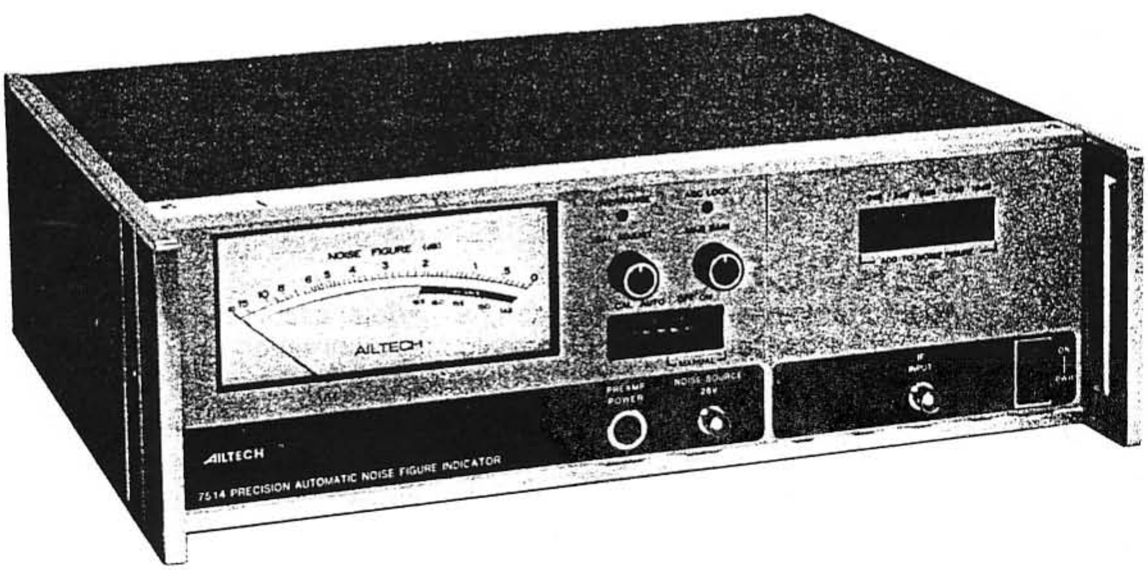
OPERATION AND
MAINTENANCE MANUAL

AILTECH
7514 PRECISION AUTOMATIC NOISE FIGURE INDICATOR



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CHAPTER I

GENERAL

1-1. INTRODUCTION

1-2. This Instruction Manual is for the AILTECH 7514 Precision Automatic Noise Figure Indicator (PANFI), Figure 1-1, and contains physical and functional descriptions, installation and inspection procedures, operating and maintenance instructions, and a parts list. All schematics, electrical and assembly drawings are included, as are appendices for the applicable optional features. Options included in a specific instrument are indicated in the part number, which can be found on a rear panel nameplate.

1-3. GENERAL DESCRIPTION

1-4. The AILTECH 7514 PANFI is an instrument which provides an analog readout of the noise figure of a unit under test (UUT). Utilizing a unique proprietary circuit design, the instrument is also capable of front panel control of the ENR calibration within the noise figure closed loop without the need for external signal generators or other equipment.

1-5. The PANFI is approximately 17 inches (43 cm) wide and 13 inches (33 cm) deep (see Figure 1-2). Optional Rack Mount Angle Brackets (Option 11) are required for rack installation. The instrument will fit in a standard 5-1/4 inch (13.3 cm) panel opening.

1-6. SAFETY PRECAUTIONS

1-7. The PANFI is a low power instrument, but when a unit is opened for service, there is the possibility of contacting the AC line. The potential hazard is reduced by covering all exposed contact points with insulating material. These instruments should be serviced by technically qualified personnel only.

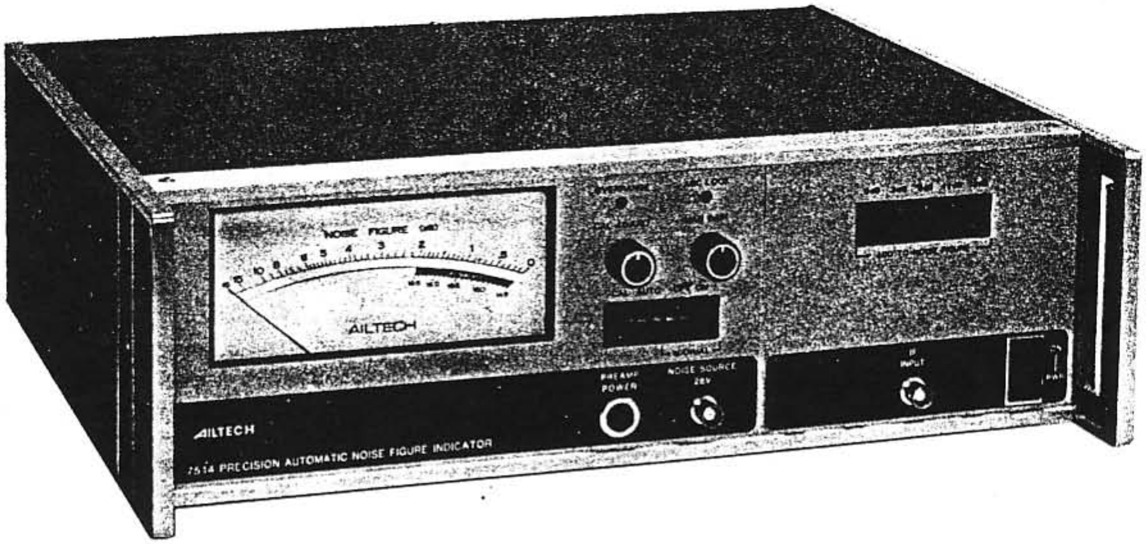

FIGURE 1-1. AILTECH 7514 PRECISION AUTOMATIC NOISE FIGURE INDICATOR

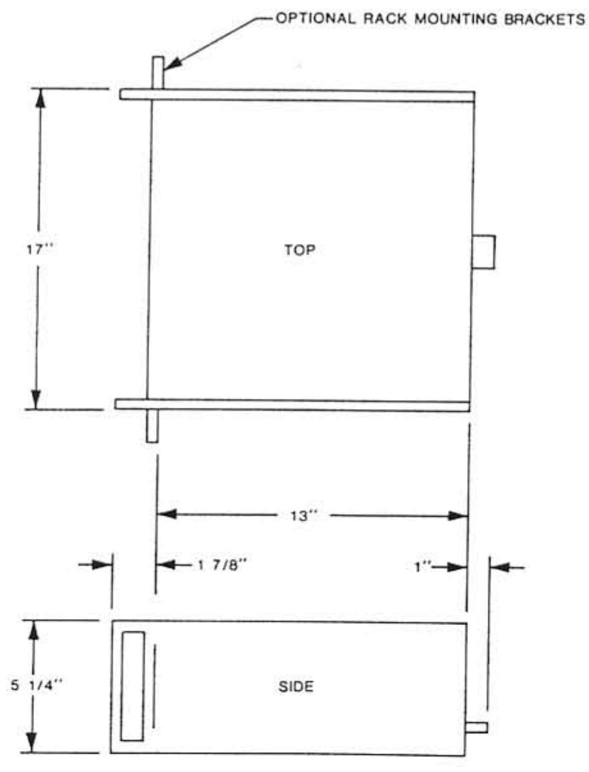

FIGURE 1-2. MODEL 7514 OUTLINE DIMENSIONS

TABLE 1-1. TECHNICAL SPECIFICATIONS

Noise Figure Ranges	0 to 33 dB in five ranges; scale to infinity on all ranges	
Full Scale Range	0, 3, 6, 12, and 18 dB	
Accuracy* (automatic mode) (Note 1)	Typical ±0.05 dB + 0.05 dB per 3 dB increment + 0.1 dB per range increment	
	0-dB range	0 to 3 ±0.10 dB 3 to 6 ±0.12 dB
	3-dB range	3 to 6 ±0.15 dB 6 to 9 ±0.20 dB
	6-dB range	6 to 9 ±0.20 dB 9 to 12 ±0.25 dB
	12-dB range	12 to 18 ±0.4 dB
	18-dB range	18 to 21 ±0.75 dB 21 to 33 ±1.0 dB
AGC	65 dB	
Input Sensitivity (Note 2)	-76 dBm (25 μV)	
Input Frequency	30 MHz with a 6-MHz bandwidth (nominal)	
Operating Modes	Automatic, manual, and calibrate	
Input Impedance	50 ohms (nominal)	
Control Ranges -		
Input Level (AGC) (Note 3)	65 dB (minimum)	
Manual Gain	50 dB (nominal)	
ENR Calibration	14.5 to 16.5 dB	
Meter Indications	Noise Figure, Excess Noise Ratio	

Outputs -	
Noise Source	28 volts, CW or modulated
Preamplifier Power	Voltage required for operation of AILTECH 136 Preamplifiers
Recorder	50 mV, 5 kilohms ungrounded for full-scale deflection
Input Power	115/230 VAC ±15%, 2A/1A, 50-400 Hz
Size	14-7/8" L x 17" W x 5-1/4" H (37.8 x 43.2 x 13.3 cm)
Weight	21 lb. (9.5 kg) net

*As compared to manual measurement (excluding noise source) using the AILTECH 32 Precision Attenuator.

<u>Notes</u>:

1. Accuracy in the automatic mode is defined as the maximum permissible deviation from a manual measurement made under the same conditions.
2. Lowest noise input level (noise source off), at which valid automatic measurements may be performed.
3. Range of noise level (including Y-factor) over which valid measurements may be performed.

For more information, call or write:

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1-8. A standard three-wire, polarized line cord is supplied with the instrument, and mates with an internationally accepted EMI/RFI line filter. The connector complies with all current and proposed domestic and international requirements for commercial test equipment.

1-9. TECHNICAL SPECIFICATIONS

1-10. A listing of technical specifications is provided in Table 1-1. Outline illustrations are presented in Figure 1-2.

1-11. FUNCTIONAL DESCRIPTION

1-12. General

1-13. The 7514 Precision Automatic Noise Figure Indicator is designed for both field and laboratory applications where simplicity and high accuracy instrumentation are required. The 7514 is capable of providing fully automatic testing via a continuous indication of noise figure for a variety of components, assemblies and receivers. Simplified functional operation is described in the following paragraphs; a detailed functional description is provided in Chapter IV. All AILTECH solid-state noise sources from 10 to 18 MHz are usable with the PANFI described herein (see paragraph 1-22).

1-14. The 7514 PANFI in a Typical Application

1-15. In a typical measurement setup for transistors, amplifiers, mixers, receivers, etc., such as that shown in Figure 1-3, the PANFI furnishes modulated low-level DC power to the noise source, which in turn provides alternating noise-on and noise-off periods to the unit under test.

1-16. An intermediate frequency (IF) is derived internal to the UUT in the case of a complete transceiver, or externally by means of added downconverters. This signal, which consists of periods of IF noise from the UUT alone, alternating with periods of UUT noise plus that added by the noise source, is applied to the PANFI input. The difference between the two detected levels derived from the IF signal is related to the noise performance of the UUT. This difference is synchronously detected and displayed directly as noise figure by the 7514 PANFI.

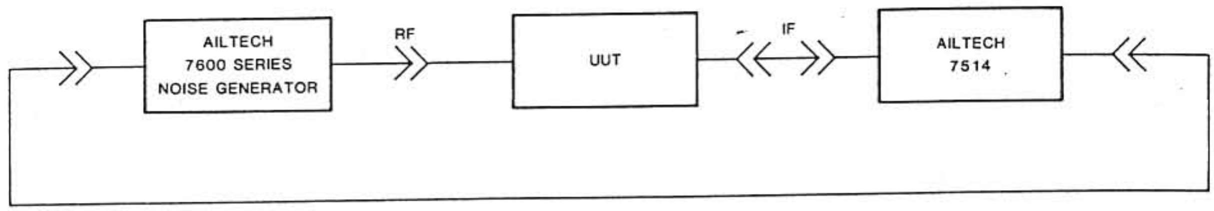


FIGURE 1-3. TYPICAL MEASUREMENT SETUP USING THE AILTECH 7514 PANFI

1-17. AUXILIARY OUTPUTS

1-18. The only auxiliary output is the Recorder Output on the rear panel. It is outputted on a double banana jack. Its output is 50 mV DC (at full-scale deflection) into an ungrounded 5 kΩ impedance.

1-19. OPTIONS

1-20. The following options are available for the 7514 PANFI, and are listed here for reference and identification purposes.

a. Option 09, Broadband Mixer Input. Addition of a broadband mixer with all ports (RF, LO, IF) available at the front panel. The mixer covers 10 to 1000 MHz. The Option also includes a digitally selected internal LO with bandpass filters for IF's of 21.4, 36, 45, 60, 70, and 160 MHz.

b. Option 11, Rack Adaptor Brackets. Permits mounting the AILTECH 7514 PANFI into a standard 19-inch rack.

TABLE 1-2. APPLICABLE NOISE SOURCES

Part Number	07615	07616	07617	7650-X (1)	7660-X (1)
Frequency Range (GHz)	0.01-1.5	1-12.4	12.4-18	(2)	(2)
Excess Noise Ratio (dB)	15.5±0.5	15.5±0.5	15.5±1	See Fig. 1-7	See Fig. 1-7
Calibration Freq. (GHz)	0.03,0.3, 1.0, 1.5	1,2,3.95, 8.2,12.4	12.4,15, 18	3 points specified at time of order	
ENR Accuracy (3) (dB)	±0.3	±0.3	±0.25	±0.5 (4)	±0.5 (4)
VSWR (maximum)	1.2	1.2	1.3	4:1	4:1
Output Connector	N male	N male	OSM female	N male	OSM female
Input Connector	BNC female	BNC female	BNC female	BNC female	BNC female
Input Requirements	28 volts at less than 30 mA	28 volts at less than 30 mA	28 volts at less than 30 mA	28 volts at 30 mA maximum	28 volts at 30 mA maximum

NOTES:
1. Last digit assigned to each specific noise source at time of order.
2. Up to 15% of the center frequency from 10 MHz to 18 GHz - wider bandwidths available.
3. Accuracy of the ENR data supplied at the calibration frequencies.
4. Higher accuracy available.

a. 07615 10 to 1500 MHz

b. 07616 1 to 12.4 GHz

c. 07617 12.4 to 18 GHz

d. 07660 Typical High Level System Noise Source

FIGURE 1-4. TYPICAL NOISE SOURCES USED WITH THE 7514

1-21. ACCESSORIES

1-22. Noise Generators. A complete measurement setup requires a noise generator in addition to the PANFI. The 7514 is designed to operate with solid-state noise sources of the 7600 series. Table 1-2 lists the applicable sources, and Figure 1-4 illustrates some typical noise generators. Figure 1-5 shows 7650/7660 maximum ENR vs frequency.

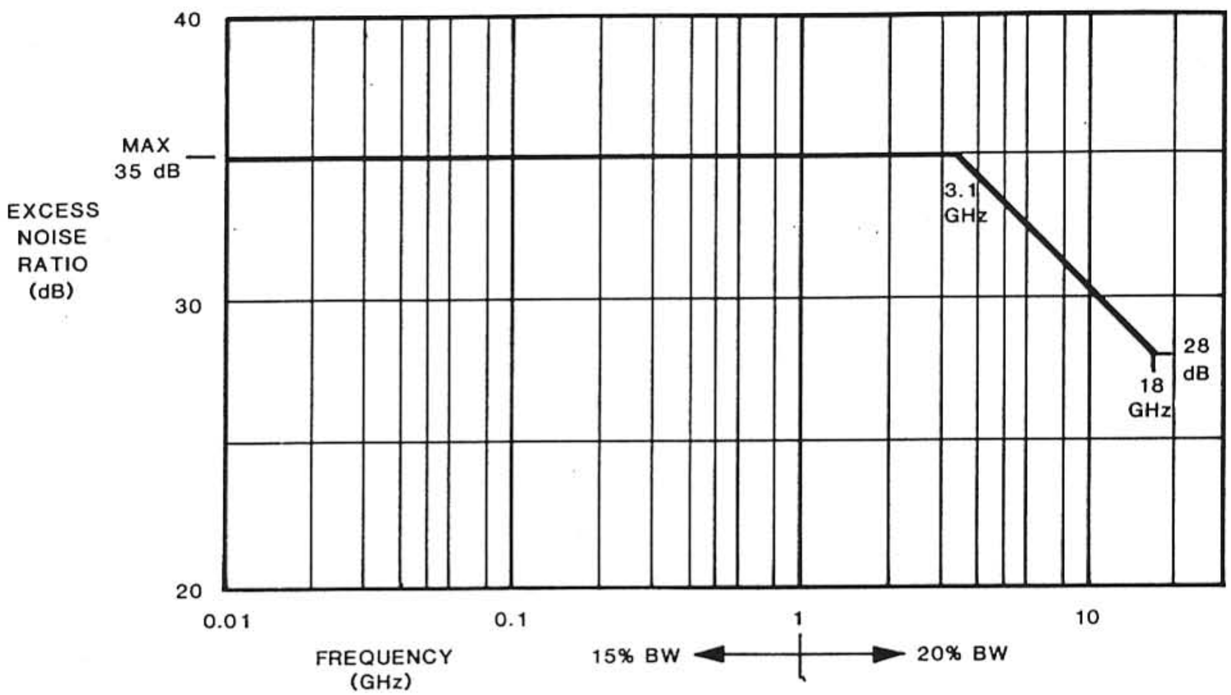


FIGURE 1-5. 7650/7660 MAXIMUM ENR VS FREQUENCY

1-23. Precision Attenuation. The AILTECH 32 Series Precision Attenuators are tuned, continuously variable attenuators which provide an accurate means of measuring Y-factor. These instruments are necessary for routine, periodic noise figure recalibration of the 7514 PANFI. However, for critical applications where it is desired to improve precision by recalibrating on-line on a short term basis, the Precision Attenuator becomes a valuable adjunct to the measurement setup. These attenuators (see Figure 1-6) are available at common intermediate frequencies in rack mount, cased, and unmounted configurations.

FIGURE 1-6. AILTECH 32 PRECISION ATTENUATOR
(Cased Version)

1-24. TEST EQUIPMENT

1-25. Table 1-3 lists the test equipment recommended for use in testing, adjusting, and servicing the 7514 PANFI.

TABLE 1-3. RECOMMENDED TEST EQUIPMENT

Description	Specification	Recommended Model
Precision Attenuator	IF equal to 7514	AILTECH 32 Series
Signal Generator	Calibrated output from -80 to 0 dBm at 7514 IF	Wavetek 2001
Digital Multimeter	4-1/2 digits	Systron-Donner 7004A
Vector Voltmeter	10 to 100 MHz	PRD 2020
Oscilloscope	200 MHz 3 dB BW	Tektronix 475
Noise Generator	Compatible with UUT and 7514	AILTECH 76 Series
Amplifier	Compatible with Noise Generator and PANFI	(Simulates UUT)

CHAPTER II

INSTALLATION

2-1. INTRODUCTION

2-2. This chapter describes unpacking, inspection, preparation for use, and initial checkout of the AILTECH 7514 Precision Automatic Noise Figure Indicator.

2-3. UNPACKING, INSPECTION, AND DAMAGE CLAIMS

2-4. No special instructions or precautions are necessary for unpacking the PANFI; the instrument is ready for use immediately upon receipt. The following checks should be made to insure that no damage has occurred during shipment.

a. Inspect the shipping container prior to acceptance from the carrier. Note any damage to the shipping container on the carrier's receipt.

b. Inspect the instrument for damage. Check for dents, scratches, broken switches, connectors, etc.

c. Remove the top and bottom covers and inspect for broken components or loose hardware.

d. If damage is not apparent until after the instrument has been accepted, file a claim for concealed damage with the carrier within 5 days after receipt. All packaging material must be kept for inspection by the carrier's agent. A copy of the claim must be forwarded to Eaton Corporation.

