# Section 4
# Troubleshooting

## 4-1. INTRODUCTION

4-2. This section of the manual contains troubleshooting information for the 8860A. The information is divided into five major parts. They are:

1. General Maintenance
2. Troubleshooting Approach
3. Analog Troubleshooting
4. Digital Troubleshooting
5. Troubleshooting Aids

## 4-3. GENERAL MAINTENANCE

4-4. Disassembly Procedure

**WARNING**

**TO AVOID ELECTRICAL SHOCK HAZARD, DISCONNECT LINE POWER AND ANY INPUT CONNECTIONS FROM THE 8860A BEFORE STARTING THE DISASSEMBLY PROCEDURE.**

4-5. Disassemble the 8860A as follows:

1. Disconnect the 8860A from line power; remove all front (and rear) panel inputs.
2. Remove the four screws located on the bottom of the chassis, and pull the top cover straight up and off.
3. For access to the analog circuitry, remove the guard cover by unscrewing its four top screws (the guard cover is the large metal cover with adjustment holes). Both analog circuit boards can be removed by pulling them straight up.
4. Remove the Display PCB by pulling the bottom off the chassis, disconnecting the five INPUT terminal wires, and pulling the entire front panel assembly forward. The front panel and the circuit board are held together by the connector to the Controller PCB.
5. Refer to Section 8 for identification of the circuit board assemblies. Each assembly unplugs from its connector.

**CAUTION**

**Do not contaminate the area around the INPUT terminal connections on the main PCB or the front end of the AC/DC Scaling PCB. Low level leakage can result in calibration errors.**

## 4-6. Cleaning

4-7. To clean the front panel and exterior surfaces of the 8860A, use a soft cloth dampened with either a mild solution of detergent and water or anhydrous ethyl alcohol.

**CAUTION**

**Do not get water on the transformer. The transformer will absorb the water and eventually fail. Use special care when cleaning the fragile hybrid assemblies; they are easily damaged.**

**CAUTION**

**If fluorocarbons or other solvents are used to clean the pcbs, keep it off switches and potentiometers. Solvents will remove the lubricants from these components and shorten service life.**

4-8. To clean the interior of the unit, use clean, dry air at low pressure (<20 psi). If contaminants remain, clean the individual pcbs using warm water. The AC/DC Scaling and the A/D and Ohms PCBs may be safely washed with all components intact; the Main PCB requires special handling.

4-9. The Main PCB may also be cleaned using warm water. However, in doing so do not get the armature relays or the transformer wet. The recommended approach is to cover the transformer and remove the armature relays during the washing process. Remove relays K1, K3, and K4 by unplugging them from the pcb; do not remove the reed relay.

4-10. After washing the pcbs, remove excess water using clean dry air at low pressure. Dry the pcbs in an oven at a temperature of 50° C or less.

4-11. Fuse Replacement

**WARNING**

**TO AVOID ELECTRICAL SHOCK HAZARD, DISCONNECT THE POWER CORD BEFORE SERVICING THE FUSE. AC LINE VOLTAGE IS PRESENT WHEN THE POWER CORD IS CONNECTED.**

4-12. The power fuse (F1) is accessible from the rear panel. Replace the fuse, if necessary, with an MDL (slow-blow) ¼-ampere fuse with a voltage rating (125V or 250V ac) exceeding the line voltage.

### 4-13. Static Awareness

4-14. Whenever troubleshooting, follow procedures outlined on the yellow Static Awareness sheet located in this manual. These procedures are intended to prevent damage to MOS devices due to static charge.

### 4-15. Pin Numbering

4-16. Note that pin 1 of each integrated circuit is identified by a square solder pad on the circuit board. Connector pins are numbered as shown in Section 8, in the figure labeled Interconnection of Assemblies.

### 4-17. Extender Cards

4-18. The following extender cards are available for troubleshooting the 8860A plug-in pcb assemblies. The extenders may be used during troubleshooting and functional testing. However, all extenders must be removed during the performance test and the calibration procedure. Order by model number.

| EXTENDER BOARD | MODEL NUMBER |
|---|---|
| A/D and Ohms Converter PCB | 8860A-4007 |
| AC/DC Scaling PCB | 8860A-4008 |
| Calculating Controller (-004) and IEEE-488 Interface (-005) | 8860A-4009 |

## 4-19. TROUBLESHOOTING APPROACH

4-20. Figure 4-1 shows the recommended approach for troubleshooting the 8860A. When the instrument fails to perform as expected, use Table 4-1 to identify the fault as analog, digital, or power supply related. Then proceed to the analog or digital troubleshooting procedures. If additional circuit details are required after the fault area is located, refer to the theory of operation in Section 3 and the schematic diagrams in Section 8.

## 4-21. POWER SUPPLY CHECK

4-22. Table 4-2 lists the basic power supply voltages, their test points and tolerances, and the circuits they supply. Test point locations are shown in Figure 4-2. Check each of the power supply voltages using the following procedures:

1. In-Guard Supply
   Connect the common lead of a DMM to In-Guard Common. Measure each of the three in-guard voltages (+5V, +15V, -15V). Each supply voltage should be within the tolerance indicated in Table 4-2.
2. Out-Guard Supply
   Connect the common lead of the DMM to Out-Guard Common. Measure the outguard +5V supply. It should measure within the tolerance indicated in Table 4-2.

*NOTE*

*By clipping jumper wires, you can remove the ±15 volt supply to the RMS-to-DC Converter (wires W3 and W4) and Ohms Converter (wires W10 and W11). This should only be done to help locate a fault which is overloading the ±15 volt supplies.*

## 4-23. ANALOG TROUBLESHOOTING

4-24. A list of test points for troubleshooting the analog section of the 8860A is shown in Table 4-3. Verify the overall operation of the analog section by confirming the presence of these voltages. If a voltage is incorrect, make a detailed check of the indicated circuit location or section. Procedures for troubleshooting the individual analog sections are given in the following paragraphs. The sections are covered in the following order:

- AC/DC Scaling
- RMS-to-DC Converter
- Ohms Converter
- Precision Voltage Reference
- A/D Converter

*NOTE*

*The A/D & Ohms board can be operated with the AC/DC Scaling board removed; however, the reverse is not true. DO NOT TRY TO OPERATE THE AC/DC SCALING BOARD WITH THE A/D & OHMS BOARD REMOVED. (The AC/DC Scaling ground connections are made on the A/D & Ohms board.)*

### 4-25. AC/DC Scaling

4-26. The following procedures assume that the signal path from the front panel INPUT terminals to the AC/DC Scaling PCB has been checked and is operating properly. The AC/DC Scaling Extender Card is necessary for the following procedures.

4-27. The AC/DC Scaling circuitry is functionally divided into two parts, the Front End and the Amplifier Section.

