also be 0.5 volts, as will the drop across R4. Since the inputs to IC1 are essentially equal, its output is zero (offset, of course, by the few microvolts required to drive the output of the second amplifier to +1.0 volts). Note that the sum of the voltages across the four resistors, R1 through R4, equal the sum of the input voltage and the second amplifier output voltage.

4-8 Consider the conditions that are obtained when the short circuit is removed from the output terminals and a 100 ohm resistor is connected across them. The reference level to the non-invertering input of the second amplifier will now be above ground due to the current through the load resistor, R . This will drive the output of the second amplfier in a positive direction. A point of stability will be reached when the output of the first amplifier is equal to the level applied to the non-inverting input of the second amplifier. Again, this condition is obtained when the voltage drops across R1 and R2 are equal to those across R3 and R4. This will occur when the output of the second amplifier is at +1.1 volts. The drop across range resistor R is then at

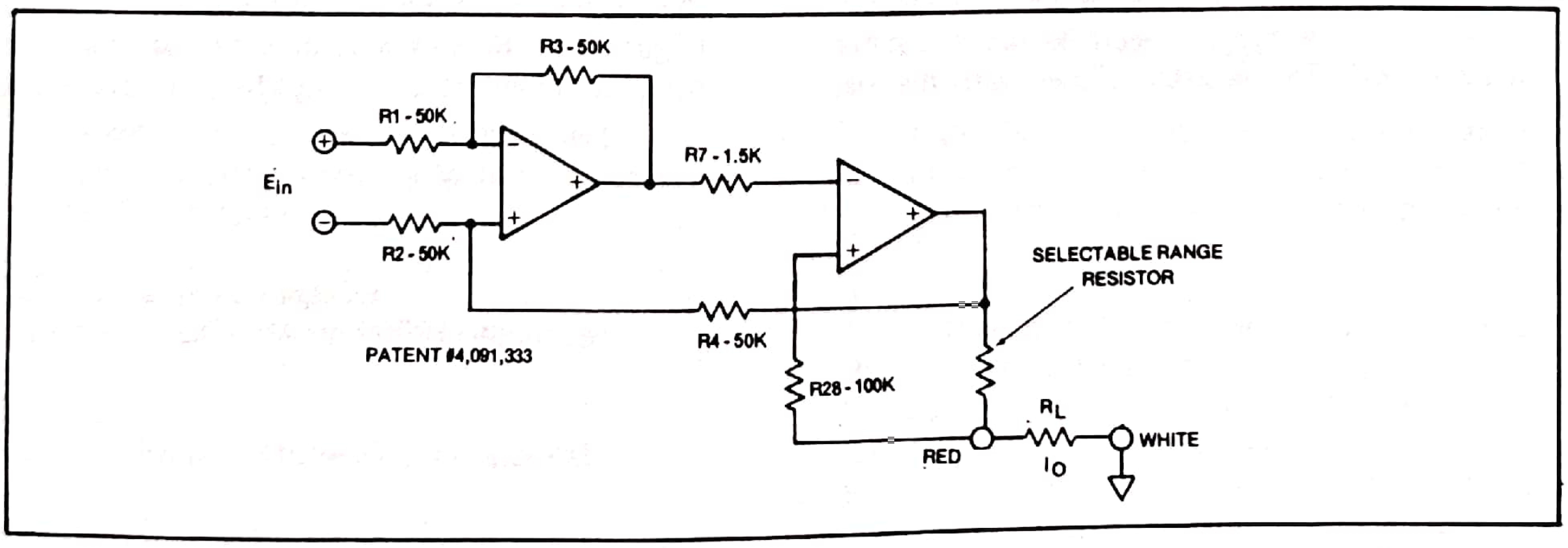


Figure 4-1. Simplified Diagram, Transconductance Amplifier (Voltage to Current Converter).

+1.0 volts, as it was when the output terminals were shorted. The current through the load is then 10 milliamperes. Although the resistance across the output terminals has been increased from zero to 100 ohms, the current flowing across the output terminals remains at 10 milliamperes. Note that the voltage difference between the output of the first amplifier and the output of the second amplifier is always equal to the voltage applied to the input terminals. When the input signal is increased to +2 volts, the potential difference between the output of the first amplifier and the output of the second amplifier increases to 2 volts. The drops across resistors R1, R2, R3 and R4 are then all equal at 1 volt. The current through the 100 ohm load would then increase to 20 milliamperes, proportional to the input voltage increase. If a 200 ohm resistor is connected across the output terminals, the output of the second amplifier will increase to 4 volts and the current through the combination of range and load resistors will remain at 20 milliamperes.

4-9 The system tends to maintain a voltage across the range resistor proportional to the input voltage. Selecting different values for the range resistor will result in different current levels through those resistors to maintain a 1.0 volt DC drop with 1 volt DC at the input terminals. Though shown as a single operational amplifier in the diagram of Figure 4-1, the second amplifier, as shown in the schematic diagram of Figure 5-5, is comprised of operational amplifiers IC2 and IC7 and current amplifiers consisting of transistors Q1 through Q8. The transistors are divided into two groups to form a "totem pole" arrangement capable of passing 10 amperes to the load with positive and negative polarity outputs in accordance with input polarity. Q1 and Q8 operate as constant current sources to bias the parallel connected sets of output transistors. R8 and R9 provide adjustment of the operational amplifier offsets.

4-10 RANGE SELECTION

4-11 The current output ranges of the Models 2500-E and 2500-EP are selected by inserting different range resistors between the amplifier output and the RED load connector. This changes the value of the selectable range resistor shown in Figure 4-1. This is accomplished with the six-station push button switch assembly on the Model 2500-E and by actuating relays K1 through K6 (Figure 5-6) in the Model 2500-EP through a rear panel connector. (K10 is operated, in turn, by K6). Calibration potentiometers across the individual range resistors permit precise adjustment of the proportion between input voltage and output current. Adjustment of these potenitometers is covered in Section V.

4-12 RANGE INDICATORS

4-13 Refer to Figure 5-5. The level sensors of IC3 and IC4 provide the drive for the three range indicator LED's, DS1 through DS3. Those of IC3 compare the output of IC1, which is proportional to the output voltage, to levels developed in the voltage divider comprised of R10 through R19. This divider is connected across the +15 and −15 volt supply lines. The inputs to IC3-1 and IC3-7 are positive with respect to ground and those to IC3-8 and IC3-14 are negative. When the output of IC1 is between 0 and 5 volts, all of IC3's outputs are at −15 volts and the junction of R20, R21 and R22 is at −10 volts. Thus, the outputs of IC4-1 and IC4-7 are also at +15 volts. This forces the output of IC4-8 to +15 volts to light DS3 (GRN). As the output transistions +7 volts, the output of IC7-3 goes to +15 volts, forcing the output of IC4-1 to +15 volts, turning on DS2 (ORG) and also forcing the output of IC4-8 to −15 volts which extinguishes DS3. As the voltage transitions to +10 volts, the output of IC3-1 goes to +15 volts. This forces the output of IC4-7 to +15 volts, turning on DS1 (RED). The output of IC4-1 is forced low, turning off DS2. The output of IC4-7 holds IC4-8 at −15 volts, keeping DS3 turned off.