2-5. ANCILLARY ITEMS

2-6. Each 7514 PANFI is accompanied by a mating line cord, and one instruction manual. Before discarding the shipping container, make sure these items are removed.

2-7. Mounted to the inside right frame, is an extender board (852-1647) that can be used when troubleshooting the four plug-in PC boards.

2-8. RACK MOUNTING

2-9. Rack Mounting Adapter Kit, Option 11, is required to secure the AILTECH 7514 in a standard 19-inch rack. The kit consists of two right-angle brackets which bolt to the side of the unit. Complete assembly instructions are provided with the kit.

2-10. PREPARATION FOR USE

2-11. Prior to shipment from the factory, the line voltage adapter on the rear panel is set to the value appropriate for the shipping destination. However, it is good practice to check this setting prior to operating the instrument (see Figure 3-1). The line fuse, F1, should also be checked to make certain it is the correct value for the line voltage selected:

230 VAC: F1 - 1 amp, Slo-Blo

115 VAC: F1 - 2 amp, Slo-Blo

a. If it is necessary to change the line voltage setting:

   1. Disconnect the power cord from the instrument.

   2. Slide the plastic cover to the left to gain access to the full assembly. Using the fuse extractor that is part of the assembly, remove the fuse.

   3. Remove the voltage-select card that is located directly below the fuse holder, inside the assembly. Reinsert this card such that the proper line voltage is on the upper left side of the card. (See Figure 2-1.)

4. Insert the proper fuse, and slide the plastic cover back over the fuse.

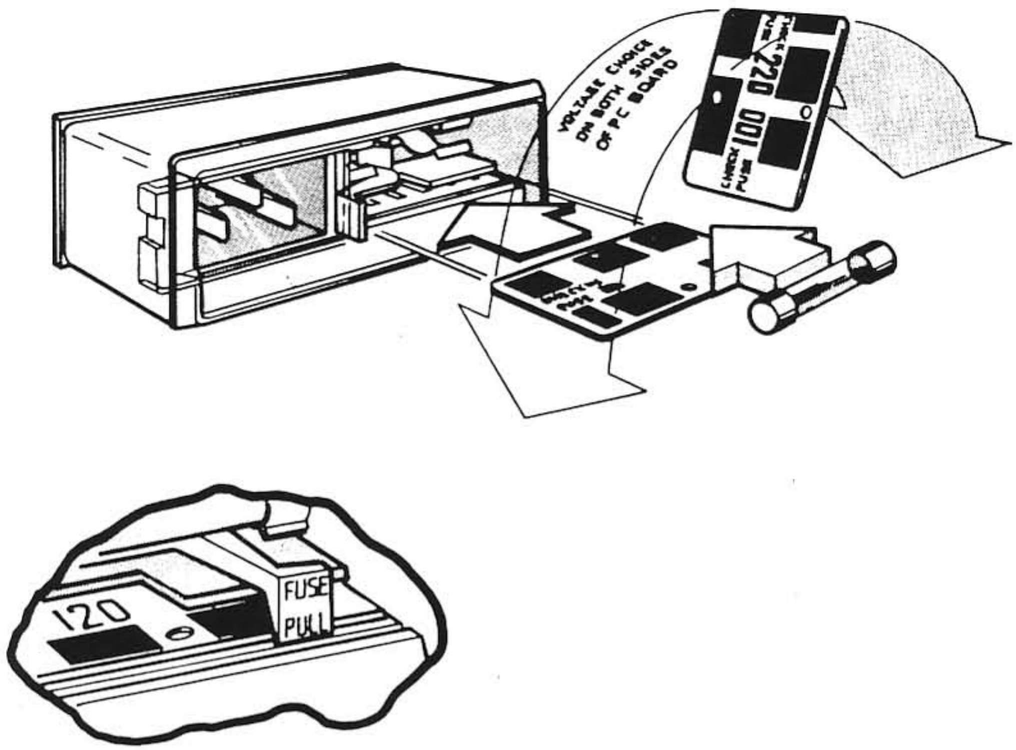


FIGURE 2-1. AC-INPUT RECEPTACLE AND FUSE ASSEMBLY

2-12. INITIAL CHECKOUT

2-13. This operational checkout is a preliminary test, and is not intended to validate performance standards. (For complete Validation Procedure, refer to Chapter V.) Figure 3-1 and Table 3-1 locate and describe the function of the controls, indicators, and connectors referenced below.

2-14. The equipment required for initial operational checkout is as follows:

a. Oscilloscope - Tektronix 475 (or equivalent)

b. Signal Generator - Boonton Model 102A (or equiv.)

c. Digital Multimeter - Systron Donner 7004A (or equiv.)

2-15. General

2-16. Perform the procedures detailed under paragraph 2-11. Connect the line cord to the appropriate AC power source.

WARNING

The 7514 Precision Automatic Noise Figure Indicator is a low power instrument, but routine precautions should be observed due to the possibility of contact with the applied AC line.

2-17. Checkout Procedures

a. Set the power ON/OFF switch to ON position, allow a few minutes for stabilization, and note that:

   1. The red OVERRANGE indicator will be OFF.

   2. The green AGC LOCK will be OFF.

   3. The 0 dB ADD TO NOISE FIGURE switch indicator and AUTO switch indicator only, are illuminated. If the unit contains the 09 Option, the LO OFF switch indicator will also be illuminated.

b. Depress the MANUAL OFF switch of the mode switches. Connect the multimeter, set up to read +28 volts DC, to the BNC connector on the front panel marked NOISE SOURCE. Note that the multimeter reads 0 ±0.5 volts.

c. Depress the MANUAL ON switch. Note that the multimeter reads +28.00 volts ±0.05 volts.

d. Disconnect the multimeter. Depress the AUTO switch. Connect the oscilloscope to the NOISE SOURCE BNC connector on the front panel. Note that the output is a rectangular, positive pulse, alternating between 0 and +28 volts, at about a 400-Hz rate and 50% duty cycle.

e. Disconnect the oscilloscope and depress the MAN-OFF switch. Turn the MANUAL GAIN fully clockwise and depress the 0 dB ADD TO NOISE FIGURE switch.

f. Connect a signal generator, set to 30 MHz, to IF input. Set the signal generator output to about -76 dBm.

g. Increase the output level of the signal generator. Note that the noise figure indication decreases as the signal level increases.

h. Depress the AUTO switch. With the output of the signal generator at -73 dBm, the AGC LOCK green light should be illuminated.

i. Set the signal generator output to 0 dBm. Both the AGC LOCK and the OVERRANGE red light should be illuminated.

j. Set the output of the signal generator to -73 dBm again. Depress the CAL switch. By turning the CAL knob on the front panel, the needle should move partially across the right end of the meter.

k. Depress each switch to insure that each indicator will illuminate.

NOTE

If the instrument fails any portion of the checkout procedure, it requires adjustment or repair. Refer to Chapter V for adjustment and troubleshooting instructions. If the unit is still under warranty, contact your local Eaton Corporation/EID representative.

CHAPTER III

OPERATING INSTRUCTIONS

3-1. GENERAL

3-2. This chapter provides a description of the 7514 Precision Automatic Noise Figure Indicator operating controls, indicators and connectors, and typical operating procedures.

3-3. DESCRIPTION OF OPERATING CONTROLS, INDICATORS AND CONNECTORS

3-4. The front and rear panel controls, indicators and connectors are listed in Table 3-1, and illustrated in Figure 3-1.

3-5. SETUP PROCEDURES

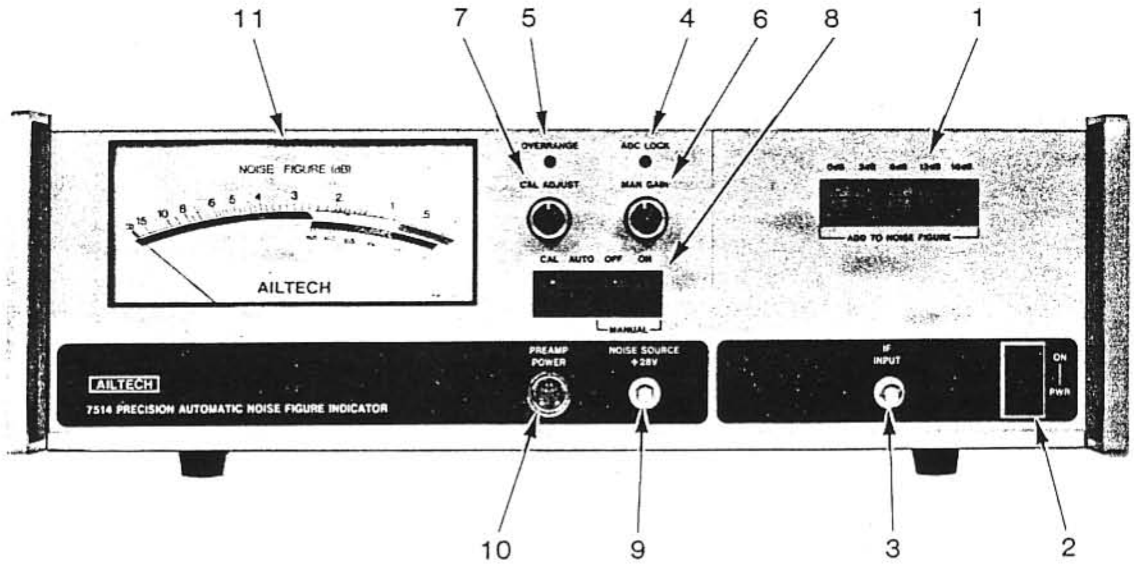
3-6. The AILTECH 7514 PANFI is normally applied to the continuous or periodic measurement of a single receiving system, or repeated measurements of similar types of devices (as on a production line test station). Therefore, some care should be exercised in setting up the measurement system to insure the validity of the indicated results.

3-7. There are three major factors to be considered in setting up the measurement system:

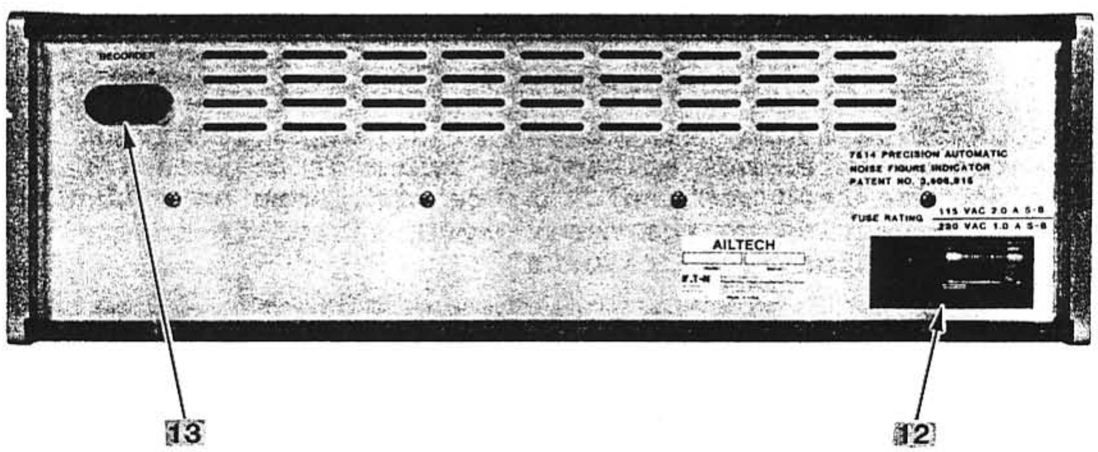
a. Interconnections.

b. Establishment of the correct Excess Noise Ratio (ENR) setting on the noise figure meter.

c. Establishment of signal levels within the measurement range of the PANFI.



a. Front Panel



b. Rear Panel

FIGURE 3-1. 7514 CONTROL, INDICATOR, CONNECTOR LOCATIONS

TABLE 3-1. AILTECH 7514 PANFI CONTROLS, INDICATORS AND CONNECTORS

Key (Figure 3-1)	Title	Reference Designation	Function
1	SCALE SELECTOR	S501-S505	Selects and indicates desired noise figure scale.
2	ON-OFF	S501	Lever switch controls application of AC power.
3	IF INPUT	J503	BNC female connector for application of IF signal.
4	AGC LOCK	LED406	Green indicator is illuminated when the input IF level exceeds PANFI noise level sensitivity.
5	OVERRANGE	LED405	Red indicator is illuminated when the input IF level exceeds PANFI noise level.
6	MANUAL GAIN	R403	10-turn pot that adjusts IF postamplifier gain during manual operation.
7	CAL ADJUST	R401	10-turn pot that calibrates PANFI for selected excess noise ratio.
8 (a)	CAL	S401	Sets meter to read calibration of instrument to known excess noise ratio of external noise generator.
8 (b)	AUTO	S402	Sets meter to read automatic noise figure.
8 (c)	MANUAL OFF	S403	Converts instrument to total power receiver and turns noise generator off.
8 (d)	MANUAL ON	S404	Converts instrument to total power receiver and turns noise generator on continuously.
9	+28 VOLTS	J403 BNC female	Supplies 0 VDC, +28 VDC, or 0 to +28 volt waveform used to energize AILTECH 76XX Noise Generators or drive AILTECH 7175 Triggerable Gas Tube Power Supply.
10	PREAMP POWER	J402	Provides +20 V and +40 V DC power for AILTECH 136XX Series Preamplifiers.
11	METER	M401	Indicates Noise Figure and excess noise ratio (ENR).
12	AC INPUT	J1	Recessed plug for application of primary AC input with fuse and AC input voltage selector.
13	RECORDER OUTPUT	J305	Output connector for external recorder.

3-8. Interconnections

3-9. In general, most measurements utilizing the 7514 PANFI will be of the bench type, and the setup will be similar to those shown in Figure 3-2.

3-10. The noise source can be any of the AILTECH 76 Series selected for frequency compatibility with the RF input of the device-under-test (DUT). See Table 1-2 for a listing of applicable units.

3-11. If the noise source is a typical laboratory noise generator with an excess noise ratio (ENR) between 14.0 and 16.5, such as the AILTECH 7615, 7616, and 7617 Noise Generators, it can be connected directly to the input of the DUT.

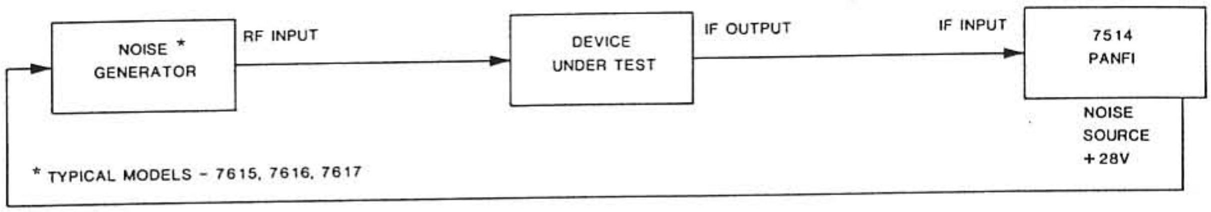
3-12. If the noise source is a high level unit with an ENR greater than 16.5 dB - such as most units in the 7650, 7660 series, a calibrated attenuator sufficient to reduce the ENR to a value between 14.0 and 16.5 dB must be inserted between the noise source and the input of the DUT.

3-13. The 7514 PANFI is provided with 30 MHz as the standard input frequency. If the DUT output is at a frequency different from the PANFI's center frequency, it will be necessary to provide some form of conversion.

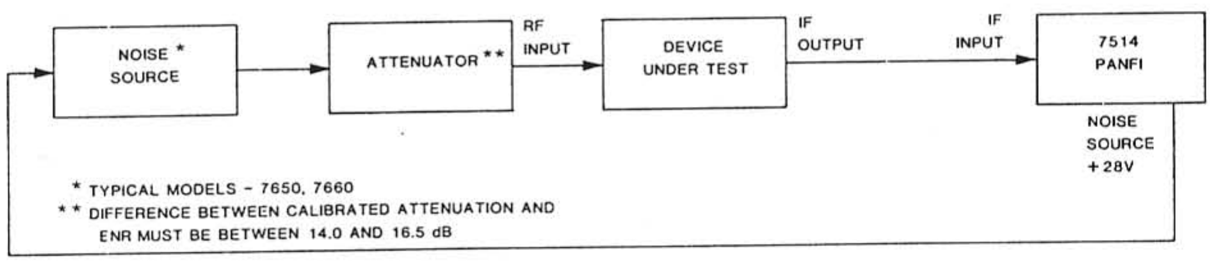
3-14. AILTECH offers the -09 Option for this purpose, and is detailed in the 09 Option manual.

Option 09 can be used as a fixed frequency conversion, with an integral local oscillator at the following frequencies: 21.4, 36, 45.4, 60, 70, and 160 MHz. The input also has a pre-selector filter for each of the above frequencies (20 dB rejection for f_c + 60 MHz, except 160 which is f_c - 60 MHz). An external oscillator may also be used to 1000 MHz for any other frequency desired.

3-15. Using the external oscillator option, the readings are "double-sideband" and corrections to the measured results may be required (see paragraph 3-39). However, the fixed frequency readings are "single-sideband" and do not require corrections.



a. Setup for Bench Measurements Using Noise Sources With ENR's Between 14.0 and 16.5 dB



b. Setup for Bench Measurements Using High-Level Noise Sources

FIGURE 3-2. BENCH MEASUREMENT SETUPS

3-16. Excess Noise Ratio

3-17. The accuracy of the 7514 depends upon accurate setting of the front panel meter, using the CAL adjust. Any error in this switch setting is translated directly, dB for dB, to the noise figure and gain indications.

3-18. Laboratory or bench-type noise generators such as the AILTECH 7615, 7616, and 7617 (see Figure 1-5) have an ENR versus frequency calibration chart attached or printed on the generator body, and are accompanied by a record of calibration. System noise sources, such as the 7650 and 7660, are also accompanied by calibration records.

3-19. To determine the ENR displayed on the meter, put the unit into the CAL mode:

a. Locate the two frequencies on the noise source calibration record (or calibration chart) that that straddle the RF input frequency of the DUT (assuming the input frequency does not coincide with a calibration point).

b. Use straight line interpolation to determine the basic noise source ENR.

c. If the setup is as shown in Figure 3-2(a), adjust the CAL adjust on the front panel, to display the result in (b) on the meter (green scale).

d. If the setup is as shown in Figure 3-2(b), subtract the attenuation (in dB) from the ENR determined on (b). Adjust the CAL adjust to display the resulting difference on the meter (green scale).

3-20. Establishing the Correct Signal Levels

3-21. The green LED, labeled AGC LOCK, will illuminate when the input noise signal is high enough for the 7514 to make an ENR reading in the CAL mode, or noise figure indication in the AUTO mode.

3-22. The sensitivity of the unit is -76 dBm with a nominal bandwidth of 5 MHz. The noise OFF condition determines the AGC LOCK LED illumination.

3-23. The red LED, labeled OVERRANGE, will illuminate when the input level exceeds the AGC range. The reading will lose accuracy due to compression when the red LED is illuminated. The green LED will stay illuminated.

3-24. The noise ON condition determines the OVERRANGE LED illumination. This is set at approximately 0 dBm.

3-25. AUTOMATIC NOISE FIGURE MEASUREMENT USING GAS-DISCHARGE NOISE GENERATOR

3-26. To make an automatic noise figure measurement using the gas-discharge noise generator, proceed as follows:

a. Connect the equipment as shown in Figure 3-3.

CAUTION

If an AILTECH 7010, 7011, or 7012 Coaxial Noise Generator is being used, observe the caution note at the end of this section.