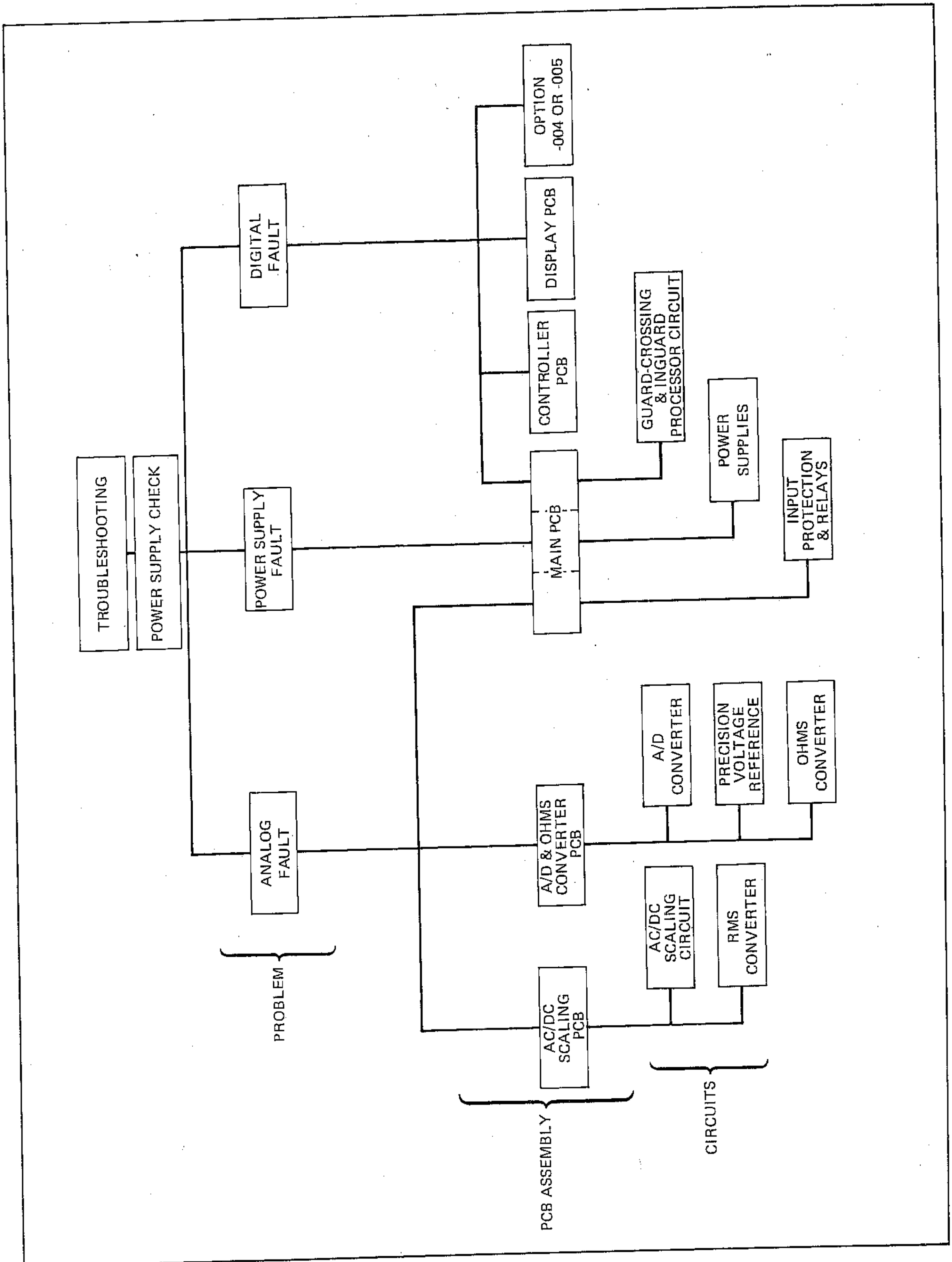



**Figure 4-1. Troubleshooting Approach**

Table 4-1. Distinguishing Analog and Digital Faults at Front Panel

| ANALOG FAULT |
|---|
| An analog fault exists if a measurement reading is incorrect, but the following functions operate correctly:<br>• Front panel indicator lights respond properly when a measurement function is selected (e.g., switch from VDC to VAC to Ω2T).<br>• Decimal point is positioned correctly in response to a range change.<br>• Annunciators (mV, V, Ω, kΩ, MΩ) light up properly for each function and range.<br>• A number can be stored and recalled from the High, Low, or Offset registers.<br>Analog faults are located inside the guard on one of three pcbs:<br>• Main PCB Assembly<br>• AC/DC Scaling PCB Assembly<br>• A/D and Ohms Converter PCB Assembly |
| **DIGITAL FAULT** |
| A digital fault usually exhibits at least one of the following svmptoms:<br>• Display appears faulty; reading does not change or display segments do not light.<br>• One digit is bright, others are off.<br>• All display and indicator lights are off.<br>• Instrument fails to respond to a front panel push button.<br>Digital faults are located on one of four PCB Assemblies:<br>• Controller PCB Assembly<br>• Display PCB Assembly<br>• Main PCB Assembly<br>• Option -004 or -005 PCB Assemblies |

1. The Front End includes:
   a. Input Divider U1 and associated capacitors
   b. Voltage clamp circuit
   c. JFET switches, including A1
   d. Active Filter U3

2. The amplifier section includes:
   a. Dual JFET Q17 and amplifier U14
   b. Bootstrap Amplifiers Q16 (with U5), U6A, and U6B

4-28. Proper waveforms for the AC/DC Scaling board are shown in Figure 4-3, for a +1V dc input, VDC. These signals are referred to in Table 4-4, which lists typical fault symptoms for the AC/DC Scaling PCB. When troubleshooting frequency response problems, voltage test measurements can load the front end circuitry. To avoid circuit loading, measure front end voltages only at the specified test points. Voltages below 2V rms may be injected at various points in the front end (e.g., A1-17, A1-6, A1-9) and measured at appropriate test points.

4-29. Excessive leakage current in the front end JFETs can be pinpointed using the following guidelines:

1. Leakage in a JFET adversely affects a circuit only when the JFET is off (not conducting).
2. The leakage path may be from drain to source, preventing a fully off condition, or from gate to source.
3. Identify and inspect those JFETs that are off when leakage symptom is present. For example, if a dc offset disappears when the filter is enabled (Q11 on), then Q11 is probably defective.

### 4-30. RMS-to-DC Converter

4-31. Table 4-5 lists some general fault symptoms and corrections for the RMS Converter. Detailed procedures which may be used to check various functional aspects of the RMS Converter are given in the following paragraphs. The first procedure checks the VAC+VDC function. The second checks the VAC function. If a fault is identified, investigate the components that precede the test point location.

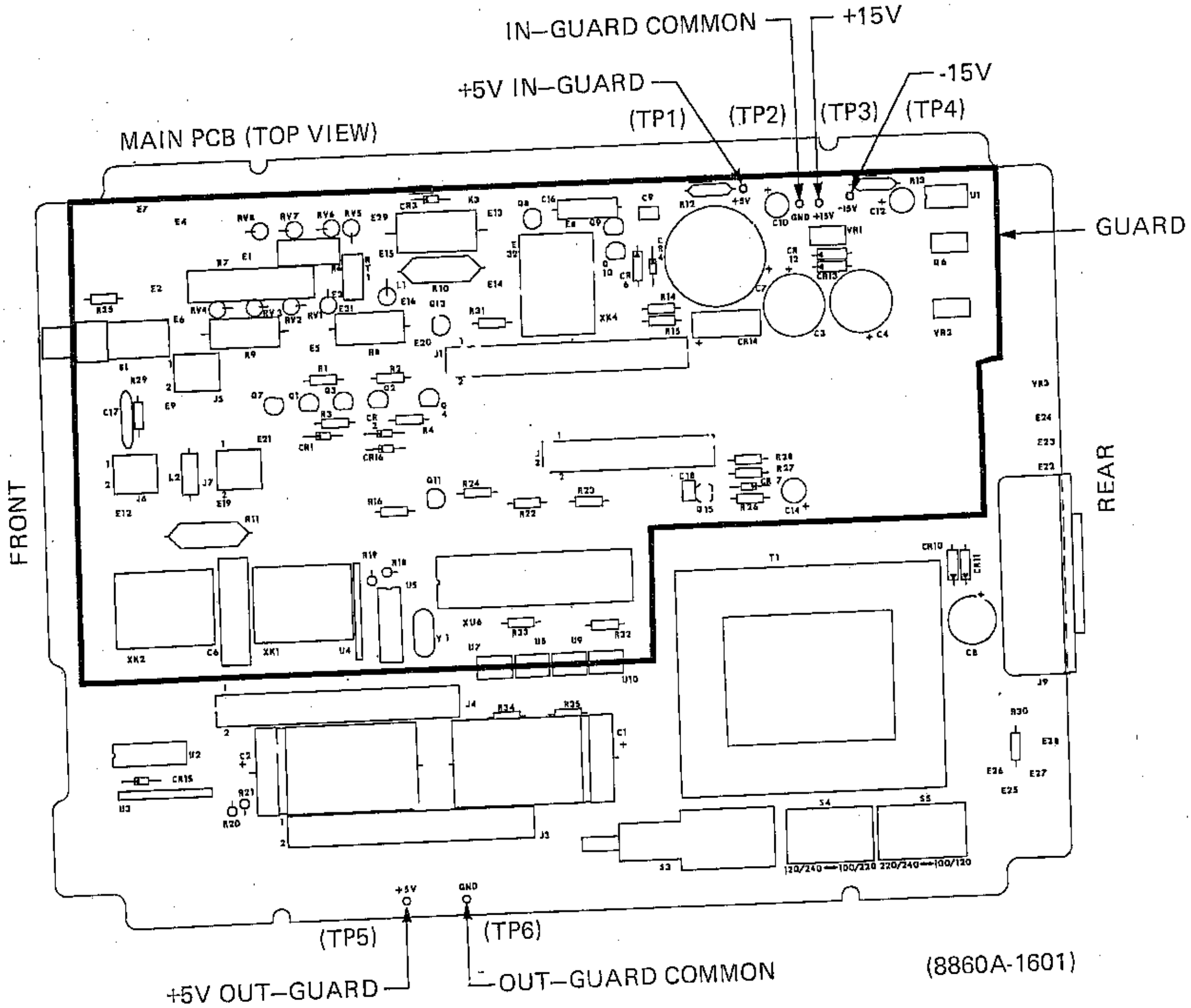



Figure 4-2. Power Supply Test Points

Table 4-2. Power Supply Assignments (Troubleshooting Section, Power Supply)

| POWER SUPPLY | TEST POINTS | TOLERANCE | SUPPLIES ONLY THE FOLLOWING CIRCUITRY |
|---|---|---|---|
| In-guard +15V<br>-15V<br>(relative to inguard common, TP2) | TP3<br>TP4 | 14.25V to 15.75V<br>-14.25V to -15.75V | On the AC/DC Scaling PCB (A4):<br>all circuitry except comparator reference level (R40, R41)<br>On the A/D & Ohms PCB (A5):<br>all circuitry except U21 and comparator reference level (U20) |
| In-guard +5V<br>(relative to inguard common, TP2) | TP1 | 4.7V to 5.3V | On the Main PCB (A1):<br>-15V supply (U1)<br>in-guard processor (U6)<br>opto-isolator circuitry (U5)<br>relay coils (K1-K4)<br>On the AC/DC Scaling PCB (A4):<br>comparator reference level (R40, R41)<br>On the A/D & Ohms PCB (A5):<br>binary to 1-of-4 decoder (U21)<br>comparator reference levels (U20) |
| Out-guard +5V<br>(relative to outguard common, TP6) | TP5 | 4.7V to 5.3V | On the Main PCB (A1):<br>opto-isolator circuitry (U2)<br>The entire Display PCB (A2)<br>The entire Controller PCB (A3), which includes:<br>outguard processor<br>local ROM<br>external-trigger one-shot<br>associated latches, flip-flops, and drivers<br>The entire Calculating Controller Option (-004)<br>The entire IEEE-488 Interface Option (-005) |

**Note: The test points are labeled on the schematic, but not on the circuit board itself.**

4-32. This procedure functionally checks the RMS Converter by tracing a dc signal through the converter while the dc-coupled VAC+VDC function is enabled. Set the 8860A to the VAC+VDC function and the 2V range.

1. Apply +1.000V dc between the HI and LO INPUT terminals of the 8860A.
2. Using the test DMM, measure TP5 on the AC/DC Scaling PCB. The measurement should be within 10 mV of the input value.
3. Move the DMM input to test point E2, the input to the RMS Converter. The voltage measured should be the same as that at TP5.
4. Measure the voltage at TP3, the output of U8. It should measure approximately -1.6V.
5. Reverse the polarity of the input signal and measure the voltage at TP3 again. It should measure approximately +1.6V. If tests 4 and 5 fail, U8, U15, CR6, or CR7 may be at fault.
6. Measure the voltage at TP2. It should be 0V ±20mV.
7. Measure the voltage at TP1. It should be -1.2V ±0.1V.
8. Measure the voltage at U19A-1. It should be +5.0V ±25mV.
9. Measure the voltage at E3. It should be +1.0V ±5mV. An offset may be present since auto-zero is not functional for VAC+VDC measurements.

