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Section 1: Power-On Voltage Tests for the 143 and 465 Boards

This section describes the power-on voltage tests that should be performed before calibrating a 143 Profiler and Signal Linearizer Board.

NOTE: Any warranty service to be performed at the customer's site must be previously approved in writing by Kurz Instruments. Nonwarranty service should be performed only by a certified electrical technician. Refer to Appendix A for component layouts and schematics.

1.1 System Interconnections

For the EVA 4000 or IK-EVA 4200 systems to operate properly, the interconnections between the Series 195 Current-Transmitter Enclosure and the Series 193 System Electronics Enclosure must be correct. In most cases, a cable harness is connected between field terminals in the 195 and 193 enclosures. Since each configuration of each EVA and IK-EVA system varies it is best to refer to the field wiring drawings supplied with your system to verify the system interconnections.

1.1.1 Sensor Connections to the 465 Current-Transmitter Boards

The sensor wires should be connected to terminal block 2 (TB2) on the appropriate 465 Current-Transmitter Board as as indicated in Figure 1-1 and Table 1-1. Verify that the four wires from each sensor in the EVA or IK-EVA probes are connected to Terminal Block 2 on the appropriate 465 Current-Transmitter Board in the Series 195 enclosure. As shown in the Table 1-1, the colors of the sensor wires may vary, depending on the kind of cable used.

For EVA 4000 transmitter-attached systems where the 195 enclosure is attached to the probe support, these connections have been made at the factory. When installing the EVA 4000 transmitter-separate and IK-EVA 4200 systems, you have to connect the sensor wires before the system is operational.

The four wires for Sensor # 1 (or Sensor A) should be connected to the 465 Current Transmitter Board #1 (FT1) in the 195 enclosure. The four wires for Sensor # 2 (or Sensor B) should be connected to the 465 Current Transmitter Board #2 (FT2), the four wires for Sensor # 3 (or Sensor C) should be connected to the 465 Current Transmitter Board #3 (FT3), and the four wires for Sensor # 4 (or Sensor D) should be connected to the 465 Current Transmitter Board #4 (FT4). The locations of the 465 Current Transmitter Boards inside the 195 enclosure are shown in Figure 1-1.

Figure 1-1. *465 Current-Transmitter Boards Inside 195 Enclosure*

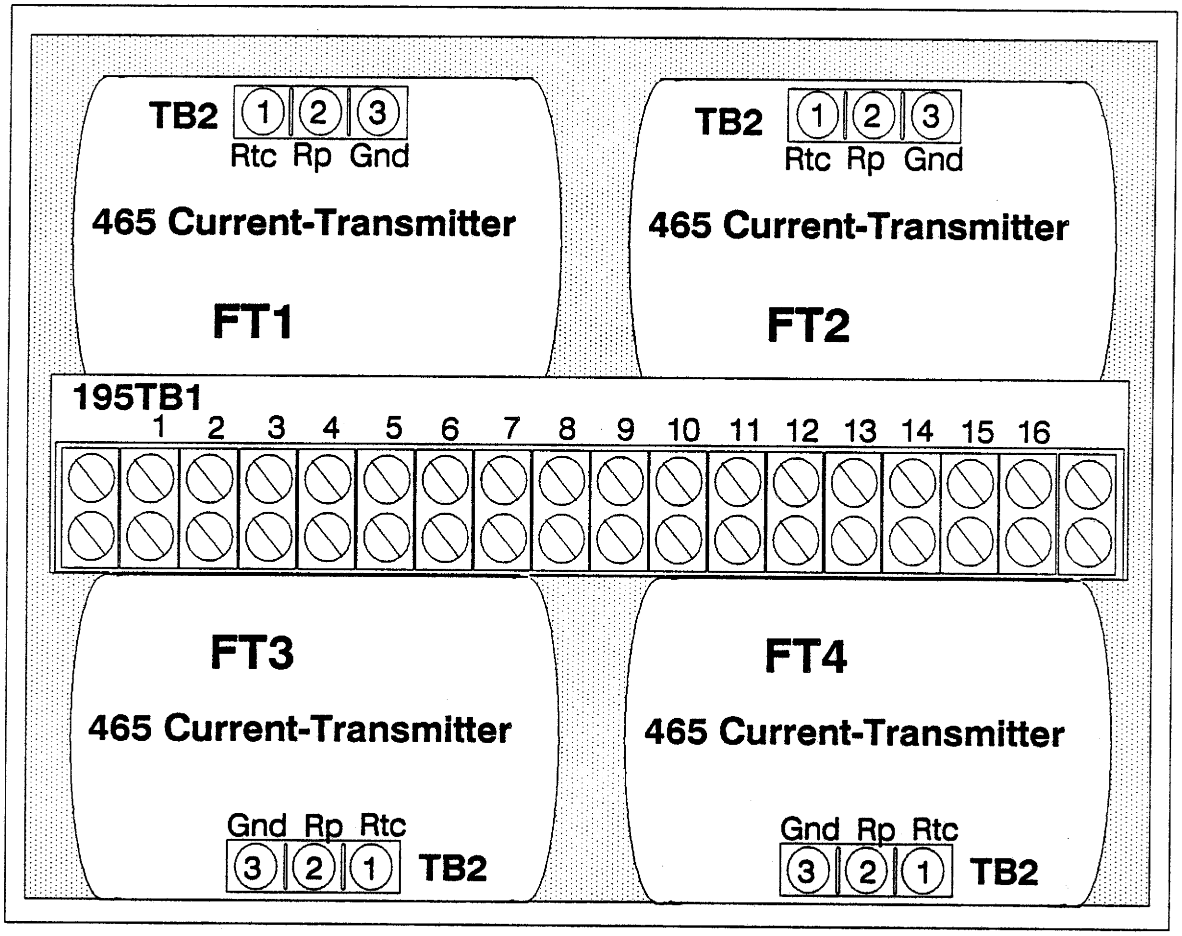


Table 1-1. *Sensor Cable Wire Colors and Terminal Connections*

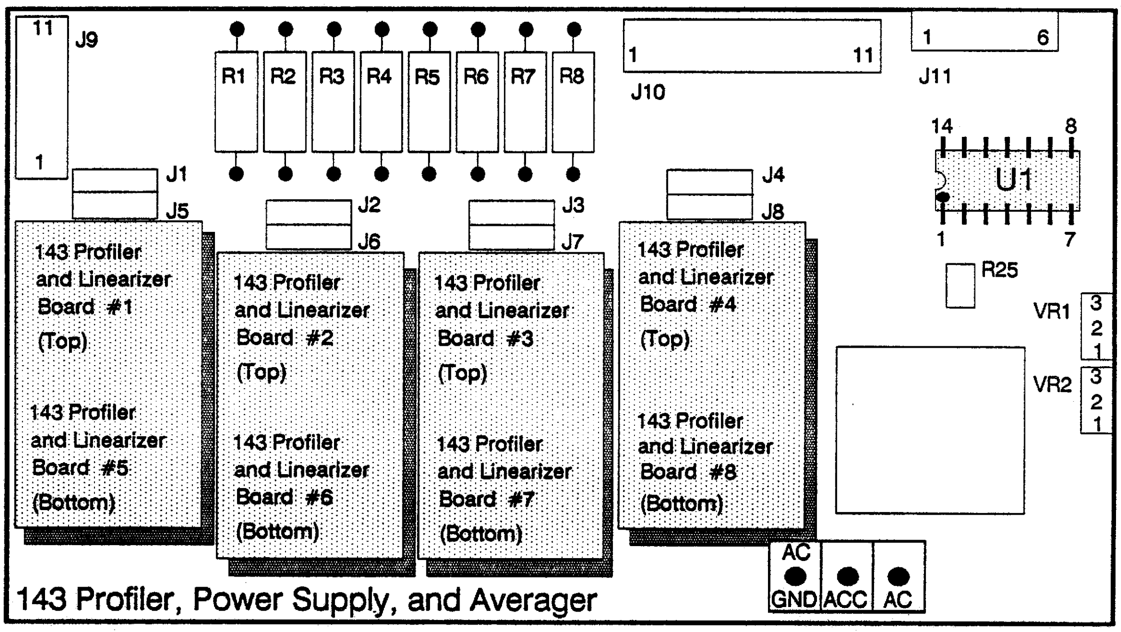
Signal	Color			Terminal
	Teflon Cable	Teflon Wire	Tefzel Cable	
R_{tc}	White/Blue	White	White/Blue	1
R_p	White/Orange	Red	White/Orange	2
R_{tc} GND	White	White	White	3
R_p GND	White/Green	Red	White/Green	3
Shield	*shield*	N/A	*shield*	*

** Shield is used on remote current-transmitter electronics and is connected to earth ground at electronics. The circuit ground used on the current-transmitter board (i.e. Rtc GND, Rp GND, and GND) is not connected to any other ground.*

1.2 Testing the 143 Profiler, Power Supply, and Averager Board

The electronics assembly inside the 151 module consist of the 143 Profiler, Power Supply, and Averager Board (baseboard) and one to eight 143 Profiler and Signal Linearization Boards (one per sensor). The smaller 143 Profiler and Signal Linearization Boards are mounted on top of the 143 Profiler, Power Supply, and Averager Board (baseboard). If there are more than 4 sensors in the system, additional 143 Profiler and Signal Linearization Boards are piggy-backed above the others. The electronic assembly is shown in Figure 1-2.

Figure 1-2. *Locations of the 143 Profiler and Linearizer Boards on the 143 Profiler, Power Supply, and Averager Board*

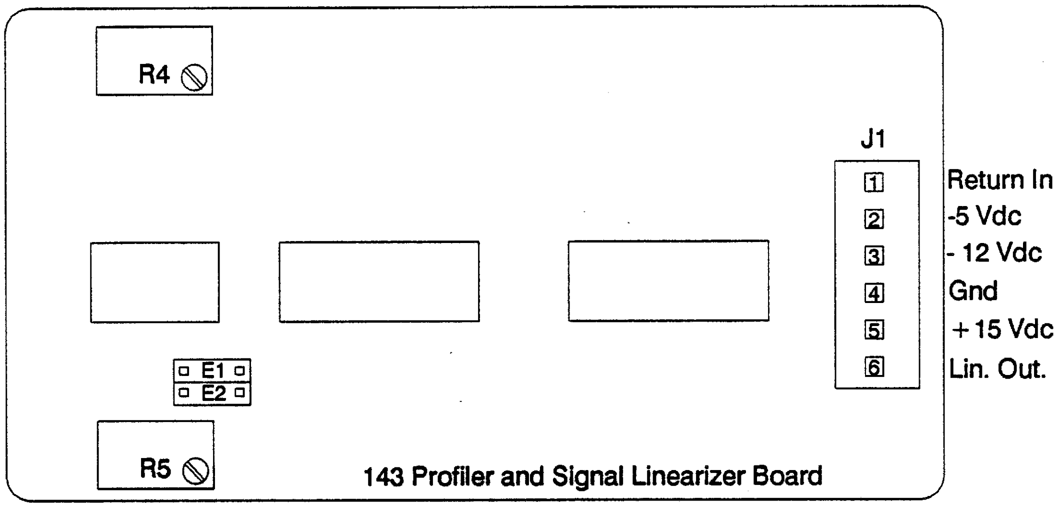


To test the power supplies provided by the 143 Profiler, Power Supply, and Averager Board, you will need:

- a digital voltmeter accurate to +/-.001 Vdc
- a flat-bladed screwdriver with a narrow blade and a long shaft

It is easiest to measure the supplies at the connector J1 on the 143 Profiler and Linearizer Boards. It is through this connector that the signals are transmitted between the 143 Profiler, Power Supply, and Averager Board (baseboard) and each of the 143 Profiler and Linearizer Boards. Refer to Figure 1-3 for the location of J1 on the 143 Profiler and Linearizer Board.

Figure 1-3. *143 Profiler and Linearizer Board*



The placement of the 143 Profiler and Linearizer Boards on the 143 baseboard is shown in Figure 1-2. The connector J1 on the linearization board for sensor #1 is connected to J1 on the 143 baseboard, J1 on the the linearization board for sensor #2 is connected to J2 on the 143 baseboard, J1 on the the linearization board for sensor #3 is connected to J3 on the 143 baseboard, and so on.

All test steps **except** step 4 can be verified with the 143 Profiler, Power Supply, and Averager Board (and the adjoining 143 linearizer boards) disconnected from the 465 board. This allows you to remove and test the 143 board outside of the enclosure. When the 143 board is removed from the enclosure a power source must be connected as follows:

AC Gnd. - Terminal Block 1, Terminal # 1
ACC - Terminal Block 1, Terminal # 2
AC - Terminal Block 1, Terminal # 3

The location of the AC connections is shown in Figure 1-2.

You can verify the power supplies to each of the linearization boards or a single board that is associated with a particular sensor. An example of the test procedure for testing the 143 circuits for sensor #1 is described in this subsection.

Step 1: Measure the voltage between pins 3 (-12 Vdc) and 4 (GND) of J1 on the 143 linearizer board for sensor #1. The voltage should be -12.000 +/- 0.36 Vdc.

As shown in Figure 1-1, the linearizer for sensor #1 is located on the left-hand side of the board. Connector J1 on the linearizer board is connected to J1 on the baseboard. If there are more than 4 sensors in the system, the linearizer for sensor #1 is mounted on top of spacers above the linearizer for sensor #5.

If this voltage is absent or out of range, check the connection between the 143 baseboard and the 143 linearizer board. If the connection is good, measure the voltage between pins 1 (GND) and 3 (-12 Vdc) of VR1 on the 143 Profiler, Power Supply, and Averager Board. If the voltage on pin 3 is absent, check the AC connections to the 143 baseboard. Refer to Figure 1-2 on page 1-4 for the locations of VR1 and the AC connections on the 143 Profiler, Power Supply, and Averager Board.

Step 2: Measure the voltage between pins 5 (+15 Vdc) and 4 (GND) of J1 on the 143 linearizer board for sensor #1. The voltage should be +15.000 +/- 0.45 Vdc.

If this voltage is absent or out of range, check the connection between the 143 baseboard and the 143 linearizer board. If the connection is good, measure the voltage between pins 2 (GND) and 3 (+15 Vdc) of VR2 on the 143 Profiler, Power Supply, and Averager Board. If the voltage on pin 3 is absent, check the AC connections to the 143 baseboard. Refer to Figure 1-2 on page 1-4 for the locations of VR2 and the AC connections on the 143 Profiler, Power Supply, and Averager Board.

Step 3: Measure the voltage between pins 2 (-5 Vdc) and 4 (GND) of J1 on the 143 linearizer board for sensor #1. Adjust R25 to get a voltage of -5.000 +/- 0.001 Vdc.

If this voltage is absent or out of range, check the connection between the 143 baseboard and the 143 linearizer board. If the connection is good, measure the voltage between pins 5 (GND) and 7 (-5 Vdc) of U1 on the 143 Profiler, Power Supply, and Averager Board. If the voltage on pin 7 is absent, check the AC connections to the 143 baseboard. Refer to Figure 1-2 on page 1-4 for the locations of U1 and the AC connections on the 143 Profiler, Power Supply, and Averager Board.