4-14 When the output is forced in the negative direction, a similar sequence occurs. However, IC3-8 and IC3-14 outputs will transistion rather than those of IC3-7 and IC3-1.

4-15 The Model 2500-EP has three transistors, Q15, Q16 and Q17, driven by the outputs of IC4-1, IC4-7 and IC4-8 that, in turn, drive the coils of three relays, K7, K8 and K9 (Figure 5-6). Remote indicators can be connected to the contacts of these relays through the rear panel connector.

SECTION V

MAINTENANCE

5-1 INTRODUCTION

5-2 This section of the manual contains information necessary for the maintenance of the Models 2500-E and 2500-EP AC-DC Current Calibrators. Included are a list of required test equipment, calibration procedures and a troubleshooting guide.

5-3 REQUIRED TEST EQUIPMENT

5-4 The following items of test equipment will be required to calibrate the Models 2500-E and 2500-EP:

DC Voltage Standard
0 to 1V DC, ±0.003% accuracy.

5-Digit Digital Voltmeter (DVM)
±0.003% accuracy.
10 Megohms minimum input impedance on 1V DC range.

Precision DC Shunt Resistors
0.1000 ohms, ±0.003%
1.0000 ohms, ±0.003%
10.000 ohms, ±0.003%
100.00 ohms, ±0.003%
1.0000K ohms, ±0.003%
10.000K ohms, ±0.003%

DC Nullmeter
10 Microvolts sensitivity

5-5 If the AC Frequency Response Test of Paragarph 5-29 is to be conducted, the following items of test equipment will be required:

Thermal Transfer System
Fluke Model 540, or equivalent, with current shunts for 10 amperes, 1 ampere, 0.1 ampere, and 0.01 ampere.

High Impedance AC Amplifier
Valhalla Scientific Model 2009 or equivalent.

AC Voltmeter
Hewlett Packard 3450A001, or equivalent.

DC Voltage Standard
Optimation Model 126, or equivalent.

AC Current Shunts
0.1000 ohms, ±0.005%.
1.0000 ohms, ±0.005%.
10.000 ohms, ±0.005%.
100.00 ohms, ±0.005%.
1.0000K ohms, ±0.005%.
10.000K ohms, ±0.005%.

High Impedance AC Amplifier
Valhalla Scientific Model 2009, or equivalent.

5-6 CALIBRATION PROCEDURE

5-7 The following procedure should be performed on a routine basis to insure that the instrument remains within its specified accuracy. The calibration procedure should be performed after repairs are made on any of the accuracy determining components. Apply AC power and allow one hour for the instrument to stabilize.

5-8 OUTPUT IMPEDANCE ADJUSTMENT

5-9 Connect the equipment as shown in Figure 5-1 with a 900 ohm resistor for R_S and a 100.00 ohm resistor for R_L. Close the switch and set the DC Voltage Standard output at zero volts DC. Check for an indication on the Nullmeter of less than ±100 microvolts. Adjust the front panel ZERO control for a Nullmeter reading of ±100 microvolts, or less.

5-10 Set the DC Voltage Standard to 1.00 volt DC. Adjust R52 for a Nullmeter reading of ±100 microvolts, or less. Open and close the switch across R_S. The output voltage displayed on the DVM should change from 1 volt to 10 volts.

NOTE

If the Nullmeter reads less than ±200 microvolts at both positions of the switch, proceed to paragraph 5-12. If not, proceed to paragraph 5-11.

5-11 Open and close the switch across R_S and observe the direction and magnitude of change indicated on the Nullmeter. Adjust R48 for a Nullmeter reading change of less than ±100 microvolts between the open and closed positions of the switch. The total offset of the output generated by adjusting R48 can be ignored. Only the change in the reading between switch positions is of importance at

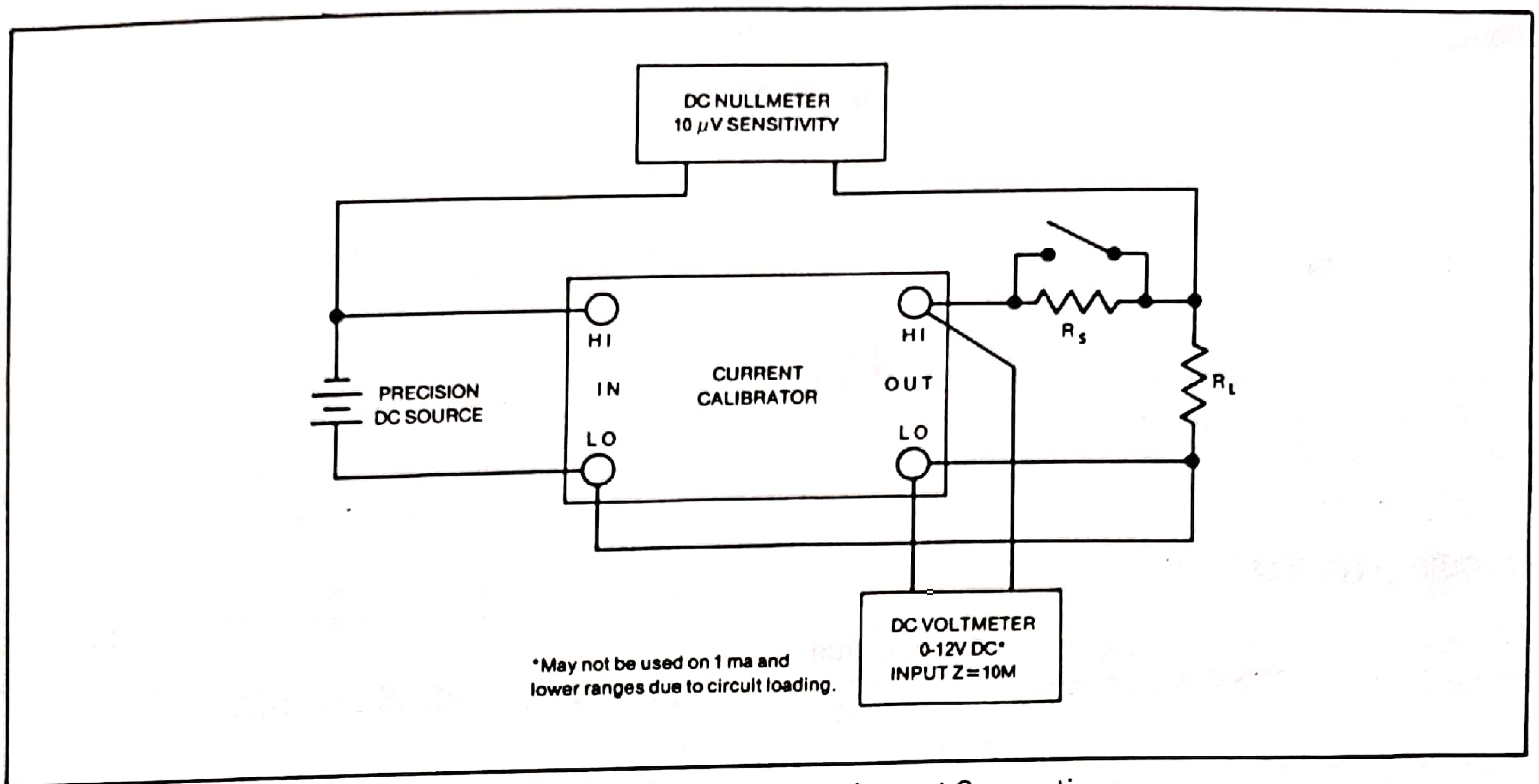


Figure 5-1. DC Calibration Test Equipment Connections.

this point. After adjusting R48, repeat the steps of paragraphs 5-9 and 5-10.