4-33. This procedure functionally checks the RMS Converter by tracing an ac signal through the converter while the VAC function is enabled. Set the 8860A to the VAC function and the 2V range.

### Table 4-3. Quick Check to Locate Faulty Analog Circuit

**TEST POINTS ON THE MAIN PCB**

**Use these test points to check the signal path from the front panel input terminals, through the input relays, to the AC/DC Scaling PCB:**

| TEST POINT | LOCATION | TEST POINT VOLTAGE UNDER THESE CONDITIONS: | |
|---|---|---|---|
| | | 1V DC INPUT, VAC+VDC, 2V RANGE | 1V rms @ 300 Hz INPUT, VAC, 2V RANGE |
| E2 | Junction of W6 and R7 | 1V dc | — |
| E19 | Junction of W11 and L2 (checks K1) | 1V dc | — |
| E29 | Junction of K3 and W12 (checks K3) | 1V dc | — |
| E19 | Checks K2 | — | 1V rms |

**TEST POINTS ON THE AC/DC SCALING PCB**

| TEST POINT | LOCATION | TEST POINT VOLTAGE UNDER THESE CONDITIONS: | |
|---|---|---|---|
| | | 10V DC INPUT, VDC, 20V RANGE TRIG ARM ENABLED | 10V DC INPUT, VAC+VDC, 20V RANGE, TRIG ARM DISABLED |
| TP8 | AC/DC Scaling (output of JFET bias amplifier) | 100 mV dc +/-25 mV* | 100 mV dc +/-25 mV* |
| TP5 | AC/DC Scaling (Output of scaling amplifier) | 0V dc +/-10 mV* | 1V dc +/-10 mV* |
| TP2 | RMS Converter (U16 inverting input) | 0V dc +/-20 mV* | 0V dc +/-20 mV* |
| TP3 | RMS Converter (Output of absolute value converter) | 0V dc +/-500 mV* (Will be very noisy) | Approx. -1.6V dc |
| TP1 | RMS Converter (Output of 2X log amplifier) | — | Approx. -1.2V dc |
| E3 | RMS Converter (Output of RMS Converter) | 0V dc +/-5 mV | 1V dc +/-5 mV* |

*These are dc offset voltages; the tolerances are approximate. Steady, noise free readings are more important than accuracy.

Table 4-3. Quick Check to Locate Faulty Analog Circuit (cont.)

| TEST POINTS ON THE A/D & OHMS CONVERTER PCB | | | | | |
|---|---|---|---|---|---|
| TEST POINT | LOCATION | TEST POINT VOLTAGE ACCORDING TO RANGE WITH THE INPUT TERMINALS SHORTED | | | |
| | | 200Ω/ 2 kΩ | 20 kΩ | 200 kΩ/ 2 MΩ | 20 MΩ |
| U1-10 | Ohms Converter | 8.6V to 9.7V | 7.1V to 7.3V | 6.95V to 7.05V | 0.69V to 0.71V |
| TP9 | Ohms Converter | 7.00V below the reading at U1-10 | | | |
| U10-2 | Precision Reference | -0.99980V to -1.00000V dc | | | |
| U10-3 | Precision Reference | -6.478V to -6.482V dc | | | |
| Enable the TRIG ARM function before measuring the following test points: | | | | | |
| TP11 | A/D Converter | 0Vdc +/-50 mV | | | |
| TP12 | A/D Converter | 0V dc +/-50 mV | | | |
| TP13 | A/D Converter | 0V dc +/-50 mV | | | |
| Turn the 8860A power off, and remove the AC/DC Scaling PCB. Turn the power back on, and select the VAC function, 2V range. Temporarily connect A2-7 (A/D input) to U10-2 (-1 volt reference) with a clip-lead wire. The display reading should be a value from .99960 to 1.00020. Reinstall the AC/DC Scaling PCB after this test. | | | | | |

1. Apply a 1V, 100 Hz sine wave to the 8860A HI and LO INPUT terminals. Using a scope, monitor TP5 on the AC/DC Scaling PCB. The ac input should appear as a clean, undistorted sine wave.
2. Move the scope probe to TP3 of the absolute value converter. The signal should appear as in Figure 3-4 (TP3).
3. Move the scope probe to TP1 of the 2X Log Amplifier. The signal should appear as in Figure 3-4 (TP1). The waveform should be free of oscillations and noise. Waveform symmetry is not critical. If the waveform is not correct the problem is in the 2X log amplifier, the log feedback amplifier, or the antilog amplifier.
4. Using the DMM, measure the dc output voltage of the RMS-to-DC converter at E3. It should measure +1V dc with an applied input of 1V rms ac.

4-34. The following tests should be performed if the RMS-to-DC Converter is functional but will not calibrate properly:

1. Short the 8860A input terminals. Select VAC function, 20V range.
2. Measure the voltage at TP5. It should be 0 ±0.01 mV dc.
3. Measure the voltage at TP2. It should be 0 ±0.01 mV dc.
4. Using a scope, check TP3 to see that R46 can provide adjustment on either side of zero. If the adjustment is not possible, U15 or the 2X log amplifier may be at fault.

### 4-35. Ohms Converter

4-36. If the voltage at point U1-10 is outside the values given in Figure 4-3 the Ohms Converter is at fault. To isolate the fault, temporarily disable the feedback loop by connecting a short across R4 with a clip lead. Then check the operational amplifier by placing a short across the 8860A INPUT terminals, selecting Ω2T function and 2 MΩ range, and shorting TP9 on the Ohms Converter to (E5). In this configuration, pins 26 and 29 of hybrid A1 should measure within 10 mV of each other (at approximately +12.75V dc). Also, the voltage at U4-6 should be within 7 mV of TP9.

NOTE

*Disconnect the jumper from TP9 and E5 before continuing.*

4-37. The reference current can be tested by checking the voltage between TP9 and the cathode of CR1 while the 8860A is on the 2 KΩ range. The voltage should be 7.00V dc. (The short across R4 may be left in place.) JFETs Q8

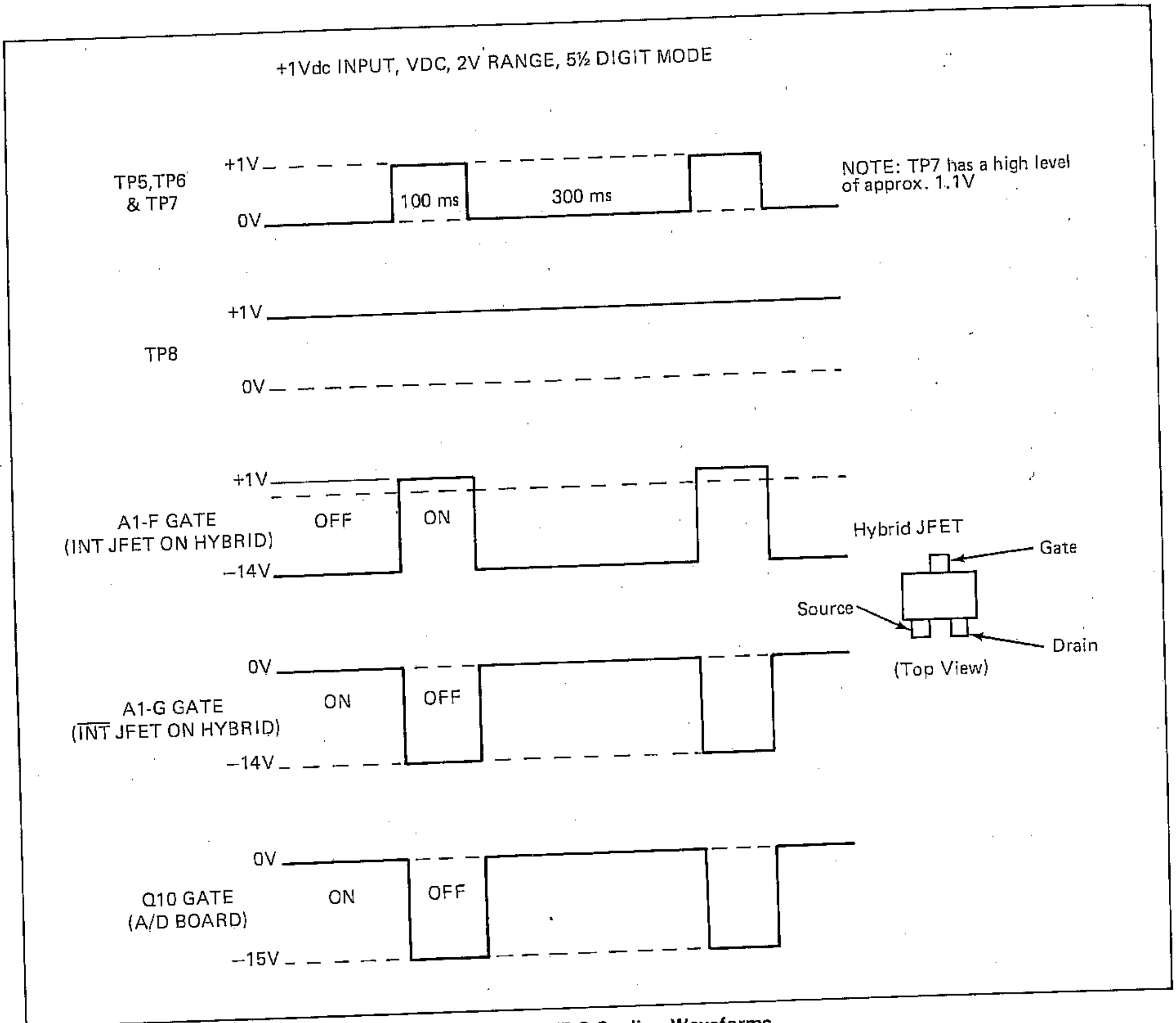



**Figure 4-3. AC/DC Scaling Waveforms**

and Q9 on the Main PCB are important for leakage control as well as protection. If either JFET leaks excessively, readings on the high-resistance ranges will drift during warm-up.