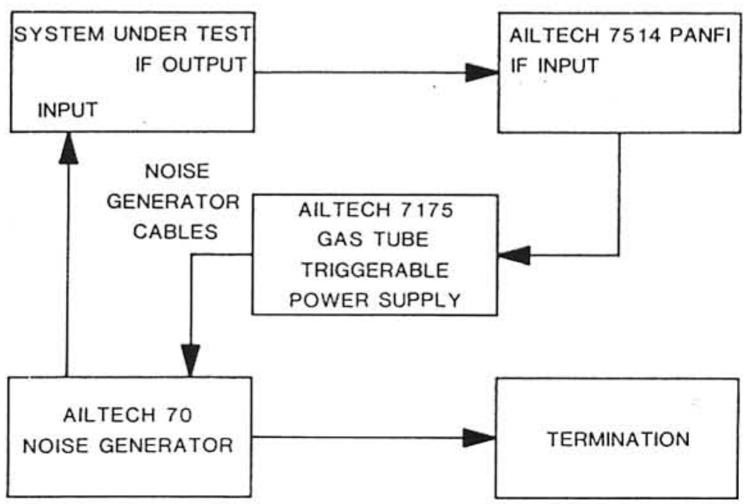


FIGURE 3-3. AUTOMATIC NOISE FIGURE MEASUREMENT USING GAS-DISCHARGE NOISE GENERATOR

b. Set the 7175 in the REMOTE mode.

c. Set GENERATOR CURRENT control, on the 7175, fully counterclockwise.

d. Depress MANUAL OFF button on the 7514.

e. Apply AC power to the 7514 and 7175.

f. Depress MANUAL ON button, and adjust GENERATOR CURRENT control on 7175 for the meter current setting recommended in Table 3-2.

g. Depress CAL button and rotate the scale selector switch to all positions; note that the AGC LOCK front panel indicator is illuminated. This indicates that the input signal is above the minimum required level. (If it is not, the gain of the device under test may be too low.)

h. While observing the CALIBRATE scale (green band) of the front panel meter, rotate the CAL ADJ control to obtain the appropriate excess noise ratio for the noise generator being used (see Table 3-2).

i. After depressing the AUTO button, rotate the scale selector switch to obtain a convenient reading on the NOISE FIGURE scale of the front panel meter.

NOTE

The AGC LOCK indicator must be on for all automatic noise figure readings; if it is not on, the gain of the device may be too low. If the OVERRANGE indicator is on, attenuation is required.

j. Read the noise figure (in dB) of the system under test, on the meter. (Add scale selector range to meter reading for correct noise figure reading of device under test.)

CAUTION

(7010, 7011, 7012 Noise Generators)

A high-voltage pulse is required to ignite the noise lamp within these generators. Capacitive coupling between the anode of the lamp and the helical transmission line causes an attenuated sample of the ignition pulse to appear at the RF output ports. Even with one port terminated with a 50-ohm load, the amplitude of the pulse at the other port can be as high as 5 volts. If the device under test has a solid-state front end, it should be protected from this pulse. A 3-dB attenuator between the noise generator output and the unit under test will usually suffice, although higher values of attenuation may be used if desired. The value of the attenuator (in dB) must then be subtracted from the measured value of noise figure (in dB) in order to obtain the true noise figure of the DUT.

TABLE 3-2. METER CURRENT SETTINGS

Generator	Excess Noise Ratio (ENR) (dB)	Tube Current (mA)
7001	See 7001 case	Not applicable
7010	15.65	175
7012	15.75	175
7052	15.75	175
7053	16.15	150
7091	16.15	150
7096	16.30	100

3-27. AUTOMATIC NOISE FIGURE MEASUREMENT USING SOLID-STATE NOISE GENERATOR

3-28. To make an automatic noise figure measurement using solid-state noise generator, proceed as follows:

a. Connect equipment as shown in Figure 3-4.

b. Apply AC power.

c. Depress the CAL button. The AGC LOCK light must be on, and the OVERRANGE light must be off. If not, the input signal to the PANFI must be adjusted.

d. Use the CAL ADJ control to set the front panel meter to the excess noise ratio (on the CALIBRATE scale, in dB) of the solid-state noise source. The scale selector may be in any position. The system is now calibrated.

e. Depress the AUTO mode button, and set the scale selector for an on-scale meter reading.

f. Read the noise figure (in dB) of the device under test, on the meter. (Add scale selector range to meter reading for correct noise figure reading of the device under test.)

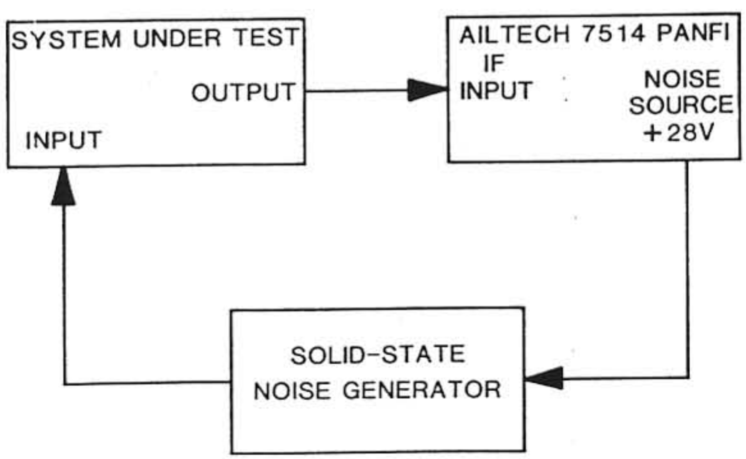


FIGURE 3-4. AUTOMATIC NOISE FIGURE MEASUREMENT USING SOLID-STATE NOISE GENERATOR

3-29. MANUAL NOISE FIGURE MEASUREMENT USING SOLID-STATE NOISE SOURCE

3-30. To make a noise figure measurement (Y-factor) using the Solid-State Noise Source, proceed as follows:

a. Set up the equipment as shown in Figure 3-5.

CAUTION

The Solid-State Noise Source Generators must be driven by their proper modulators for a correct noise figure reading.

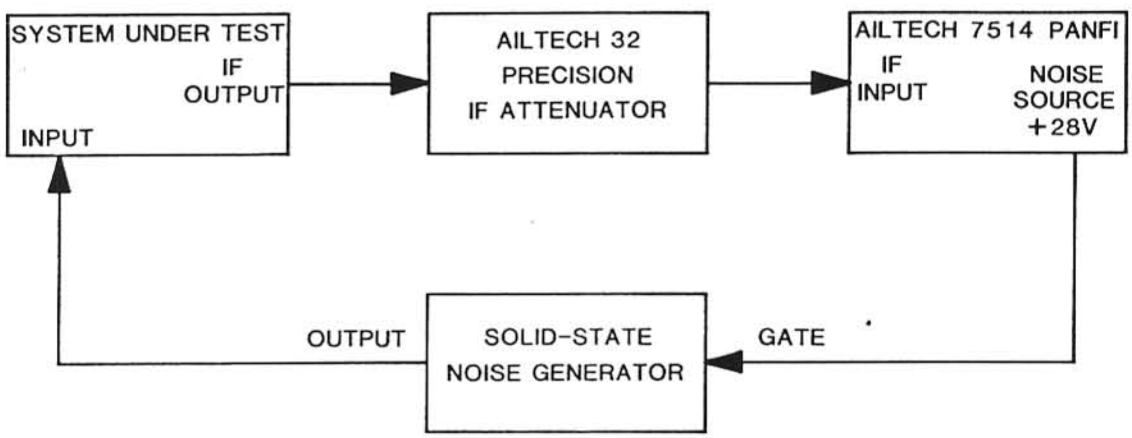


FIGURE 3-5. MANUAL NOISE FIGURE MEASUREMENT USING SOLID-STATE NOISE GENERATOR

b. Depress the MANUAL OFF button.

c. Set the scale selector to the 0-dB position, or some convenient location.

d. Apply AC power.

e. Adjust the GAIN control and the Precision

Attenuator for a convenient reference reading on the PANFI meter.

f. Note attenuator reading.

g. Depress the MANUAL ON button.

h. Increase the Precision Attenuator setting until the PANFI meter returns to the reference noted in Step (e). Note this attenuator reading.

i. Subtract the attenuator reading in Step (f) from that noted in Step (i); this is the Y-factor (in dB).

Noise figure may be calculated from Equation 3-1.

$$F_{(dB)} = ENR_{(dB)} -10 \text{ Log } (Y-1) \qquad (3\text{-}1)$$

In the preceding equation the ENR is the actual effective value after decoupling or attenuation (if any) - not the setting of the thumbwheel switch. Y-factor is expressed as a power ratio.

3-31. The noise parameters may also be calculated using the AILTECH Noise Figure Slide Rule (Figure 3-6) or the nomograph of Figure 3-7.

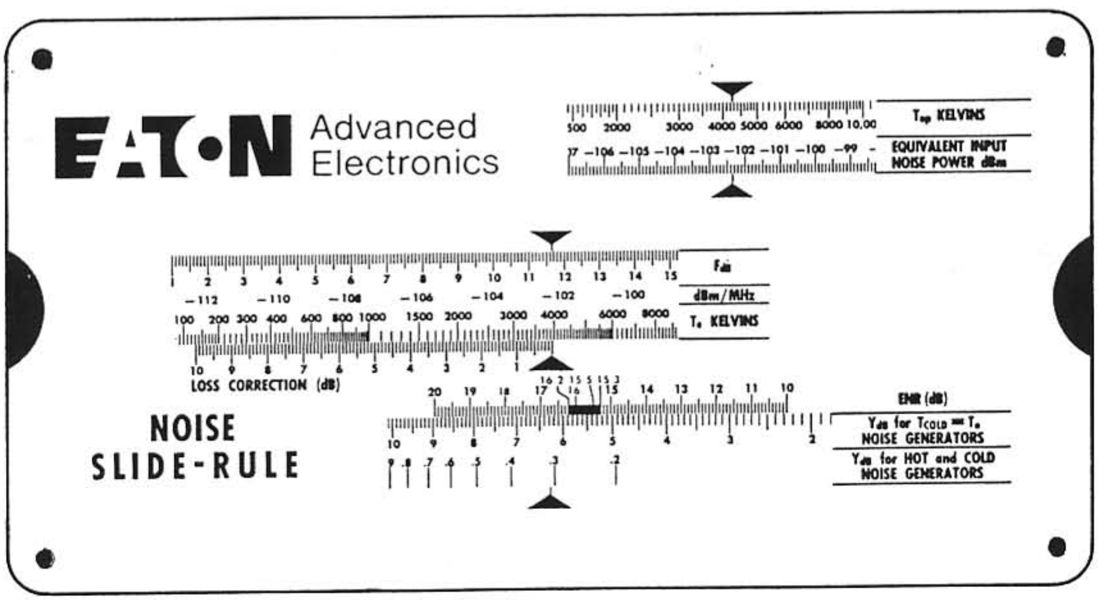


FIGURE 3-6. AILTECH NOISE FIGURE SLIDE RULE

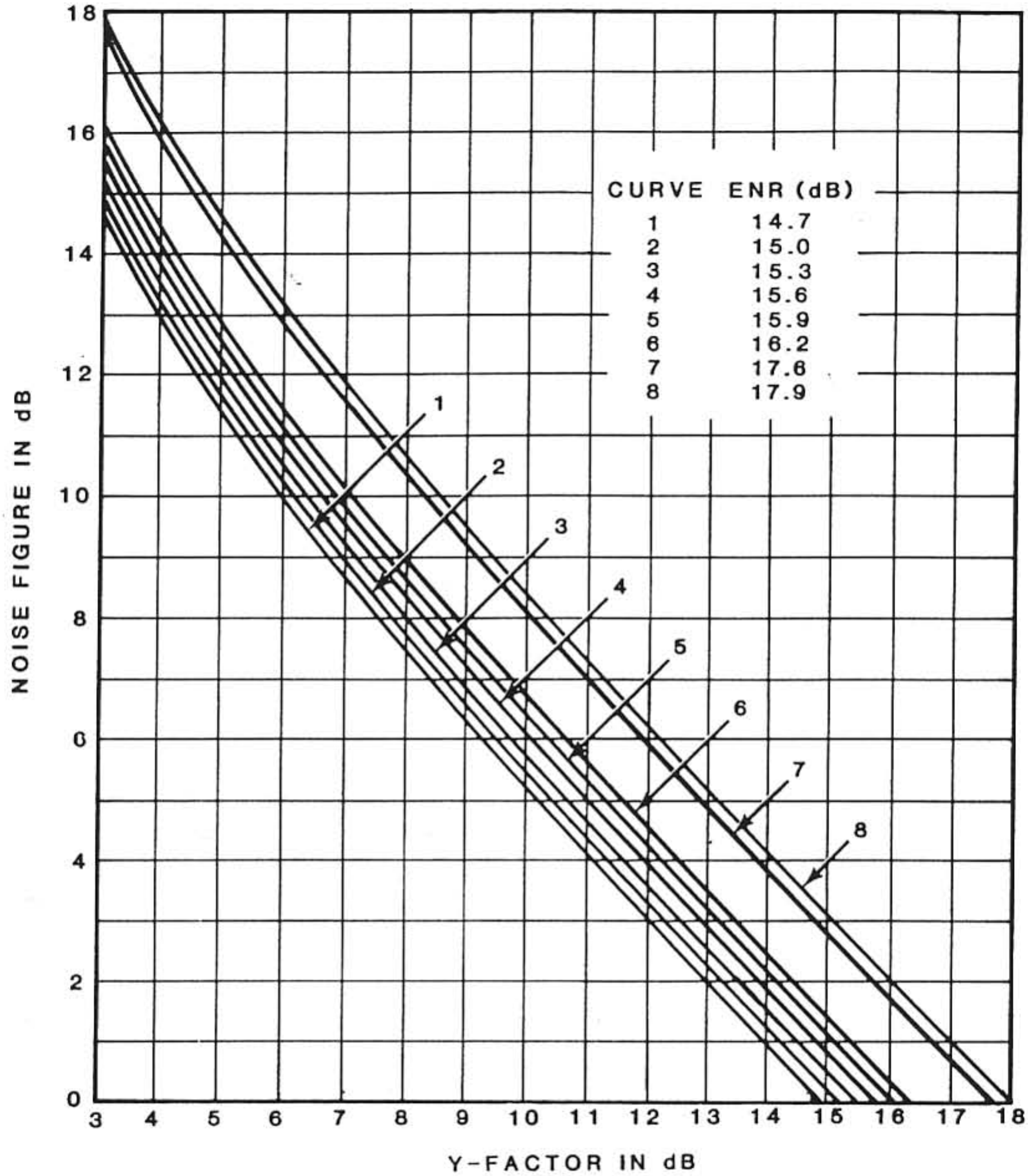


FIGURE 3-7. Y-FACTOR VERSUS NOISE FIGURE

3-32. To check for possible reading errors, depress the MANUAL OFF button and readjust the attenuator to obtain the same reading noted in Step (e) on the PANFI meter.

3-33. ACCURACY CONSIDERATIONS

3-34. <u>Image Response and Second-Stage Noise Corrections</u>

3-35. A major application of the AILTECH 7514 PANFI is the characterization of RF amplifier modules. In general, the output of the DUT must be connected by means of a mixing process to the IF of the 7514. Figure 3-8 shows the typical setup.

3-36. The mixer in Figure 3-8 can be either an external mixer or the internal -09 Option. Depending upon the passband of the DUT, its relation to the mixing sidebands, and the gain of the DUT at these sidebands, it may be necessary to correct the noise figure indication.

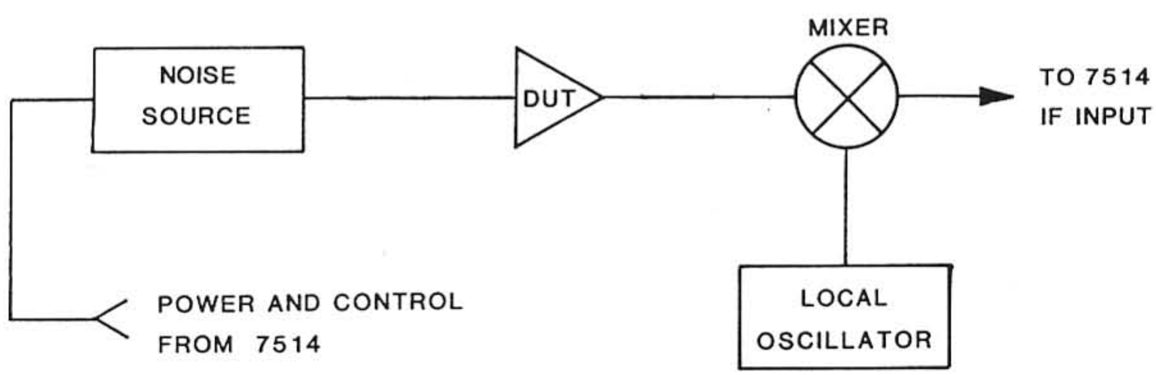


FIGURE 3-8. TYPICAL RF AMPLIFIER MEASUREMENT SETUP

3-37. DUT Output Equals 7514 IF or Option 09 Preselected Frequencies

3-38. When the output frequency of the DUT equals the PANFI input frequency, the mixer is not required. Since the 7514 internal noise figure is typically 14 dB, the second stage noise contribution will generally be minor. If the gain of the DUT is very low, the true noise figure can be calculated from:

$$F_1 = F_{1-2} - \frac{F_2 - 1}{G_1} \qquad (3\text{-}2)$$

where,

F_1 = noise figure of the DUT

F_{1-2} = overall, measured noise figure

F_2 = noise figure seen looking into the 7514 IF input

G_1 = gain of the DUT

All elements of Equation 3-2 are expressed as dimensionless ratios - not in dB's. Figure 3-9 is a nomograph which calculates F_1 directly in dB from the other quantities measured in dB.

3-39. Broadband DUT (Using External LO)

3-40. When the passband of the DUT is very broad, two noise sidebands (one above, and one below the mixer local oscillator frequency) are downconverted to the IF.

3-41. The noise figure indication will be the double-sideband, overall noise figure of the measurement setup. Depending upon the DUT gain and final application, the indication may have to be corrected. If the gains of both sidebands are equal, then Equation 3-2 or Figure 3-9 may be used to correct the result if it is noted that F_2 equals the double-sideband (measured) noise figure of the mixer.