5-12 10 AMPERE RANGE

5-13 Connect a 0.1000 ohm resistor for R_L and close the switch across R_S. Select the 10A range and set the DC Voltage Standard for zero volts. Check for an indication of less than ±100 microvolts on the Nullmeter. Adjust the front panel ZERO, if required.

5-14 Set the DC Voltage Standard to 1.00 volt. Adjust R58 for an indication on the Nullmeter of less than ±200 microvolts.

5-15 1 AMPERE RANGE

5-16 Connect a 1.0000 ohm resistor for R_L. Select the 1A range and set the DC Voltage Standard for zero volts. Check for an indication of less than ±100 microvolts on the Nullmeter. Adjust the front panel ZERO, if required.

5-17 Set the DC Voltage Standard to 1.00 volt. Adjust R56 for an indication on the Nullmeter of less than ±200 microvolts.

5-18 100 MILLIAMPERE RANGE

5-19 Connect a 10.000 ohm resistor for R . Select the 100MA range and set the DC Voltage Standard for zero volts. Check for an indication of less than ±100 microvolts on the Nullmeter. Adjust the front panel ZERO, if required.

5-20 Set the DC Voltage Standard to 1.00 volt. Adjust R54 for an indication on the Nullmeter of less than ±200 microvolts.

5-21 10 MILLIAMPERE RANGE

5-22 Connect a 100.00 ohm resistor for R_L. Select the 10MA range and set the DC Voltage Standard for zero volts. Check for an indication of less than ±100 microvolts on the Nullmeter. Adjust the front panel ZERO, if required.

5-23 Set the DC Voltage Standard to 1.00 volt. Adjust R52 for an indication on the Nullmeter of less than ±200 microvolts.

5-24 1 MILLIAMPERE RANGE

5-25 Connect a 1.0000K ohm resistor for R_L. Select the 1MA range and set the DC Voltage Standard for zero volts. Check for an indication of less than ±100 microvolts on the Nullmeter. Adjust the front panel ZERO, if required.

5-26 Set the DC Voltage Standard to 1.00 volt. Adjust R50 for an indication on the Nullmeter of less than ±200 microvolts.

5-27 100 MICROAMPERE RANGE

5-28 Connect a 10.000K ohm resistor for R_L. Select the 100uA range and set the DC Voltage Standard for zero volts. Check for an indication of less than ±100 microvolts on the Nullmeter. Adjust the front panel ZERO, if required.

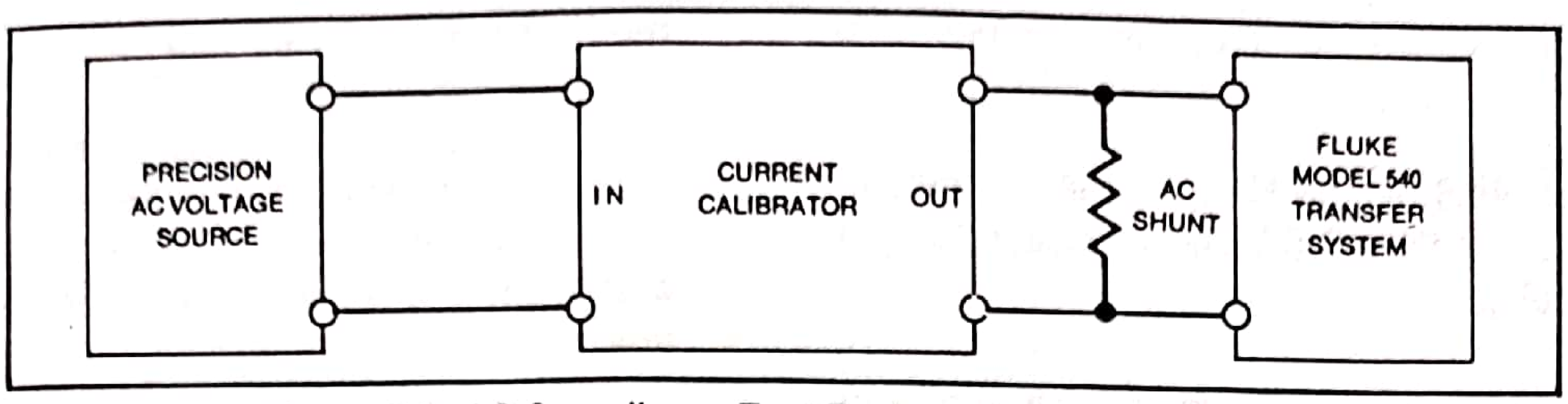


Figure 5-2. AC Compliance Test Equipment Connections.

5-29 Set the DC Voltage Standard to 1.00 volt. Adjust R47 for an indication on the Nullmeter of less than ±200 microvolts.

5-30 FREQUENCY RESPONSE

5-31 The frequency response test need not be performed on a routine basis as the 10 KHz bandwidth is inherent in the design. The frequency response test is an exacting procedure requiring specialized test equiment listed in paragraph 5-5 but not usually found in most service laboratories. Before attempting to perform this test, it is recommended that paragraph 3-13, Application Information, be completely reviewed and that the test operator satisfy himself that he thoroughly understands the sources of errors and compensates for them during the test. If test equipment other than that listed in paragraph 5-5 is to be used, the specifications should be compared with those of the equipment listed to insure that they are exact equivalents.

5-32 10 AMPERE RANGE

5-33 Connect the Fluke Model A40-10 (10 Ampere) shunt to the output of the AC-DC Current Calibrator and to the input of the Fluke Model 540 Thermal Transfer System, as shown in Figure 5-2. Set the Model 540 MODE switch to the AC TRANSFER position and the RANGE switch to SHUNT.

5-34 Select the 10A range on the AC-DC Current Calibrator and apply 1.00 volts RMS at 100 Hz from the AC Voltage Standard to the input of the AC-DC Current Calibrator. Null the galvanometer on the Model 540 to zero.

5-35 Increase the frequency output of the AC Voltage Standard to 1000 Hz and verify that the output does not change by more than 0.06%.