4-38. If the Ohms Converter malfunctions only on certain ranges, then the output voltages from U6 and U7 should be checked. Use the switch state table shown with the Ohms Converter schematic in Section 8.

4-39. The voltages across the U1 resistors 7.017, 70.71, and 778.9 kilohms should be 7.00V dc when the associated range is selected, and 0.00V dc otherwise. Each resistor can be checked in-circuit for the correct resistance value with an ohmmeter when either the 2MΩ or 20 MΩ range is selected. Isolation between pins 9, 12, and 16 on A1 can also be measured with either the 2 MΩ or 20 MΩ range selected. For example, the resistance between pins 12 and 16 of A1 should be approximately 77.8 kilohms, which is the series value of R3, 70.71 kilohms and 7.017 kilohms.

## 4-40. Precision Voltage Reference

4-41. Voltage readings at pins 1, 2 and 3 of resistor network U10 should be within the following limits. Refer to the theory of operation (Precision Voltage Reference) in Section 3 for help in troubleshooting the voltage reference.

1. U10-1: 0.0V
2. U10-2: -1.0V ±100 uV
3. U10-3: -6.48V ±1 mV

4-42. The reference amplifier U22, and resistors R41 and R42 must be replaced as a set if U22 is faulty. After U22 is replaced, perform the jumper selection procedure given at the end of this section under Post Repair Procedures.

## 4-43. A/D Converter

4-44. Troubleshooting information for the A/D Converter is presented in four parts. First, a list of possible problems and symptoms is given in Table 4-6. This is followed by a functional check of the A/D Converter with

Table 4-4. Typical Symptoms of AC/DC Scaling Faults

| SYMPTOMS | INSTRUCTIONS OR COMMENTS |
|---|---|
| DC PROBLEMS<br>1. Input bias current at front panel terminals exceeds 100 pA*<br>2. Downscale performance in VDC, 200 mV and 20V ranges is out of specification<br>3. Downscale, low frequency signals read too high on 200 mV range of VAC but not in VAC+VDC (see following note) | Symptom may indicate excessive leakage current in a JFET (dual JFETs Q16 and Q17 are usually not at fault). If the faulty JFET is localized to hybrid A1, replace the entire hybrid assembly. Otherwise, replace discrete JFETs one at a time until the fault clear. Use the guidelines mentioned in the preceding paragraph to identify leaking FETs. |
| **NOTE**<br>In VAC and VAC+VDC, the display will indicate a reading (typically less than 400 counts in the 200 mV range) even when the input is shorted. This reading will not affect the rated accuracy over the specified input range and does not indicate a fault condition. | |
| 4. VDC function inoperative, VAC operative | Check for the presence of the waveforms shown in Figure 4-3. Check operation of the INT, $\overline{INT}$, or A1-D JFETs. |
| AC PROBLEMS<br>1. Excessive peaking of frequency response on the 20, 200, or 700 VAC ranges | Check the voltage at TP8. If it exhibits peaking, then the fault is ahead of the scaling amplifier in the front end. Check both Q6 on the AC/DC Scaling PCB and Q13 on the Main PCB. |
| 2. Poor frequency response on the 200 mV or 2V range, VAC | Check R10, R11, C8, and the JFET switches in the front end. Check U6B and C17, and the voltage at TP7; it should be approximately 2 X Vin. Check the ON resistance of Q12 and Q18. It should be less than 30 ohms. |

*To measure input bias current, select VDC and the 200 mV range, short the input terminals and note the display reading. Remove the short and replace it with a 1 megohm resistor in parallel with 0.1 uF capacitor. Note the new reading. A large difference between readings indicates a large input bias current. Calculate the bias current by dividing the difference between voltage readings by 1 megohm. For example, a 100 uV difference corresponds to a 100 pA input bias current

autozero enabled. Next, timing diagrams and waveforms are given for a properly operating A/D Converter. Finally, a few useful troubleshooting tips are given.

## 4-45. INITIAL A/D CHECK IN AUTOZERO

4-46. Enable the autozero mode by pressing FCN, then TRIG ARM on the front panel, or by changing the setting of switch S3, as shown in Figure 4-6. Measure the voltages at TP11, 10, and 12. If they are within the following limits, autozero is working.

1. TP11 should read OV ±25 mV dc.
2. TP10 should read OV ±10 mV dc.
3. TP12 should read OV ±10 mV dc; its ac-coupled rms voltage should be less than 1 mV ac.

## 4-47. A/D TIMING DIAGRAM

4-48. A timing diagram for the switching JFETs in the A/D Converter is shown in Figure 4-4.

## 4-49. A/D WAVEFORMS

4-50. The waveforms for a functional A/D Converter are shown in Figure 4-5. These waveforms occur when the 8860A is operating in the continuous mode rather than locked into the autozero mode.

4-51. With +1V dc applied to the 8860A INPUT terminals, the waveform at TP11 should appear as shown in Figure 4-5. There should be no droop or rise in voltage during the INT (integrate) or DE (discharge) periods. Droop can be caused by either a leaky or shorted JFET or

Table 4-5. Typical Symptoms of RMS Converter Faults

| SYMPTOMS | INSTRUCTIONS OR COMMENTS |
| --- | --- |
| 1. RMS Converter does not respond | Check voltages at TP3 and TP1 as described earlier in this section under RMS-to-DC Converter. If the voltages at TP3 are incorrect, the problem is usually in the absolute value circuitry. If TP1 is incorrect, the problem is probably in the 2X log amplifier, the log feedback amplifier or the anti-log amplifier. If U17 or U20 require changing, jumpers W5 through W8 need to be reconfigured. Refer to the Post Repair Procedures at the end of this section for the jumper replacement procedures. |
| 2. RMS Converter is functional, but the reading is noisy. | U15 may be defective. Also check U16, U8 and the logging arrays (U17 and U20). |
| 3. Poor downscale performance on all ranges. | Check calibration adjustments for TP5 (R27), RMS Zero (R46), RMS offset (R54), or R73. Also check U15 and U19. |

Table 4-6. Typical Symptoms of A/D Converter Faults

| SYMPTOM | POSSIBLE CAUSE |
| --- | --- |
| 1. Incorrect Scale Factor | • Precision reference malfunction.<br>• Q10 faulty or has drive signal missing. |
| 2. Nonlinear Response | • One or more JFETs on the A2 hybrid are faulty.<br>• AZ2 or Delta-2 operation is faulty. |
| 3. Persistent Overrange Indication | • Precision reference malfunction.<br>• Integrator, slope amplifier, or A/D comparator malfunction. |
| 4. Unstable (Noisy) Reading | • Faulty op amps or JFETs within the autozero loop. C7 may also be defective. |
| 5. Excessive Offset | • Faulty JFETs in the autozero loop, or drive signals missing.<br>• Q8 or Q9 faulty, or their drive signals are absent.<br>• Offset is not properly adjusted. |
| 6. Full Scale Reading Not Possible | • Integrator malfunction or faulty operation of Q4. |

by a defective JFET driver (U15-U17). The figure also shows the correct response to a +1 mV dc and a +1.9V dc input. Notice that the DE width varies in proportion to the magnitude of the input signal.

4-52. The waveform shown in Figure 4-5 for the junction of C7 and Q5 is the signal that should appear at the integrator summing junction with inrange and overrange inputs. Improper response to overrange inputs suggests a malfunction during AZ2, particularly of Q4 or its driver.

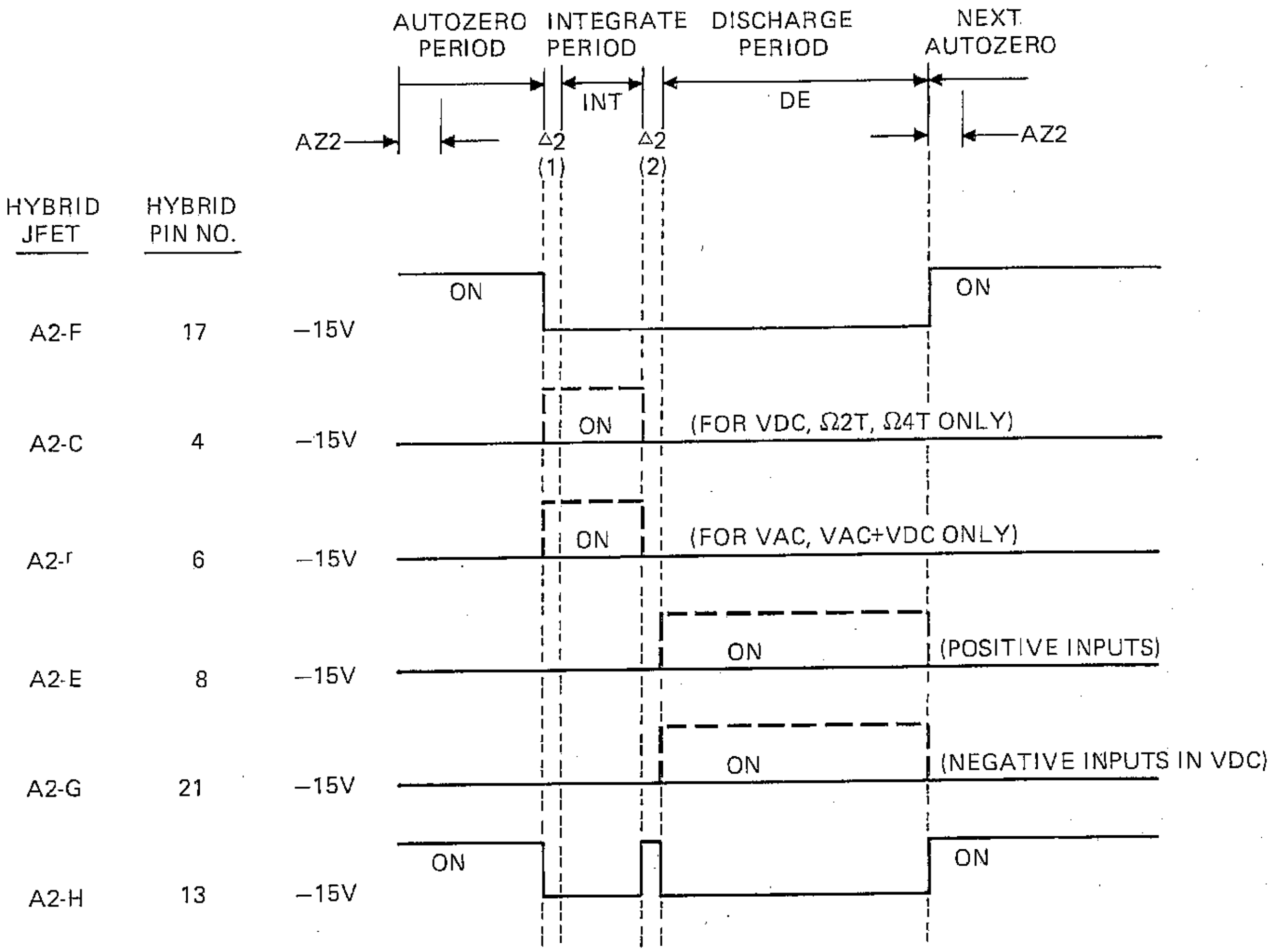
4-53. The waveforms shown for the junction of R47 and Q5 give a quick check of JFET Q5 and transistor Q12. The pulses occur during the two Delta-2 periods.