Step 4: Measure the voltage between pins 1 (RET IN) and 4 (GND) of J1 on the 143 linearizer board for sensor #1. This is the current-sense voltage derived from the sensor's return signal. With no flow passing by the sensor, the voltage should be approximately 0.6 Vdc. With maximum flow, the voltage should be approximately 2.00. This voltage is nominal. Refer to the calibration certificates that accompany your system.

If this voltage is absent or out of range, check the connection between the 143 baseboard and the 143 linearizer board. If the connection is good, measure the voltage between pin 1 (GND) and the pin 2 of J10 on the 143 Profiler, Power Supply, and Averager Board. The return signals for sensors 2 through 8 can be measured on pins 3 through 9, respectively. Refer to Figure 1-2 on page 1-4 for the locations of J10 on the 143 Profiler, Power Supply, and Averager Board.

If the voltage on J10 pin 2 (or pin 3-9) is absent, check the connections between the 195 Current-Transmitter Enclosure and the 193 System Electronics Enclosure. Refer to the field wiring interconnection drawings supplied with your system to verify that the return signal for that sensor is present at the correct field terminal. If it is not, check the appropriate 465 Current-Transmitter Board.

1.3 465 Current-Transmitter Board Bridge-Voltage Tests

To perform the current-transmitter board bridge-voltage test, you will need a digital voltage meter accurate to within +/-.001 Vdc.

Before you perform the test, check to make sure that the following four conditions are met:

- The sensor wires are correctly wired to the appropriate 465 Current-Transmitter Board as described in Section 1.1.1.
- No flow is moving past the sensor.
- AC power is supplied to the 143 Profiler, Power Supply, and Averager Board.

The test consists of checking the voltages between pairs of test points on the current-transmitter board. The test points are labeled on the board itself as "TP1", "TP2", and "TP3". They are called out for easy reference in Figure 1-4 (465R4) and Figure 1-5 (465R5). Although the 465R5 board has additional test points, only "TP1", "TP2", and "TP3" are used for this test procedure.

Figure 1-4. *465R4 Current-Transmitter Board Test Points*

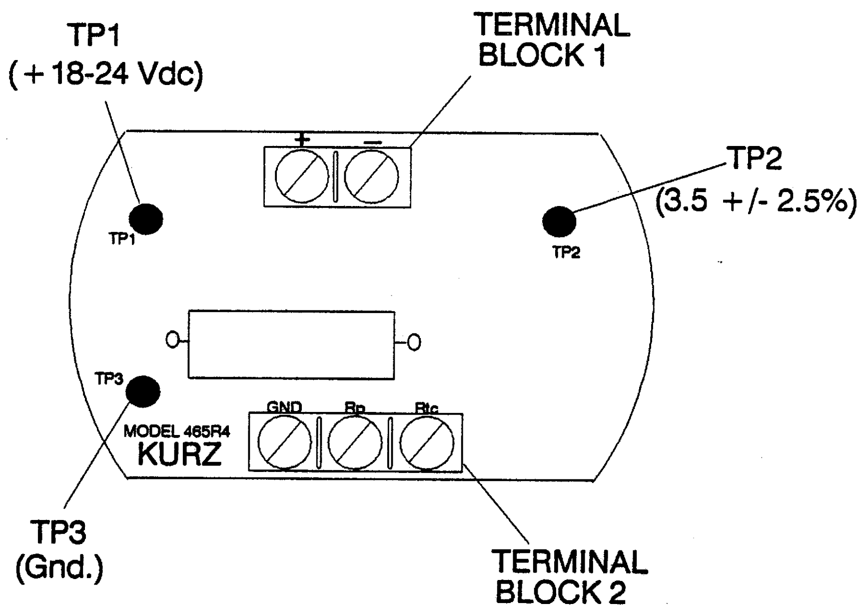
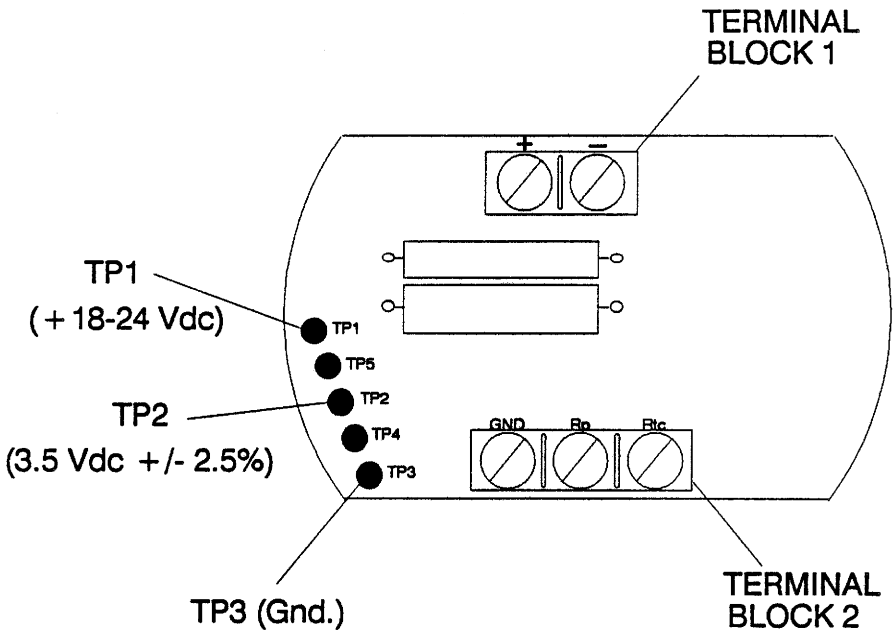


Figure 1-5. *465R5 Current-Transmitter Board Test Points*



Step 1: Check the voltage between Test Point 1 (TP1) and Test Point 3 (TP3, ground). This is the unregulated supply voltage (from the 435R1 board) and should read in the range of +18-24 Vdc.

Step 2: Check the voltage between Test Point 2 (TP2) and Test Point 3 (TP3, ground). This is the bridge voltage and should read 3.5 Vdc +/- 0.0875 (2.5% of 3.5 Vdc), under no flow conditions. This is the nominal reading; refer to your calibration certificate for the exact rated voltage of your unit.

CAUTION: If the bridge voltage is +5 Vdc or more (with no flow moving past the sensor), and the voltage does not start to drop below five volts within five to ten seconds, turn power off **immediately**. Supplying power for more than five to ten seconds under these conditions may result in damage to the probe.

Section 2: Calibrating the 151 Linearization Module

The recalibrate the 151 Linearization Module used in an EVA or IK-EVA system you will need:

- A digital voltmeter accurate to +/-.001 Vdc.
- A Laminar Flow Element (LFE) or wind tunne.l
- A thermometer placed in such a way as to accurately determine the temperature of the air flowing through the laminar flow element.
- A barometer to measure the pressure in the area in which the flow meter is calibrated.
- The certification sheets supplied by Kurz with the system.
- Laminar flow element graph that is supplied with the NBS-traceable laminar flow element.
- Data sheets or worksheets for recording calibration information. A sample calibration data sheet is provided in Appendix A. You are free to duplicate this sheet for your use when calibrating the system.

The digital voltmeter, laminar flow element, thermometer, and barometer used to calibrate the system should be NBS-traceable.

2.1 Check Voltages and Wiring Interconnections

Before you begin calibrating the 151 Linearization Module, make sure you have completed the tests described in Section 1. This includes verifying the voltages on the 143 Profiler, Power Supply, and Averager Board and 465 Current-Transmitter Boards.

Also, the connections should have been checked between:

(1.) the sensor wires and the 465 boards inside the 195 enclosure
(2.) the 195 enclosure and the 193 enclosure
(3.) the 143 Power Supply, and Averager Board (baseboard) and each 143 Profiler and Linearizer Board in the system.

If you are removing a 151 module from the 193 enclosure, refer to Appendix A for information on how to connect the electronics.

2.2 Record Flow Rates

Record the flow rates for the calibration points in the first column of the table used on the data sheet. The flow velocities are listed on the certification sheets provided with your system.

However, if you want to calibrate the system to measure a different flow range:

Step 1: Record the maximum flow rate in the last row of the flow column, point #11.

Step 2: Divide the maximum flow rate by 10. This is the decremental value that will be used to obtain flow rates for calibration points #2 through #10. For example if the maximum flow rate is 1500 SFPM (Standard Feet Per Minute) then the decremental value is 150.

Step 3: Subtract this value from the maximum flow rate (point #11) to obtain the flow rate for point #10.

For example if the maximum flow rate (point #11) is 1500 SFPM, then the value for point #10 is 1350 SFPM (1500-150). Next, subtract the decremental value from the flow rate for calibration point #10 to obtain the value for point #9 (1350-150 = 1200). Continue to subtract the decremental value from each calculated flow rate to obtain the flow rate of the preceeding calibration point until you have calculated the rate for point #2.

Step 4: After you have calculated the flow rate for calibration point #2, divide this rate by half to obtain the flow rate for calibration point #1.

Step 5: The value for calibration point #0 is 0.

If you were calibrating an EVA or IK-EVA system that had a flow range of 0-1500 SFPM, the flow ranges would be as shown in Figure 2-1.

Figure 2-1. *Calibration Velocities Recorded on Data Sheet (Example)*

	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA
0	0						
1	75						
2	150						
3	300						
4	450						
5	600						
6	750						
7	900						
8	1050						
9	1200						
10	1350						
11	1500						

	Break Point Voltage	Linear Vdc	Linear Output mA
1			
2			
3			
4			
5			
6			
7			

LFE S/N: ________________
Model #: ________________
DVM S/N: ________________
Temp. S/N: ________________
Bar. S/N: ________________
Freq. Ctr S/N: ________________
Pipe Size: ________________
Pipe Area: ________________
4-20mA Range: ____________

Date Due: ________________
LFE Area: ________________
Date Due: ________________
Date Due: ________________
Date Due: ________________
Date Due: ________________
I.D.: ____________________

Model: ________________
Range: ________ Range 2: ________
Power: VAC _____ Hz _____ VDC ___
Current Mode: YES _____ NO _____
DVM Reading: ____________
Bar. Pressure: ______________ "hg
Temperature: ______________ ° F
Calculated: R2 _______ R7 _______
Summing Amp.: Rf _____ Cap ______

COMMENTS

VOLTAGE DATA

Rectified: +V: _______ -V: _______
Regulated: +V: _______ -V: _______
Vdc Ref.: ________________
BV: Zero Flow: ____________
BV: Max Flow: ____________

CURRENT SENSE VOLTAGE

Zero Flow: ______________
Max. Flow: ______________
For Sensor Safety Circuit Only:

2.3 Record "Inches H_2O"

Record the "Inches H_2O" listed for each flow range from the laminar flow element graph supplied with your laminar flow element (LFE). Depending on the type of laminar flow element you have purchased from Kurz Instruments, the flow values will either be in velocity (such as Standard Feet Per Minute, SFPM) or in units of mass flow (Standard Cubic Feet per Minute, SCFM). Examples of laminar flow element graphs and "Inches H_2O" values are shown in Figures 2-2 and 2-3, on pages 2-5 and 2-6.

The laminar flow elements are calibrated for standard conditions of 25°C (70°F) temperature and 29.92 Hg. barometric pressure. Given standard conditions, the manometer attached to the LFE should indicate the "Inches H_2O" for a specified flow rate as shown by the laminar flow element graph. For example, the graph shown in Figure 8 indicates that when the flow is increased to 1900 SFPM (under standard conditions of 25°C and 29.92 Hg. pressure) the manometer should show 2" of water.

In most cases the temperature and/or pressure will not be standard and you will adjust for these differences later in the calibration procedure.

Figure 2-2. *Example of Laminar Flow Element Graph for Laminar Flow Element*

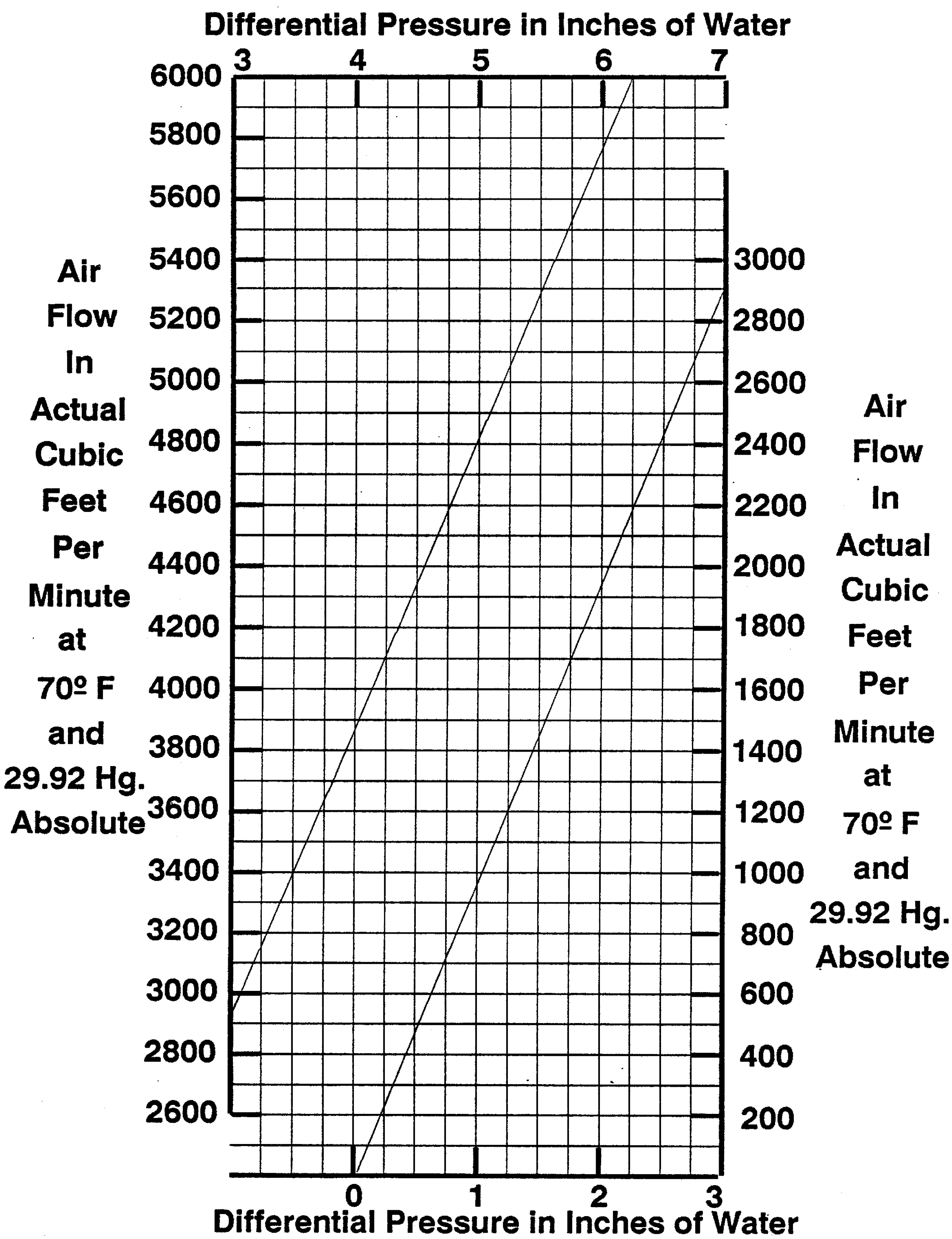


Figure 2-3. *"Inches H2O" Values from Laminar Flow Element Graph Shown in Figure 2-2*