5-36 Increase the frequency output of the AC Voltage Standard to 5000 Hz and verify that the output does not change by more than 0.15% from that of paragraph 5-34.

5-37 Increase the frequency output of the AC Voltage Standard to 10 KHz and verify that the output does not change by more than 0.15% from that of paragraph 5-34.

5-38 1 AMPERE RANGE

5-39 Connect the Fluke Model A40-1 (1 Ampere) shunt in place of the A40-10. Repeat the steps of paragraphs 5-34 through 5-37.

5-40 100MILLIAMPERE RANGE

5-41 Connect the Fluke Model A40-.1 (100 Milliampere) shunt in place of the A40-1. Repeat the steps of paragraphs 5-34 through 5-37.

5-42 10 MILLIAMPERE RANGE

5-43 Connect the Fluke Model A40-.01 (10 Milliampere) shunt in place of the A40-.1. Repeat the steps of paragraphs 5-34 through 5-37.

5-44 1 MILLIAMPERE RANGE

5-45 Connect the equipment as shown in Figure 5-3 using the 1.000K ohms shunt. Total shunt capacitance, including

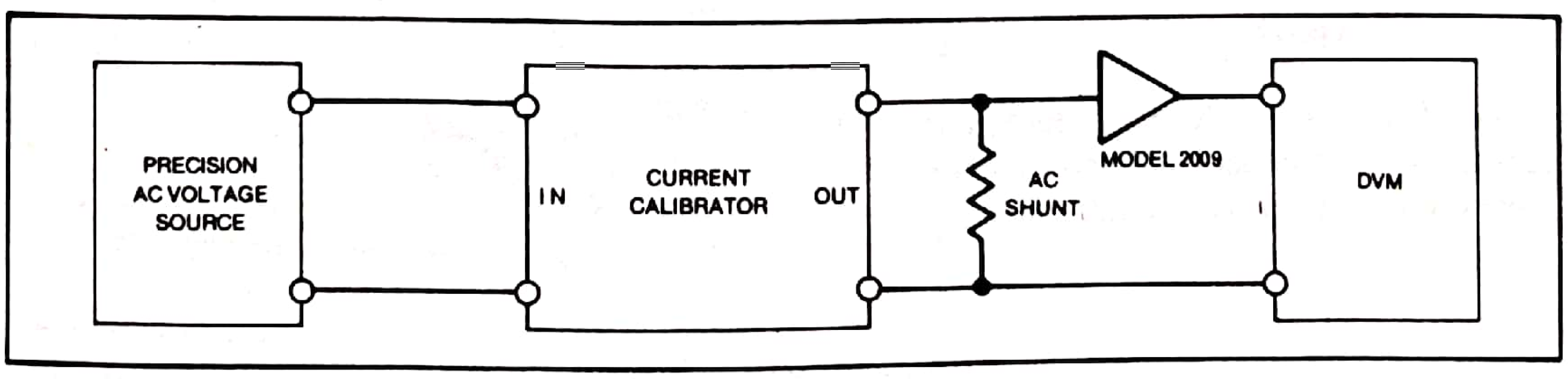


Figure 5-3. AC Test Equipment Connections, Lower Ranges.

leads and resistor capacitance, must not exceed 200 picofarads.

5-46 Apply 1 volt RMS at 100 Hz from the AC Voltage Standard to the input of the AC-DC Current Calibrator and record the DMV reading.

5-47 Increase the frequency of the AC Voltage Standard to 1000 Hz and verify that the DVM reading does not change by more than 0.06%.

5-48 Increase the frequency of the AC Voltage Standard to 5000 Hz and verify that the reading of the DVM does not change by more than 0.15% from that obtained in the step of paragraph 5-46.

5-49 Increase the frequency of the AC Voltage Standard to 10 KHz and verify that the DVM reading does not change by more than 0.15% from that obtained in the step of paragraph 5-46.

5-50 100 MICROAMPERE RANGE

5-51 Connect the equipment as shown in Figure 5-3 using the 10.00K ohms shunt. Total shunt capacitance, including leads and resistor capacitance, must not exceed 20 picofarads.

5-52 Apply 1 volt RMS at 100 Hz from the AC Voltage Standard to the input of the AC-DC Current Calibrator and record the DMV reading.

5-53 Increase the frequency of the AC Voltage Standard to 1000 Hz and verify that the DVM reading does not change by more than 0.06%.

5-54 Increase the frequency of the AC Voltage Standard to 5000 Hz and verify that the reading of the DVM does not change by more than 0.15% from that obtained in the step of paragraph 5-52.

5-55 Increase the frequency of the AC Voltage Standard to 10 KHz and verify that the DVM reading does not change by more than 0.15% from that obtained in the step of paragraph 5-52.

NOTE

For factory certifications with National Bureau of Standards traceability, contact your local Valhalla sales representative or Valhalla Scientific, Inc.

5-56 TROUBLESHOOTING

5-57 Difficulties with precision equipment often arise due to misinterpretation of the specifications. Make a careful check with precision test equipment to determine that the equipment is malfunctioning before proceeding with repair procedures.

5-58 POWER SUPPLY

5-59 The +20 volt and −20 volt supplies are formed by transformer T1 and diode rectifiers CR5, CR6, CR7 and CR8. These supplies are unregulated and the voltage will vary from 17 volts to 24 depending on line voltage and load.

5-60 The +15 volt supply is formed by regulating the +20 volt supply with IC5. The −15 volt supply is formed by similarly regulating the −20 volt supply with IC6. These voltages will vary slightly from unit to unit, due to component tolerances. Typically, they will be near 14.4 volts.

5-61 AMPLIFIER SERVICING

5-62 Before attempting to service the amplifiers of the AC-DC Calibrators, it is recommended that the technician review the Theory of Operation presented in Section IV. The following procedure is only an aid to isolate a catastrophic malfunction to a local area. Short the input terminals and short the output terminals. With the differential DC voltmeter, measure the voltage from the junction of R40 and R46 to pin 4 of IC1. This voltage must be less than 15 millivolts. If it is greater than 15 millivolts, IC1 is most likely defective. If it is less than 15 millivolts, the malfunction is in the second amplifier (and/or the current amplifiers), or the feedback network.

NOTE

If IC1, IC2, IC7, Q1, Q8 or R59 through R64 are replaced, the **AC FREQUENCY RESPONSE TEST MUST BE PERFORMED.** Contact your Valhalla sales representative or Valhalla Scientific, Inc. if the AC Frequency Response Test is not satisfactory.