4-54. The two TP10 waveforms of Figure 4-5 show the normal signal at the integrator output for inputs of +1V dc and overrange. Note during overrange that the voltage returns very rapidly to zero during the AZ2 period.

4-55. The two TP12 waveforms of Figure 4-5 show the signal that should be present at TP12 for +1V dc and 0.0V dc (shorted) inputs. Voltage limiting is caused by diodes CR5, 6, 8, and 9. When the input voltage is zero, one of two waveforms is present at TP12, depending on the sign of the display (+0.0 or -0.0). The voltage at TP12 should not change more than 3 mV during the integrate period.

## 4-56. A/D TROUBLESHOOTING TIPS

4-57. Signal paths ahead of the A/D Converter can be bypassed by removing the AC/DC Scaling board and applying dc test voltages to A2-3 for VDC and A2-7 for VAC. When VAC is selected, no polarity sign appears.




NOTE:

1. Each JFET timing diagram represents the gate voltage. In the high state the gate is pulled up to the same voltage as the JFET channel.
2. The transitions with dashed lines are conditional as indicated.
3. Hybrid JFET A2-A is ON and stays ON as long as EXT. REF. is selected. Hybrid JFET A2-B is ON and stays ON as long as EXT. REF. is not selected
4. The lengths of the Δ 2 periods are exaggerated for clarity.

**Figure 4-4. Timing Diagram for A/D Converter JFETs**

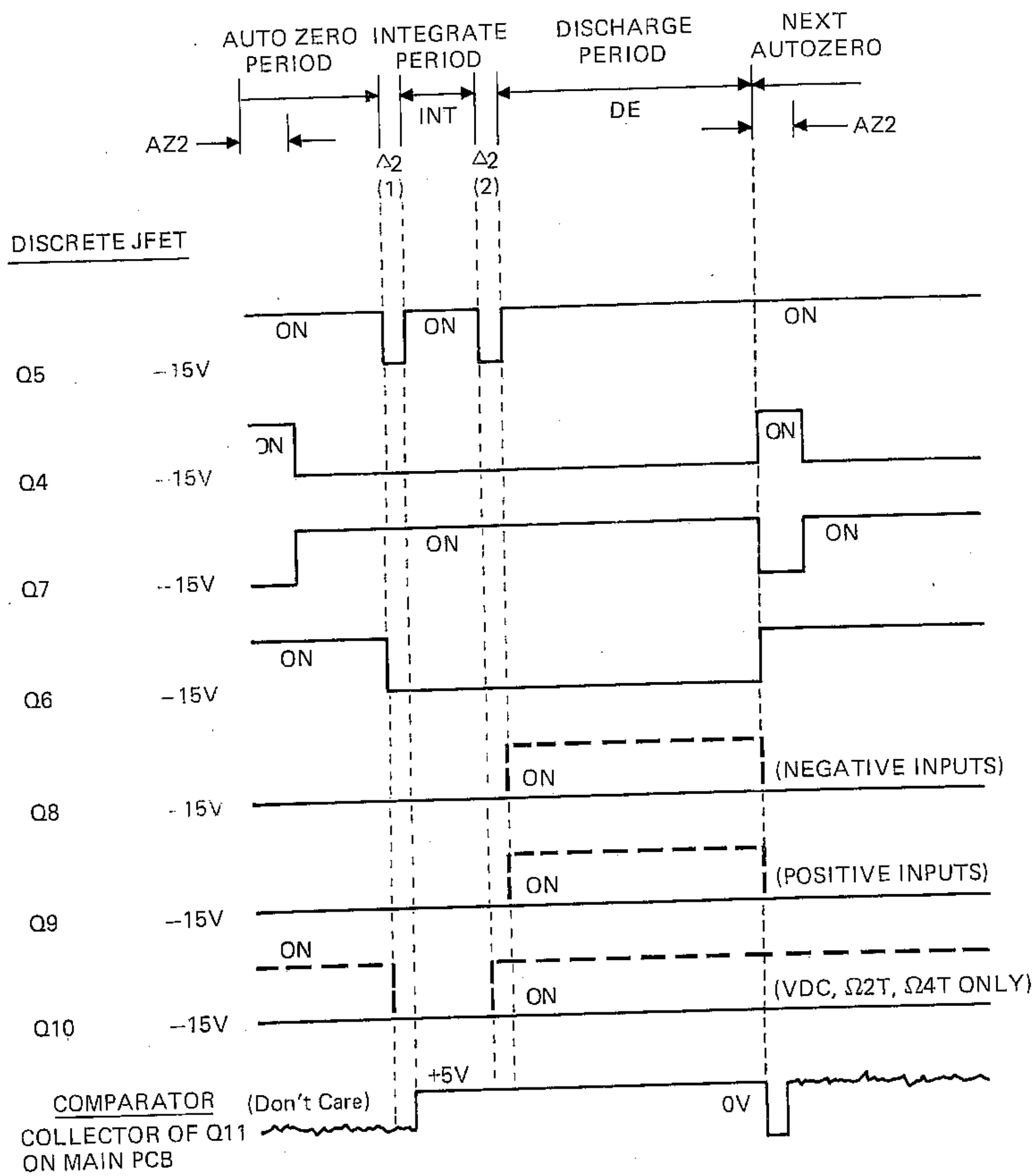



Figure 4-4. Timing Diagram for A/D Converter JFETs (cont)