	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA
0	0	0					
1	75	.090					
2	150	.160					
3	300	.310					
4	450	.470					
5	600	.620					
6	750	.780					
7	900	.930					
8	1050	1.090					
9	1200	1.245					
10	1350	1.410					
11	1500	1.575					

	Break Point Voltage	Linear Vdc	Linear Output mA
1			
2			
3			
4			
5			
6			
7			

LFE S/N: ____________
Model #: ____________
DVM S/N: ____________
Temp. S/N: ____________
Bar. S/N: ____________
Freq. Ctr S/N: ____________
Pipe Size: ____________
Pipe Area: ____________
4-20mA Range: ____________

Date Due: ____________
LFE Area: ____________
Date Due: ____________
Date Due: ____________
Date Due: ____________
Date Due: ____________
I.D.: ____________

Model: ____________
Range: ________ Range 2: ________
Power: VAC _____ Hz _____ VDC ___
Current Mode: YES _____ NO _____
DVM Reading: ____________
Bar. Pressure: ____________ "hg
Temperature: ____________ °F
Calculated: R2 ______ R7 ______
Summing Amp.: Rf _____ Cap _____

COMMENTS

VOLTAGE DATA
Rectified: +V: _______ -V: _______
Regulated: +V: _______ -V: _______
Vdc Ref.: ____________
BV: Zero Flow: ____________
BV: Max Flow: ____________

CURRENT SENSE VOLTAGE
Zero Flow: ____________
Max. Flow: ____________
For Sensor Safety Circuit Only:
Zener _______ V Ballast ________

2.4 Record the Ideal Voltages on the Data Sheet

Record the ideal voltages for each calibration point in the appropriate column. Starting with the maximum voltage of 5.000 Vdc for calibration point #11, decrement the previous ideal voltage by .5 Vdc until you have the ideal voltage for calibration point #2. Then divide the ideal voltage of calibration point #2 by half to derive the ideal voltage for point #1. Calibration point #0 is always 0. Calibration point #11 is always 5.000.

The "ideal voltages" recorded should be:

Calibration Point	Ideal Voltage
#0	0.000 Vdc
#1	0.250 Vdc
#2	0.500 Vdc
#3	1.000 Vdc
#4	1.500 Vdc
#5	2.000 Vdc
#6	2.500 Vdc
#7	3.000 Vdc
#8	3.500 Vdc
#9	4.000 Vdc
#10	4.500 Vdc
#11	5.000 Vdc

2.5 Position Sensor in Wind Tunnel or Laminar Flow Element

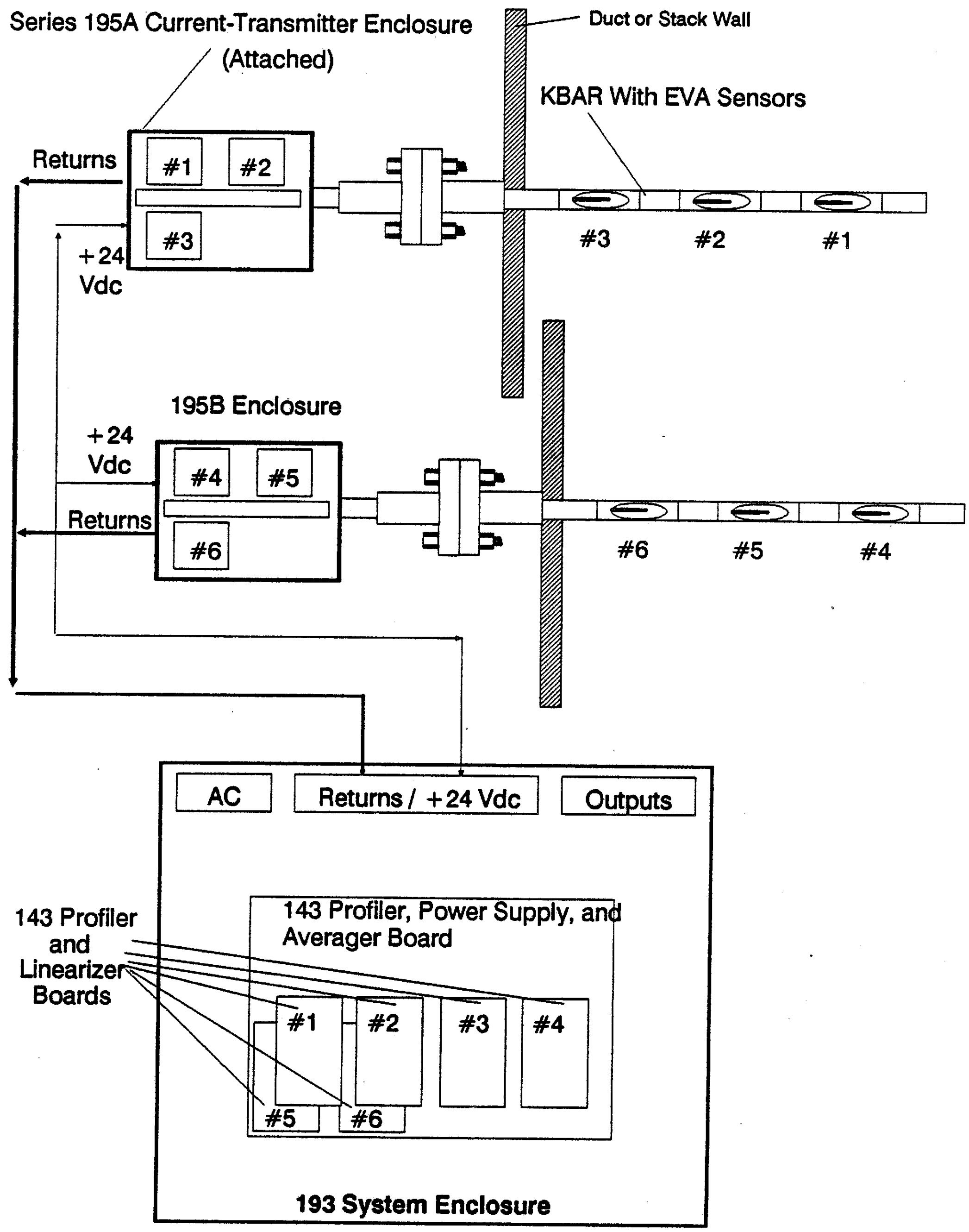
Position the sensor in the wind tunnel or Laminar Flow Element (LFE). If you are using a 400C-P or 400B-P, align the sensor 3" out and in the center of the flow coming out of the laminar flow element. The short sting of the dual-sting sensor should face the on-coming flow.

If you are using a 400A or 400B LFE insert the probe into coupling provided in the LFE chamber. The probe should be oriented so that the short sting of the dual-sting sensor should face the on-coming flow.

Verify that the manometer is connected to the pressure ports of the LFE.

Sensor #1 (or the lowest numbered sensor on the probe) is the sensor that is the most remote from the mounting flange on the K-BAR or IK-BAR probe. Figure 2-4 shows the sensors, 465 Current-Transmitter Boards, and 143 Profiler and Linearizer Boards for a 6-sensor system consisting of two separate probes, with 3 sensors each.

Figure 2-4. *EVA or IK-EVA System with 6 EVA Sensors*



2.6 Measure Current-Sense Voltage

Now you are ready to begin adjusting the flow through the wind tunnel or LFE. The flow will be adjusted to a specific level or reading on the water manometer used with the wind tunnel or LFE. The manometer reflects flow rates according to inches of water. First zero the manometer to read 0 inches of water with no flow.

The LFE is calibrated to a temperature of 25° C (70° F) and a barometric pressure of 29.92 inches Hg. Because the pressure and temperature at which you are calibrating the electronics will vary from these conditions, you must first "correct" the flow rate to the temperature and barometric pressure at which the board is calibrated.

For each calibration point starting with the maximum flow rate you must:

Step 1: Read the current temperature

Step 2: Use Table 2-1, on the next page, to derive the Temperature Correction Factor (TCF)

Step 3: Read the actual (current) barometric pressure (PA)

Step 4: Derive the Density Correction Factor (DCF).

If you are using the 400B-P or the 400C-P use the following formula:

$$DCF = \left(\left(\frac{H_2O}{13.6} + PA\right) / PS\right)(TCF)$$

If you are using the 400A, or an 400B, use the following formula:

$$DCF = \left(\frac{PA}{PS}\right)(TCF)$$

Where:

DCF = Density Correction Factor
H_2O = "Inches of Water" (from column 2 of data sheet)
PA = Actual Pressure read from barometer
PS = Pressure Standard
TCF = Temperature Correction Factor

Table 2-1. *Temperature Correction Factor*

Temp ºF	+0	+1	+2	+3	+4	+5	+6	+7	+8	+9
50	1.0848	1.0810	1.0773	1.0735	1.0698	1.0661	1.0625	1.0583	1.0552	1.0516
60	1.0480	1.0444	1.0409	1.0373	1.0339	1.0303	1.0269	1.0234	1.0200	1.0165
70	1.0132	1.0097	1.0064	1.0031	0.9997	0.9964	0.9931	0.9899	0.9866	0.9833
80	0.9802	0.9769	0.9738	0.9705	0.9674	0.9643	0.9611	0.9581	0.9549	0.9519
90	0.9489	0.9458	0.9428	0.9397	0.9368	0.9338	0.9308	0.9279	0.9250	0.9220

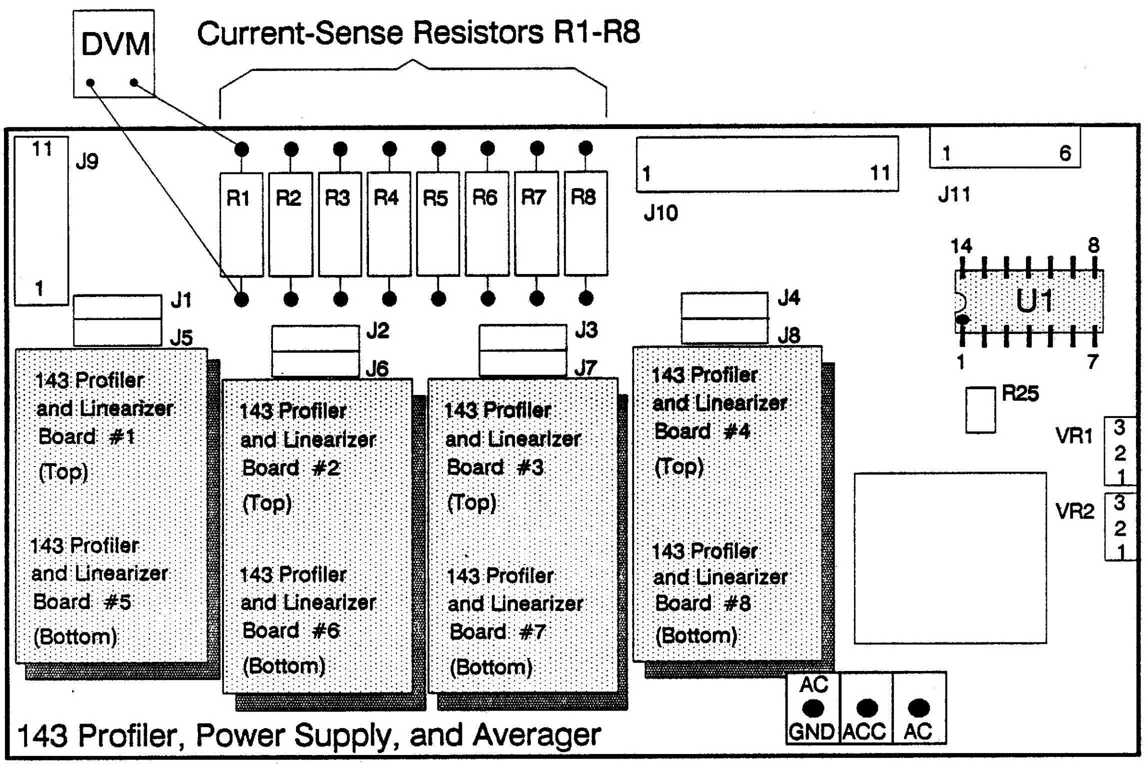
Step 5: Divide the "Inches of H_2O" recorded under the column heading "Inches H_2O" by the density correction factor to derive the "Actual Inches of H_2O". Adjust the flow of the wind tunnel LFE so that the reading on the manometer matches the calculated "Actual Inches of H_2O "

Step 6: Measure the voltage across the current-sense resistor that corresponds to the sensor being tested. The current-sense resistors, R1 through R8, are on the 143 Profiler, Power Supply, and Averager Board, in the upper left-hand corner of the board. Refer to Figure 2-5. R1 is the current-sense resistor for sensor #1, R2 is the current-sense resistor for sensor #2, R3 is the current-sense resistor for sensor #3, and so on. Each 143 Profiler, Power Supply, and Averager Board (baseboard) supports up to 8 sensors.

The current drawn by the velocity sensor (Rp) and transmitted by the each of the 465 Current-Transmitter Boards is dropped across the current-sense resistor to create the 0.6 Vdc to 2.00 Vdc (typical) current-sense voltage. At no flow, the current-sense voltage should be around 0.6 Vdc. At maximum flow, the current-sense voltage might be as high as 2.00 Vdc.

Step 7: Record the current-sense voltage (C.S.V.) under the column heading "Current Sense Voltage". Since the temperature of the air flowing through the LFE can vary over time, it is recommended that steps 1-7 are repeated for each calibration point. See the data sheet in Figure 2-6.

Figure 2-5. *Current-Sense Resistors on the 143 Profiler, Power Supply, and Averager Board (baseboard)*



This is the last procedure that requires the use of the LFE or wind tunnel. All other procedures can be done on a bench with the 143 Profiler, Power Supply, and Average Board (and associated 143 Profiler and Linearizer Boards) removed from the system. However, if you do remove the 143 baseboard or 151 Linearization Module from the 193 enclosure, be sure to connect AC to the board, as shown above.