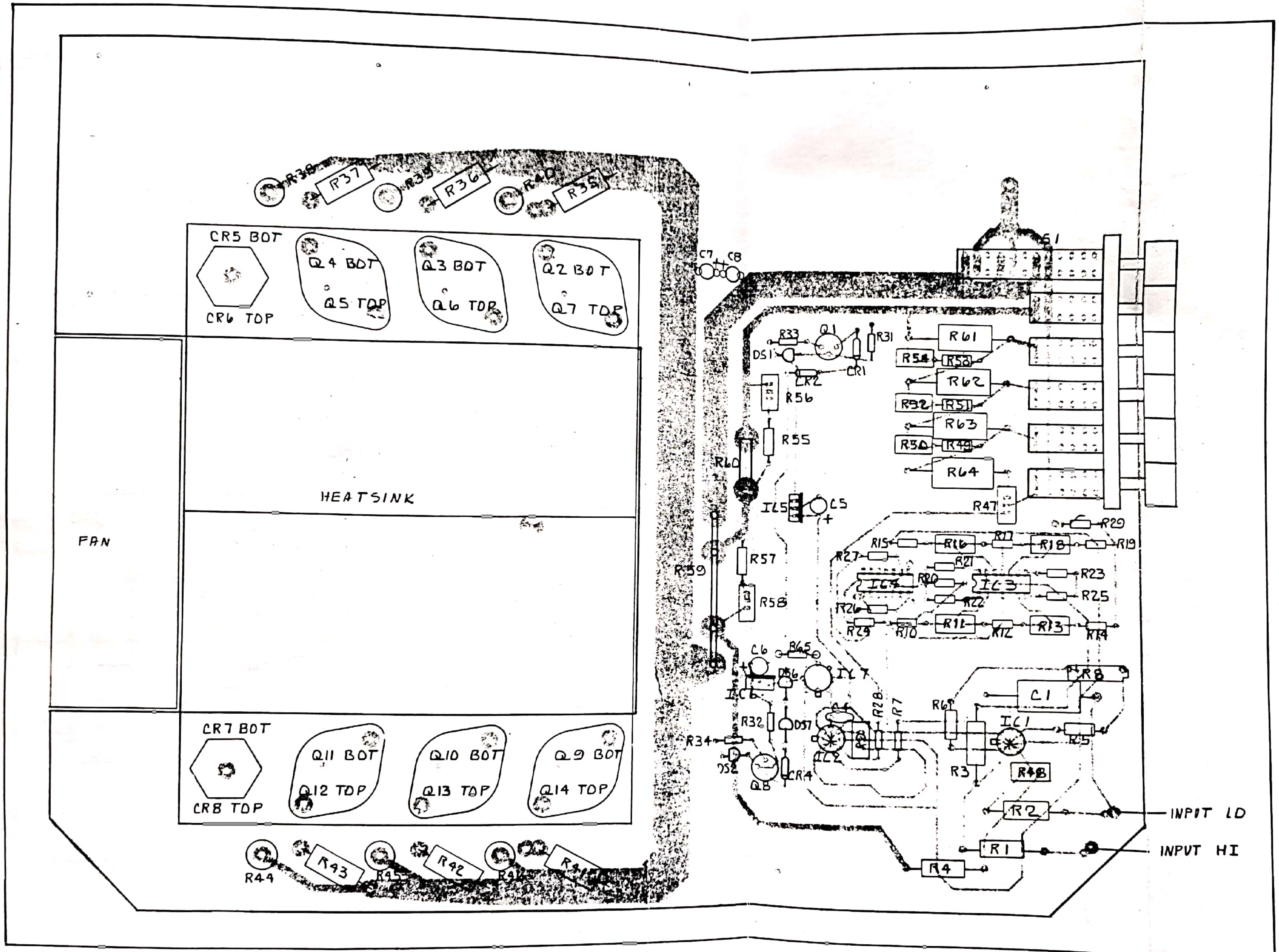


Figure 5-4. Component Locations, Circuit Board.

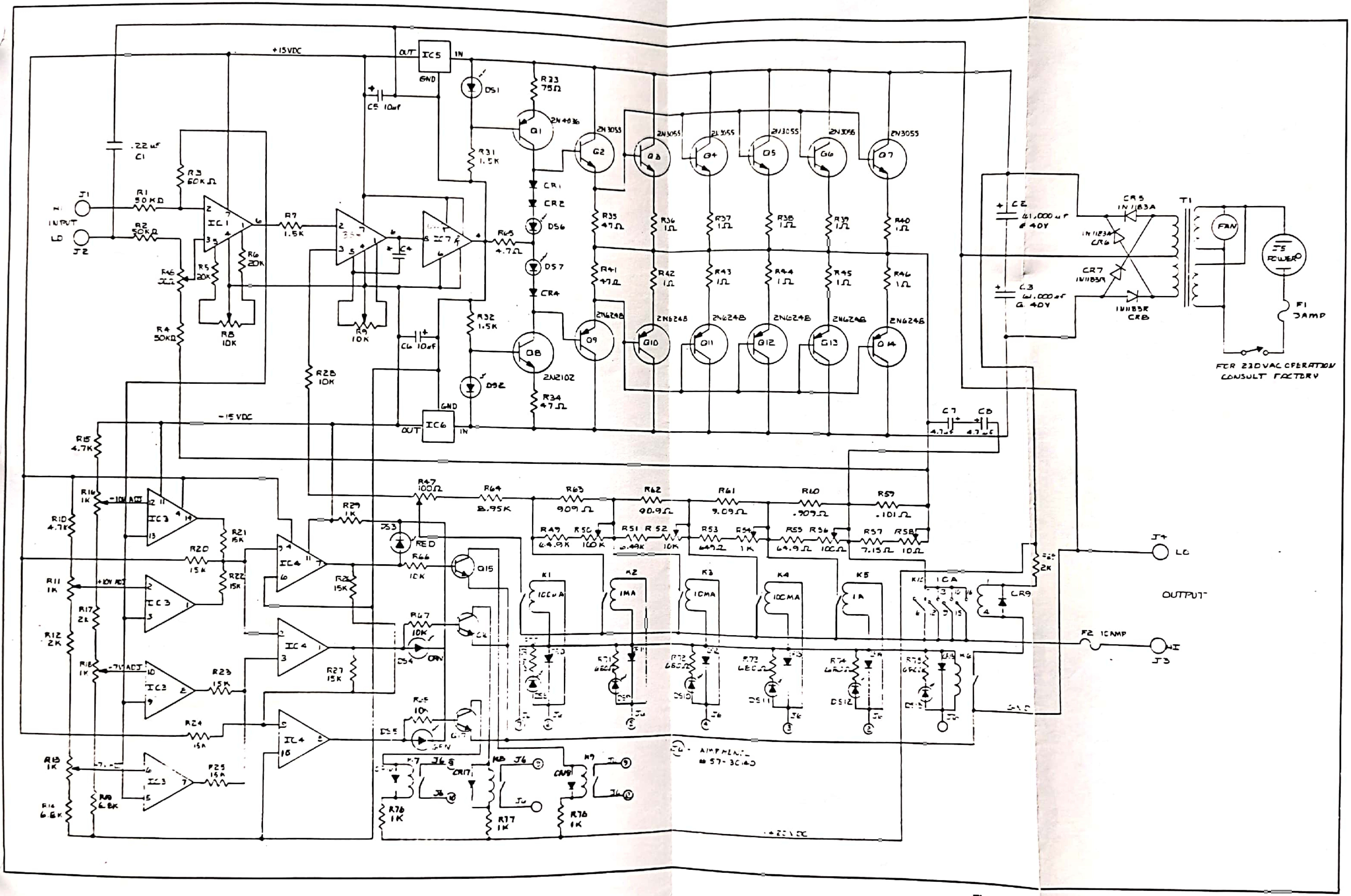


Figure 5:6. Schematic Diagram, Model 2500-EP AC-DC Calibrator.