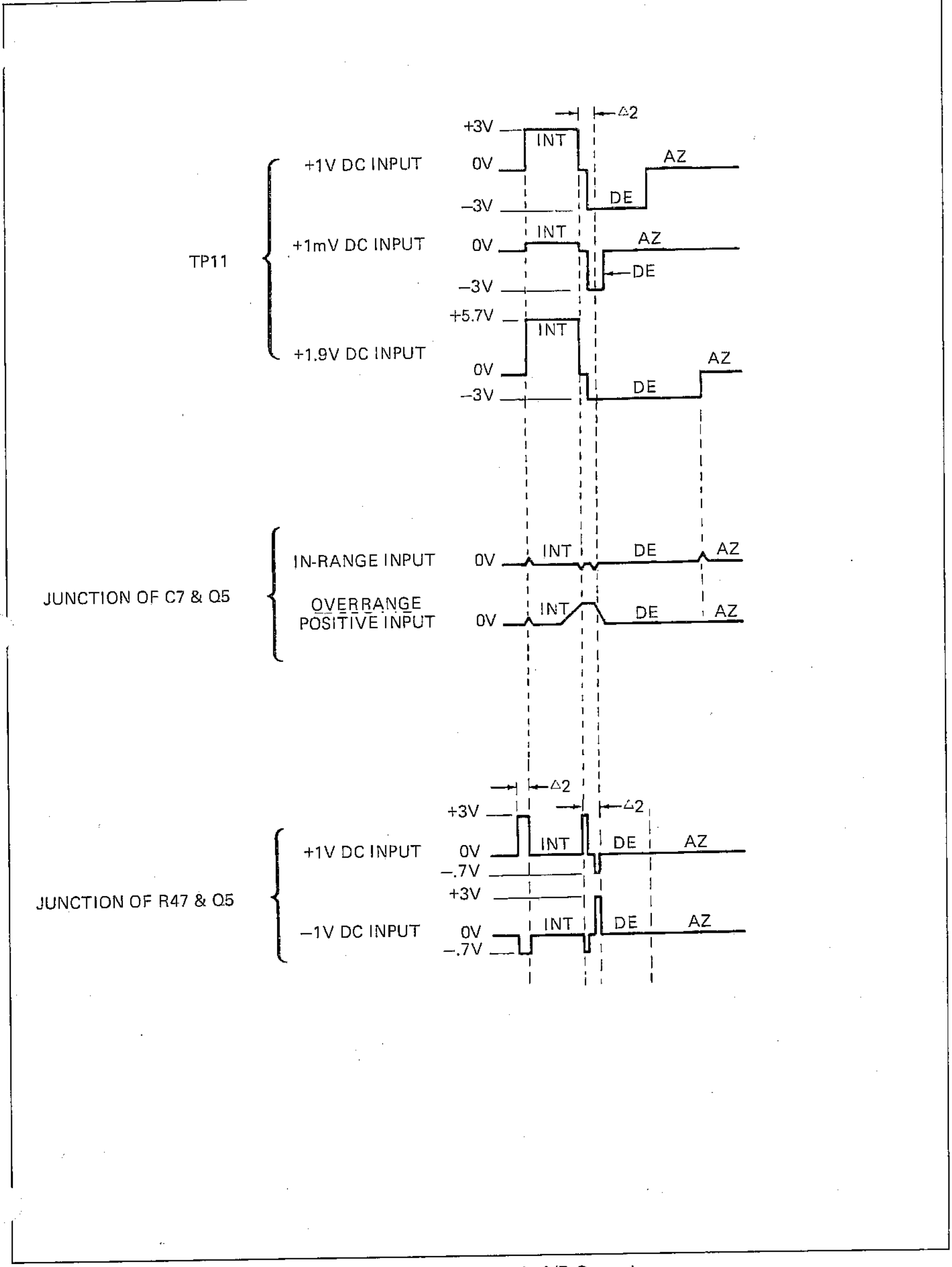



**Figure 4-5. Signal Waveforms in A/D Converter**

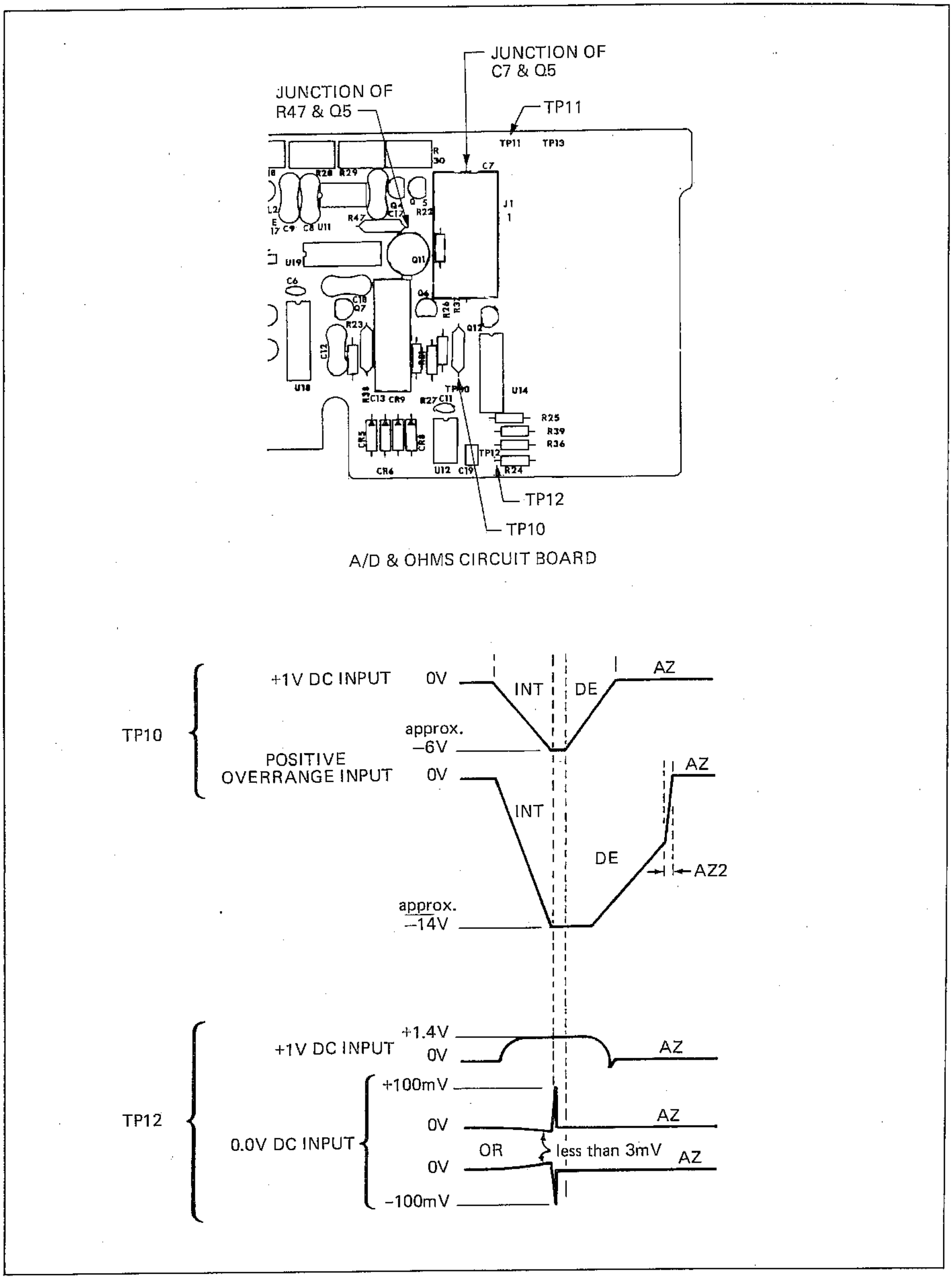



**Figure 4-5. Signal Waveforms in A/D Converter (cont)**

4-58. Operation in the 4½ or 3½ digit mode makes the A/D cycle easier to observe, due to the higher sample rate. To select the 3½ digit mode, set switch S1 to the TM1 position. This switch, shown in Figure 4-6, is located on the top edge of the Controller PCB.

*NOTE*

*Be sure to return both S1 and S3 slide switches to NORM after trouble shooting. Otherwise the instrument will remain in autozero or in the 3½ digit mode.*

## 4-59. DIGITAL TROUBLESHOOTING OF BASIC INSTRUMENT

4-60. General troubleshooting information for the digital section of the 8860A is given in Table 4-7. The table provides a list of solutions for general symptoms. The symptoms are separated into two categories: error message displayed or no error message displayed. Error code descriptions follow the table.

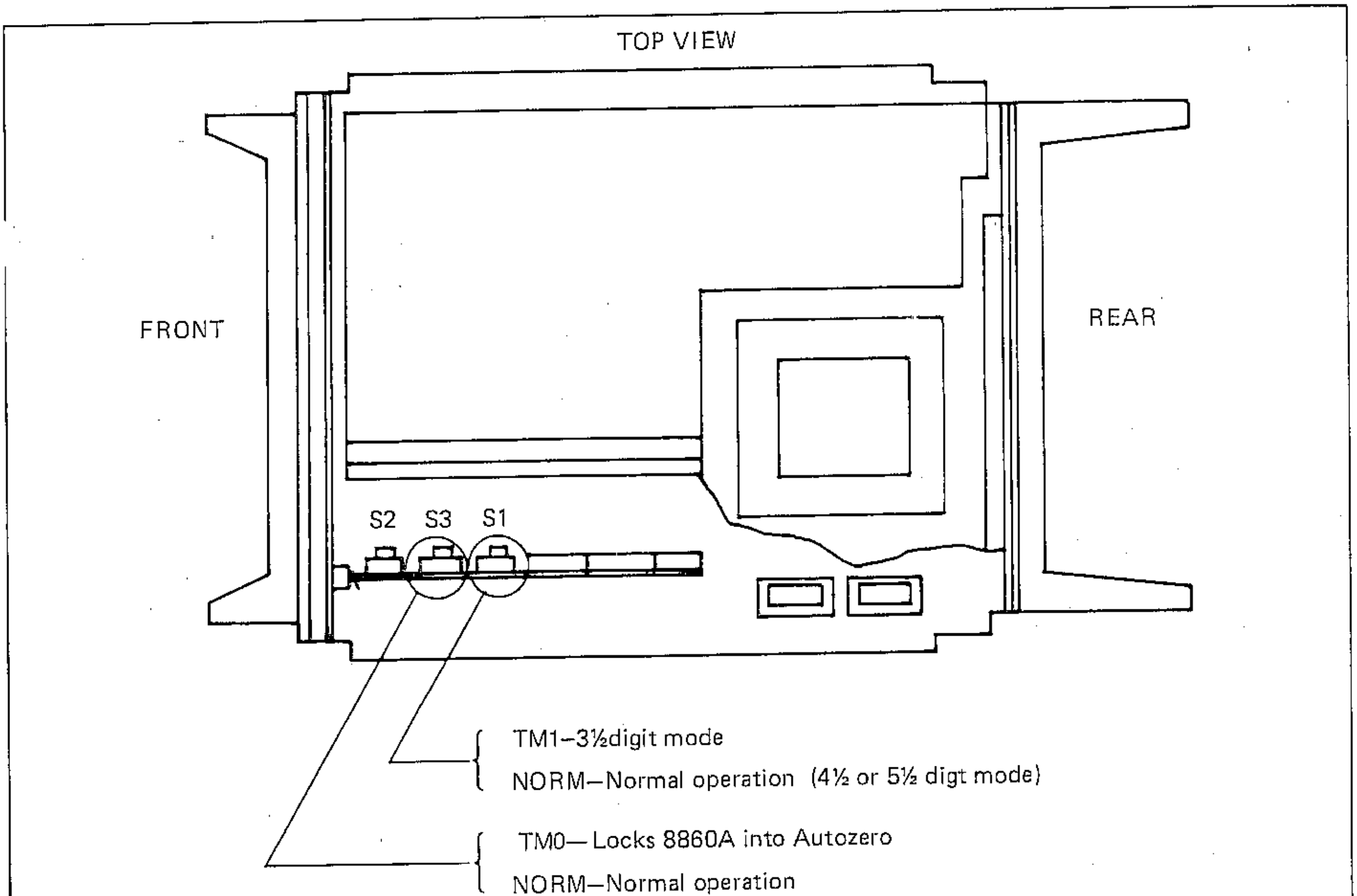
### 4-61. Error Messages

4-62. Basic instrument error mesages fall into two categories: user errors and internal DMM errors. User errors can generally be corrected at the front panel. They are:

Err 10 — External reference has been selected, but the -007 option circuit board is not installed. To correct, install the option or cancel the selection.