Figure 2-6. *Current-Sense Voltages Measured for an EVA Sensor*

	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA
0	0	0	0.000	0.900			
1	75	.090	.250	1.075			
2	150	.160	.500	1.157			
3	300	.310	1.000	1.251			
4	450	.470	1.500	1.309			
5	600	.620	2.000	1.349			
6	750	.780	2.500	1.384			
7	900	.930	3.000	1.412			
8	1050	1.090	3.500	1.439			
9	1200	1.245	4.000	1.460			
10	1350	1.410	4.500	1.483			
11	1500	1.575	5.000	1.500			

	Break Point Voltage	Linear Vdc	Linear Output mA
1			
2			
3			
4			
5			
6			
7			

LFE S/N: ____________

Model #: ____________

DVM S/N: ____________

Temp. S/N: ____________

Bar. S/N: ____________

Freq. Ctr S/N: ____________

Pipe Size: ____________

Pipe Area: ____________

4-20mA Range: ____________

Date Due: ____________

LFE Area: ____________

Date Due: ____________

Date Due: ____________

Date Due: ____________

Date Due: ____________

I.D.: ____________

Model: ____________

Range: ________ Range 2: ________

Power: VAC _____ Hz _____ VDC ___

Current Mode: YES _____ NO _____

DVM Reading: ____________

Bar. Pressure: ____________ "hg

Temperature: ____________ ° F

Calculated: R2 _______ R7 _______

Summing Amp.: Rf _____ Cap _____

COMMENTS

VOLTAGE DATA

Rectified: +V: _______ -V: _______

Regulated: +V: _______ -V: _______

Vdc Ref.: ____________

BV: Zero Flow: ____________

BV: Max Flow: ____________

CURRENT SENSE VOLTAGE

Zero Flow: ____________

Max. Flow: ____________

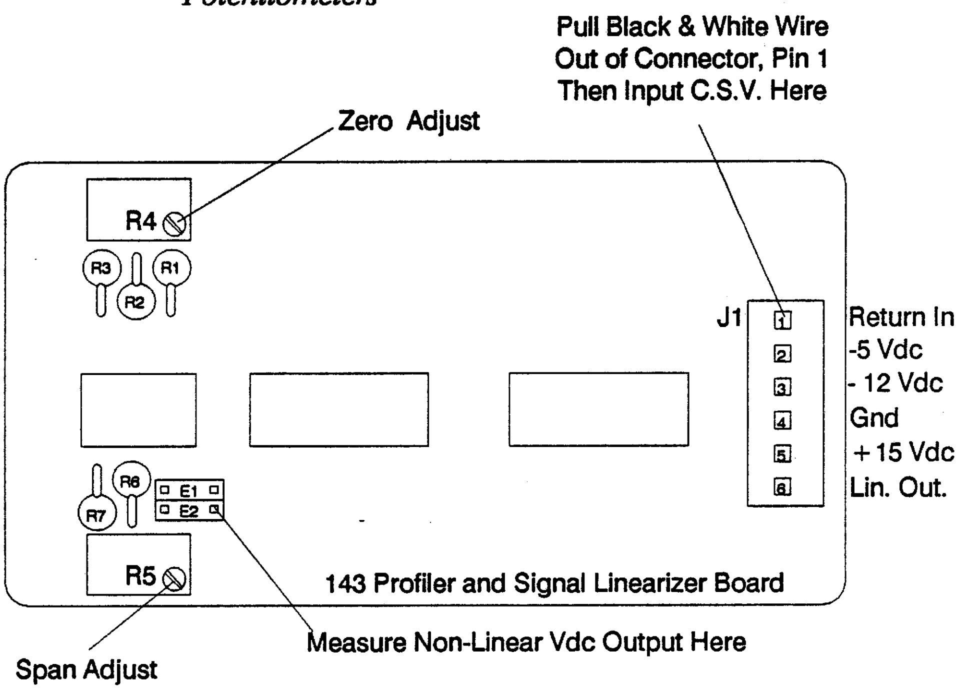
For Sensor Safety Circuit Only:

Zener ________ V Ballast ________

2.7 Adjusting the Zero and Span Potentiometers

The zero and span circuitry on each of the 143 Profiler and Linearizer Boards converts the current-sense voltage to a 0-5 Vdc non-linear signal. The zero and span calibration procedure requires using a variable 0-5 Vdc power source to input current-sense voltages into the zero and span circuit on the 143 Profiler and Linearizer Board. The voltages input to the circuit are the low and high current-sense voltage that you measured in Section 2.6. You will then adjust the zero and span potentiometers on the corresponding 143 Profiler and Linearizer Board. The procedure should be performed for each sensor in the system. The locations of the power supply input and the zero and span potentiometers are shown below.

Figure 2-7. *143 Profiler and Linearizer Board, Zero and Span Potentiometers*



Step 1: Put the test cable in place of the cable that is normally connected between the 143 Profiler, Power Supply, and Averager Board (baseboard) and the 143 Profiler and Linearizer Board. The test cable transmits all the same signals except for the return signal coming in from the sensor and normally transmitted to the 143 linearizer board through pin 1 of J1. See figure above.

Step 2: Use the variable power supply to input a voltage that is equal to the lowest current-sense voltage. This voltage will be listed under the column heading "Current Sense Voltage" for calibration point #0. Input the voltage to pin 1 of J1 on the 143 Profiler and Linearizer Board. In the example used in Figure 2-5, this would be a 0.900 Vdc input (Make sure you installed the test cable described in Step 1.)

Measure the voltage between pin 4 (GND) and the either side of the solder jumper E2 on the 143 linearizer board. (The jumper E2 should be installed unless you have a non-linear system.) You should check for zero voltage as quickly as possible because, after several minutes at zero flow, the heat produced by the velocity winding (Rp) begins to affect the ambient temperature winding (Rtc).

With the low current-sense voltage input, the measured voltage should be 0.000 +/- 0.25 Vdc. If necessary, adjust the zero-control potentiometer R4 until you get a reading of 0.000 Vdc.

If zero cannot be adjusted to its proper value using the zero-control potentiometers, proceed with Step 3 below and then to Section 2.8.

Step 3: Use the variable power supply to input a voltage that is equal to the highest current-sense voltage. This voltage will be listed under the column heading "Current Sense Voltage" for calibration point #11. Input the voltage to pin 1 of J1 on the 143 Profiler and Linearizer Board. In the example used in Figure 2-5 this would be a 1.500 Vdc input. (Make sure you installed the test cable described in Step 1.)

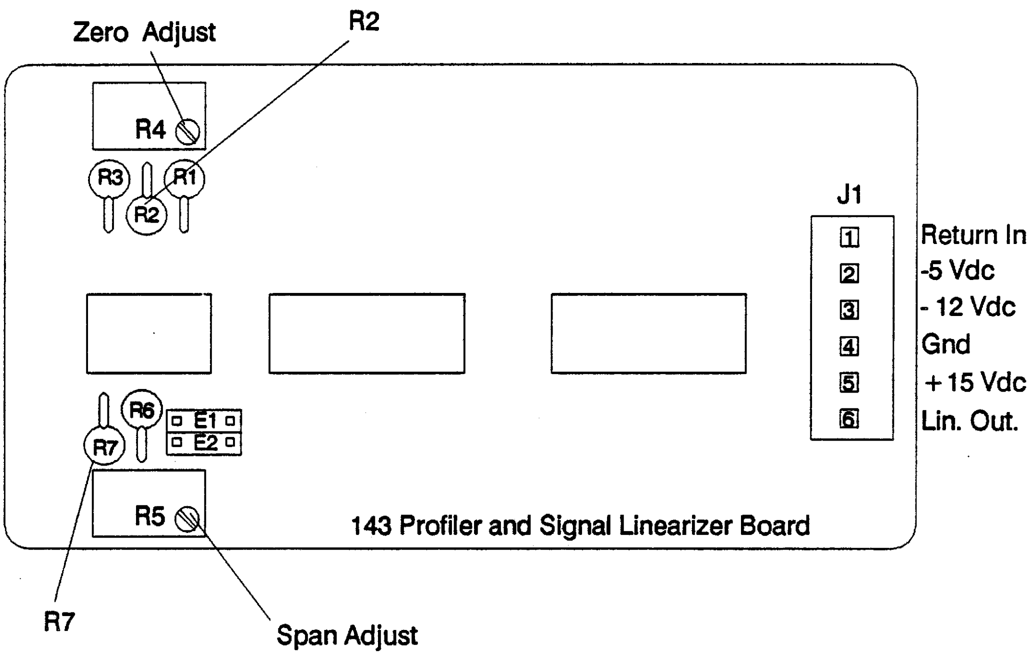
With the high current-sense voltage input, the measured voltage should be 5.000 Vdc. If necessary, adjust the span-control potentiometer R5 until you get a reading of 5.000 Vdc

If the span cannot be adjusted to its proper value using the span-control potentiometers, proceed to the next section, Section 2.8. If both the zero and span potentiometers adjusted correctly skip the next section (Section 2.8) and proceed to Section 2.9.

2.8 Correcting the Zero and Span Voltages, R2 and R7

The resistors R2 and R7 should be changed only when adjustments to the zero (R4) and span (R5) potentiometers do not correct to 0.000 Vdc or 5.000 Vdc when the low and high current-sense voltages are input to the zero and span circuit. The locations of R2 and R7 are shown in Figure 2-8.

Figure 2-8. *143 Profiler and Linearizer Board, Resistors R2 and R7*



The following formula is used to obtain resistor values for R2 and R7:

$$R2 \text{ in } K\,ohms = (50 / C.S.V.L) - 1$$

$$R7 \text{ in } K\,ohms = (1 / (C.S.V.L. - C.S.V.H.))\ (45.45)$$

Where:

C.S.V.L = Low Current-Sense Voltage

C.S.V.H = High Current-Sense Voltage

Insert the values for *C.S.V.L* and *C.S.V.H.* into the formula. The answer to the formula will be in K ohms (Kilo ohms). To get ohms multiply by 1000 for direct ohm value.

2.9 Calculate the Non-Linear Voltages

By performing the zero and span adjustments previously, you have adjusted the non-linear voltage of calibration point #0 to 0.000 Vdc and adjusted the non-linear voltage of calibration point #11 to 5.000 Vdc. Next you will calculate the non-linear voltages for the flow rates at the other calibration points.

The formula for calculating the non-linear voltage for a specific current-sense voltage is:

Non-Lin. Vdc = (C.S.V.P. - C.S.V.L.) / Factor Constant

where:

C.S.V.P. is the current-sense voltage for the calibration point for which you are calculating the non-linear voltage.

C.S.V.L. is the current-sense voltage for calibration point #0.

The Factor Constant is derived from the formula:

Factor Constant = (C.S.V.H. - C.S.V.L.) / 5

where:

C.S.V.H. is the current-sense voltage for calibration point #11.

C.S.V.L. is the current-sense voltage for calibration point #0.

Step 1: Using the formula:

Factor Constant = (C.S.V.H. - C.S.V.L.) / 5

calculate the Factor Constant.

Subtract the low current-sense voltage from the high current-sense voltage. Divide this number by 5 to derive the Factor Constant.

Using the values entered into the data sheet shown in Figure 2-7 on page 2-12:

Factor Constant = (1.500 Vdc. - .900 Vdc) / 5

Factor Constant = .12 = ((1.500 Vdc. - .900 Vdc) / 5)

The low current-sense voltage (the value in the "Current Sense Voltage" column for calibration point #0) is .900 Vdc. The high current-sense voltage (the value in the "Current Sense Voltage" column for calibration point #11) is 1.500 Vdc. Subtract the low current-sense voltage (.900 Vdc) from the high current-sense voltage (1.500 Vdc) and divide this value (.600 Vdc) by 5. A factor constant of .12 is derived from this calculation.

Step 2: Next calculate the non-linear voltage for calibration point #1 using the formula:

Non-Lin. Vdc = (C.S.V.P. - C.S.V.L.) / Factor Constant

Using the values entered into the data sheet shown in Figure 2-7 on page 2-12:

1.458 Vdc = (1.075 Vdc - .900 Vdc) / .12

The low current-sense voltage (the value in the "Current Sense Voltage" column for calibration point #1) is 1.075 Vdc. The low current-sense voltage (the value in the "Current Sense Voltage" column for calibration point #0) is .900 Vdc. Subtract the low current-sense voltage (.900 Vdc) from the current-sense voltage of calibration point #1 (1.075 Vdc) and divide this value (.175) by the factor constant of .12. A non-linear voltage of 1.458 Vdc is derived from this calculation.

Step 3: Continue to calculate the non-linear voltage for each current-sense voltage listed for calibration points #1 through point #10.

The calculations for the current-sense voltages are listed below. The non-linear values are entered in the data sheet as shown in Figure 2-9 on the next page.

Non-Lin. Vdc = (C.S.V.P. - C.S.V.L.) / Factor Constant

#0: *0.000 Vdc = (.900 Vdc - .900 Vdc) / .12*

#1: *1.458 Vdc = (1.075 Vdc - .900 Vdc) / .12*

#2: *2.142 Vdc = (1.157 Vdc - .900 Vdc) / .12*

#3: *2.925 Vdc = (1.251 Vdc - .900 Vdc) / .12*

#4: *3.408 Vdc = (1.309 Vdc - .900 Vdc) / .12*

#5: *3.742 Vdc = (1.349 Vdc - .900 Vdc) / .12*

#6: *4.033 Vdc = (1.384 Vdc - .900 Vdc) / .12*

#7: *4.267 Vdc = (1.412 Vdc - .900 Vdc) / .12*

#8: *4.492 Vdc = (1.439 Vdc - .900 Vdc) / .12*

#9: *4.667 Vdc = (1.460 Vdc - .900 Vdc) / .12*

#10: *4.858 Vdc = (1.483 Vdc - .900 Vdc) / .12*

#11: *5.000 Vdc = (1.500 Vdc - .900 Vdc) / .12*

Figure 2-9. *Non-Linear Voltages Calculated for each Calibration Point*

	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA
0	0	0	0.000	0.900	0.000		
1	75	.090	.250	1.075	1.458		
2	150	.160	.500	1.157	2.142		
3	300	.310	1.000	1.251	2.925		
4	450	.470	1.500	1.309	3.408		
5	600	.620	2.000	1.349	3.742		
6	750	.780	2.500	1.384	4.033		
7	900	.930	3.000	1.412	4.267		
8	1050	1.090	3.500	1.439	4.492		
9	1200	1.245	4.000	1.460	4.667		
10	1350	1.410	4.500	1.483	4.858		
11	1500	1.575	5.000	1.500	5.000		

	Break Point Voltage	Linear Vdc	Linear Output mA
1			
2			
3			
4			
5			
6			
7			

LFE S/N: ______________
Model #: ______________
DVM S/N: ______________
Temp. S/N: ______________
Bar. S/N: ______________
Freq. Ctr S/N: ___________
Pipe Size: ______________
Pipe Area: ______________
4-20mA Range: ___________

Date Due: ______________
LFE Area: ______________
Date Due: ______________
Date Due: ______________
Date Due: ______________
Date Due: ______________
I.D.: ________________

Model: ______________
Range: ________Range 2: ________
Power: VAC _____Hz_____VDC___
Current Mode: YES _____ NO _____
DVM Reading: ___________
Bar. Pressure: ___________ "hg
Temperature: ___________ ° F
Calculated: R2 _______ R7 _______
Summing Amp.: Rf _____ Cap _____

COMMENTS

VOLTAGE DATA
Rectified: + V: _______ -V: _______
Regulated: + V: _______ -V: _______
Vdc Ref.: ______________
Bv: Zero Flow: ___________
Bv: Max Flow: ___________