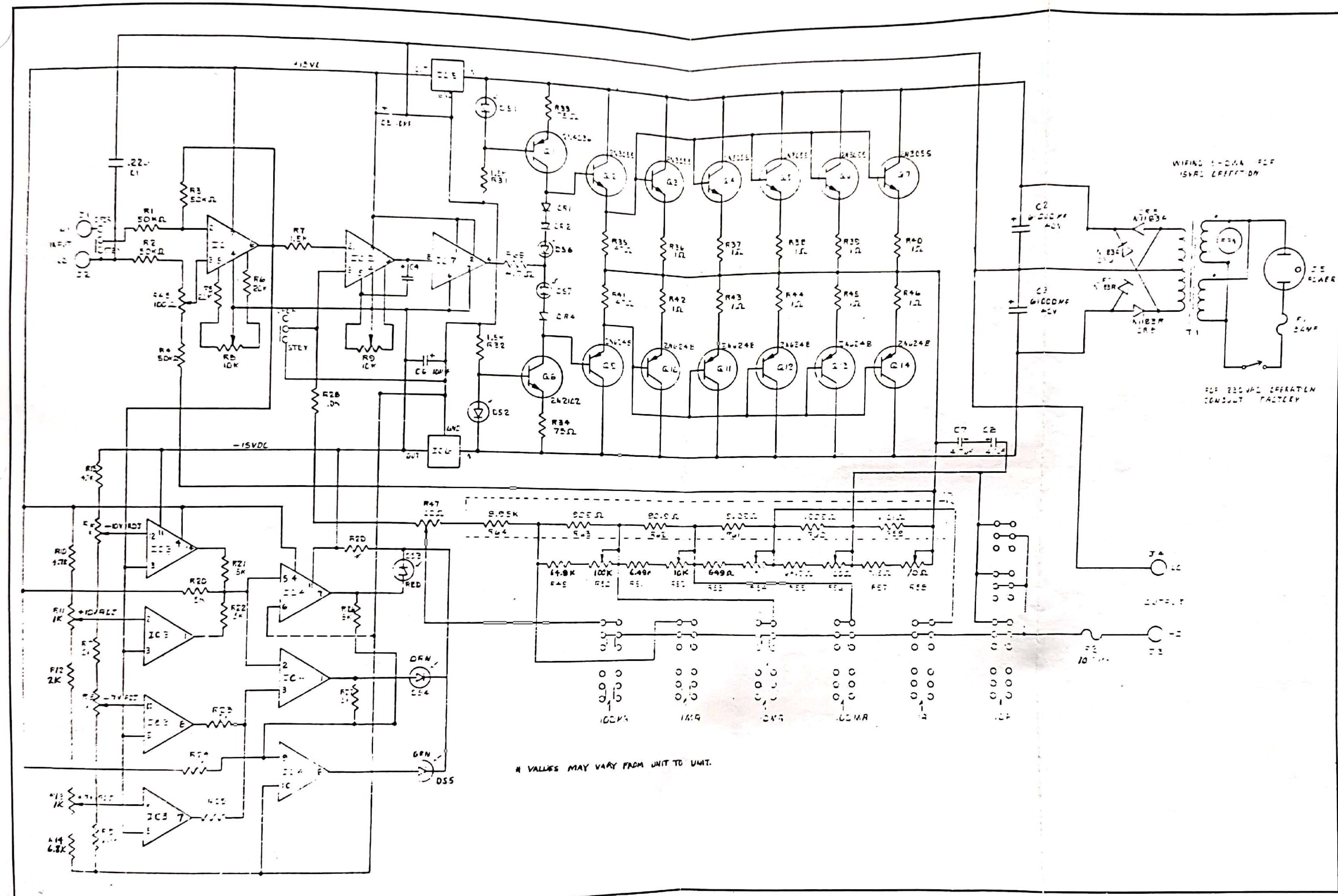


Figure 5-5. Schematic Diagram, Model 2500-E AC-DC Calibrator.

Valhalla Scientific Inc — PARTS LIST

REF. DES.	V.S. P/N	DESCRIPTION	MFG.	MFG. P/N
C 1	2-50000	Cap. Poly .22µf	27557	PA2A224
C 2,3	2-40003	Cap.Elec. 61000mf 40V	00853	DCM613U0400D2B
C 4		Factory Select		
C 5,6	2-30001	Cap. Tan 10µf/25V	05397	T360B106M025AS
C 7,8	2-30000	Cap Tan 4.7/10V	05397	T360B475M025AS
DS 1,2,6,7	5-01005	LED	00001	MV5074
DS 3	5-01011	LED, RED Panel Mtg.	28480	5082-4655
DS 4	5-01012	LED YEL Panel Mtg.	28480	5082-4555
DS 5	5-01013	LED GRN Panel Mtg.	28480	5082-4955
CR 1,2,4	3-20000	Diode	07263	IN4148
CR 5,6	3-20011	Diode, Rect.	07263	IN1183A
CR 7,8	3-20012	Diode, Rect. Rev. Pol.	07263	IN1183RA
F 1	5-04003	Fuse 3A	75915	3AG3A
F 2	5-04005	Fuse 10A	75915	3AG10A
IC 1,2	3-30117	IC Op-Amp	27014	LH0052H
IC 3,4	3-30031	IC Quad Op-Amp	27014	LM324N
IC 5	3-30036	IC Reg Pos 15V	27014	LM340T
IC 6	3-30037	IC Reg Neg 15V	27014	LM320T
IC 7	3-30069	IC Op-Amp	27014	LH0002CH
J 1,3	5-10021	Binding Post, RED	83330	257-RED
J 2,4	5-10020	Binding Post, BLK	83330	257-BLK
J 5	5-10063	Power Recpt.	82389	EAC301
Q 1	3-10002	Transistor, PNP	03713	2N4036
Q 2-7	3-10008	Transistor, NPN PWR	86684	2N3055
Q 8	3-10007	Transistor, NPN	86684	2N2102
Q 9-14	3-10009	Transistor, PNP PWR	86684	2N6246
R 1,2,3,4	1-20034	Res. Fxd. 50K .01%	53504	1-20034
R 5,6	1-10012	Res. Fxd. 20K 1%	81349	RN60C2002F
R 7,31,32	1-01043	Res. Fxd. 1.5K 5%	81349	RC07GF152J
R 8	1-50016	Res.Var. 10K	91637	878110K
R 9,52	1-50012	Res. Var. 10K	80294	3255W-10K
R 10,15	1-01053	Res. Fxd. 4.7K 5%	81349	RC07GF472J
R 11,13,16,18,54	1-50013	Res. Var. 1K	80294	3255W-1K
R 12,17	1-01045	Res. Fxd. 2K 5%	81349	RC07GF202J
R 14,19	1-01057	Res. Fxd. 6.8K 5%	81349	RC07GF582J
R 20-27	1-01063	Res. Fxd. 15K 5%	81349	RC07GF153J
R 28	1-01061	Res. Fxd. 10K 5%	81349	RC07GF103J
R 29	1-01041	Res. Fxd. 1K 5%	81349	RC07GF102J
R 47,56,48	1-50014	Res. Var. 100Ω	80294	3255W-100Ω
R 35,41	1-01015	Res. Fxd. 47Ω 5%	81349	RC07GF470J
R 33,34	1-01018	Res. Fxd. 75Ω 5%	81349	RC07GF750J
R 36-40, 42-46	1-30001	Res. Fxd. 8 Watts	44655	1500-1Ω
R 49	1-10072	Res. Fxd. 64.9K 1%	81349	RN60C6492F