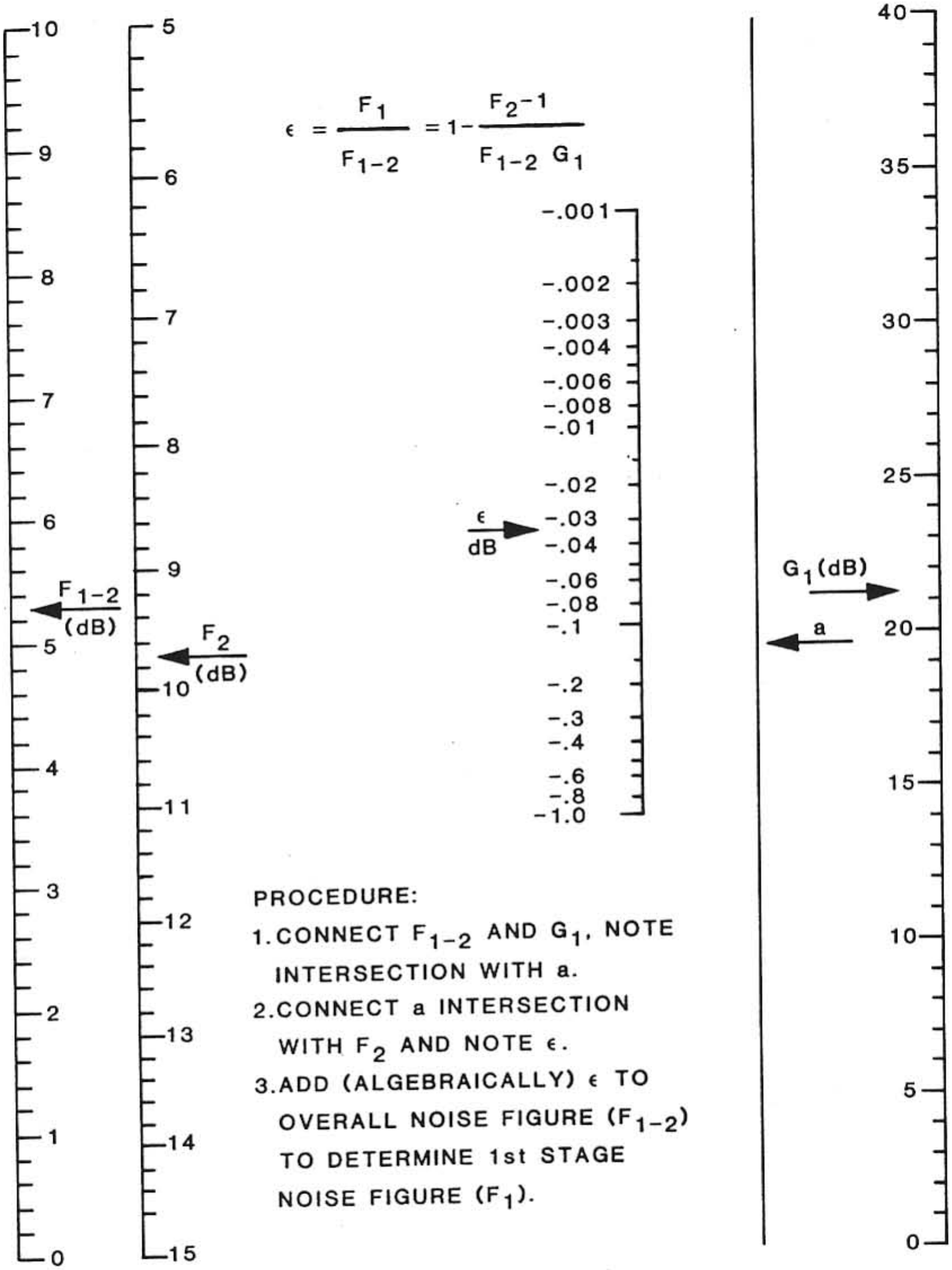


FIGURE 3-9. NOMOGRAPH, CORRECTION FOR SINGLE-CHANNEL SECOND STAGE NOISE FIGURE

3-42. Narrowband DUT (Using External LO)

3-43. When the DUT is narrow band, only one sideband will exhibit significant gain. However, the mixer still generates internal noise in both sidebands and could introduce an error.

3-44. The noise figure indication is the true noise figure of the overall setup. If the gain of the DUT is relatively low in comparison to the mixer noise figure, it should be corrected as shown below:

$$F_1 = F_{1-2} - \frac{2(F_2 - 1)}{G_1} \qquad (3\text{-}3)$$

where, as noted before, F_2 is the double-sideband noise figure seen looking into the mixer. Figure 3-9 can be used to calculate F_1 directly in dB simply by reducing the value of G_1 by 3 dB for use with the chart.

3-45. NOISE GENERATOR ERROR AND CALIBRATION

3-46. In the case of solid-state noise generators, the excess noise ratio is a function of the semiconductor fabrication, the coaxial mount, and the bias (power supply). AILTECH 76 Solid-State Noise Generators are designed for constant noise power outputs across their frequency bands. They exhibit less than ±0.5 dB across their specified frequency spectrums. The precision modulator in the AILTECH 7514 PANFI which drives the AILTECH 76 Solid-State Noise Generators, keeps changes in ENR due to bias below ±0.005 dB.

3-47. Any uncertainty in the ENR of a noise generator will cause a direct uncertainty in the noise figure measured, and should be taken into account when computing the total accuracy of a noise figure measurement, whether manual or automatic.

3-48. When greater accuracy than is normally obtained is required, AIL Division, Eaton Corporation can calibrate solid-state noise generators to uncertainties as low as ±0.11 dB at specific frequencies with traceability to the National Bureau of Standards (NBS). This is accomplished by the AILTECH Noise Generator Calibration Facility which uses the AILTECH 82 Noise Calibration System. This system is capable of comparing the output of a noise generator to NBS calibrated noise standards, such as AILTECH 80 Noise Standards, to within ±0.05 dB. Consult with the factory or your local sales representative for further information.

3-49. NOISE GENERATOR TERMINATION TEMPERATURE

3-50. The definition of noise figure is based on a termination temperature of 290 K (the reference temperature). If this condition is not met, the measured value of noise figure must be corrected. This correction (δ) in dB, determined from Figure 3-10 or equation 3-4 is algebraically added to the measured noise figure (also expressed in dB).

$$\delta - 10 \log \left[1 - \frac{T_1 - T_0}{T_2 \quad T_2} - \frac{T_1 - T_0}{T_0 \quad F_m} \right] \qquad (3\text{-}4)$$

where,

T_1 = actual temperature of the termination

T_2 = effective temperature of the noise generator in the ON condition

T_0 = 290 K

F_m = measured noise figure

3-51. SWR DIFFERENTIAL

3-52. The difference in SWR of the noise generator between the hot (or ON) condition and cold (or OFF) condition may have a significant effect upon the gain and noise figure of some high-gain, negative-input-resistance devices (parametric amplifiers, masers, etc.). The change in gain due to source impedance variations for high-gain amplifiers (greater than 15 dB) can be closely approximated by:

$$\frac{\Delta G}{G} \approx \frac{\Delta |Z_o|}{|Z_o|} G^{1/2} \qquad (3\text{-}5)$$

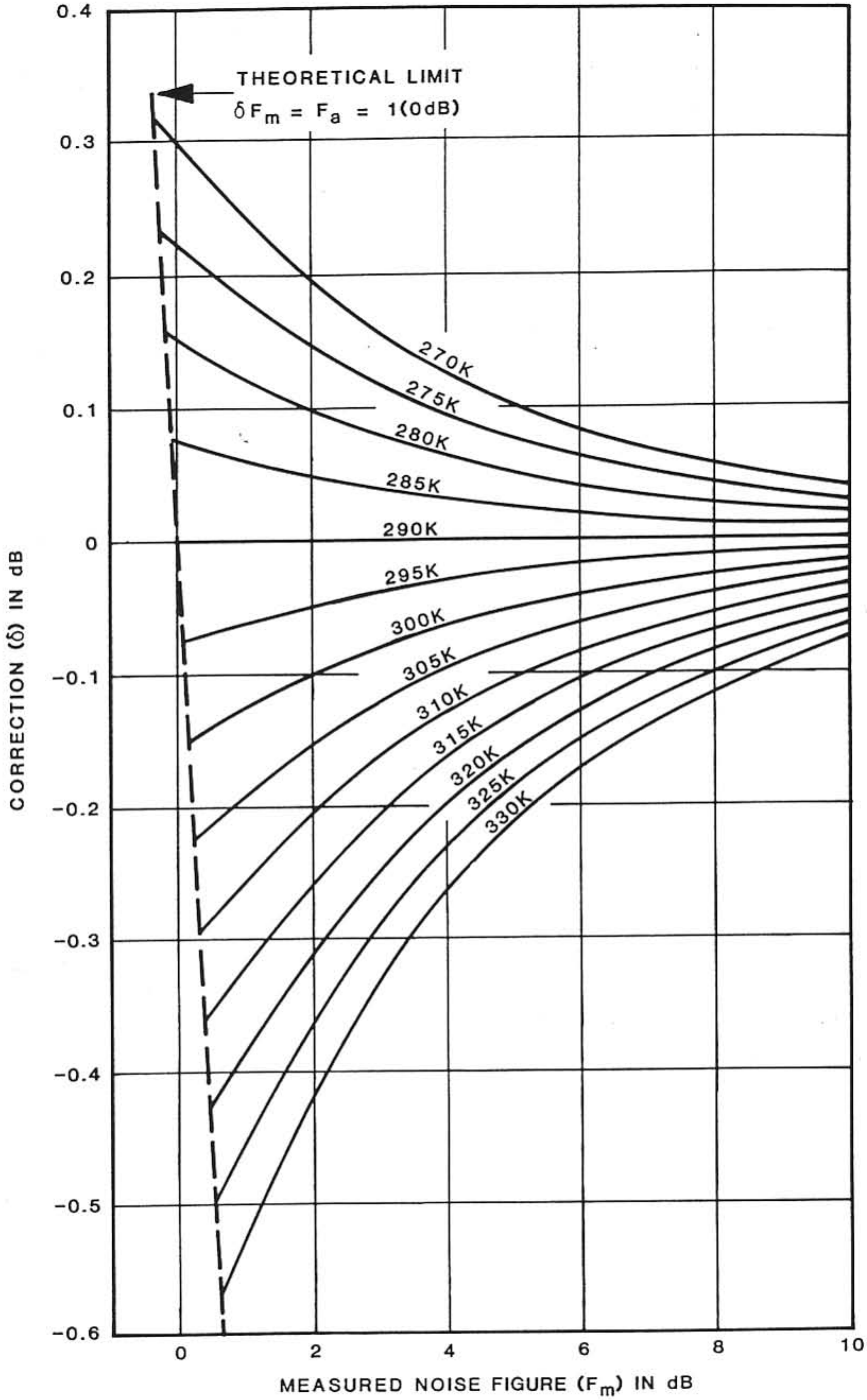


FIGURE 3-10. EFFECT OF TERMINATION TEMPERATURE NOT EQUAL TO 290 K FOR NOISE GENERATOR WITH NOMINAL 15.3-dB EXCESS NOISE RATIO

where,

G = amplifier gain

Z_o = source impedance

ΔG = change in gain

ΔZ_o = change in source impedance

3-53. This change in gain will cause an error in the MANUAL or AUTO method of measurement. The true Y-factor can be obtained from:

$$Y_{true} = Y_{measured\ (dB)} - \Delta G_{dB} \quad (3\text{-}6)$$

3-54. ΔG can be measured exactly by coupling a test signal into the amplifier input through a 20 or 30-dB directional coupler and observing the output as the noise generator is turned on and off. The test signal power should be at least 20 dB greater than the noise power at the amplifier input, but not large enough to cause limiting in the system.

3-55. A second solution would be to provide isolation, by means of a ferrite device, between the amplifier input and the noise source. This would reduce the impedance variation seen by the amplifier. The insertion loss of the isolator would add directly (in dB) to the noise figure of the device under test.

3-56. The uncertainty in the measured noise figure, due to changes in the noise performance of the device under test caused by mismatch changes in the noise source, can be estimated by:

$$dF_{dB} = \pm \frac{4.34\frac{dM}{M}}{1 - \frac{1}{Y}} \quad (3\text{-}7)$$

where,

$$\frac{dM}{M} = \frac{(1 + |\Gamma_r|\ |\Gamma_1|)^2}{1 - |\Gamma_r|\ |\Gamma_2|^2} - 1 \quad (3\text{-}8)$$

where,

Γ_r = reflection coefficient of device under test

Γ_1 = reflection coefficient of noise generator in OFF condition

Γ_2 = reflection coefficient of noise generator in ON condition

3-57. CABLE LOSS

3-58. Any loss introduced between the noise generator and the device under test will cause an apparent change in the excess noise ratio of the generator. Those losses should be measured accurately and subtracted (in dB) from the ENR of the generator. This corrected ENR should be used when setting up during the calibration mode of operation, or in the calculations for a manual measurement.

3-59. SYSTEM BANDWIDTH

3-60. The system bandwidth of a noise figure measuring setup includes the instrument making the measurement, as well as the device under test. Therefore, if an amplifier with a 5-MHz bandwidth were measured with an instrument having a 1-MHz bandwidth, the result would, in general, be an optimistic (or low) noise figure reading.

3-61. With this condition, it is necessary to make several measurements so as to have measured the spot noise figure of the device under test completely across its band of operation. These numbers are then averaged to give the true noise figure. This error can be eliminated by using an instrument with a bandwidth equal to, or wider than, the device under test.

3-62. The equation for the overall noise figure of a two-stage device is

$$F_{12} = F_1 + \frac{F_2 - 1}{G_1} \qquad (3\text{-}9)$$

where all terms are in power ratios, and

F_1 = noise figure of the first stage

F_2 = noise figure of the second stage

F_{12} = overall noise figure of the two stages

G_1 = power gain of the first stage

3-63. A common error, when making a manual Y-factor measurement, is to attempt to make a correction for the insertion loss of the attenuator and the noise figure of the following unit; this is incorrect.

3-64. The correct noise figure in a manual Y-factor measurement is given by equation 3-10.

$$F = \frac{ENR}{Y-1} + \frac{1}{G_1} \qquad (3\text{-}10)$$

where,

F = noise figure of the device under test

Y = Y-factor

G_1 = gain of the system preceding the attenuator

ENR = excess noise ratio of the noise generator being used.

3-65. AUXILIARY OUTPUTS

3-66. The only auxiliary output is the recorder output. It provides a DC voltage proportional to the full-scale reading on the meter.

CHAPTER IV

THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This chapter contains general measurement theory and associated mathematics, an overall functional block diagram description of the PANFI, and detailed circuit descriptions.

4-3. GENERAL THEORY

4-4. <u>Noise Figure Theory</u>

4-5. Noise Figure can be defined as the ratio of the noise power available at the output of a network, when the input termination is at the standard reference temperature (T_o = 290 K), to that which would be available at the output of an ideal noiseless network of otherwise identical characteristics. This can be expressed mathematically as:

$$F = \frac{N_o}{GN_i} \qquad (4\text{-}1)$$

where:

F = Noise Figure Ratio

N = Noise Power (i = input, o = output)

G = Gain of Network

By rearranging Equation 4-1,

$$N_o = N_iFG \qquad (4\text{-}2)$$

The noise power available at the input is that generated by the input termination, and can be written as:

$$N_1 = kT_oB \tag{4-3}$$

where:

k = Boltzmann's constant = 1.38×10^{-23} joules/K

B = Bandwidth in Hz

T_o = Standard Reference Temperature (290 K)

NOTE

All temperatures in these equations are expressed as absolute temperatures (kelvins) and are related to the centigrade (Celsius) scale as follows:

$K = °C + 273$

Substituting in Equation 4-2,

$$N_o = kT_oBFG \tag{4-4}$$

Expansion of this relation yields:

$$N_o = [kT_oB + (F-1)kT_oB]G \tag{4-5}$$

Although Equation 4-5 expresses noise figure implicitly in terms of its effect on the network output, it is sometimes considered more basic than Equation 4-1 because:

- It can be used to show the effect of an input termination temperature differing from the reference temperature (T_o).
- It can be conveniently represented pictorially.
- It provides the basis for an indirect, but convenient method of measuring noise figure.

Figure 4-1 is a representation of Equation 4-5. Noise source A is the input termination while noise source B is a fictitious source representing network contribution to the noise output with reference to the input.

4-6. Noise Figure Measurement

4-7. Figure 4-1 can be modified as indicated in Figure 4-2. A switch has been added so that the original input termination (A) can be disconnected, and the network input terminated in a second source (C) at temperature T_2 (the temperature of the noise generator).

The available output power of the network for this condition is:

$$N_o = \left[kT_2B + kT_oB(F-1)\right] G \qquad (4-6)$$

Dividing Equation 4-6 by Equation 4-4 yields:

$$\frac{N_{o2}}{N_{o1}} = \frac{T_2 + T_o\ (F-1)}{T_oF} \qquad (4-7)$$

Adding -1 to both sides of the equation and rearranging terms yields:

$$F = \frac{\left(\frac{T_2}{T_o} -1\right)}{\left(\frac{N_{o2}}{N_{o1}} -1\right)} \qquad (4-8)$$

Equation 4-8 is the basic relation for determining noise figure. The numerator is called excess noise ratio and is usually expressed simply as ENR. It represents the relative increase in noise power at the network input when the switch is operated. If ENR is known, the ratio N_{o2}/N_{o1} (commonly called Y-factor) can be measured, and the noise figure computed from Equation 4-8. Note that it is not necessary to measure the absolute power levels at the network output, merely their ratio.

Therefore,

$$F = \frac{ENR}{Y-1} \qquad (4-9a)$$

or expressed in dB,

$$F_{(dB)} = ENR_{(dB)} - 10 \text{ Log } (Y-1) \qquad (4-9b)$$

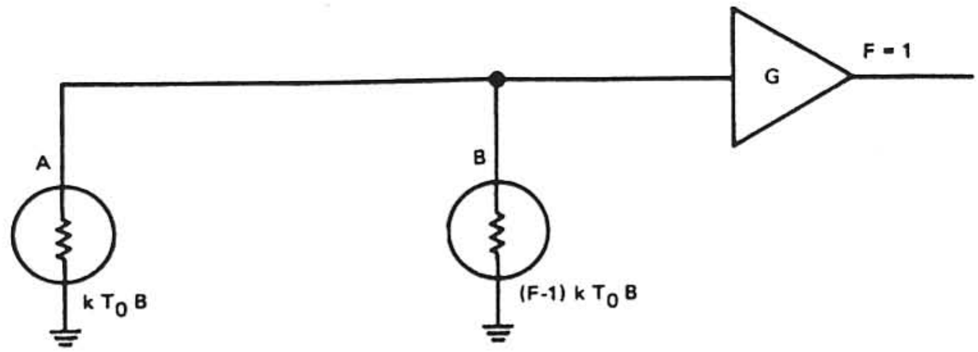


FIGURE 4-1. EQUIVALENT NOISE REPRESENTATION OF A NOISY NETWORK

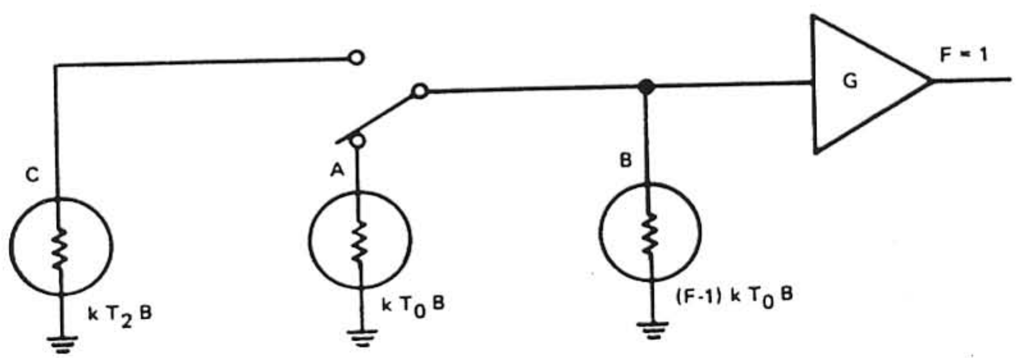


FIGURE 4-2. EQUIVALENT REPRESENTATION OF NOISE FIGURE MEASUREMENT SETUP

4-8. MANUAL NOISE FIGURE MEASUREMENT

4-9. There are several methods of measuring Y-factor and, indirectly, noise figure. However, only the most common method is discussed here.

4-10. Figure 4-3 is a block diagram showing the basic setup of equipment. The noise generator can be any one of a number of devices of known excess noise ratio. The most common are: (1) the gas-discharge lamp, in which the excess noise ratio is primarily a function of the type of gas, the diameter of the discharge column, and the gas pressure, and (2) the new solid-state noise generators, such as the AILTECH 76 series.

4-11. When the noise generator is turned off, the input of the receiver under test sees a passive termination at T_o and the detector level meter indicates some value indicative of N_{o1} in Equation 4-8. When the noise generator is turned on, the output level will increase because of the increase of noise at the input. This new level is indicative of N_{o2}.

4-12. If the attenuation between the receiver output and the detector is increased until the detector level is the same as with the noise source off, then this increase is the Y-factor (N_{o2}/N_{o1}) expressed in dB (assuming the attenuator is calibrated in dB). This value can then be converted to a power ratio, substituted in Equation 4-9, and the receiver noise figure computed.