CURRENT SENSE VOLTAGE
Zero Flow: ______________
Max. Flow: ______________
For Sensor Safety Circuit Only:
Zener ________V Ballast ________

2.10 Graphing Data and Drawing Data From Curve

2.10.1 Graphing the Non-Linear Voltages

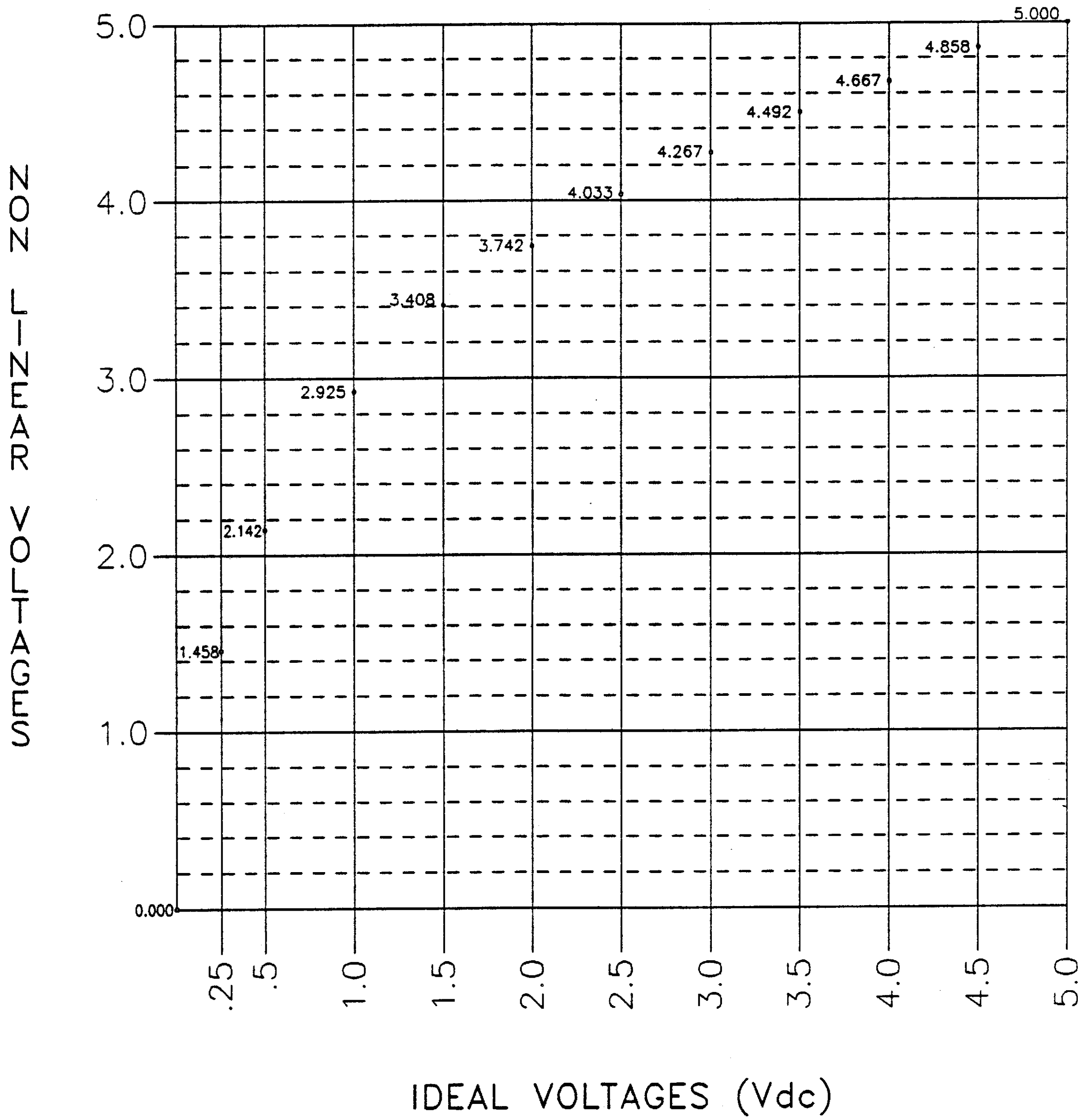
Next you will need to graph the non-linear voltages calculated as described in Section 2.9 against the ideal voltage. The ideal voltages are plotted on the x-axis and the non-linear data are plotted on the y-axis.

For example, the x-coordinates and the y-coordinates used in the previous example are:

X-Axis (Ideal Voltage)	Y-Axis (Non-Linear Data)
0 Vdc	0.000 Vdc
.250 Vdc	1.458 Vdc
.500 Vdc	2.142 Vdc
1.000 Vdc	2.925 Vdc
1.500 Vdc	3.408 Vdc
2.000 Vdc	3.742 Vdc
2.500 Vdc	4.033 Vdc
3.000 Vdc	4.267 Vdc
3.500 Vdc	4.492 Vdc
4.000 Vdc	4.667 Vdc
4.500 Vdc	4.858 Vdc
5.000 Vdc	5.000 Vdc

Figure 2-10 shows this data plotted on a graph.

Figure 2-10. *Graph of Non-Linear Voltages vs. Ideal Voltages*



The 0-5.000 Vdc "Ideal Voltage", across the horizontal axis, is going to later correspond to a 0-5.000 volts DC output needed to be adjusted for, with a vertical axis non-linear 0-5.000 volts DC input.

Draw a curve through data points with one continual slope, avoiding a straight point-to-point connection of data points.

The graph for the previous example is shown in Figure 2-11 on the following page.

2.10.2 Drawing Data From the Curve

Identify on the y-axis (vertical-axis) the 7 standard breakpoint voltages for the 151 Linearization Module. These should be:

Breakpoint #1	.711
Breakpoint #2	1.431
Breakpoint #3	2.157
Breakpoint #4	2.797
Breakpoint #5	3.563
Breakpoint #6	4.309
Breakpoint #7	5.000

Draw a horizontal line from each breakpoint voltage on the y-axis to a point on the curve. At that point on the curve draw a vertical line down to the baseline of the x-axis. The data on the x-axis represents the 0-5 Vdc output after the non-linear breakpoint voltage has been linearized.

For example, the curve used in Figure 2-11 now has the linearized "ideal voltages" at each of the breakpoints as shown in Figure 2-12 on page 2-24.

Now that you have derived the ideal voltages for each of the 7 breakpoints, fill in the column in the data sheet, labeled "Linear Vdc". The data sheet for the previous example is completed as shown in Figure 2-13 on page 2-25.

Figure 2-11. *Curve for Non-Linear Voltages vs. Ideal Voltages*

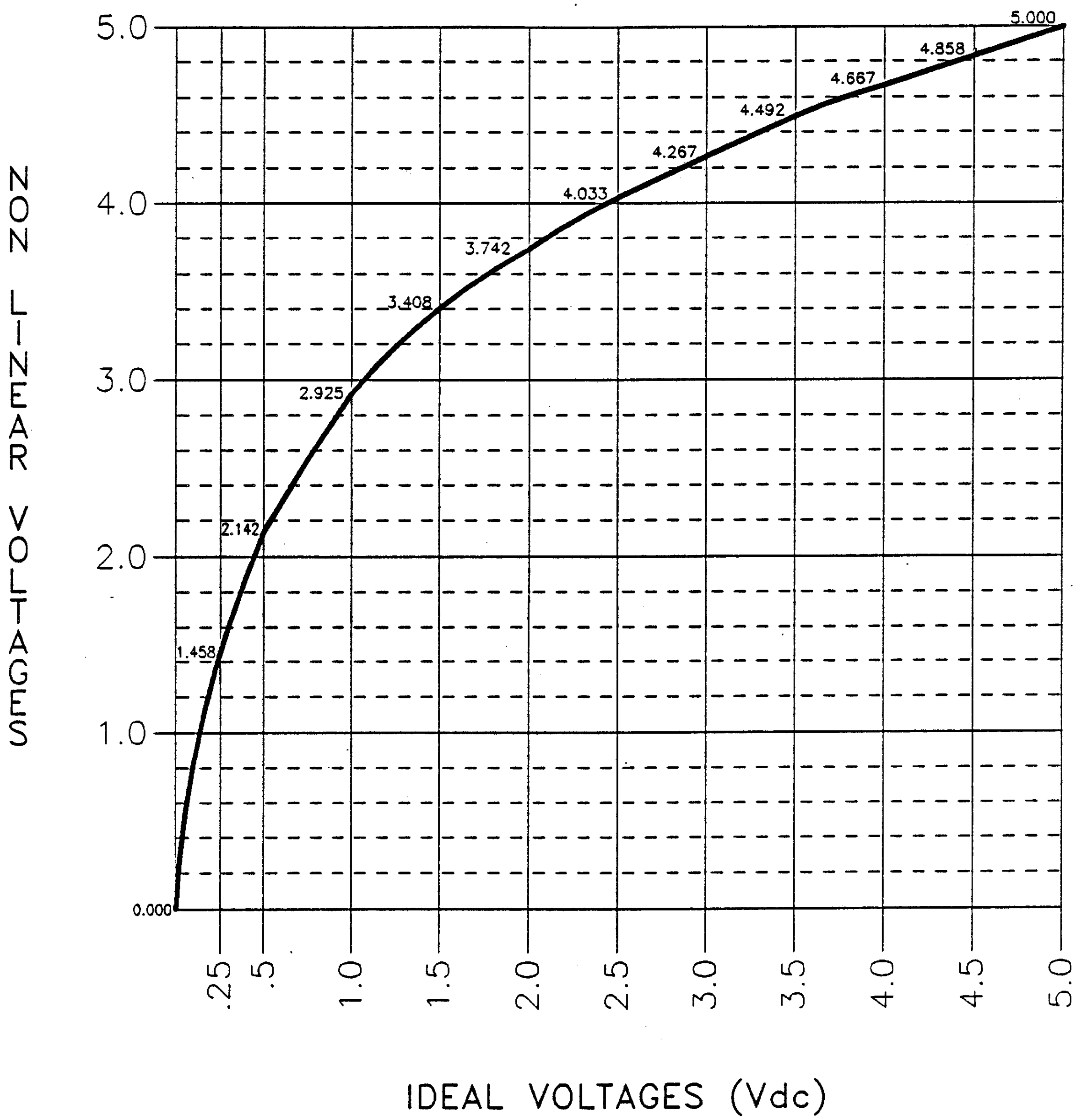


Figure 2-12. *Linearized Breakpoint Voltages*

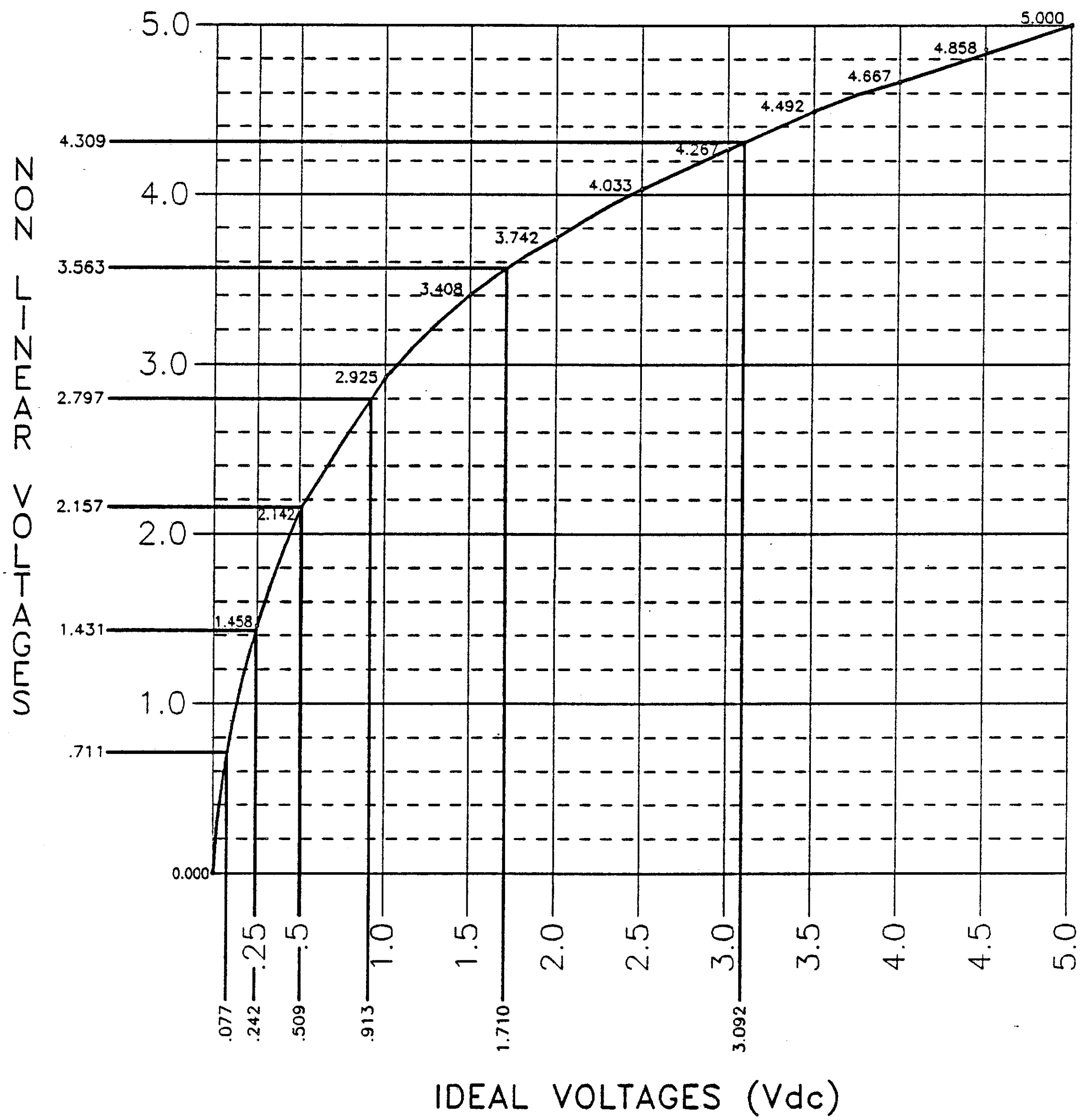


Figure 2-13. *Data Sheet with Linearized Breakpoints, "Linear Vdc"*

	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA		Break Point Voltage	Linear Vdc	Linear Output mA
0	*0*	*0*	*0.000*	*0.900*	*0.000*			1	*.711*	*.077*	
1	*75*	*.090*	*.250*	*1.075*	*1.458*			2	*1.431*	*.242*	
2	*150*	*.160*	*.500*	*1.157*	*2.142*			3	*2.157*	*.509*	
3	*300*	*.310*	*1.000*	*1.251*	*2.925*			4	*2.797*	*.913*	
4	*450*	*.470*	*1.500*	*1.309*	*3.408*			5	*3.563*	*1.710*	
5	*600*	*.620*	*2.000*	*1.349*	*3.742*			6	*4.309*	*3.092*	
6	*750*	*.780*	*2.500*	*1.384*	*4.033*			7	*5.000*	*5.000*	
7	*900*	*.930*	*3.000*	*1.412*	*4.267*						
8	*1050*	*1.090*	*3.500*	*1.439*	*4.492*						
9	*1200*	*1.245*	*4.000*	*1.460*	*4.667*						
10	*1350*	*1.410*	*4.500*	*1.483*	*4.858*						
11	*1500*	*1.575*	*5.000*	*1.500*	*5.000*						