MODEL: 2500E | TITLE: Current Calibrator | SHT 1 OF 2

Valhalla Scientific Inc — PARTS LIST

REF. DES.	V.S. P/N	DESCRIPTION	MFG.	MFG. P/N
R 50	1-50024	Res. Var. 100K	80294	3255W-100K
R 51	1-10071	Res. Fxd. 6.49K 1%	81349	RN60C6491F
R 53	1-10070	Res. Fxd. 649Ω 1%	81349	RN60C6490F
R 55	1-10069	Res. Fxd. 64.9Ω 1%	81349	RN60C649RF
R 57	1-10068	Res. Fxd. 7.15Ω 1%	81349	RN60C7R15F
R 58	1-50018	Res. Var. 10Ω	80294	3255W-10
R 59	1-20046	Res. Fxd. .101Ω WW	53504	1-20046
R 60	1-20047	Res. Fxd. .909Ω WW	53504	1-20047
R 61	1-20048	Res. Fxd. 9.09Ω WW	53504	1-20048
R 62	1-20049	Res. Fxd. 90.9Ω WW	53504	1-20049
R 63	1-20050	Res. Fxd. 909Ω WW	53504	1-20050
R 64	1-20051	Res. Fxd. 8.95K .1% WW	53504	1-20051
R 65	1-01004	Res. Fxd. 4.7Ω 1/4W 5%	81349	RC07GF4R7J
S 1	5-03008	Range Switch	53504	5-03008
S 2	5-03009	Power Switch	83330	ST-40A
S 3	5-03030	Stand By Switch	Schadow	ZF FA200 Blk Yel/2UEI
T 1	4-20009	Power Transformer	53504	2500-011
1 ea.	4-30015	P.C. Board	53504	2500E-700D
2 ea.	4-10049	Heat Sink	53504	2500-206B
1 ea.	4-10050	Ground Bracket	53504	2500-207A
4 ea.	4-10051	MTG Bracket	53504	2500-208
1 ea.	4-10052	Rear Panel	53504	2500-209A
1 ea.	4-10053	Front Panel	53504	2500-210B
2 ea.	4-10065	Heant Sink Support Bkt.	53504	2500-211A
1 ea.	4-10223	Chassis Assembly		B-525-15-1700H
1 ea.	5-10059	Fan, 115VAC 50-60Hz	Rotron	MU2A1
2 ea.	5-10060	Finger Guard	02660	760-9601-43
2 ea.	5-10057	Socket 8 Pin Round		81CS
12 ea.	5-10005	Standoff	88245	1530B-3/16
2 ea.	5-10018	Fuse Holder		42004A
2 ea.	5-10062	Capacitor Mtg. Bracket	90201	VR12
*1 ea.	5-10067	Power Cord	70903	17250
*4 ea.	5-10015	Rubber Feet		2084 Blk/467 Black

* Do Not Issue to Production

MODEL: 2500E | TITLE: Current Calibrator | SHT 2 OF 2

Valhalla Scientific Inc — PARTS LIST

REF. DES.	V.S. P/N	DESCRIPTION	MFG.	MFG. P/N
	FOR 2500EP DELETE THE FOLLOWING STANDARD PARTS LIST		FROM	
S 1	5-03008	Range Switch	53504	5-03008
1 ea.	4-10053	Front Panel	53504	2500-210
1 ea.	4-10052	Rear Panel	53504	2500-209
	ADD THE FOLLOWING PARTS			
CR 9-18	3-20000	Diode	07263	IN914
DS 8-13	5-01011	LED, RED	28480	5082-4655
J 6	5-10090	Conn. Cable	02660	57-30140
K 1-9	5-03012	Relay	Clair	PRME1A005
K 10	5-03019	Relay	P & B	R10S-E1-Z4-J2.5K
Q 15-17	3-10003	Transistor NPN	04713	2N5172
R 66-68	1-01061	Res. Fxd 10K 1/4W 5%	83149	RC07GF103J
R 70-75	1-01037	Res. Fxd. 680Ω 1/4W 5%	83149	RC07GF681J
R 76-78	1-01041	Res. Fxd. 1K 1/4W 5%	83149	RC07GF102J
P 6	5-10089	Conn. Panel	02660	57-40140
1 ea.	4-30040	P.C. Board	53504	2500EP-700
1 ea.	4-10149	Front Panel	53504	2500-223
1 ea.	4-10150	Rear Panel	53504	2500-224
1 ea.	5-10143	Relay Socket	P & B	27E338
1 ea.	5-10144	Hold Down Spring	P & B	20C250