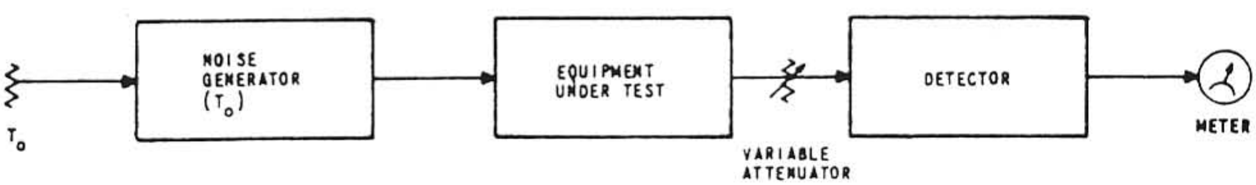


FIGURE 4-3. BLOCK DIAGRAM OF EQUIPMENT SETUP FOR DETERMINING NOISE FIGURE

4-13. This method of noise figure measurement is preferred because:

a. The signal level entering the detector (usually a test receiver such as the AILTECH 136 Receiver or AILTECH 75, in the manual mode) is kept at a constant level. Nonlinearities, the detector law, and so on, are all held constant. In fact, the receiver may be operated in a nonlinear, or partially saturated condition. The only effect this has upon the measurement is a reduction in the resolution of the meter.

b. The noise figure of the detector (or receiver) and the insertion loss of the attenuator make no contribution to the noise figure of the device under test. Again, the only effect a high insertion loss and high receiver noise figure has upon the measurement is a loss of resolution.

c. If the meter change was read (in dB or any convenient ratio) instead of keeping its level constant, then the system must be checked very accurately for nonlinearities. Also, the meter must be calibrated over the range it is expected to operate.

4-14. AUTOMATIC NOISE FIGURE MEASUREMENTS

4-15. The preceding paragraphs derived the procedure for performing manual noise figure measurements. It is evident that, if a large number of measurements are required, or if the noise figure is being used as a measure of system performance while the system is being tuned or set up, these methods can become quite cumbersome and time consuming. The basic elements of the Precision Automatic Noise Figure Indicator are shown in general block form in Figure 4-4.

4-16. The first requirement for this type of system is a method of periodically turning the noise generator on and off. A free-running multivibrator, operating at approximately 400 Hz, modulates the DC power supply for the noise generator, alternately energizing and deenergizing the unit.

4-17. The resulting two noise levels are applied to the DUT. The output of the receiver consists of a nearly square-wave modulated noise. The lower level represents the system noise when its input is normally terminated. The higher level is the DUT noise plus the generstor noise.

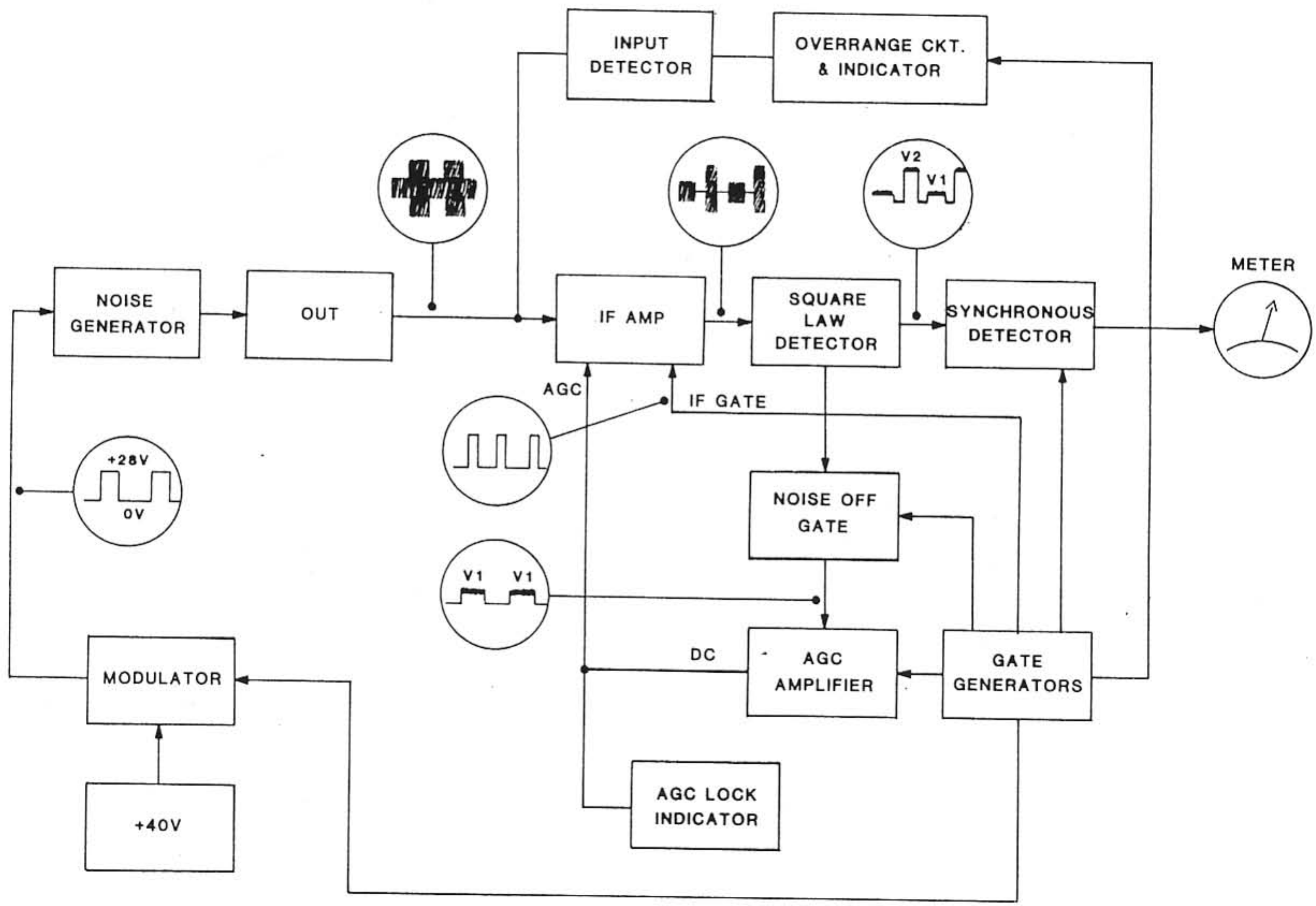


FIGURE 4-4. OVERALL FUNCTIONAL BLOCK DIAGRAM, 7514 PANFI

4-18. These signals are further amplified by the postamplifier, and then detected by a square law device providing two voltages proportional to the noise powers in the IF signal. The input is also detected by the input linear detector to insure that the input level does not exceed the capabilities of the 7514. The overrange red LED will indicate this condition.

4-19. The amplified noise signal is sampled by a second square law detector which is gated to provide an output only during the time the generator is gated off. Its output is then converted to a DC signal proportional to this noise-off condition. When this DC level exceeds a reference voltage, the AGC LOCK green LED will indicate that the AGC is maintaining the noise-off level of the postamplifier at a constant level.

4-20. The square law detector provides an output voltage proportional to the input power. This output will consist of two voltage levels (V_1 and V_2), proportional to the two levels of noise power at the input to the postamplifier.

$$\text{Noise-on voltage: } V_2 = pN_2 \tag{4-10}$$

$$\text{Noise-off voltage: } V_1 = pN_1 \tag{4-11}$$

where,

p = constant

N_1, N_2 = Noise power at the output of the UUT

4-21. The peak-to-peak amplitude of the square wave measured by the synchronous detector, and the resultant voltage is indicated by the meter.

Therefore, the meter voltage

$$V_m = c\ (V_2 - V_1) \tag{4-12}$$

where,

c = constant

From Equations 4-10 and 4-11

$$V_m = p(N_2 - N_1) \tag{4-13}$$

Rearranging terms

$$V_m = pN_1 \left(\frac{N_2}{N_1} - 1\right) \tag{4-14}$$

From the previous discussions,

$$\frac{N_2}{N_1} = Y \qquad (4\text{-}15)$$

Therefore,

$$V_m = pN_1\ (Y - 1) \qquad (4\text{-}16)$$

From Equation 4-9a,

$$V_m = pN_1 \frac{ENR}{F} \qquad (4\text{-}17)$$

4-22. Equation 4-17 indicates that, if ENR is known and N_1 is constant (a condition satisfied by the gated detector and AGC amplifier), the meter voltage is inversely proportional to the noise figure of the device under test. This is a highly desirable result since lower noise figures read closer to full scale and, thus, greater resolution is achieved. Note also that because a square law detector is used, the meter scale, when calibrated in dB, becomes logarithmic, and thus produces a natural expansion on the upper half of the scale (where low noise figures are indicated).

4-23. CIRCUIT DESCRIPTIONS

4-24. The following paragraphs describe the operation of the circuits within the PANFI. The order in which each description is presented generally is by complete subassembly description. Schematics will be found in Chapter V, Maintenance and Adjustments. The diagrams are printed on fold-out sheets so they can be followed simultaneously with the circuit descriptions. Chapter VI contains the Replaceable Parts List.

4-25. Main Board

4-26. Operational Description. The main board (852-1626) is a single PC board mounted on the main chassis. The board provides the interconnection among all of the other sections of the 7514. The schematic diagram and parts location, pertinent to the following discussion, is in Figure 5-13. All component symbol numbers are in the range of 300-399 on the schematic, and in the replaceable parts list.

4-27. Main Board Detailed Description. All interconnections on the main board are accomplished through quick disconnect connectors.

Connector Number	Type	Destination
J301	6-Pin Jack	Power Supply
J302	6-Pin Jack	AGC/IF Detector Amplifier
J303	6-Pin Jack	Postamplifier
J304	6-Pin Jack	09 Option (if incorporated)
J305	3-Pin Jack	Recorder Out (Rear Panel)
J306	36-Pin PC Plug-in	Multimeter Board
J307	36-Pin PC Plug-in	AGC/Overrange Board
J308	36-Pin PC Plug-in	Relay Board
J309	36-Pin PC Plug-in	Relay Driver Board
J310	6-Pin Jack	+28 Volt out, Preamplifier Connector (Front Panel)
J311	20-Position Jumper	Panel Board #1
J312	20-Pin Cable	Panel Board #2

4-28. Panel Board #1

4-29. Operational Description. Panel Board #1 (852-1636) is mounted to the larger of the two front panels. It is connected to the main board via a 20-position jumper. This board contains the mode switches, the CAL ADJUST and MANUAL GAIN controls, and signal level indicators. The schematic pertinent to the following discussion is in Figure 5-13. All component symbol numbers are in the range of 400-499 on the schematic diagram and in the parts list. See Figure 5-14 for component layout.

4-30. Detailed Description, Panel Board #1. This board contains the four momentary switches with built-in LED indicators for the mode selection. The switches are set in the normally-open position. When the switch is depressed, the contacts close, and +15 volts is connected to the logic of the relay driver board.

4-31. The red LED (LED405) for the OVERRANGE indicator, and the green LED (LED406) for the AGC LOCK are mounted on this board. These signal level indicators are aligned with the windows on the front panel.

4-32. The CAL ADJUST pot (R401) is mounted through a hole in the PC board, to the front panel. It is connected to the board via a 6-pin connector. The CAL ADJUST pot is used to set the noise generator ENR on the meter in the calibrate mode. The ENR is displayed in the green band on the right portion of the meter.

4-33. The MANUAL GAIN pot (R402) is also mounted through a hole in the PC board, to the front panel. It is connected to the board via a 6-pin connector. The MANUAL GAIN pot is used to select a convenient place on the meter scale from which to make a manual Y-factor measurement of the device under test. The voltage from R402 passes through R403 of Panel Board #1, and R107, R113 and R118 of the postamplifier, in order to AGC the level outputted from the postamplifier that is displayed on the meter.

4-34. Panel Board #2

4-35. Operational Description. Panel Board #2 (852-1638) consists of a single PC board that is mounted on the smaller of the two front panels. It is connected to the main board via a 20-conductor ribbon cable. The board contains the momentary switches for the ADD-TO-NOISE FIGURE scale selection. The schematic pertinent to the following discussion is found in Figure 5-13. All component symbol numbers are in the range of 500-599 on the schematic diagram, parts list, and component layout (Figure 5-15).

4-36. Panel Board #2 Detailed Description. This board contains the five momentary switches with built-in LED indicators for the ADD-TO-NOISE FIGURE scale selection. The switches are set in the normally-open position. When the switch is depressed, the contacts close, and +15 volts is connected to the logic of the relay driver board. Panel Board #2 also contains R501 which is the dropping resistor for the POWER-ON LED (LED501).

4-37. Relay Driver Board

4-38. Operational Description. This relay driver board (852-1634) circuitry is contained on a single plug-in PC board. The board is located in the front connector (J309) of the main board. The board contains the relay drivers for both the mode switches and the ADD-TO-NOISE FIGURE scale switches. The schematic diagram pertinent to the following discussion is located in Figure 5-17. All component symbol numbers are in the range of 900-999 on the schematic, and in the parts list.

4-39. On power turn-on, an initializing circuit sets the unit into the AUTO mode, and 0 dB on the ADD-TO-NOISE FIGURE selection scale. After turn-on, both switch groupings operate independently.

4-40. Relay Driver Board Detailed Description. Each switch grouping contains three sections; initialization, decoder, and interface circuitry. Only the mode switch will be discussed in detail. Upon power turn-on, Q901 is kept off until C901 is charged through R901. This places a logic high on the set of flip-flop U901-A through CR902. A logic high is placed on the reset bus of all four flip-flops U901-A,B and U902-A,B through CR903. CR906, CR908, and CR911 prevent the sets of flip-flops U901-B and U902-A,B from seeing the logic high.

4-41. A logic high to the reset alone of a CD4013 flip-flop forces the $\overline{Q}$ output to a logic high. Therefore, after Q901 turns on, and the high is removed from the reset bus, $\overline{Q}$ stays high. All clocks are grounded so only logic changes to the sets and resets will affect the $\overline{Q}$ outputs. U901-A, however, has both its set and resets connected to a logic high. This is an invalid condition that forces both outputs Q and $\overline{Q}$ to be at a logic high. This unstable state will be corrected when either the set or reset becomes a logic low.

4-42. When Q901 turns on, the cathodes of both CR902 and CR903 become back biased. The voltage for the set input, however, has been stored in C902. This decays with a time constant of approximately R904 times C902. At the same time, the voltage on the reset input also decays. Due to the resistor divider of R905 and R913, the voltage on the reset input is one-half that on the set input so it sees a logic low before the set input. A logic high on the set input alone forces $\overline{Q}$ low. CR904 is used to isolate the set input from the common reset bus.

4-43. The $\overline{Q}$ outputs drive the interfaces on the relay board directly. They also drive the interface quad comparator U903 on the relay driver board. The inverting inputs of the quad comparator U903 are equal to approximately +7.5 volts. This is derived from the resistor divider of R919 and R920. The $\overline{Q}$ outputs of U901 and U903 are connected to the noninverting inputs of U903. When $\overline{Q}$ is a logic low, the output of the comparator in U903 is low. Since the output is an open collector, U903 then sinks current and turns on the appropriate switch LED on the front panels.

4-44. There are six outputs to the Relay Board. Table 4-1 illustrates the logic relationships.

TABLE 4-1. OUTPUT TO RELAY BOARD

Pin #5	J309-L	J309-M	J309-K	J309-H	J309-J	J309-N
Signal Names	IN1	IN2	IN3	IN4	IN5	IN6
Auto	L	H	H	H	L	H
Cal	H	H	H	L	L	L
Man. On	H	H	L	H	H	H
Man. Off	H	L	H	L	H	H

The outputs IN1, IN4, and IN6 use diode logic to "OR" the two outputs where necessary. If either "OR" connected output is a logic low, then the output is a logic low.

4-45. After initialization, the operator may change the mode of operation by simply depressing another switch. To describe the circuit conditions, assume the CAL mode switch has been depressed, and the unit was in the AUTO mode.

4-46. The front panel switches are momentary switches. They are connected in the normally-open position. When the switch is depressed, +15 V is connected to the cathodes of CR905 and CR906. R906 is used to keep the cathodes from floating above ground. C903 is immediately charged through CR905 and the set input to U901-B is at a logic high. The common reset bus is also at a logic high through CR906. No change occurs on the U902 flip-flops since their $\overline{Q}$ is already a logic high. However, U901-A $\overline{Q}$ is reset to a logic high when the switch is depressed. When the switch is released, the reset to U901-B immediately falls to a logic low. The set is held high by C903, and the $\overline{Q}$ output goes low. The set voltage decays by the time constant of R907 and C903.

4-47. It should be noted that the ratio of every other time constant (R904 x R902 vs R907 x R903) is 100. This is to help prevent two switches from being activated in the relay driver board when two adjacent switches are accidently pressed. No damage to the circuitry will occur, but an invalid state will exist. The switches with the longer time constant also contain a resistor and diode (i.e. R905, CR904) that connect their sets to the reset bus. These switches have been given priority; that is, if two adjacent switches are pressed, the one with priority will be selected. An example is - if both CAL and AUTO are pressed, the mode selected will be AUTO since its logic high on its set input and the reset bus will exist longer. The diode (CR904) is used to isolate the set from receiving reset bus logic high.

4-48. The ADD-TO-NOISE FIGURE scale selection works in the identical manner. Each section is comprised of totally independent circuitry.

4-49. Postamplifier Detector Board

4-50. Operational Description. The 7514 Postamplifier Detector circuitry consists of a single PC board encased in an aluminum can (P/N 212875). It is mounted on the underside of the chassis. The board consists of an input detector, a three-stage automatic gain controlled IF amplifier, a diode switch, and a square-law detector. The schematic pertinent to the following discussions is Figure 5-11. Figure 4-5 , Timing Diagram, will be helpful to this discussion. All symbol numbers are in the range of 100-199 on the schematic diagram and in the parts list.

4-51. The input detector is used to provide a DC pulsed voltage proportional to the input level. This is used by the overrange circuitry to indicate excessive input levels.

4-52. The gain of the IF amplifier is controlled by the output of the AGC board which is a DC voltage that varies with input signal level. This is applied to the AGC input of the Postamplifier in order to keep the signal level to the square law detector constant during the NOISE OFF condition.