LFE S/N: ______________
Model #: ______________
DVM S/N: ______________
Temp. S/N: ______________
Bar. S/N: ______________
Freq. Ctr S/N: ______________
Pipe Size: ______________
Pipe Area: ______________
4-20mA Range: __________

Date Due: ______________
LFE Area: ______________
Date Due: ______________
Date Due: ______________
Date Due: ______________
Date Due: ______________
I.D.: ______________

Model: ______________
Range: ________ Range 2: ________
Power: VAC ____ Hz ____ VDC ____
Current Mode: YES _____ NO _____
DVM Reading: __________
Bar. Pressure: ____________ "hg
Temperature: ____________ ° F
Calculated: R2 ______ R7 ______
Summing Amp.: Rf _____ Cap _____

<u>COMMENTS</u>

<u>VOLTAGE DATA</u>
Rectified: +V: _______ -V: _______
Regulated: +V: _______ -V: _______
Vdc Ref.: ______________
BV: Zero Flow: __________
BV: Max Flow: __________

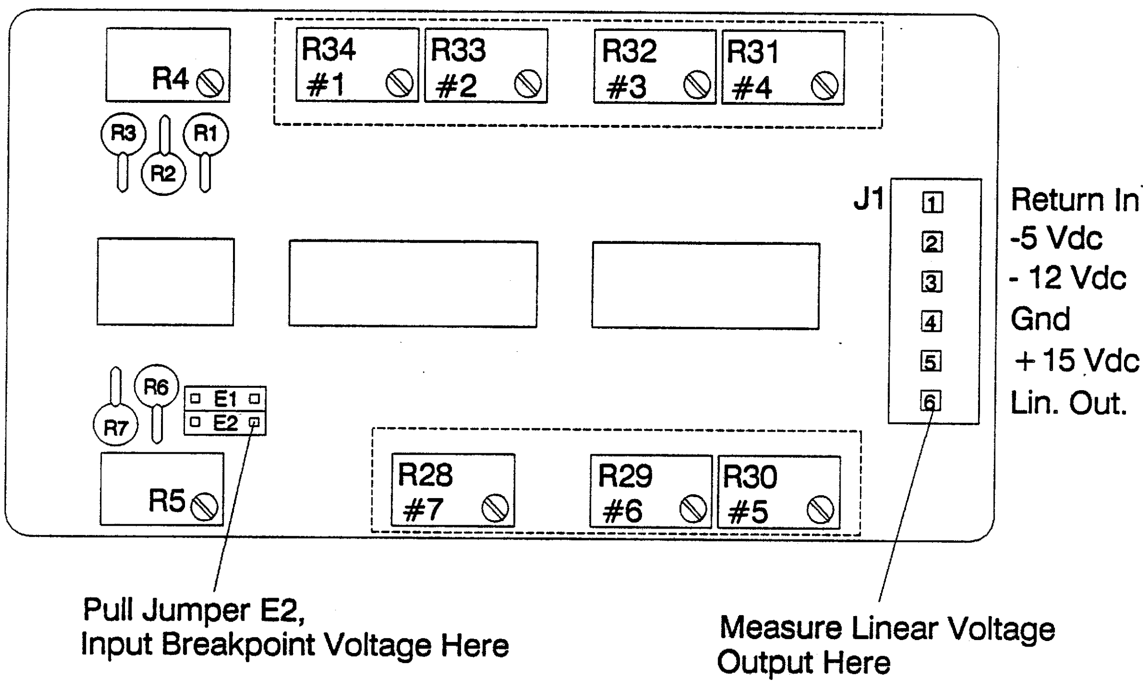
CURRENT SENSE VOLTAGE
Zero Flow: ______________
Max. Flow: ______________
For Sensor Safety Circuit Only:

2.11 Adjusting Linear Voltages for each Breakpoint

Working with data from the "Break Point Voltage" and "Linear Vdc" columns, set up 143 Profiler and Linearizer Board as follows.

Step 1: Pull out jumper E2. Refer to the diagram of the 143 Profiler and Linearizer Board in Figure 2-14. You will be adjusting the potentiometers shown within the dotted lines in the following steps. You will start by adjusting R34 and work clockwise through the potentiometers.

Figure 2-14. *Potentiometers Adjusted for Linearization Circuit of the 143 Profiler and Linearizer Board*



Step 2: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of jumper E2 that is equivalent to the breakpoint #1 voltage. Refer to the figure above for the location of E2. Measure the voltage at pin 6 of J1. Adjust R34 for the output voltage listed in the "Linear Vdc" for breakpoint #1.

Given the data used in the previous example, you would adjust R34 so that the meter measures 0.077 Vdc when a .711 Vdc supply voltage is input on the right-hand side of jumper E2.

Step 3: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of jumper E2 that is equivalent to the breakpoint #2 voltage. Measure the voltage at pin 6 of J1. Adjust R33 for the output voltage listed in the "Linear Vdc" for breakpoint #2.

Given the data used in the previous example, you would adjust R33 so that the meter measures 0.242 Vdc when a 1.431 Vdc supply voltage is input on the right-hand side of jumper E2.

Step 4: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of the jumper E2 that is equivalent to the breakpoint #3 voltage. Measure the voltage at pin 6 of J1. Adjust R32 for the output voltage listed in the "Linear Vdc" for breakpoint #3.

Given the data used in the previous example, you would adjust R32 so that the meter measures .509 Vdc when a 2.157 Vdc supply voltage is input on the other side of jumper E2.

Step 5: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of jumper E2 that is equivalent to the breakpoint #4 voltage. Measure the voltage at pin 6 of J1. Adjust R31 for the output voltage listed in the "Linear Vdc" for breakpoint #4.

Given the data used in the previous example, you would adjust R31 so that the meter measures .913 Vdc when a 2.797 Vdc supply voltage is input on the right-hand side of jumper E2.

Step 6: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the breakpoint #5 voltage. Measure the voltage at pin 6 of J1. Adjust R30 for the output voltage listed in the "Linear Vdc" for breakpoint #5.

Given the data used in the previous example, you would adjust R30 so that the meter measures 1.710 Vdc when a 3.563 Vdc supply voltage is input on the right-hand side of jumper E2.

Step 7: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of jumper E2 that is equivalent to the breakpoint #6 voltage. Measure the voltage at pin 6 of J1. Adjust R29 for the output voltage listed in the "Linear Vdc" for breakpoint #6.

Given the data used in the previous example, you would adjust R29 so that the meter measures 3.092 Vdc when a 4.309 Vdc supply voltage is input on the right-hand side of jumper E2.

Step 8: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of jumper E2 that is equivalent to the breakpoint #7 voltage. Measure the voltage at pin 6 of J1. Adjust R28 for the output voltage listed in the "Linear Vdc" for breakpoint #7.

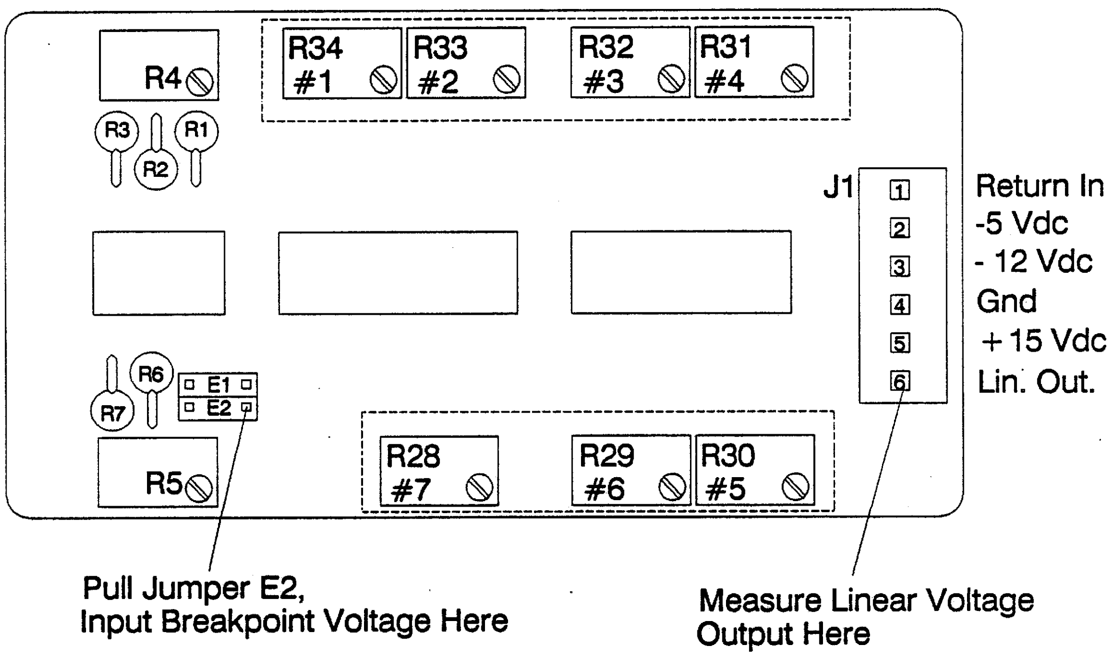
Given the data used in the previous example, you would adjust R28 so that the meter measures 5.000 Vdc when a 5.000 Vdc supply voltage is input on the right-hand side of jumper E2.

2.12 Checking the Linear Section for Accuracy

The linear section, if adjusted properly, should yield a plus or minus 2% of reading plus .5% of fullscale or better over a 10 to 1 range. The procedure for checking the accuracy of the linear section is much like the procedure for adjusting the linear voltages for each breakpoint voltage. However, instead of inputting breakpoint voltages to right-hand side of jumper E2, you will use the variable 0-5.000 supply to input the non-linear voltages listed on the data sheet, in the "Non-Linear Voltage" column for each calibration point. Measure the voltage at pin 6 of J1 on the 143 linearizer board and fill in the "Actual Output Voltage" column for each calibration point. Refer to Figure 2-21 for locations of the jumper E2 and pin 6 of J1.

If the unit passes the accuracy test, no further adjustments are needed, and unit is ready for use. If the unit fails, then bad data exists in flow set up or graphing, and the data should be verified.

Figure 2-15. *Locations of E2 and J1 on the 143 Linearizer Board*



Step 1: With zero volts (.000) input to the right-hand side of E2, measure the voltage output on pin 6 of J1. Record this voltage in the "Actual Output Voltage" for calibration point #0. The voltage should be no more than .025 Vdc.

Step 2: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #1. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #1.

Given the data used in the previous example, you would input a non-linear voltage of 1.458 Vdc for calibration point #1. For a non-linear voltage of 1.458 Vdc, the ideal voltage is .250 Vdc. Therefore the voltage measured at pin 6 should be no more than .280 Vdc or less than .220 Vdc.

Here is how we derived these numbers:

2% of .250 Vdc = .005 Vdc (2% of ideal voltage for calibration point #1)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.005 Vdc + .025 Vdc = .030 Vdc (+/- range)

.250 Vdc + .030 = .280 Vdc

.250 Vdc - .030 = .220 Vdc

Step 3: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #2. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #2.

Given the data used in the previous example, you would input a non-linear voltage of 2.142 Vdc for calibration point #2. For a non-linear voltage of 2.142 Vdc, the ideal voltage is .500 Vdc. Therefore the voltage measured at TS #2 should be no more than .535 Vdc or less than .465 Vdc.

Here is how we derived these numbers:

2% of .500 Vdc = .010 Vdc (2% of ideal voltage for calibration point #2)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.010 Vdc + .025 Vdc = .035 Vdc (+/- range)

.500 Vdc + .035 = .535 Vdc

.500 Vdc - .035 = .465 Vdc

Step 4: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #3. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #3.

Given the data used in the previous example, you would input a non-linear voltage of 2.925 Vdc for calibration point #3. For a non-linear voltage of 2.925 Vdc, the ideal voltage is 1.000 Vdc. Therefore the voltage measured at pin 6 should be no more than 1.045 Vdc or less than .955 Vdc.

Here is how we derived these numbers:

2% of 1.000 Vdc = .020 Vdc (2% of ideal voltage for calibration point #3)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.020 Vdc + .025 Vdc = .045 Vdc (+/- range)

1.000 Vdc + .045 = 1.045 Vdc

1.000 Vdc - .045 = .955 Vdc

Step 5: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #4. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #4.

Given the data used in the previous example, you would input a non-linear voltage of 3.408 Vdc for calibration point #4. For a non-linear voltage of 3.408 Vdc, the ideal voltage is 1.500 Vdc. Therefore the voltage measured at pin 6 should be no more than 1.555 Vdc or less than 1.445 Vdc.

Here is how we derived these numbers:

2% of 1.500 Vdc = .030 Vdc (2% of ideal voltage for calibration point #4)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.030 Vdc + .025 Vdc = .055 Vdc (+/- range)

.500 Vdc + .055 = 1.555 Vdc

1.500 Vdc - .055 = 1.445 Vdc

Step 6: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #5. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #5.

Given the data used in the previous example, you would input a non-linear voltage of 3.742 Vdc for calibration point #5. For a non-linear voltage of 3.742 Vdc, the ideal voltage is 2.000 Vdc. Therefore the voltage measured at pin 6 should be no more than 2.065 Vdc or less than 1.935 Vdc.

Here is how we derived these numbers:

2% of 2.000 Vdc = .040 Vdc (2% of ideal voltage for calibration point #5)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.040 Vdc + .025 Vdc = .065 Vdc (+/- range)

2.000 Vdc + .065 = 2.065 Vdc

2.000 Vdc - .065 = 1.935 Vdc

Step 7: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #6. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #6.

Given the data used in the previous example, you would input a non-linear voltage of 4.033 Vdc for calibration point #6. For a non-linear voltage of 4.033 Vdc, the ideal voltage is 2.500 Vdc. Therefore the voltage measured at pin 6 should be no more than 2.575 Vdc or less than 2.425 Vdc.

Here is how we derived these numbers:

2% of 2.500 Vdc = .050 Vdc (2% of ideal voltage for calibration point #6)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.050 Vdc + .025 Vdc = .075 Vdc (+/- range)

2.500 Vdc + .075 = 2.575 Vdc

2.500 Vdc - .075 = 2.425 Vdc

Step 8: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #7. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #7.

Given the data used in the previous example, you would input a non-linear voltage of 4.267 Vdc for calibration point #7. For a non-linear voltage of 4.267 Vdc, the ideal voltage is 3.000 Vdc. Therefore the voltage measured at pin 6 should be no more than 3.085 Vdc or less than 2.915 Vdc.