Err 11 – Front panel ZERO function has been attempted, but the input is greater than the allowed range of ±99 uV or ±99 mΩ. To correct, verify that the input terminals are shorted.

Err 13 – Exponent magnitude is too large. This occurs when attempting to enter a number which exceeds ±1.99999 X $10^{99}$ into the High, Low, or Offset register (e.g., NUM 2 EEX 99 FCN STORE HIGH).




Note:

1. If, while S3 (TM0) is set to Autozero, power is turned off and back on, the display will remain blank. Correct by switching S3 off and back on.
2. Switch S2 is set for the ac line frequency (50 or 60 Hz) to maximize line rejection for the 4½ digit mode.

**Figure 4-6. Slide Switches Used in Troubleshooting**

**Table 4-7. Digital Troubleshooting of Basic Instrument**

This table is divided into two sequences: choose the first if an error message is displayed, or the second if an error message is not displayed. Both sequences assume that the fault is digital and not analog. Perform the steps in sequence; stop when the fault disappears. Remove the 8860A from line power before unplugging printed circuit boards or removing components.

IF AN ERROR MESSAGE IS DISPLAYED (Err 12, 14, 15, 16, or 17), the fault is confined to the guard-crossing circuitry, one of the microprocessors, or the interconnections:

| SUSPECT AREA | INSTRUCTION |
|---|---|
| 1. Loose Connector | Remove and reseat the Controller PCB (in case it was jarred loose from its connector). Check to see if this clears the fault. |
| 2. Power Supply (Main PCB) | Measure the +5V out-guard supply voltage. It should be +4.7 to +5.3V dc. |
| 3. Out-guard Microprocessor (U2 on Controller PCB) | Replace U2, observing static precautions. |
| 4. In-guard Microprocessor (U1 on Main PCB) | Replace U1. |
| 5. Guard-Crossing Circuitry (on Main PCB) | With any of these error messages, transmissions between micro-processors will stop. Test each opto-isolator individually, as in Table 4-8, and observe the waveform at the noted test point. A good opto-isolator will produce an inverted 5V square wave at the test point. |
| 6. I/O Expander (U3 on Controller PCB) | If the fault has still not cleared, check the PROG control line (pin 7) and data lines (pins 8, 9, 10, 11). Replace this device (U3) if any lines are stuck high or low. (Access these pins from the non-component side of the board.) |

IF NO ERROR MESSAGE IS DISPLAYED, then the in-guard microprocessor and guard-crossing circuits are probably good. The fault is instead on either the Controller or Display PCB. The following sequence of steps checks all integrated circuits, U1 through U11, on the Controller PCB. Perform these steps in sequence:

| SUSPECT AREA | INSTRUCTION |
|---|---|
| 1. Connector or Slide Switches (on Controller PCB) | Remove and reseat the Controller PCB (in case it was jarred loose from its connectors). Also make sure that slide switches S1 (TM1/NORM) and S3 (TM0/NORM) at the top edge of the board are in their normal position (NORM). |
| 2. Digital Option (-004 or -005) | If present, remove the option PCB (Calculating Controller or IEEE-488). If the fault clears, troubleshoot the option assembly using the procedures given in Section 6 of this manual. |
| 3. Power Supply (on Main PCB) | Check the output of the +5V out-guard supply. It should be 4.7V to 5.3V. |
| 4. Out-guard Microprocessor (U2 on Controller PCB) | Replace U2 observing static precautions. Check pin 4, the reset line. It should be at +5V after power up; if stuck low, C1 may be defective. |
| 5. Crystal | Check line ALE (pin 11 of U2) for a 400 kHz square wave. If this signal is not present, crystal Y1 or capacitors C2 or C3 may be defective. Check either pin of the crystal for a 1V pk-pk sinusoid, 6MHz waveform. |

Table 4-7. Digital Troubleshooting of Basic Instrument (cont)

| SUSPECT AREA | INSTRUCTION |
|---|---|
| 6. Display PCB | If one or more of the 7-segment display digits never light up, check pins 2, 4, and 6 of U7 on the Controller PCB for activity (these lines scan the display and keyboard). If all lines are switching, the Controller PCB is probably good; check the Display PCB, devices U1 and Q1 through Q8. All U1 outputs should be switching. Also make sure the Controller and display PCBs are firmly seated in their connectors. If at least one of pins 2, 3, or 6 of U7 (on the Controller PCB) is stuck high or low, suspect the Controller PCB, especially devices U3 or U7. Check the corresponding input pins of U7 for activity. |
| 7. Bad LED Display Segment | Replace the 7-segment digit. |
| 8. Segment Drivers | If the same segment on all digits is out, suspect segment driver U4 or U5 on the Controller PCB. Also check the series resistors U6, R4, R5, R6, and the connector (P2). |
| 9. Local Program Memory (ROM) (U9 on Controller PCB) | Replace if a spare is available; check to see if fault has cleared. |
| 10.Control Lines (on Controller PCB) | With a known good out-guard microprocessor in place, look at the control signals $\overline{PSEN}$, ALE, and PROG generated by the processor; all should be switching. If one is stuck high or low, remove the ICs connected to that line until the line is freed. |
| 11.Data Bus (on Controller PCB) | Check the data bus for a stuck line; all lines should be switching. If a line is stuck high or low, suspect U9 or U10. Check U10 as described in step 12. |
| 12.Address Latch (U10 on Controller PCB) | If you suspect that address latch U10 is faulty, use a dual-trace scope to check its operation. Trigger the scope on ALE and look at the input and output of each bit. If ALE and the latch are working properly, the output follows the input value when ALE is high and latches when ALE goes low. |
| 13.Resistor Network (U8 on Controller PCB) | Check U8 for a bad resistor, using a low-voltage ohmmeter (to prevent diode turn-on). With U8 in the circuit, all resistors should measure somewhere between 5 kΩ and 40 kΩ. |
| 14.External Trigger | U11 and half of U1 is used to condition the external trigger signal (the other half of U1 is used to condition a signal from a digital option). If devices U1 or U11 are faulty, they will not hang up the instrument unless U1-13 is low. This pin should be high when a digital option is not present in the instrument. |

Err 18 — An input or offset value exceeds 1999.99V or 19.9999 MΩ. To correct, reduce the value to an acceptable level.

4-63. Error numbers 12, 14, 15, 16, and 17 represent ·ernal DMM errors, and when they persist, generally ..dicate a hardware failure in the guard-crossing. Hardware faults associated with these error codes are confined to the opto-isolator circuitry, the in-guard microprocessor, the I/O Expander U3, the out-guard microprocessor, or the paths connecting these devices. The troubleshooting procedure is basically the same for each of these errors, and is given in Table 4-7. (A high input voltage transient may cause an Err 14, 15, 16, or 17 to be displayed for up to 4 seconds. This is not considered a fault condition.)

4-64. When the in-guard and out-guard microprocessors communicate, they check the accuracy of the transmission in each direction: Err 12, 14, and 15 indicate errors in communication from in-guard to out-guard circuits: Err 16

**Table 4-8. Testing Guard-Crossing Circuitry**

1. For out-guard to in-guard circuit paths:
   a. Remove the Controller PCB from connector J3.
   b. Check the clock path by applying a square wave (0 to +5V) to J3-15, and, using a scope, observe the resulting waveform at U6-14. Record the propagation time.
   c. To check the data path, repeat step b using J3-13 as the input and U6-15 as the output.
2. For in-guard to out-guard circuit paths:
   a. Remove U6 (the in-guard microprocessor) and the Controller PCB from their sockets.
   b. Check the clock path by applying a square wave (0 to +5V) to U6-12, and, using a scope observe the resulting waveform at U2-1. Record the propagation time.
   c. To check the data path, repeat step b using U6-13 as the input and U2-2 as the output.
3. The measured propagation times of the two paths should differ by less than 7 us. A greater difference will cause occasional transmission errors. A difference greater than 15 us will cause a continuous error message to be displayed.
4. Measure the voltage at pin 4 of each opto-isolator with the square wave applied as in steps 1 and 2. The high level should be at least 0.42V.
5. If either the propagation delay or the voltage level requirements are not met, replace the opto-isolator.

and 17 indicate errors in communication from out-guard to in-guard circuits.

Err 12 — Measurement data received by the out-guard microprocessor from in-guard circuitry is not BCD. The out-guard microprocessor receives measurement data bit-by-bit. Every four bits is verified as a BCD character (0-9). If a hexadecimal character (A, B, C, D, E, or F) occurs, for whatever reason (e.g., bad data or lost synchronization), Err 12 is declared.

Err 14 — The out-guard microprocessor cannot start receiving data from in-guard circuitry. After transmitting command data to the in-guard circuits, the out-guard microprocessor waits up to 3.5 seconds in remote or 4.2 seconds in local for the in-guard microprocessor to respond. This is enough time for any complete measurement cycle. If the out-guard microprocessor does not receive a message or receives a wrong message, it declares Err 14.

Err 15 — The out-guard microprocessor has received either invalid data or no data. If, after the in-guard microprocessor starts transmitting, the out-guard microprocessor receives the incorrect clock bit, or has to wait longer than 518 $\mu s$ for data, Err 15 is declared.

Err 16 — The out-guard microprocessor cannot start transmitting to the in-guard microprocessor. When the out-guard microprocessor is ready to transmit to the in-guard circuit, it sends a ready message. If the in-guard microprocessor does not echo the message within 3.4 seconds, Err 16 is declared.

Err 17 — A transmission error from the out-guard microprocessor to the in-guard microprocessor has occurred. When data is sent to the in-guard microprocessor, each bit is echoed back to the out-guard microprocessor. The in-guard microprocessor must correctly echo each bit within 495 $\mu s$, or Err 17 is declared.