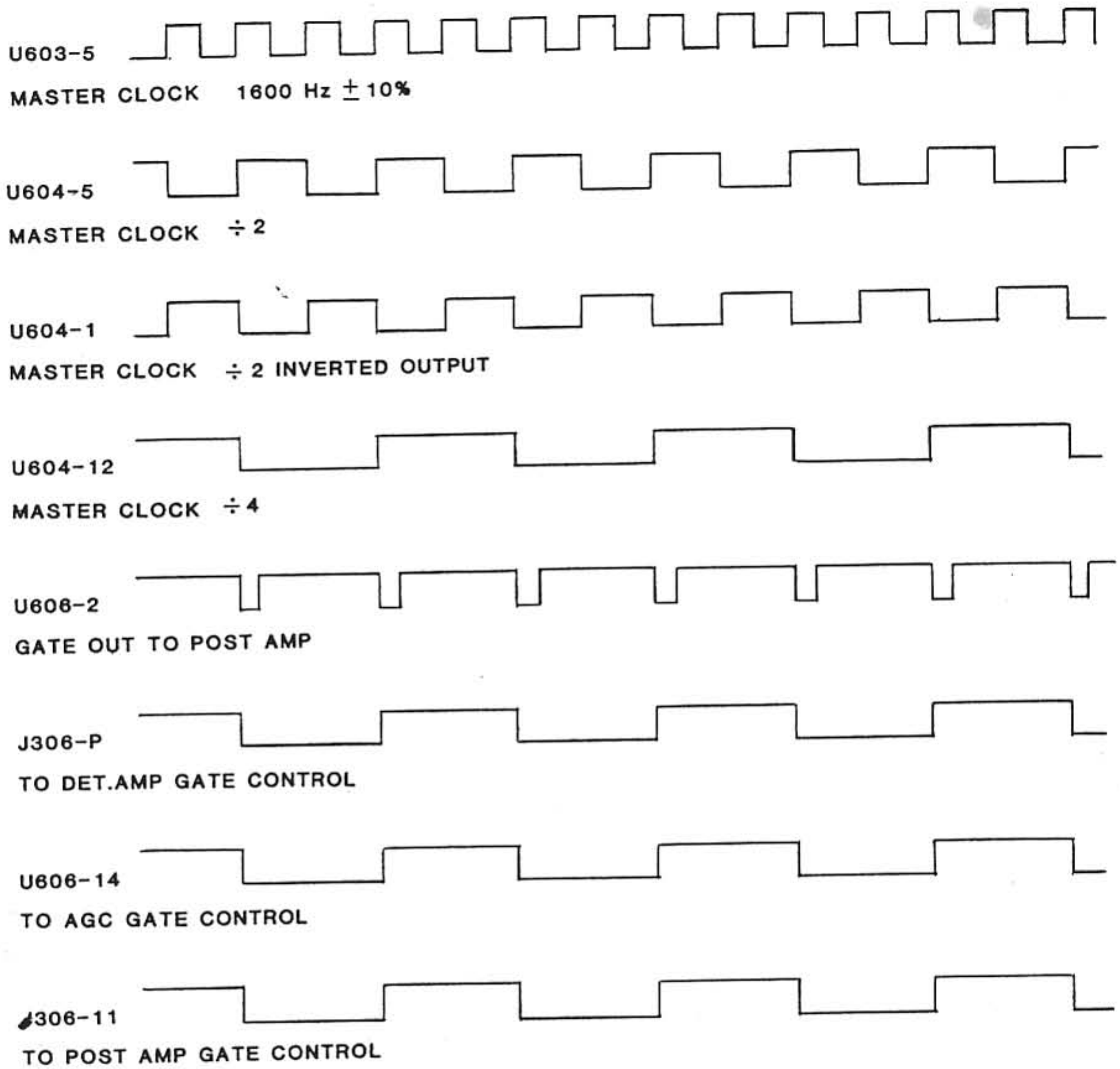


FIGURE 4-5. TIMING DIAGRAM

4-53. The AGC range of the amplifier is from approximately +27 dB gain to greater than 40 dB attenuation.

4-54. The output of the IF amplifier is fed into the diode switch. This switch, in the AUTO and CAL mode is used to clamp out any edge variations of the noise generators. In the MANUAL modes, the diode switch is used to set a reference level in order to obtain a manual "Y" factor.

4-55. The output of the diode switch is fed into the square law detector. This detector mixes the IF noise signal with itself, thereby producing a DC voltage pulse corresponding to the noise level input. This signal is fed to the multimeter board which displays the noise figure.

4-56. The output of the diode switch is also applied to the AGC IF Amplifier/Detector board. This is labeled "IF OUT".

4-57. <u>Postamplifier Detailed Circuit Description</u>

4-58. <u>Input Detector</u>. The Input detector is buffered from the input by R139 in order to prevent any loading. A germanium diode (CR106) is used to attain greater detected levels for lower input levels. The load resistor for the detector is R140 which is parallel to a second load resistor (R705) in the AGC/Overrange board. The load capacitor is the parallel combination of C142 and C143.

4-59. <u>Variable Gain Amplifier</u>. The Postamplifier is the input circuitry of the 7514 PANFI. L101 is used to adjust the input for a 50-ohm match. The IF amplifier section consists of four transistor stages, Q101-Q104, arranged as common emitters. Q101-Q103 are the variable gain stages.

4-60. The transistor stages are synchronously tuned to a center frequency of 30 MHz, with an overall bandwidth of 5 MHz. Each of the first three stages are designed to have a bandwidth greater than 20 MHz. This is to prevent the center frequency or bandwidth from changing as their gain changes.

4-61. Interstage coupling is achieved by using autotransformers T101-T104. These are adjusted to provide proper impedance matching for the desired bandwidth and gain.

4-62. Q101 and Q102, the first two stages, use heavy emitter degeneration and high current to prevent saturation when the input level is high requiring the gain to be AGC'd down near its minimum. Input signal levels having a peak value of 0 dBm can be handled by the IF amplifier when the gain is decreased fully.

4-63. Three pin diodes (CR101, CR102, CR103) are used to provide gain control in the first three stages. As the DC current in these diodes is increased, their impedance decreases, thereby reducing the transistor stage gain in the common emitter configuration.

4-64. The current through the pin diodes is converted by the voltage across resistors R107, R108, and R109. The input DC voltage to these resistors comes from the AGC board.

4-65. The AGC board provides a DC voltage between 0 and +2 volts. The voltage increases as the input level of noise-off increases. The gain control range is over 70 dB. This gives the PANFI a 65-dB dynamic range.

4-66. The gain of the fourth stage, Q104, is not under AGC control. The gain is selected in calibration for an input signal level sensitivity of -76 dBm. This stage also drives the diode switch.

4-67. Diode Switch. The diode switch is composed of pin diodes CR104 and CR105. They are used to gate the signal through to the square law detector. Their output is also fed to the IF amplifier of the AGC IF Amplifier/Detector module.

4-68. When the gate control, C138 input, is a positive voltage, CR105 is biased on (low impedance), and CR104 is biased off (high impedance). This allows the input signal to pass through to the detector. When the gate control, C138 input, is a negative voltage, CR105 is biased off, and CR104 is biased on. This blocks the input signal from passing through to the detector. The actual signal reduction is typically 40 dB.

4-69. During the AUTO and CAL mode of operation, the diode switch is gated off during the first 200 microseconds of the noise generator "on" time. This prevents the PANFI from being sensitive to variations of noise generator turn-on time.

4-70. During the MANUAL mode of operation, this switch is gated ON and OFF at approximately a 400-Hz rate. This provides a 400-Hz modulated noise signal that can be presented on the meter by the detector. This allows the noise generator to be operated in a CW condition and permitting a true manual measurement.

4-71. Square Law Detector. The square law detector is made up of three transistors (Q105, Q106, and Q107) and their associated components. Q105 and Q107 are arranged in a differential amplifier configuration. Q106 is a constant current source for both Q105 and Q107. The signal is AC coupled to the base of Q105 and Q106, with the base of Q107 grounded.

4-72. By applying the same signal to both bases of Q105 and Q106, the resultant current flowing through R136 is equal to the square of the input voltage (or current). Q108 is an emitter follower that simply buffers the detector output from the video amplifier. This is labeled "DETECTOR OUT".

4-73. AGC IF Amplifier/Detector Board

4-74. Operational Description. The circuitry consists of a single PC board encased in an aluminum can (P/N 212881). This board consists of three sections: an IF amplifier, a diode switch, and a square law detector. The schematic diagram pertinent to the following discussion is in Figure 5-12. All symbol numbers are in the range of 200-299 on the schematic and in the parts list.

4-75. The IF OUT from the Postamplifier is fed into the IF IN of the IF amplifier. This signal is amplified by 20 dB, and passed through the diode switch to the square law detector. The diode switch is gated to only pass the noise-off signal.

4-76. The AGC IF Amplifier Detector's output is derived from a 20-dB larger signal, and is designed to track errors from the Postamplifier square law detector. Its output, labeled DETECTOR OUT, is fed to the Video In of the AGC/Overrange board, and in the MANUAL modes into the Video In of the Multimeter board.

4-77. AGC IF Amplifier Detailed Circuit Description.

4-78. IF Amplifier. The amplifier consists of Q201, Q202, and Q203. The open loop gain is determined by Q201 and Q202.

Q203 is an emitter follower that buffers the IF Amplifier from the diode switch.

4-79. The amplifier uses two types of feedback, AC and DC. The DC feedback consists of R210 and R205. The AC feedback consists of R210 and R207. The 20-dB overall gain is determined by R210 and the parallel combination of R205 and R207. This is set at 20 dB. This gain is not under AGC control. The bandwidth of the amplifier is 100 MHz so as not to affect the bandwidth of the IF signal from the Postamplifier.

4-80. Diode Switch. The diode switch is composed of pin diodes CR201 and CR202. They are used to gate the signal through to the square law detector.

4-81. When the gate control (C224 input) is a positive voltage, CR202 is biased on (low impedance), and CR201 is biased off (high impedance). This allows the input signal to pass through to the detector. When the gate control (C224 input) is a negative voltage, CR202 is biased off, and CR201 is biased on. This blocks the input signal from passing through to the detector. The actual signal reduction is typically 40 dB.

4-82. During the AUTO and CAL modes of operation, the diode switch is gated on and off at approximately 400 Hz rate. The switch is gated on during the noise-off period. This sets the reference level from which the AGC/Overrange board holds the noise-off level constant.

4-83. During the MANUAL mode of operation, this switch is gated on and off at a 400-Hz rate. This provides a 400 Hz modulated noise signal that can be presented on the meter by the detector. This allows the noise generator to be operated in a CW condition, and permitting a true manual measurement.

4-84. Square Law Detector. The square law detector is made up of three transistors, Q204, Q205, and Q206, and their associated components. Q204 and Q206 are arranged in a differential amplifier configuration. Q205 is a constant current source for both Q204 and Q206. By applying the same signal to both bases of Q204 and Q205, the resultant current flowing through R222 is equal to the square of the input voltage (or current). Q207 is an emitter follower that simply buffers the detector output from the video amplifier. This is labeled "DETECTOR OUT".

4-85. AGC/Overrange Board

4-86. Operational Description. The AGC/Overrange board consists of a single plug-in PC board (852-1630), located in the second from the rear connector (J307) on the main board. This board consists of the AGC circuitry and the overrange circuitry. The schematic for this board is contained in Figure 5-15, and all symbol numbers are in the 700-799 range for the schematic and in the parts list.

4-87. The AGC section produces a DC voltage necessary to keep the noise-off level constant. This voltage is applied to the AGC input of the postamplifier during the AUTO and CAL modes only.

4-88. The overrange section samples the detected noise-on level from the postamplifier. This voltage is integrated and compared to a reference voltage to determine an excessive input level. This level will also come from the 09 Option if incorporated.

4-89. AGC/Overrange Board Detailed Circuit Description

4-90. AGC. U704-A is an operational amplifier that buffers the video in from from the AGC-IF detector amplifier. The video-in signal is a 400-Hz waveform consisting of a square-law detected noise-off signal, and a detected gated off noise-on signal. This gated noise signal is used as a reference by the AGC circuitry.

4-91. The output of U704A is chopped by FET Q701. By AC coupling through C710, and using Q701 as a chopper, the DC level is restored. The DC level had been lost by AC coupling throughout the system. Q701 clamps the output of U704A to ground during the noise-on time. This nearly square waveform is then integrated by R722 and C710. CR701 is used to prevent latchup by Q701, during mode changes. This integrated waveform is compared by U705A to the reference level as determined by the ENR of noise diode. As long as the integrated voltage does not exceed the reference voltage, the output of the comparator U705A is high. This keeps Q702 off.

4-92. Q702 is the current source for C712. C712 is the integrating capacitor for the comparator U705A. It smooths out the comparator changes. When the noise-off level is too high, the voltage on C711 increases until the postamplifier has been AGC'd to the proper level. If the input level decreases, then R728 helps the capacitor voltage to decay down to the correct level. VR704 is used to speed up meter responses as the modes of operation are changed, by clamping the AGC voltage at C711 to approximately +4.3 volts.

4-93. U704B is an operational amplifier that is used as a buffer for the voltage on C711. Q703 is in the feedback loop in order to provide larger current drives than U704B can reliably supply. CR702 increases the AGC voltage for easier AGC lock indicator light illumination. The AGC lock light illumination is a comparison of the AGC voltage and a preset reference. When the AGC voltage exceeds the reference, the outputs of U705B,C,D go low; thereby driving the indicator on. R730 is used to provide hysteresis so that the light will not flicker.

4-94. Overrange. U702A, C705, and U701B form a sample and hold circuit which monitors the detected noise-on voltage.

4-95. U701A provides gating to the sample and hold circuit so that only the noise-on portion of the modulated noise voltage is applied to integrating capacitor C705. This voltage is then compared by U701B to a preset overrange threshold voltage determined by by resistors R707 and R708. When the detected noise-on voltage exceeds the overrange threshold voltage, the output of U701B goes high, which causes the outputs of U703A,B, and C to go low, illuminating the red overrange indicator (LED 405).

4-96. Relay Board

4-97. Operational Description. The 7514 Relay Board consists of a single plug-in PC board (852-1632) located in the second socket (J308) from the front on the main board. The board consists of interface circuitry and 24 relays. The schematic for this board is contained in Figure 5-16, and all symbol numbers are in the range of 800-899. Figure 4-5, Timing Diagram, will also be helpful in this discussion.

4-98. Relay Board Detailed Description. The relays provide the necessary signal switching to connect the various circuits with the proper inputs for each mode of operation, and the ADD-TO NOISE FIGURE scale selection.

4-99. The interface circuitry is comprised of 24 comparators, built from six quad comparators, U801-U806. U801-U805A are used for mode control switching. U805B-U806 are used for the ADD-TO-NOISE FIGURE scale control switching. The reference voltage for U805B-U806 is derived from the resistor divider of R802 and R803. The reference voltage for U805B-U806 is derived from the resistor divider of R805 and R806. The reference voltage has been set to be higher than a logic low, but less than a logic high received from the Relay Driver Board.

4-100. The comparators have an open collector output. This allows them to sink current and, therefore, energize the relay coil or remove the current path to ground and deenergize the relay coil, breaking the relay contacts. The relays are SPST switches.

4-101. If the voltage on the noninverting input (+) is higher than the voltage on the inverting input (-), then the output cannot sink current, and the voltage drop across the coil will be 0 volts. If the voltage on the noninverting input is lower than the voltage on the inverting input, then the output will sink current. A voltage drop will then occur across the energized coil, and the contacts will be closed.

4-102. When the AC power is turned off, all relay contacts are open. Table 4-2 illustrates which relay contacts are closed under different operating conditions.

4-103. Multimeter Board

4-104. Operational Description. The 7514 Multimeter Board consists of a single plug-in PC board (852-1628), located in the rear socket (J306) on the main board. The board consists of the multivibrator timing circuit, the video amplifier synchronous detector, 28-volt modulator, and voltage reducer. The schematic for this board is contained in Figure 5-14 and all component symbol numbers are in the range of 600-699.

4-105. The multivibrator circuit provides the approximate 400-Hz square-wave output used to clock the various circuit boards of the 7514 PANFI.

4-106. The video amplifier synchronous detector is used to display the noise figure readings on the meter. Its input is the detected noise-off/noise-on signal from the Postamplifier detector circuit.

TABLE 4-2. RELAY CLOSURE TABLE

ADD-TO-NOISE FIGURE scale selector set on 0 dB

Mode	
AUTO	K801, K803, K811, K807, K814, K809, K814, K819, K820
CAL	K802, K804, K806, K809, K814, K817, K820
MAN ON	K802, K804, K806, K808, K810, K816, K815, K819, K820
MAN OFF	K802, K804, K806, K812, K808, K810, K818, K819, K820

MODE selector set in AUTO mode (all closed relays identical except K820)

ADD-TO-NOISE FIGURE Scale	
0 dB	K820
3 dB	K821
6 dB	K822
12 dB	K823
18 dB	K824

4-107. The 28-volt modulator is used to gate the solid-state noise source on or off. In order to gate gas tube noise sources, an AILTECH 7175 Gas Tube Triggerable Power Supply must also be used.

4-108. <u>Multimeter Board Detailed Circuit Descriptions</u>

4-109. <u>Multivibrator Timing Circuit</u>. U603A is the master clock. It is one half of a dual 556 timer. The clock rate is set at 1600 Hz, ±10%, as determined by R624, R625, and C619. Its output is fed into U604A, which is one half of a CD4013 CMOS flip-flop. This chip is used to provide a clock that is running at a 50% duty cycle. The clock is also divided down to 800 Hz.

4-110. The true output of U604A is then fed into U604B which divides the clock by 2 again, to approximately 400 Hz. The clock is then fed into the clock comparators, U605, through R634 and C625. R634 and C625 are used to slow down the 400-Hz rise and fall times. This is to allow the adjustment of the duty cycle of the 400-Hz clock, in order to eliminate offsets in the detector circuit. The output is fed into the noninverting terminals of U605 A and B, and the inverting terminal of U605 C and D. The other inputs are connected to the reference voltage determined by R631, R633, and potentiometer R632. This reference is varied to correct the errors in large noise figure readings. U605 is used to provide a differential square-wave output. The outputs of U605 C and D are labeled square wave A, and are used by the AGC/OVERRANGE board.

4-111. Three other clocks are also generated from the 400-Hz clock, and use U606 as an interface. U606B provides the Postamplifier with a nearly square-wave gate control in all modes of operation excluding the AUTO mode. This clock is directed to the Relay board. U606C is used to provide the 400-Hz clock to the AGC gate control of the AGC/IF Amplifier can.

4-112. The false output of U604A drives U603B which is the other half of the dual 556 timer. The high output period of the timer is approximately 200 microseconds. This is inverted by operational amplifier U606A, and is labeled GATE OUT. GATE OUT is used by the Postamplifier to block turn-on transients and variations of noise generators. This is used only in the AUTO mode.

4-113. <u>Video Amplifier Synchronous Detector Circuit</u>. This circuit receives the square-law detected input signal from the Postamplifier in the AUTO or CAL mode, and converts the pulses to an analog meter display. The signal is received in the video input of the Multimeter Board.

4-114. In the MANUAL modes, the square-law detected input signal from the AGC/IF amplifier/detector is applied to the "Video Input". In the MANUAL modes of operation the AGC IF amplifier/detector is used to provide an additional 20 dB of gain. This gives the MANUAL modes an input sensitivity of -90 dBm.

4-115. The Video Amplifier Synchronous Detector can be divided into three sections, an amplifier and a detector, and a feedback loop around the two. The Video Amplifier utilizes both AC and DC feedback for highly stable operation. U602A is a closed loop, noninverting operational amplifier with a gain of approximately 10 dB. This is then fed into the noninverting input of operational amplifier U602B.

4-116. U602B utilizes two feedback paths. The DC path uses Q603 to adjust the DC level for both U602A and U602B. C611 and R612 are required for loop stabilization, and are the limiters of meter response. CR602 and CR603 are used to prevent the "pinning" of the meter needle by clamping transients due to changing the mode of operation by the front panel mode switches.

4-117. The AC feedback path contains the meter detector. This permits the changing of the meter scales by simply decreasing the feedback resistor which increases the gain of U602B. The pick-off point is the center tap of T601, which eliminates offset on the meter due to transformer or diode imbalances. This detector section produces a current in the DC meter which is proportional to the difference in the noise-on and noise-off levels. In order to accomplish this, the current direction is controlled by T601.

4-118. A 30 volt peak-to-peak pulse derived from the 400-Hz clock is applied to pins 1 and 2 of T601. There are two possible conduction paths which are determined by the 30-volt pulse polarity. The first conduction path will assume a positive polarity on pin 5 with respect to pin 3 of T601. Since this transformer pulse is synchronized with the 400-Hz input signal, the signal to be displayed will be the positive portion (noise-on level) at the output of C616.

4-119. Due to the positive polarity of the transformer pulse, CR604 and CR606 are biased on, and CR605 and CR607 are biased off.

The input signal current splits approximately in two, with one half flowing through R617, and the other half through R619. Since CR605 and CR607 are biased off, the current through R619 is directed through the meter and rejoins the current through the parallel path of R617. Since both CR604 and CR606 are biased on, the input signal current splits in two again; half flowing through CR603 and R620, and the other half through the parallel leg of CR606 and R622. The currents then add again, at the center tap of T601, and continue through the selectable resistors in the feedback path of U602B. The resistors selected are determined by the ADD-TO-NOISE FIGURE scale switches selected on the front panel.

4-120. When a negative transformer pulse is produced at T601 (pin 5 is negative with respect to pin 3), the signal to be displayed is the negative (noise-off level) at the output of C616. The current splits - with half going through R617, and half through R619. The current through R617 flows into the negative terminal of the meter, then joins the current of R619 at pin 4 of T601. This current then goes through the selectable resistors of the feedback path of U602B.