MODEL: 2500EP

TITLE: Programmable Current Calibrator

SHT 1 OF 1

FEDERAL SUPPLY CODE for MANUFACTURERS CATALOGING HANDBOOK H4-1

00001	Monsanto, Electronic Special Products, Cupertino, Calif.
00656	Aerovox Corporation, New Bedford, Mass
00853	Sangamo Electric Company, Pickens, S.C.
01121	Allen-Bradley Company, Milwaukee, Wisc.
01255	Litton Industries, Inc., Beverly Hills, Calif.
01281	T R W Semiconductors, Inc., Lawndale, Calif.
01295	Texas Instruments, Inc., Dallas, Texas
02335	Fairchild Controls Corp., Hicksville, LI, N.Y.
02660	Amphenol Corporation, Broadview, N.Y.
03507	General Electric Company, Syracuse, N.Y.
04713	Motorola Semiconductor Prod., Inc., Phoenix, Ariz.
04963	3-M, St. Paul, Minn.
05276	Pomona Electronics Co., Inc., Pomona, Calif.
05397	Kemet, Union Carbide Corp., Cleveland, Ohio
05820	Wakefield Engineering, Inc., Wakefield, Mass.
07088	Kelvin Electric Company, Van Nuys, Calif.
07256	Silicon Transistor Corp., Garden City, N.Y.
07263	Fairchild Camera and Instr. Corp., Mt. View, Calif.
07716	I R C, Incorporated, Burlington, Iowa
07910	Continental Devices, Hawthorne, Calif.
08065	Accurate Rubber and Plastics Co., San Diego, Calif.
09026	Babcock Electronics Corp., Costa Mesa, Calif.
12405	Hysol Corporation, El Monte, Calif.
12406	Elpac, Incorporated, Fullerton, Calif.
12697	Clarostat Mfg. Co., Incorporated, Dover, N.H.
13454	Texas Crystals, River Grove, Ill.
14655	Cornell-Dubilier Elect. Corp., Newark, N.J.
14752	Electro Cube, Incorporated, San Gabriel, Calif.
16758	Delco Radio Div., General Motors, Kokomo, Ind.
17838	Mektron, California General, Inc., Chula Vista, Calif.
18324	Signetics, Sunnyvale, Calif.
18722	R C A, Mountaintop, Pa.
21604	Buckeye Stamping Company, Columbus, Ohio
25684	Victoreen Instrument Co., Inc., Oak Lawn, Ill.
27014	National Semi-Conductor Corp., Santa Clara, Calif.
27556	IMB Electronic Products, Santa Fe Springs, Calif.
28480	Hewlett-Packard Co., Palo Alto, Calif.
30983	Electra/Midland, San Diego, Calif.
44655	Ohmite Manufacturing Company, Skokie, Ill.
71279	Cambridge Thermionic Corp., Cambridge, Mass.
71400	Bussmann Mfg. Div., McGraw-Edison Co., St. Louis, Mo.
71450	CTS Corporation, Elkhart, Ind.
71468	ITT Cannon Electric, Inc., Los Angeles, Calif.
71590	Centralab Div., Globe-Union, Inc., Milwaukee, Wisc.
71785	Cinch Manufacturing Company, Chicago, Ill.
73899	J F D Electronics Company, Brooklyn, N.Y.
75915	Littlefuse, Incorporated, Des Plaines, Ill.
76055	Mallory Controls, Frankfort, Ind.
76493	J. W. Miller Company, Los Angeles, Calif.
78488	Stackpole Carbon Company, St. Marys, Pa.
80294	Bourns, Incorporated, Riverside, Calif.
81095	Triad Transformer Corp., Venice, Calif.
81312	Winchester Electronics, Oakville, Ct.
81349	Military Spec., Standardization Division, Chicago, Ill.
82389	Switchcraft, Incorporated, Chicago, Ill.
83330	Herman H. Smith, Inc., Brooklyn, N.Y.
84171	Arco Electronics, Inc., Great Neck, N.Y.
86684	R C A, Harrison, N.J.
88245	Useco Div., Litton Industries, Van Nuys, Calif.
90201	Mallory Capacitor Company, Indianapolis, Ind.
91637	Dale Electronics, Inc., Columbus, Neb.
91929	Micro Switch Div., Honeywell, Inc., Freeport, Ill.
92194	Alpha Wire Corporation, Elizabeth, N.J.
93332	Sylvania Electric Products, Inc., Woburn, Mass
98978	IERC, Burbank, Calif.
00002	Jordan Electronics, Van Nuys, Calif.
53504	Valhalla Scientific, Inc., San Diego, Calif.

PRECISION AC-DC CURRENT SOURCES

SPECIFICATIONS (25°C ±5° for 180 days)

Ranges

MODEL	1µA	10µA	100µA	1mA	10mA	100mA	1A	10A	100A
2500	■	■	■	■	■	■	■		
2500P			■	■	■	■	■		
2500E			■	■	■	■	■	■	
2500EN			■	■	■	■	■	■	
2500EP			■	■	■	■	■	■	
2555A				■	■	■	■	■	■
RESOLUTION	10pA	100pA	1nA	10nA	100nA	1µA	10µA	100µA	1mA

Dynamic Range: 0 to 200% of range up to maximum rated output.

Maximum Output Current: (DC or Peak AC) 2 amperes for 2500 & 2500P; 10 amperes for 2500E, 2500EN & 2500EP; 100 amperes for 2555A.

DC Accuracy:

2500, 2500P	±.01% of output ±.01% of range
2500E, EN, EP	±.01% of output ±.02% of range
2555A	±.03% of output ±.03% of range

AC Accuracy:

2500, 2500P	±.05% of output ±.01% of range to	1KHz
	±0.1% of output ±.05% of range to	10KHz
2500E, 2500EP	±.05% of output ±.05% of range to	5KHz
2500EN	±.05% of output ±.05% of range to	500KHz
	±0.2% of output ±.05% of range to	1KHz
	±0.5% of output ±0.1% of range to	5KHz
2555A	±.15% of output ±0.1% of range to	100Hz
	±0.2% of output ±0.2% of range to	400Hz
	±0.3% of output ±0.3% of range to	1KHz

Input Impedance: 100 Kilo-ohms all models except, 10 megohms on 2500EN.

Compliance Voltage: 10 volts DC or Peak AC all models except, 5 volts typical 4 volts minimum model 2555A.

Input/Output Ratio: 1.00000 volt input produces full scale output all models except, 10 volts for model 2500EN.

Maximum Input: 3 volts DC or Peak AC all models except, 30 volts DC or Peak AC model 2500EN.

Output Protection: Models 2500, 2500P fuse protected at 3 amps; models 2500E, 2500EN, 2500EP fuse protected at 10 amps.

Response Time: 1 millisecond to within ±0.01% of final value following input amplitude or frequency change.

Maximum Isolation Voltage: ±200 VDC or Peak AC.

Input Common Mode Rejection Ratio: 60db @ DC linearly decreasing to 40 db @ maximum frequency.

Load Regulation: Output current changes less than ±.002% per 1 volt change in compliance voltage.

Temperature Range: 0 to 50°C.

Temperature Coefficient: ±.001% of output ±.002% of range/°C for DC, below 20°C and above 30° (Double above T.C. for 2555A)

Duty Cycle: (2500 & 2500P only) 100% @ 1 ampere decreasing linearly to 25% @ 2 amperes with a 5 minute time constant.

Power: 115/230 VAC ±10% 50-60Hz.

Dimensions

MODEL	2500, 2500P	2500E 2500EN, 2500EP	2555A
Length	22.9cm/9"	38.1cm/15"	43.2cm/17"
Width	38.1cm/15"	43.2cm/17"	43.2cm/17"
Height	6.4cm/2.5"	13.3cm/5.25"	26.7cm/10.5"
Net Wt.	7 Kg/15 lbs.	14 Kg/30 lbs.	45 Kg/100 lbs.
Ship Wt.	9 Kg/20 lbs.	18 Kg/40 lbs.	66 Kg/140 lbs.

Ordering Information

Current Calibrators

2500	2500EN
2500P	2500EP
2500E	2555A

Auxilliary Instruments

2575	2009

Accessories

"C"	"R1"
"BBC"	"R2"
"HC"	"R3"
"HMF"	

Specifications and prices subject to change without notice.

Represented By:

Valhalla Scientific Inc.

[redacted]

150K