4-65. Messages are transmitted across the guard using parallel clock and data lines. The clock bit toggles with each transmitted data bit. As a data message is sent, the receiving microprocessor returns (echos) the data and clock bits to the sender for comparison. For instance, if the out-guard microprocessor transmits data bit 1, the in-guard microprocessor sends back data bit 1. This echo assures the out-guard microprocessor that the message was correctly received. The data echo occurs for each bit transmitted in either direction. Error 15 or 17 is declared when an echo bit differs from the bit sent.

4-66. Error codes 14 and 16 usually occur when the microprocessors have lost synchronization, and a transmission cannot get started. Errors 15 and 17 mean that the microprocessors started in sync, but then lost a bit. The out-guard microprocessor is the master, and the in-guard microprocessor is the slave. Whenever the echo time period elapses, the in-guard microprocessor defaults to receiving, while the out-guard microprocessor defaults to transmitting.

4-67. Error messages are buffered one deep. If, for example, two errors occur and clear within milliseconds of each other, both errors will be displayed, one after the other, for approximately 1.1 seconds each.

## 4-68. TROUBLESHOOTING AIDS

### 4-69. Visual Inspection

4-70. Visual inspection can sometimes quickly locate instrument faults, saving troubleshooting time. Use the Disassembly procedure presented earlier in this section to remove the top cover. Carefully inspect each circuit board for:

- loose or broken wires and component leads
- improperly seated plug-in assemblies
- physically damaged components
- discoloration due to arcing or overheating
- discolored or burnt capacitors or resistors
- cracked or bulging resistors, diodes, thermistors

### 4-71. Short Circuit in Power Supply

4-72. Current Tracer probes, such as the HP 547A, are usually the best way to locate a short that loads the power supply. To locate such a short, start at the output of the power supply and move the Current Tracer along the supply output path until the short is found. The Current Tracer will glow brightest at the terminal of the shorted component. Shorted logic elements are more difficult to locate because of the small currents involved.

### 4-73. Intermittent Faults

4-74. To locate intermittent and temperature induced faults, alternately warm and cool the suspect circuits. A heat gun and a can of aerosol circuit cooler are recommended as the heating and cooling agents.

### 4-75. Connectors with Poor Contacts

4-76. If connectors are suspected of making poor contact, clean the circuit board fingers by rubbing them with a cotton swab moistened with isopropyl alcohol. Do not use abrasives to clean the gold-plated contacts.

## 4-77. POST REPAIR PROCEDURES

4-78. The 8860A contains a series of factory selected jumpers in the RMS Converter and the Precision Voltage Reference circuits. After either of these circuits have been repaired by parts replacement, it may be necessary to change their jumper settings. The parts that affect the jumper settings are as follows:

- RMS Converter — U17 or U20
- Precision Voltage Reference — U22

4-79. Instructions for verifying and or relocating the jumper settings are given in Tables 4-9 and 4-10. Table 4-9 contains the procedure for the RMS Converter. The procedure for the Precision Voltage Reference is given in Table 4-10.

**Table 4-9. Jumper Selection, RMS Converter**

After replacing U17 or U20 on the RMS Converter, use the following procedure to verify and/or select the jumper locations:

1. Locate the row of sleeved jumpers adjacent to U18, the RMS resistor network.
2. Solder short lengths of solid wire in place of any jumpers that have been previously cut.
3. Install all pcb assemblies, and turn-on power to the 8860A.
4. Connect a short between the 8860A INPUT terminals, and select the VAC function, 2V range.
5. Connect a DMM between the INPUT LO terminal of the 8860A and each of the following test points on the AC/DC Scaling PCB Assembly. At each test point measure the dc voltage. If necessary, bring the voltage within limits by making the indicated adjustment.

| Test Point | Adjustment | DC Voltage Reading |
|---|---|---|
| TP5 | R27 Buffer Offset | 0.0 +/-0.2 mV |
| TP2 | R54 RMS Offset | 0.0 +/-0.2 mV |
| TP3 | R46 RMS Zero | 0.0 +/-100 mV* |

*Reading will be unsteady.

6. Disconnect both the DMM and the short across the INPUT terminals.
7. Connect an AC Calibrator with a 1V, 200 Hz output to the 8860A input terminals.
8. Center the 1V, 200 Hz adjustment (R67) and the 10 mV, 200 Hz adjustment (R73). Record the 8860A display reading.
9. Use the recorded reading and the list at the end of this procedure to determine which jumpers need to be cut.
10. Turn off power to the 8860A, remove the AC/DC Scaling PCB, and cut the appropriate jumpers.
11. Install the PCB in the 8860A, and perform the calibration procedure (see the Calibration Manual).

| RECORDED DISPLAY READING | JUMPERS | | | |
|---|---|---|---|---|
| | W5 | W6 | W7 | W8 |
| 1.00339 to 0.99664 | —— | —— | —— | —— |
| 0.99663 to 0.99497 | —— | —— | —— | cut |
| 0.99496 to 0.98999 | —— | —— | cut | —— |
| 0.98998 to 0.98508 | —— | —— | cut | cut |
| 0.98507 to 0.98023 | —— | cut | —— | —— |
| 0.98022 to 0.97544 | —— | cut | —— | cut |
| 0.97543 to 0.97071 | —— | cut | cut | —— |
| 0.97070 to 0.96603 | —— | cut | cut | cut |
| 0.96602 to 0.96141 | cut | —— | —— | —— |
| 0.96140 to 0.95685 | cut | —— | —— | cut |
| 0.95684 to 0.95234 | cut | —— | cut | —— |
| 0.95233 to 0.94788 | cut | —— | cut | cut |
| 0.94787 to 0.94347 | cut | cut | —— | —— |
| 0.94346 to 0.93912 | cut | cut | —— | cut |
| 0.93911 to 0.93481 | cut | cut | cut | —— |
| 0.93480 to 0.93056 | cut | cut | cut | cut |

**Table 4-10. Jumper Selection, Precision Voltage Reference**

After replacing U22, R41, and R42 in the Precision Voltage Reference Circuit (A/D and Ohms Converter PCB), use the following procedure to verify and/or select the jumper locations:

1. Connect a precision 1.0V dc source to the INPUT terminals of the 8860A; select the VDC function, 2V range.
2. Adjust R17 (+1V CAL) for a display reading of +1.00000. If this adjustment is achieved, the existing jumper locations are correct; perform the calibration procedure (see Calibration Manual). If the adjustment cannot be made, continue with this procedure.
3. Locate the row of sleeved jumpers adjacent to U10 in the Precision Voltage Reference circuit.
4. Solder short lengths of solid wire in place of jumpers which have been previously cut.
5. Install all pcb assemblies, and turn-on power to the 8860A.
6. With the precision 1.0V dc source still connected to the INPUT terminals, turn R7 counterclockwise until the reading no longer decreases. Record the reading.
7. Use the recorded reading and the list at the end of this procedure to determine which jumpers need to be cut.
8. Turn off the 8860A, remove the A/D and Ohms Converter PCB, and cut the appropriate jumpers.
9. Install the pcb in the 8860A, and perform the calibration procedure (see the Calibration Manual).

| RECORDED DISPLAY READING | JUMPERS | | | | |
|---|---|---|---|---|---|
| | W4 | W5 | W6 | W7 | W8 |
| 0.99923 to 0.99372 | ——— | ——— | ——— | ——— | ——— |
| 0.99371 to 0.98827 | ——— | ——— | ——— | ——— | cut |
| 0.98826 to 0.98287 | ——— | ——— | ——— | cut | ——— |
| 0.98286 to 0.97753 | ——— | ——— | ——— | cut | cut |
| 0.97752 to 0.97225 | ——— | ——— | cut | ——— | ——— |
| 0.97224 to 0.96703 | ——— | ——— | cut | ——— | cut |
| 0.96702 to 0.96186 | ——— | ——— | cut | cut | ——— |
| 0.96185 to 0.95675 | ——— | ——— | cut | cut | cut |
| 0.95674 to 0.95169 | ——— | cut | ——— | ——— | ——— |
| 0.95168 to 0.94669 | ——— | cut | ——— | ——— | cut |
| 0.94668 to 0.94173 | ——— | cut | ——— | cut | ——— |
| 0.94712 to 0.93683 | ——— | cut | ——— | cut | cut |
| 0.93682 to 0.93198 | ——— | cut | cut | ——— | ——— |
| 0.93197 to 0.92718 | ——— | cut | cut | ——— | cut |
| 0.92717 to 0.92243 | ——— | cut | cut | cut | ——— |
| 0.92242 to 0.91773 | ——— | cut | cut | cut | cut |
| 0.91772 to 0.91307 | cut | ——— | ——— | ——— | ——— |
| 0.91306 to 0.90846 | cut | ——— | ——— | ——— | cut |
| 0.90845 to 0.90390 | cut | ——— | ——— | cut | ——— |
| 0.90389 to 0.89939 | cut | ——— | ——— | cut | cut |
| 0.89938 to 0.89491 | cut | ——— | cut | ——— | ——— |
| 0.89490 to 0.89049 | cut | ——— | cut | ——— | cut |
| 0.89048 to 0.88610 | cut | ——— | cut | cut | ——— |
| 0.88609 to 0.88176 | cut | ——— | cut | cut | cut |
| 0.88175 to 0.87746 | cut | cut | ——— | ——— | ——— |
| 0.87745 to 0.87321 | cut | cut | ——— | ——— | cut |
| 0.87320 to 0.86899 | cut | cut | ——— | cut | ——— |
| 0.86898 to 0.86482 | cut | cut | ——— | cut | cut |
| 0.86481 to 0.86068 | cut | cut | cut | ——— | ——— |
| 0.86067 to 0.85659 | cut | cut | cut | ——— | cut |
| 0.85658 to 0.85253 | cut | cut | cut | cut | ——— |
| 0.85252 to 0.84851 | cut | cut | cut | cut | cut |