4-121. The net result of paragraphs 4-119 and 4-120 is that current flow is in only one direction through the meter. The meter averages the noise-on and noise-off currents to produce the displayed noise figure indication.

4-122. Resistors R620 through R623 are used to develop sufficient voltage to keep the "off" diodes turned off for any expected level of input signal.

CHAPTER V

MAINTENANCE AND ADJUSTMENTS

5-1. GENERAL

5-2. This chapter contains Performance Verification, Adjustments, and Troubleshooting. Schematics, printed circuit board component locations, an overall block diagram (Figure 5-10) and wiring diagrams will be found at the end of the Troubleshooting section. Spares and replaceable parts are listed in Chapter VI.

5-3. PERFORMANCE VERIFICATION

5-4. The following procedures (recommended at 90-day intervals) are designed to insure that the AILTECH 7514 is operating within specifications. Only those specifications critical to performance are checked. In some cases, more than one specification is verified by the same procedure. Where a specification is a function of adjustment, reference is made to the paragraph describing that adjustment. Figure 5-1 shows the location of the boards and selected components.

5-5. Table 5-1 lists test equipment required for performance verification.

5-6. Minimum Operating Level. This procedure checks the basic sensitivity of the PANFI at its center frequency. Its primary purpose is to insure that the instrument is properly tuned. If the unit fails this check, refer to paragraph 5-15.

a. Depress the front panel mode switch to AUTO.

b. Connect a signal generator to the IF input of the PANFI. Set the generator frequency to the center frequency of the 7514 PANFI. Set the generator output level to -80 dBm.

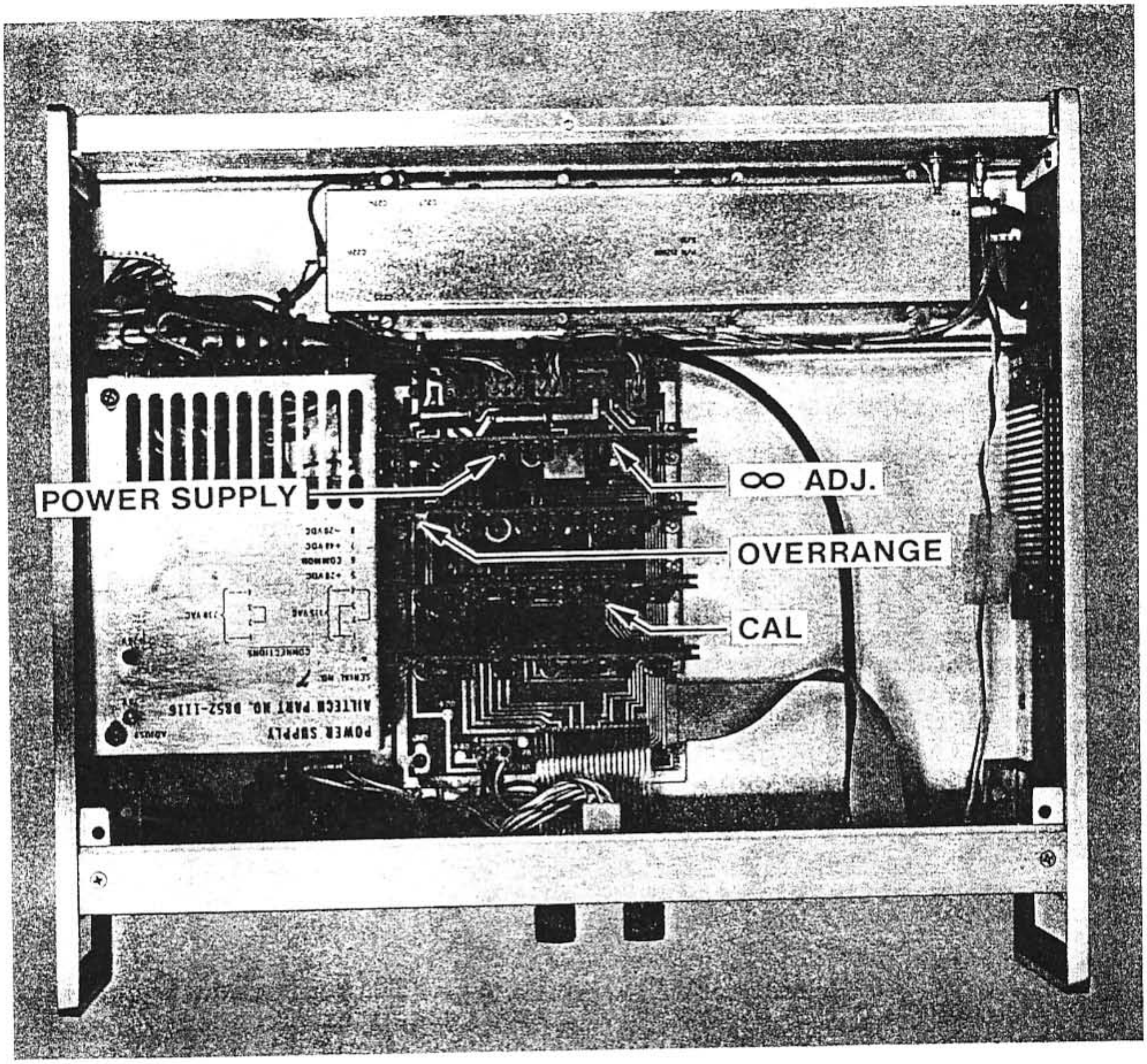


FIGURE 5-1. AILTECH 7514 BOARD AND SELECTED COMPONENT LOCATIONS

c. Increase the output level until the green AGC LOCK light on the front panel is illuminated.

d. Note that the generator level is -76 to -77 dB.

5-7. Maximum Operating Level. This procedure checks the basic sensitivity of the 7514 PANFI at its center frequency. Its primary purpose is to insure that the instrument is properly tuned. If the unit fails this check, refer to paragraph 5-15.

a. Connect a signal generator to the IF input of the PANFI. Set the generator frequency to the center frequency of the PANFI. Set the generator output level to -20 dBm.

b. Increase the output level until the red OVER-RANGE light on the front panel is illuminated.

c. Note that the generator level is +5 dBm, ±1 dB.

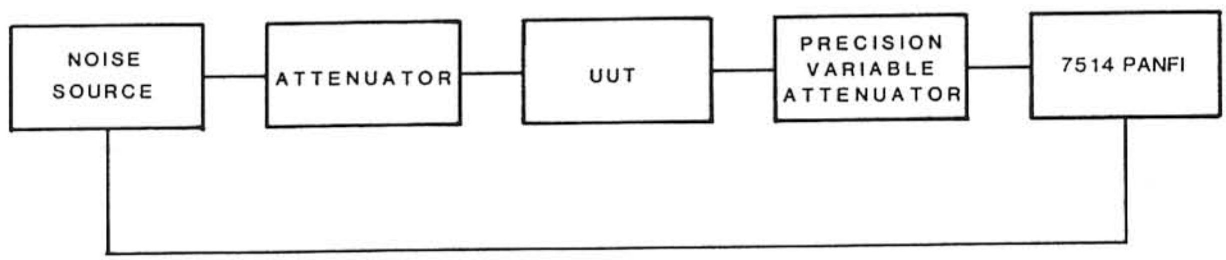


FIGURE 5-2. SETUP FOR CHECKING PANFI NOISE FIGURE ACCURACY

TABLE 5-1. TEST EQUIPMENT REQUIRED FOR PERFORMANCE VERIFICATION

Description	Recommended Manufacturer and Model
Digital Voltmeter, DC, 0 to 28 volts, 4-1/2 digits	Systron-Donner 7004A
Noise Source, frequency compatible with the input of the simulated UUT	AILTECH 7600 Series
Precision Variable Attenuator, continuously variable	AILTECH 3200 Series
Signal Generator	Wavetek 2001
Detector	Texscan CD-50
Power Supply	Power Designs TW-4005

5-8. Noise Generator Power. The purpose of this check is to insure that the voltage applied to the solid-state noise generators is within specified limits. This voltage determines the excess noise ratio of the noise generator, and the subsequent overall accuracy of the noise figure measurement. If the unit fails this check, refer to paragraph 5-14.

a. Connect a DVM to the +28 volt Noise Source output BNC connector on the front panel.

b. Depress the front panel mode switch to MAN OFF. Note that the DVM indicates less than 0.3 volts.

c. Depress the front panel mode switch to MAN ON. Note that the DVM indicates 28.00 ±0.05 volts.

d. Disconnect the DVM. Connect an oscilloscope to the Noise Source output. Depress the front panel mode switch to AUTO. Note that the waveform is a rectangular waveshape with a positive level of +28 volts, and a low level of zero.

5-9. Noise Figure Accuracy. This specification is defined as the maximum possible deviation of the PANFI indication (operating in the normal, automatic mode) from a Y-factor measurement on the same unit-under-test (UUT). The accuracy is checked by making a manual Y-factor measurement, calculating noise figure, and comparing the result to the automatic indication. In general, it is good practice to make several manual measurements and average the results.

a. Set up the equipment as shown in Figure 5-2. See paragraph 5-10 for UUT requirements. It is preferable to use a UUT that has a noise figure less than 6 dB.

b. Depress the front panel mode switch to MAN OFF.

c. Set the Precision Attenuator to 0.00 dB, and adjust the front panel MANUAL GAIN control for a convenient reference indication on the noise figure meter (preferably about 1 dB).

d. Depress the MAN ON mode switch. Note the indication decreases (lower noise figure reading).

e. Increase the setting of the Precision Attenuator until the indication returns to the reference noted in (c). Record the attenuation change, which is the Y-factor in dB.

f. Depress the MAN OFF switch. Return the Precision Attenuator to its original setting. If the indication is not within ±0.05 dB of the original reference, repeat the measurement.

g. Noise figure may be calculated from the following equation:

$$F_{(dB)} = ENR_{(dB)} - 10 \log (Y-1).$$

In the preceding equation, the ENR is the actual effective value after decoupling or attenuation (if any). The Y-factor is expressed as a power ratio.

h. Depress the CAL switch, and using the CAL ADJUST front panel switch, adjust the value displayed on the ENR calibrate scale (green scale) to the ENR used in (g). Note the AGC LOCK light must be illuminated.

i. Depress the AUTO switch. Using the Add-to-Noise Figure selector, obtain a meter indication that is on the right half of the meter scale. The AUTO reading should be within the specified value from Table 1-1. See paragraph 5-21 for adjustment.

j. In order to check the high noise figure accuracy, add attenuation between the noise source and UUT such that the noise figure plus attenuation equals approximately 24 dB.

k. Follow the same procedure as in steps (b) through (i) except for adjustment. See paragraph 5-21 for adjustment.

5-10. The simulated UUT used for this check must have sufficient gain such that the noise-off is greater than the sensitivity of the 7514. This is displayed by the AGC LOCK light being illuminated. The noise-on signal must also be below the saturation level of the 7514 PANFI. This is displayed by the OVERRANGE light being off. In addition, the input and output frequencies must be compatible with the Noise Source and the PANFI, respectively. It should also be noted that the wider the bandwidth of the IF applied to the 7514, the sooner the OVERRANGE light will illuminate.

5-11. CHECKS AND ADJUSTMENTS

5-12. Procedures for checking and adjusting the PANFI are provided in paragraphs 5-13 through 5-22. If the unit fails, proceed to the Troubleshooting Section, paragraph 5-23. All adjustments, except for the Postamplifier, can be performed with the top cover off. An extender board for the four plug-in boards is attached to the right-hand side frame (the side cover must be removed for access). This board is for troubleshooting, and is not needed for calibration. The Postamplifier adjustments require that the bottom cover be removed.

NOTE

Checks and adjustments need to be done only if the calibration or performance verification does not meet specifications.

5-13. All component symbol numbers for the 7514 PANFI printed circuit boards are listed in Table 5-2.

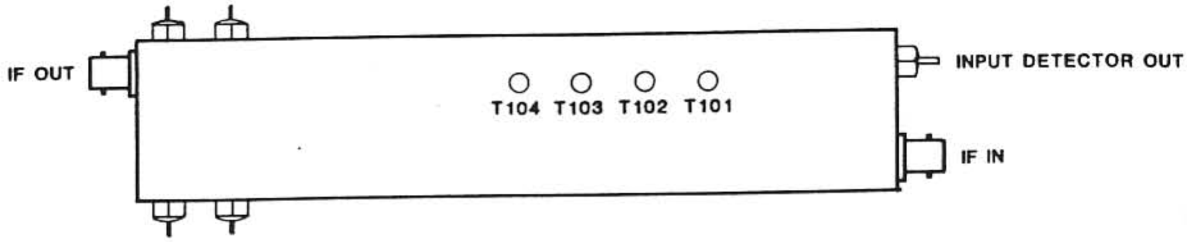
TABLE 5-2. COMPONENT SYMBOL NUMBER BREAKDOWN

Symbol Number	PC Board Name	Part Number
100-199	Postamplifier Board	212875
200-299	AGC IF Amplifier/Detector	212881
300-399	Main Board	852-1755
400-499	Panel Board #1	852-1760
500-599	Panel Board #2	852-1761
600-699	Multimeter Board	852-1756
700-799	AGC/Overrange Board	852-1757
800-899	Relay Board	852-1758
900-999	Relay Driver Board	852-1759

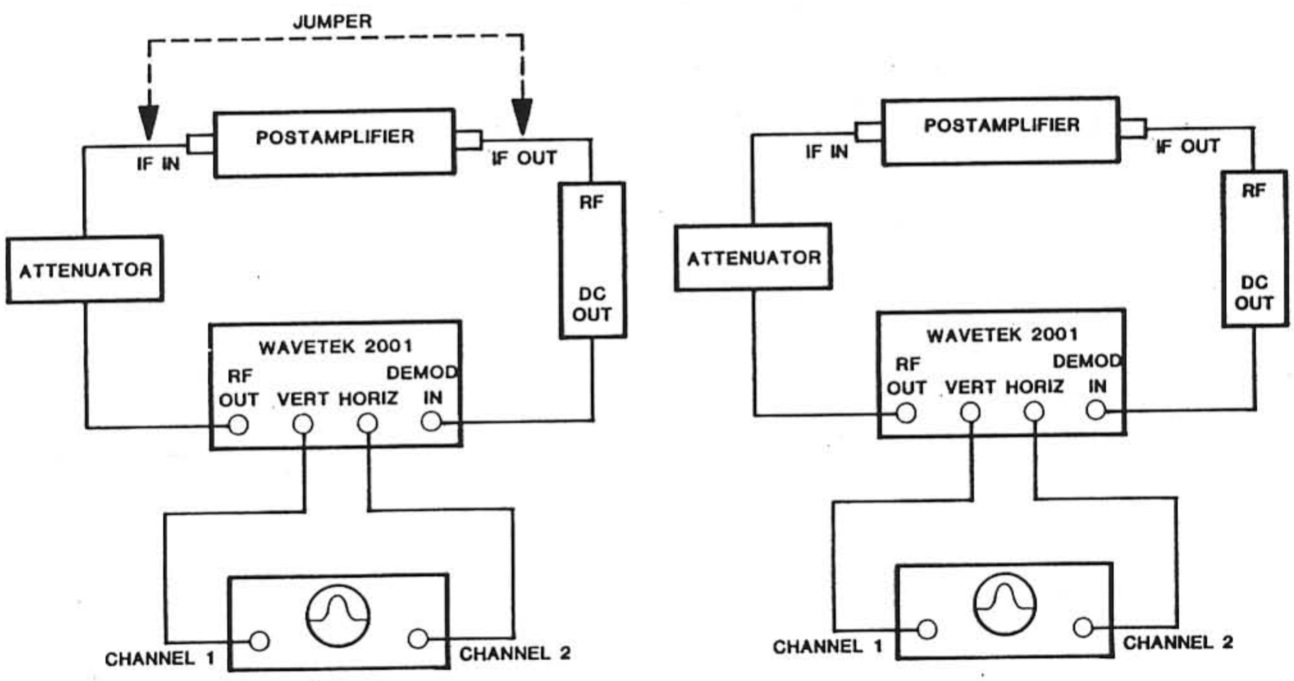
5-14. Power Supply Adjustments

a. All voltages are referenced to chassis ground. ground.

b. Use a DVM to measure and adjust the power supplies, in accordance with Table 5-3. The voltage test points are labeled on the Main Board.



a. Postamplifier Adjustment Hole Locations



b. Postamplifier Bypassed c. Postamplifier Connected

FIGURE 5-3. POSTAMPLIFIER BANDWIDTH AND GAIN TEST SETUP

TABLE 5-3. POWER SUPPLY CHECKS AND ADJUSTMENTS

Voltage (V dc)	Adjust	Test Point	Notes
+20 ± 1	Labeled pot (+20V) on Power Supply D852-1116	Front area of Main Board 852-1626.	---
-20 ± 1	Labeled pot (-20V) on Power Supply D852-1116	↓	---
+40 ± 6	No adjustment	↓	---
+28 ±.05/0 ±.3	R609 (28 V Adj. pot) on Multimeter Board 852-1628	↓	1 & 2

Notes: 1. MAN ON switch depressed

2. MAN OFF or CAL switch depressed

5-15. IF Adjustments - Postamplifier

5-16. There are four adjustments used to tune the Postamplifier. If these adjustments are improperly set, the unit could appear low in sensitivity (minimum operating level too high) or appear to have reduced AGC range. The adjustment locations are shown in Figure 5-3 (a).

5-17. If the sensitivity checked in paragraph 5-6 shows the sensitivity to be low, within 2 dB, then adjust T101 or T103 of the Postamplifier. In order to have access to T101 or T103, the bottom cover must be removed. Adjusting T101 or T103 will not affect the bandwidth of the Postamplifier.

5-18. If the Postamplifier needs further adjustment, use the following calibration procedure.

a. Connect the equipment as shown in Figure 5-3 (b), Postamplifier bypassed.

b. Adjust the signal generator/attenuator for an output of -10 dBm ±2 dB.

c. With the oscilloscope on 5 mV/Div. on channel 2, adjust channel 1 for a convenient reference line near the top of the display.

d. Connect equipment as shown in Figure 5-3 (c), Postamplifier connected. Reduce signal generator output by 32 dB.

e. Adjust T101 to obtain a symmetrical output at 30 MHz ± 0.5 MHz, and touching the referenced baseline. The bandwidth should be approximately 6 MHz. Figure 5-3 (a) illustrates the location of the adjustment holes for T101-T104.

5-19. Overrange Adjustment

5-20. The Overrange adjustment uses a sinewave to simulate the noise-on power.

a. Connect a generator to the IF input of the PANFI at 30 MHz CW ±0.5 MHz at 0 dBm, 21 dB. Connect a DVM to the input detector output (see Figure 5-3 a). The reading should be +0.07 V dc ±0.01 V; if not, see paragraph 5-23 for Troubleshooting.

b. Set generator to +5 dBm. Adjust R708 on the AGC/OVERRANGE board until the OVERRANGE light is illuminated.

5-21. Calibration Adjustments

5-22. These adjustments insure the basic accuracy of the instrument. They should be varied only if the Performance Verification check of paragraph 5-9 so indicates.

a. Check power supply voltages in paragraph 5-14.

b. If the low noise figure reading is within specification, but the higher noise figure reading is not, proceed to step (e).

FIGURE 5-4. TROUBLESHOOTING CHART, 7514 PANFI

c. Perform calibration check as described in paragraph 5-9 (a through i).

d. Adjust CAL ADJUST pot for the AUTO reading that was determined in paragraph 5-9 (g). Depress the CAL switch. Adjust R813 on the Relay Driver board until the display on the ENR calibrate scale is equal to the ENR value used in paragraph 5-9 (g).

e. Perform calibration check as described in paragraph 5-9 (j) and (k).

f. If reading is not within specification, remove the +28 V coax cable to the noise generator. This will produce an ∞ noise figure reading by the instrument. Depress the 18-dB selector of the Add-to-Noise Figure switches. If the meter indication is not within 1/4 division of ∞ adjust R632 to obtain this specification.

g. Repeat step (e).

h. If there are still problems, proceed to the Troubleshooting section (paragraph 5-23).