Here is how we derived these numbers:

2% of 3.000 Vdc = .060 Vdc (2% of ideal voltage for breakpoint #7)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.060 Vdc + .025 Vdc = .085 Vdc (+/- range)

3.000 Vdc + .085 = 3.085 Vdc

3.000 Vdc - .085 = 2.915 Vdc

Step 9: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #8. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #8.

Given the data used in the previous example, you would input a non-linear voltage of 4.492 Vdc for calibration point #8. For a non-linear voltage of 4.492 Vdc, the ideal voltage is 3.500 Vdc. Therefore the voltage measured at pin 6 should be no more than 3.595 Vdc or less than 3.405 Vdc.

Here is how we derived these numbers:

2% of 3.500 Vdc = .070 Vdc (2% of ideal voltage for calibration point #8)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.070 Vdc + .025 Vdc = .095 Vdc (+/- range)

3.500 Vdc + .095 = 3.595 Vdc

3.500 Vdc - .095 = 3.405 Vdc

Step 10: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #9. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #9.

Given the data used in the previous example, you would input a non-linear voltage of 4.667 Vdc for calibration point #9. For a non-linear voltage of 4.667 Vdc, the ideal voltage is 4.000 Vdc. Therefore the voltage measured at TS #2 should be no more than 4.105 Vdc or less than 3.895 Vdc.

Here is how we derived these numbers:

2% of 4.000 Vdc = .080 Vdc (2% of ideal voltage for calibration point #9)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.080 Vdc + .025 Vdc = .105 Vdc (+/- range)

4.000 Vdc + .105 = 4.105 Vdc

4.000 Vdc - .105 = 3.895 Vdc

Step 11: With a variable 0-5.000 volt DC supply, supply a voltage to the right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration #10. Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #10.

Given the data used in the previous example, you would input a non-linear voltage of 4.858 Vdc for calibration point #10. For a non-linear voltage of 4.858 Vdc, the ideal voltage is 4.500 Vdc. Therefore the voltage measured at pin 6 should be no more than 4.615 Vdc or less than 4.385 Vdc.

Here is how we derived these numbers:

2% of 4.500 Vdc = .090 Vdc (2% of ideal voltage for breakpoint #10)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

.090 Vdc + .025 Vdc = .115 Vdc (+/- range)

4.500 Vdc + .115 = 4.615 Vdc

4.500 Vdc - .115 = 4.385 Vdc

Step 12: With a variable 0-5.000 volt DC supply, supply a voltage to right-hand side of E2 that is equivalent to the voltage listed in the "Non-Linear Voltage" column for calibration point #11 (5.000 Vdc). Measure the voltage at pin 6 of J1. Record the voltage in the "Actual Output Voltage" for calibration point #11.

Given the data used in the previous example, you would input a non-linear voltage of 5.000 Vdc for calibration point #11. For a non-linear voltage of 5.000 Vdc, the ideal voltage is 5.000 Vdc. Therefore the voltage measured at pin 6 should be no more than 5.125 Vdc or less than 4.875 Vdc.

Here is how we derived these numbers:

2% of 5.000 Vdc = 0.1 Vdc (2% of ideal voltage for calibration point #11)

.5% of 5.000 Vdc = .025 Vdc (.5% of full scale)

0.1 Vdc + .025 Vdc = .125 Vdc (+/- range)

5.000 Vdc + .125 = 5.125 Vdc

5.000 Vdc - .125 = 4.875 Vdc

After measuring the "Actual Output Voltage", fill in the the data sheet. The example data sheet is completed as shown in Figure 2-22.

Figure 2-16. *Completed Data Sheet for the Calibation of an EVA Sensor*

	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA
0	0	0	0.000	0.900	0.000	0.000	
1	75	.090	.250	1.075	1.458	.255	
2	150	.160	.500	1.157	2.142	.514	
3	300	.310	1.000	1.251	2.925	1.042	
4	450	.470	1.500	1.309	3.408	1.538	
5	600	.620	2.000	1.349	3.742	2.002	
6	750	.780	2.500	1.384	4.033	2.518	
7	900	.930	3.000	1.412	4.267	3.040	
8	1050	1.090	3.500	1.439	4.492	3.482	
9	1200	1.245	4.000	1.460	4.667	3.972	
10	1350	1.410	4.500	1.483	4.858	4.503	
11	1500	1.575	5.000	1.500	5.000	5.000	

	Break Point Voltage	Linear Vdc	Linear Output mA
1	.711	.077	
2	1.431	.242	
3	2.157	.509	
4	2.797	.913	
5	3.563	1.710	
6	4.309	3.092	
7	5.000	5.000	

LFE S/N: ______________
Model #: ______________
DVM S/N: ______________
Temp. S/N: ______________
Bar. S/N: ______________
Freq. Ctr S/N: ______________
Pipe Size: ______________
Pipe Area: ______________
4-20mA Range: ______________

Date Due: ______________
LFE Area: ______________
Date Due: ______________
Date Due: ______________
Date Due: ______________
Date Due: ______________
I.D.: ______________

Model: ______________
Range: ________Range 2: ________
Power: VAC _____Hz_____VDC____
Current Mode: YES _____ NO _____
DVM Reading: ______________
Bar. Pressure: ______________"hg
Temperature: ______________° F
Calculated: R2 _______ R7 _______
Summing Amp.: Rf _____ Cap ______

COMMENTS

VOLTAGE DATA
Rectified: +V: _______ -V: _______
Regulated: +V: _______ -V: _______
Vdc Ref.: ______________
Bv: Zero Flow: ______________
Bv: Max Flow: ______________

CURRENT SENSE VOLTAGE
Zero Flow: ______________
Max. Flow: ______________
For Sensor Safety Circuit Only:

Section 3: Troubleshooting

This section provides troubleshooting information should problems occur during the recalibration of the 151 Linearization Module.

	Symptom	Possible Cause
1.	No -12 Vdc supply on J1-3 (J1, pin 3)	U1 or VR1 shorted or short on P.C.B. Transformer, bridge rectifier, fuse, or power cord bad.
2.	Low -12 Vdc supply on J1-3 (J1, pin 3)	Low voltage at VR1 or U1 loading down -12 Vdc supply. Check J1-3 for -12 Vdc supply being loaded down on other linearizer boards.
3.	No +15 Vdc supply on J1-5 (J1, pin 5)	U1 or VR2 shorted or short on P.C.B. Transformer, bridge rectifier, fuse, or power cord bad.
4.	Low +15 Vdc supply on J1-5 (J1, pin 5)	Low voltage at VR2 or U1 loading down +15 Vdc supply. Check J1-5 for +15 Vdc supply being loaded down on the other linearizer boards.
5.	No -5 Vdc supply on J1-2 (J1, pin 2).	No +15 Vdc supply (J1-5). U1 bad, R27 open, VR3 bad. Check D2, D3, D4, D5.
6.	Low or high -5 Vdc voltage on J1-2 (J1, pin 2).	R25 adjusted improperly, R26 or R27 improper values.
7.	No return signal (0.6-2.0Vdc) on J1-1, (J1, pin 1). Bridge voltage ok.	Probe disconnected, Q1 bad, no power getting to 465 Current-Transmitter Board, faulty connection between 195 and 193 enclosures - see Section 1-1 and Appendix A.

	Symptom	Possible Cause
8.	No bridge voltage at the 465 Current-Transmitter Board	Refer to symptom 11 and probable cause
9.	No 0-5 Vdc corresponding to no flow to maximum flow range on right-side of jumper E2. See Figure 2-7 on page 2-13.	No bridge voltage, U1 bad
10.	Low 0-5 Vdc at right-side of jumper E2. See Figure 2-7 on page 2-13.	R4 or R5 (zero and span) adjustment faulty, signal being loaded down by P.C.B., -5 Vdc supply (J1-3) drifted.
11.	No linear output voltage at J1-6 (J1, pin 6)	No input voltage, U2 bad, signal being loaded down. Jumper E2 (on linearizer board) must be installed when signal is input from the sensor (instead of from the variable power supply as described in Section 2).
12.	Linear 0-5 Vdc (J1-6) reading is incorrect	Wrong flow range being used for unit. Adjust R4 and R5 to correct 0-5 non-linear input (voltage on right side of jumper E2). Faulty component in linear section.
13.	Linear voltage output at J1-6 (J1, pin 6) above + 10 Vdc continuous.	Non-linear 0-5 volts input to high and stays high (possible bad probe), feedback resistor summing stage of linear section open, breakpoint amplifier railed out due to a faulty component.
14.	Linear 0-5 Vdc signal at J1-6 looks good, however, panel meter reads wrong	Panel meter bad, improper adjustment of voltage divider to meter input.

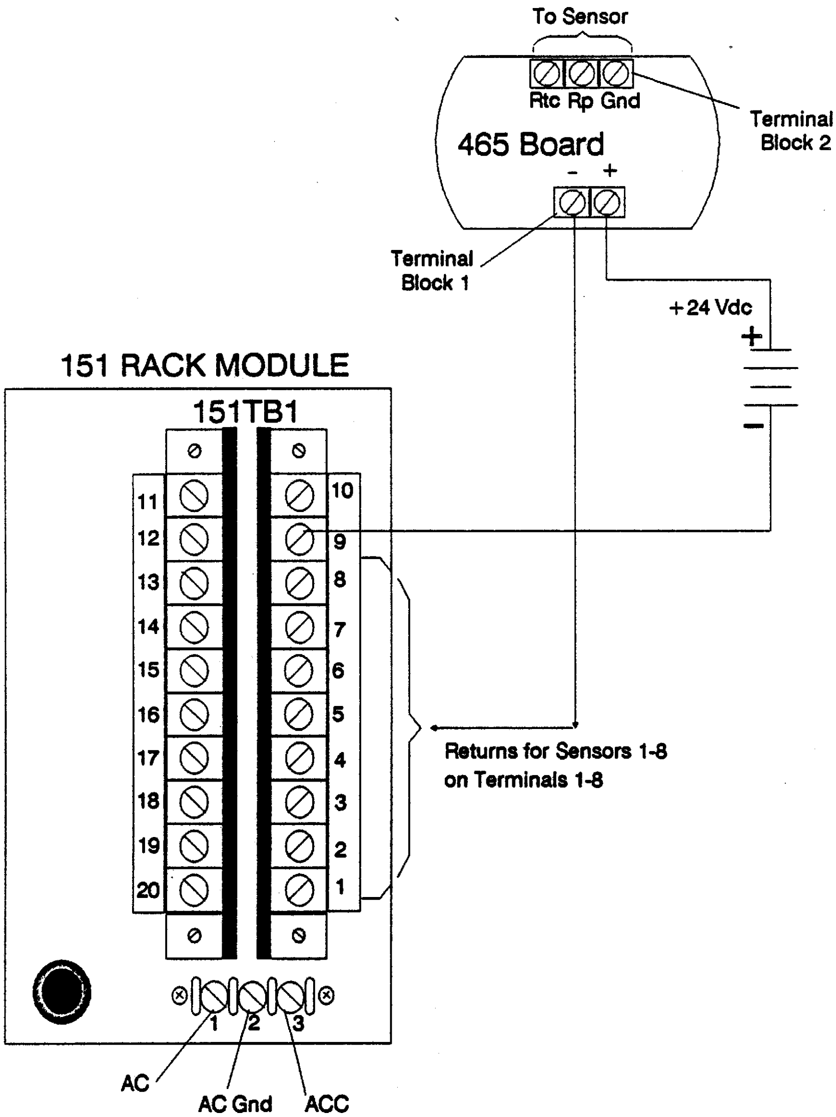
Symptom	Possible Cause
15. Integrator counts erratic or wrong number of counts with proper 0-5 Vdc input from Linear Out (J1-6)	Not properly adjusted or faulty integrator.
16. Counter won't count	Bad counter, integrator not working properly.
17. 4-20 mA signal faulty with proper 0-5 Vdc Linear Out from J1-6	Faulty adjustment, component failure on 4-20 mA board.
18. Breakpoint voltage before flipping minus is above 0.4 to 0.5 Vdc (normal off voltage breakpoint)	Positive clamping diode at that point open.
19. Breakpoint voltage won't flip minus	Positive clamping diode at that amp is shorted, no signal getting to the input of that amp.
20. Breakpoint always minus	No -5 Vdc reference getting to the input of that amp.
21. Breakpoint flips minus and rails out at + 10 Vdc or higher	Open loop gain at that amp due to open feedback resistor or diode.

End of Section 3

Appendix A: Drawings and Work Sheets

Figure A-1, below, shows how the 465 board and 151 rack module can be connected to a +24 Vdc and AC supply for testing. This allows you to remove the 151 module from the 193 enclosure during the testing. The appendix also contains component layout drawings of the 465 and 143 boards. Blank work sheets are included for your convenience. You are free to copy these for the calibration of the 151 Linearization Module.

Figure A-1. *Test Connections when the 151 Rack Module is Removed from the 193 Enclosure*



	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

	Break Point Voltage	Linear Vdc	Linear Output mA
1			
2			
3			
4			
5			
6			
7			

LFE S/N: ________________

Model #: ________________

DVM S/N: ________________

Temp. S/N: ________________

Bar. S/N: ________________

Freq. Ctr S/N: ________________

Pipe Size: ________________

Pipe Area: ________________

4-20mA Range: ____________

Date Due: ________________

LFE Area: ________________

Date Due: ________________

Date Due: ________________

Date Due: ________________

Date Due: ________________

I.D.: ____________________

Model: ________________

Range: ________Range 2: ________

Power: VAC _____Hz_____VDC___

Current Mode: YES _____ NO _____

DVM Reading: ____________

Bar. Pressure: ______________"hg

Temperature: ______________° F

Calculated: R2 _______ R7 _______

Summing Amp.: Rf _____ Cap ______

COMMENTS

VOLTAGE DATA

Rectified: +V: _______ -V: _______

Regulated: +V: _______ -V: _______

Vdc Ref.: ________________

BV: Zero Flow: ____________

BV: Max Flow: ____________

CURRENT SENSE VOLTAGE

Zero Flow: ________________

Max. Flow: ________________

For Sensor Safety Circuit Only:

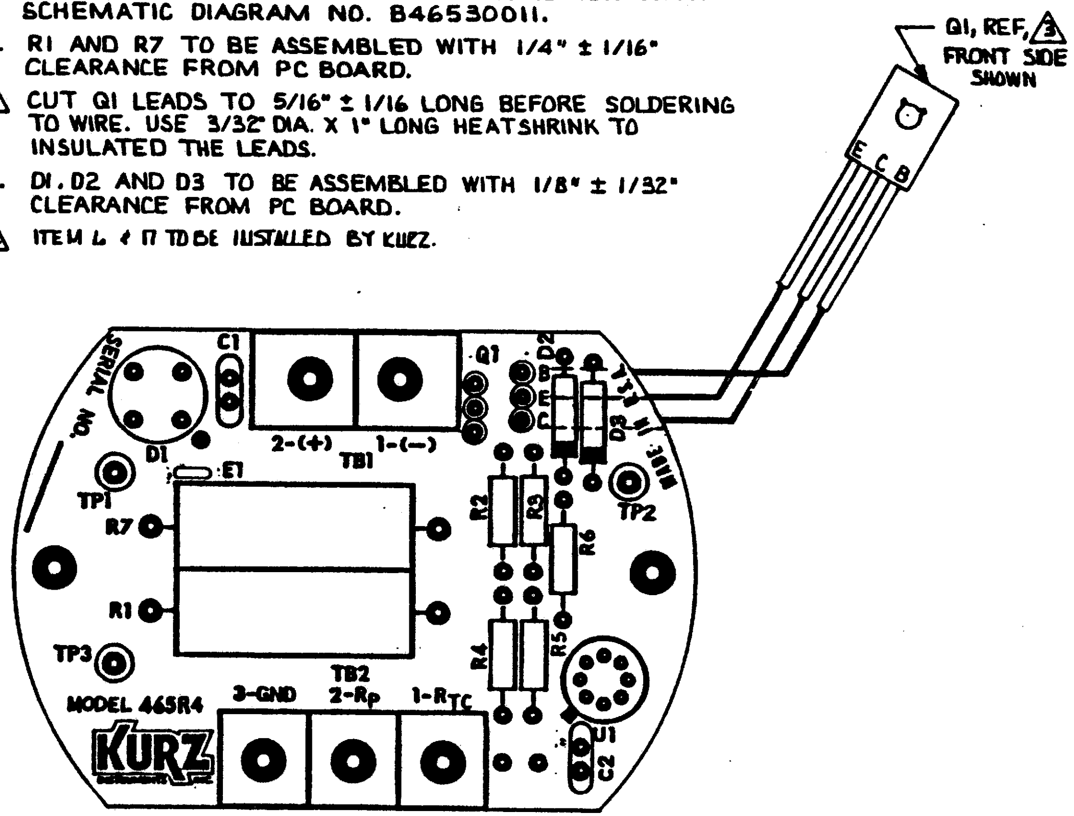
Zener ________V Ballast ________

NOTES: UNLESS OTHERWISE SPECIFIED

1. THIS DRAWING TO BE USED IN CONJUNCTION WITH SCHEMATIC DIAGRAM NO. B46530011.
2. R1 AND R7 TO BE ASSEMBLED WITH 1/4" ± 1/16" CLEARANCE FROM PC BOARD.
3. (△) CUT Q1 LEADS TO 5/16" ± 1/16 LONG BEFORE SOLDERING TO WIRE. USE 3/32" DIA. X 1" LONG HEATSHRINK TO INSULATED THE LEADS.
4. D1, D2 AND D3 TO BE ASSEMBLED WITH 1/8" ± 1/32" CLEARANCE FROM PC BOARD.
5. (△) ITEM 6 & 17 TO BE INSTALLED BY KURZ.

REVISIONS					
REV.	DESCRIPTION	DRAWN DATE/BY	CHECK DATE/BY	DESIGN DATE/BY	APPROVED DATE/BY
A	REVISED PER ECO A47114	Careaga 5-26-87	D.V. 6-1-87	N/A	6-5-87
B	REVISED PER ECO A46547009	3-7-88	3-7-88	U/A	3-7-88
C	REVISED PER ECO 47214	B.SAXON 9-1-88	9-11-88	N/A	

PART NO. ID. TABLE	
PART NO.	DESCRIPTION
-01	6" LONG WIRE ON Q1
-02	15" LONG WIRE ON Q1
-03	28" LONG WIRE ON Q1



TRANSISTOR Q1 WIRE TABLE				
Q1	COLOR	AWG	LENGTH: STD-	OPT. EVA
E	BK	#22	6"	15", 28"
C	WT	#22	6"	15", 28"
B	BL	#22	6"	15", 28"

NEXT ASSEMBLY: N/A

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE
FRACTIONS ± 1/32
ANGLES ± 0°-30'
DECIMALS
.X ± 0.1
.XX ± 0.05
.XXX ± 0.005
.XXXX ± 0.0010
ORIG. RELEASE DATE

APPROVALS	DATE
DRAWN BY J. CAREAGA	2-5-87
CHECKED BY (signature)	2-13-87
DESIGN N/A	
APPROVED (signature)	2-13-87
SABLES N/A	

KURZ INSTRUMENTS INC.

TITLE: CURRENT PC BOARD, NON INTERCHANGEABLE, MODEL 465R4, COMPONENT LAYOUT

L2

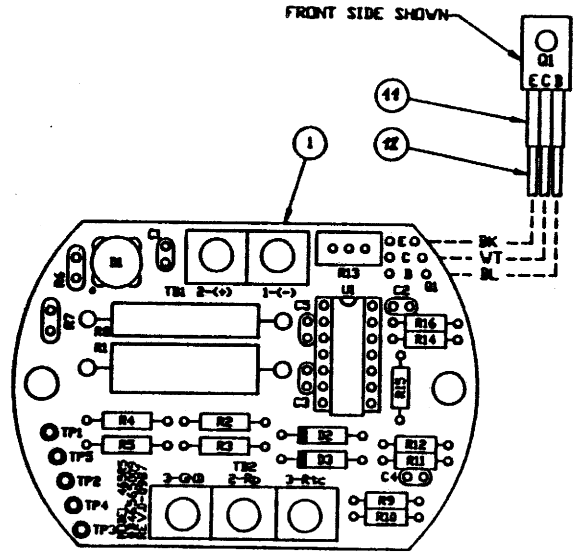
DWG. SIZE: B | DWG. NO.: 420032 | REV.: C

SCALE: 2 : 1 | SHEET: 1 OF 1

BISHOP GRAPHICS/ACCUPRESS REORDER NO. A3200

REV	DESCRIPTION				
A	REVISED PER ECO A46547011			LA	
B	REVISED PER ECO # 47214			N/A	

PART NO. IDENT.	
PART NO.	DESCRIPTION
-01	6" LONG WIRE ON Q1
-02	15" LONG WIRE ON Q1
-03	28" LONG WIRE ON Q1



NOTES:
1. SEE DWG. #346530003 FOR SCHEMATIC DIAGRAM.
2. R1 & R8 TO BE ASSEMBLED WITH 1/4"±1/16" FROM PCB.
3. CUT Q1 LEADS TO 5/16"±1/16" LG. BEFORE SOLDERING TO WIRE.
4. D1,D2 & D3 TO BE ASSEMBLED WITH 1/8" FROM PCB.
5. USE 6" WIRE LENGTH FOR STD. FOR EVA USE 15" OR 28".
6. OPTIONAL PARTS IN EXCHANGE OF R16.
7. OPTIONAL PART IN EXCHANGE OF R8.
8. INSTALL JUMPERS IN PLACE OF Z6 & Z7 IF Z6 & Z7 NOT ZERO.

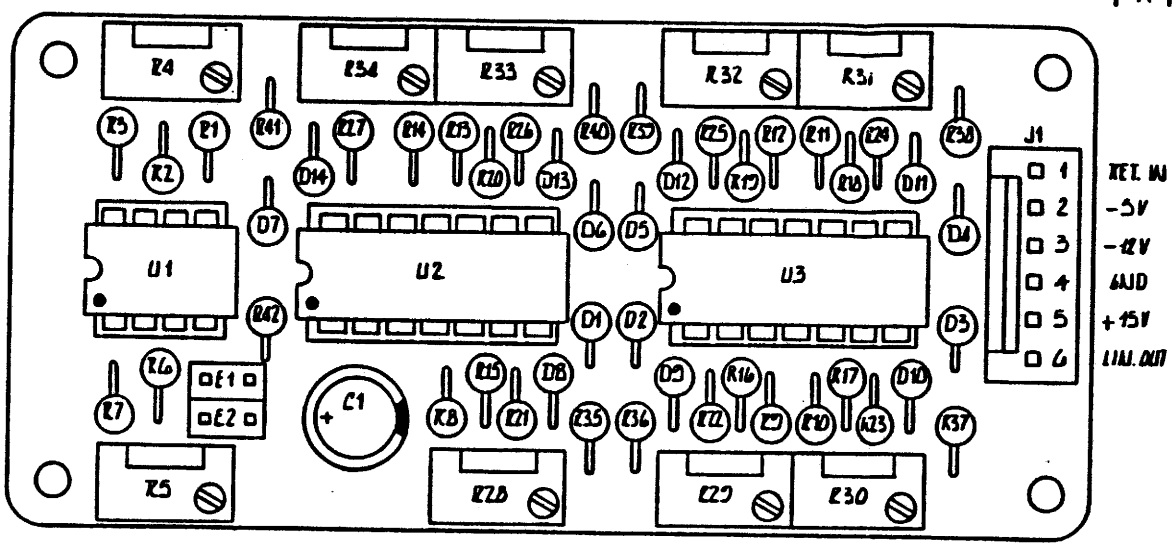
KURZ INSTRUMENTS INC.

TITLE: PCB, ASSY., 465R5

SIZE: C | DWG NO.: 420126 | REV: B

SCALE: 2/1 | SHEET 1 OF 1

REV.	DESCRIPTION	DRAWN DATE/BY	CHECK DATE/BY	DESIGN DATE/BY	APPROVED DATE/BY
A	REVISED PER ECO A14347005	Canaga 3-30-87	4-1-87		4/1/87



NOTES:
1. SEE DWG. No. B14350002 FOR SCHEMATIC DIAGRAM.
2. ALL DIODES TO BE ASSEMBLED WITH CATHODE TO P.C.B.
3. MICRO SHUNT (JUMPER) TO BE USED WITH ITEM 7 AS REQ'D.
4. FOR NON. LIN. SIG. OUT U2, U3, D1-D14, C1, R8-R42 ARE NOT REQ'D.

NEXT ASSEMBLY	D14531001

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE: FRACTIONS ± 1/32; ANGLES ± 0°-30'; DECIMALS .X ± 0.1, .XX ± 0.03, .XXX ± 0.005, .XXXX ± 0.0010
DWG. RELEASE DATE

APPROVALS		DATE
DRAWN BY	D. Dick	7/11/86
CHECKED BY	J. Canaga	9/3/86
DESIGN		
APPROVED	N. Eldridge	9/11/86

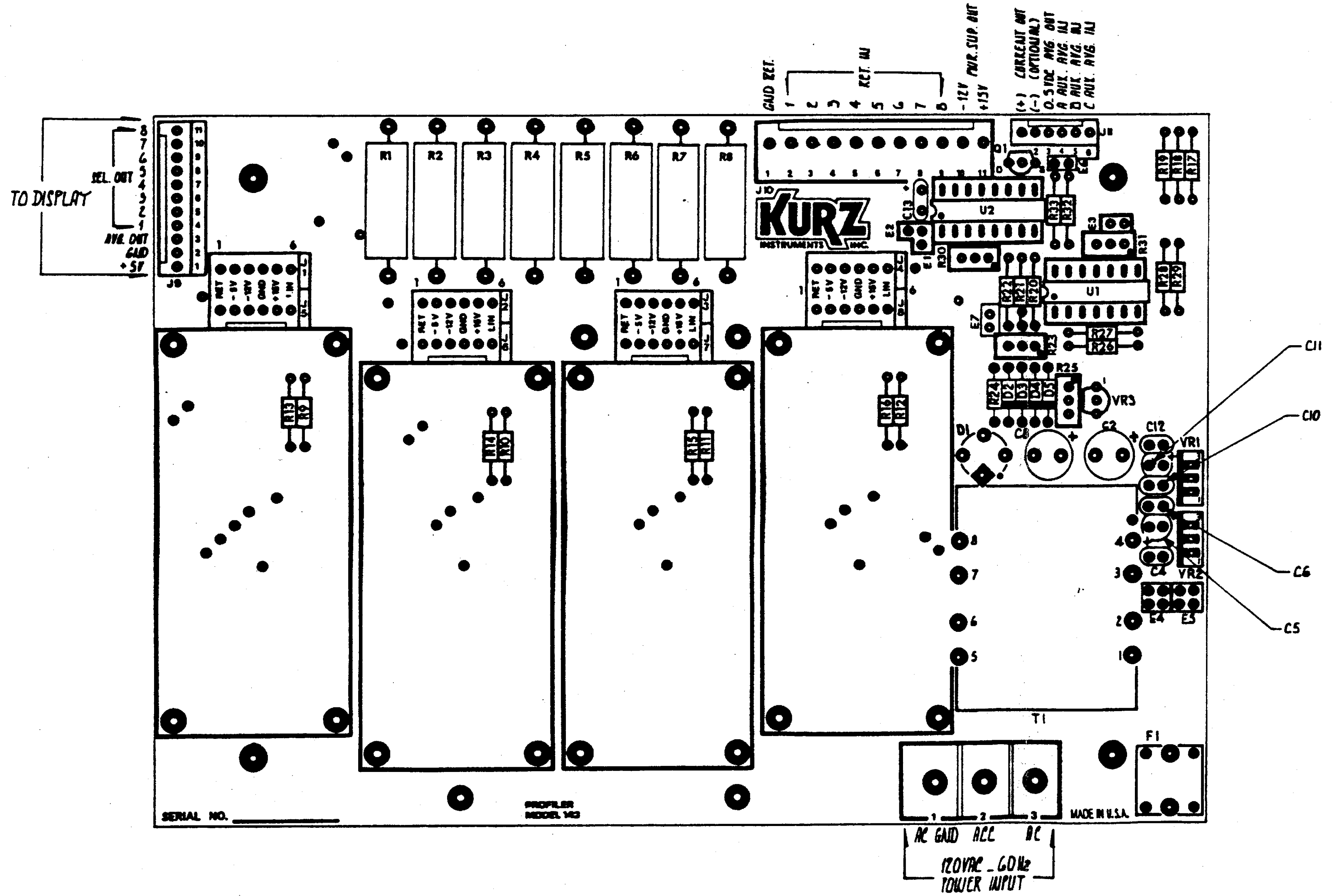
KURZ INSTRUMENTS INC.

TITLE: MODEL 143 _ PROFILER SIGNAL LINEARIZER (NON. LIN.) COMPONENT ASSY. LAYOUT.

DWG. SIZE	DWG. NO.	REV.
B	420007	A

SCALE 3/1 SHEET 1 OF 1

REV	DESCRIPTION	DRAWN DATE/BY	CHECK DATE/BY	[illegible]	APPROVED DATE/BY
A	REVISED PER ECO A14347008			N/A	
B	REVISED PER ECO A14347010		4-1-87	N/A	
C	REVISED PER ECO [illegible]	[illegible]	[illegible]	[illegible]	[illegible]



NOTES:
1. SEE DWG. No. D14330001 FOR SCHEMATIC DIAGRAM.
2. USED AS REQUIRED.
3. ELECTROSTATIC SENSITIVE DEVICES SHALL BE HANDLED AND ASSEMBLED AT STATIC FREE STATION ONLY.
4. MICRO SHUNT (JUMPER) SHALL BE USED AS REQUIRED.
5. RESISTORS R1 THRU R8 TO BE MOUNTED 1/4" UP OFF THE P.C.B.

KURZ INSTRUMENTS INC.

MODEL 143 _ PROFILER
POWER SUPPLY AND AVERAGER
COMPONENT ASSY. LAYOUT

DWG. SIZE	DWG. NO.	REV
D	420008	C

SCALE 2/1 · SHEET 1 OF 1