5-23. TROUBLESHOOTING

5-24. Performance verification and the checks and adjustments of the proceeding paragraphs are valuable aids to locating malfunctions within the 7514 PANFI. Figure 5-4 is a chart which is designed to isolate problems to a particular circuit area.

5-25. General Information

5-26. Tools

a. A special tool is required for adjusting the variable inductors of the Postamplifier. A typical type is the Spectrol trimmer adjustment tool #8-T0000.

b. Integrated circuits should be removed from their sockets using an extraction tool to minimize pin damage. A typical tool is the Augat Model T114-1.

c. Measurements taken directly from IC pins are facilitated by a spring clip designed for that purpose. Typical types are the Pomona DIP-CLIP Models 3914 and 3916.

5-27. Transistors. Plastic encapsulated, and metal can transistors are used in the 7514 PANFI. Figure 5-5 (a) illustrates the physical configurations used.

5-28. Integrated Circuits. Both linear and digital IC's are used in the PANFI. Figure 5-5 (b) illustrates the physical configurations used, and Figure 5-5 (c) provides functional descriptions.

5-29. Logic Family

5-30. All digital integrated circuits on the Relay Driver PC board are COS/MOS devices. Positive logic is used throughout, so a "True" condition is high, and a "False" condition is low. High and low voltage values are, in practice:

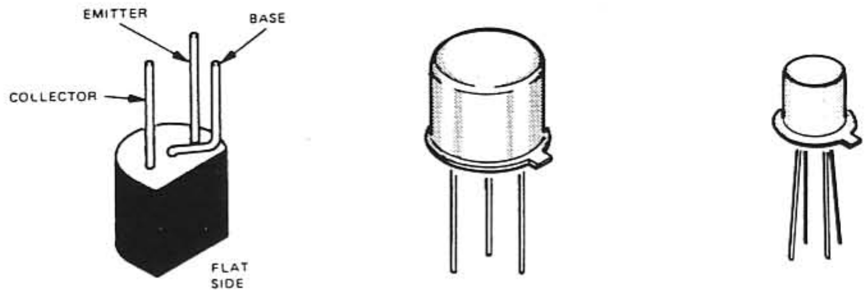
True (high or logical "1") = +8 to +15 volts
False (low or logical "0") = 0 to +3.5 volts

These values are for a nominal supply of +15 volts.

5-31. Analog Switches. An analog switch or gate which will block or pass analog signals, depending upon the condition of a control signal, is used in the PANFI. On the AGC/OVERRANGE board, the analog switches are used as the sampling gate for the OVERRANGE sample and hold circuitry.

5-32. Although the gates are complex integrated circuits, they are, for simplicity, shown as FET's on the schematics. Operation of the COS/MOS N-channel switches used on the AGC/OVERRANGE board is illustrated by Figure 5-6.

5-33. Flip-Flops. D-type, positive-edge-triggered flip-flops are used on the Multimeter board, and the Relay Driver board. Information at the input (D) is transferred to the output (Q), whenever a positive-going transition occurs at the clock input. The complementary output ($\overline{Q}$) is also available. Each circuit has independent Clear and Preset inputs which operate as follows: a LOW input to Clear sets the output LOW; a LOW input to Preset sets the output HIGH. These inputs operate independently of the Clock.



Plastic Can Metal Can

FIGURE 5-5. (a) Transistor Case Styles

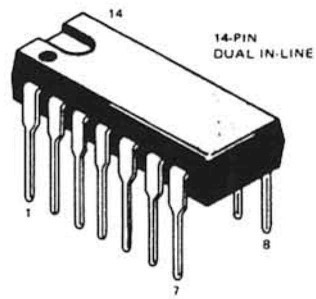


FIGURE 5-5. (b) Physical Configuration, Integrated Circuits

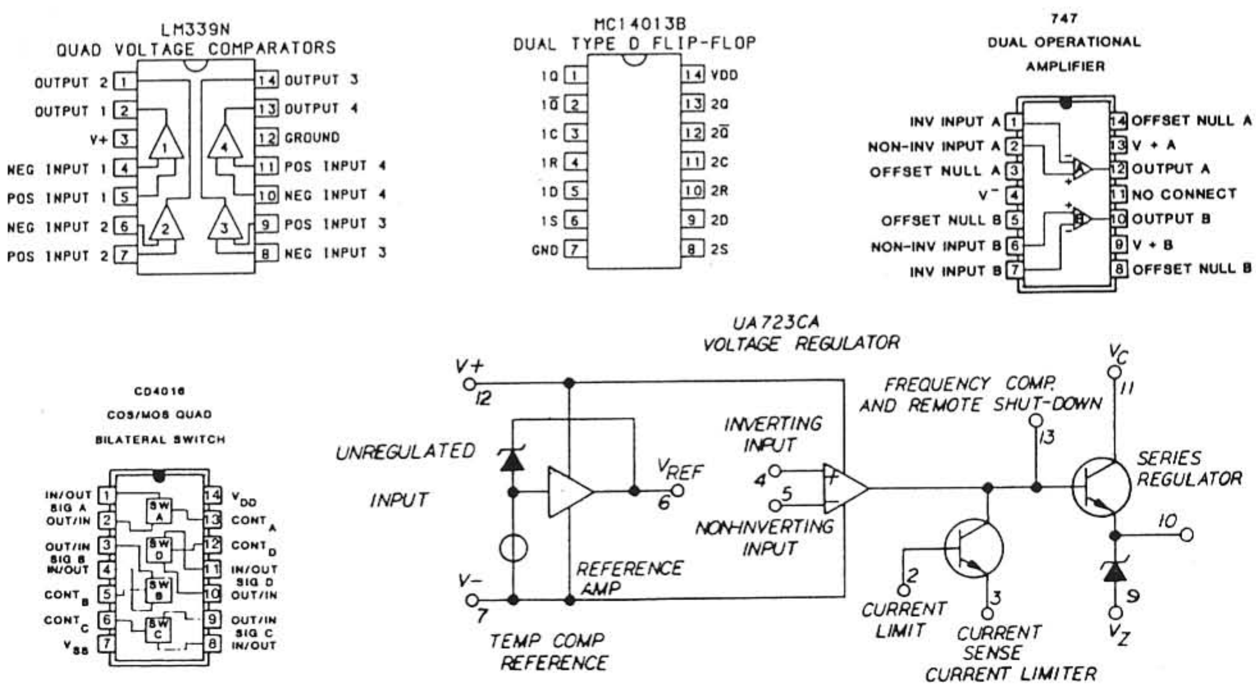


FIGURE 5-5. (c) Functional Illustrations, Integrated Circuits

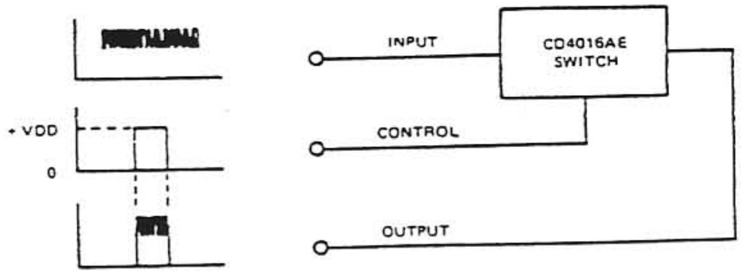


FIGURE 5-6. OPERATION OF THE COS/MOS BILATERAL SWITCH

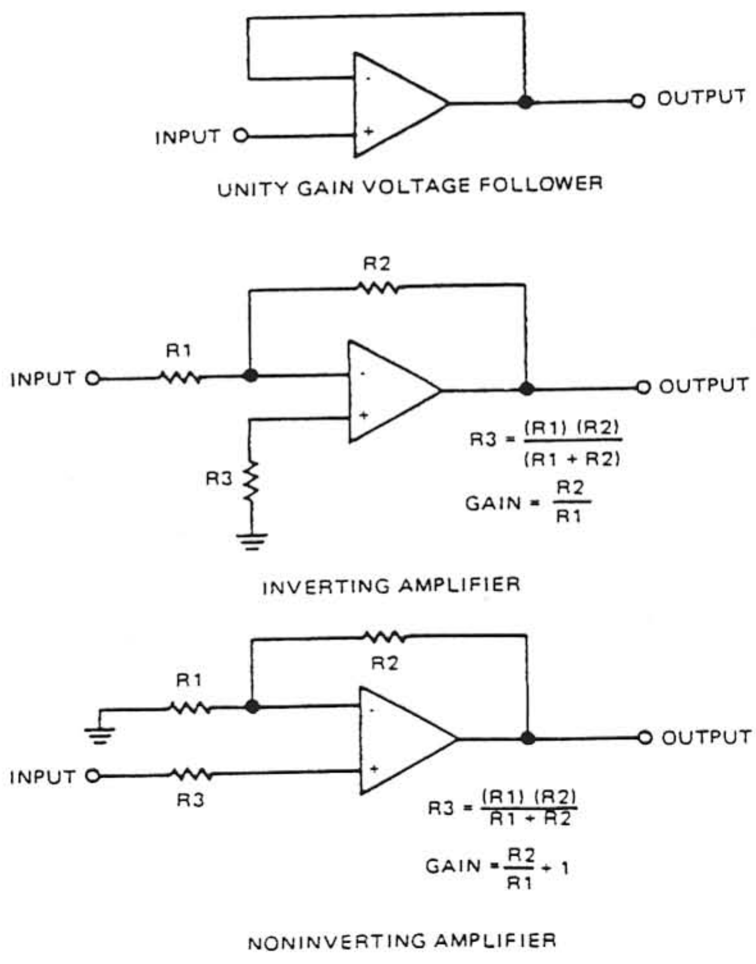


FIGURE 5-7. TYPICAL APPLICATIONS OF OPERATIONAL AMPLIFIERS

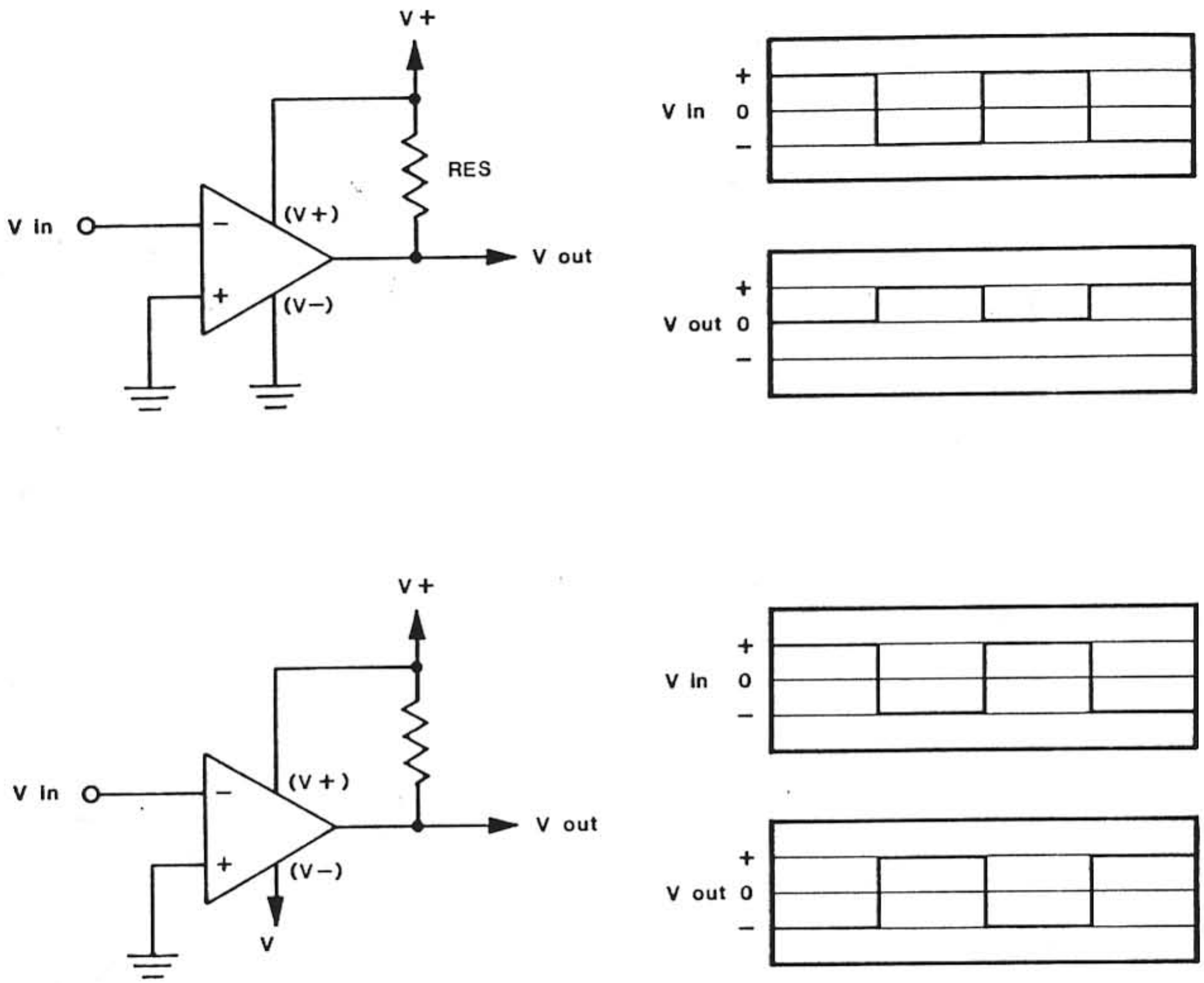


FIGURE 5-8. COMPARATOR INPUT/OUTPUT RELATIONSHIP

5-34. Operational Amplifiers. Operational amplifiers are used to implement many functions, such as summers, buffers, differential and offset amplifiers. Figure 5-7 illustrates some typical circuits.

5-35. Comparators are used to interface the CMOS logic levels to those needed by the linear circuitry. Figure 5-8 illustrates the input/output relationships.

5-36. Printed Circuit Boards. The printed circuit (PC) boards used in the 7514 PANFI are double-sided with plated-through holes; that is, there are conductor patterns on both sides of the boards, and connections from top to bottom via metallic plating of through holes.

5-37. The PC boards are susceptible to damage from excess soldering heat. Use a soldering iron of less than 60 watts rating when working on the 7514 PC boards, and use a suction device to remove excess solder from component mounting holes. If possible, when replacing a component, clip the leads of the device to be replaced close to its body; thus, the old leads can be used as wrap-around terminals for soldering the new component in place. When soldering on the PC boards, use a solder with a non-corrosive flux core, and clean the excess flux off the board after all the soldering is complete. Damaged sections of the printed wiring can be repaired by soldering a length of bare, tinned copper wire across the damaged area.

5-38. Printed Circuit Board Connectors. Connections to the printed circuit boards are made via AMP Type 87133-X connectors. Connector tool, AMP 91084-1 is required to service these connectors. Pin number layouts, as they appear on the boards, are shown on the overall wiring diagram. In general, the pins are numbered consecutively with the numbers increasing in the same direction in each row (as contrasted to the continuous system used with IC's). This is illustrated in Figure 5-9 which is the layout of a 10-pin connector.

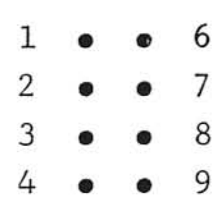


FIGURE 5-9. PIN NUMBERING LAYOUT OF A TYPICAL AMP 87133 CONNECTOR (VIEW LOOKING DOWN ON THE MATING PINS)

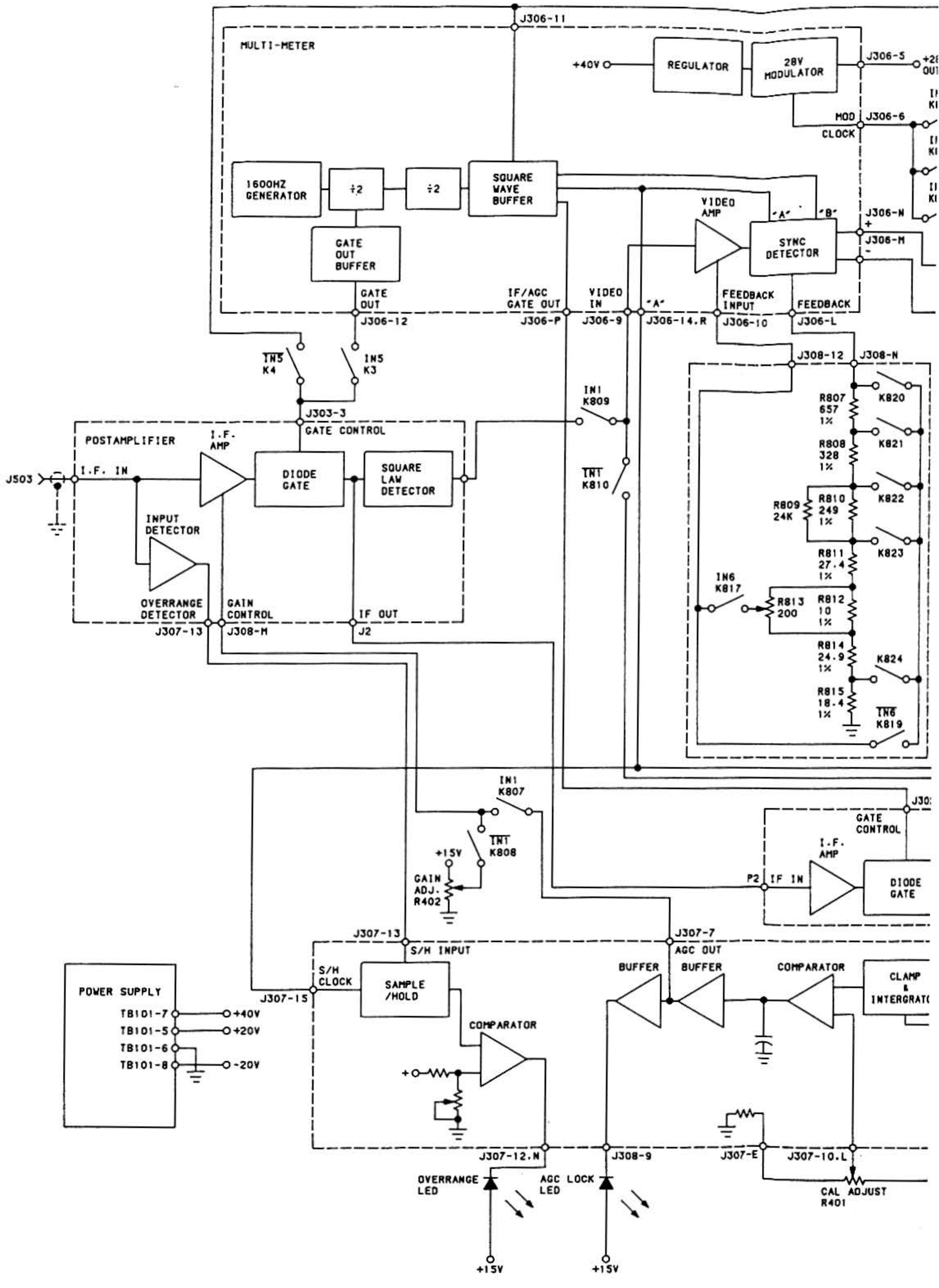
5-39. FACTORY SERVICE

5-40. In the event a difficult service problem occurs, contact your nearest Eaton Corporation Regional Office or Sales Representative by letter, TWX or phone. Please indicate the model number, serial number, and specific details of the difficulty involved, with as much additional information as you consider necessary to aid in pinpointing the cure to the problem.

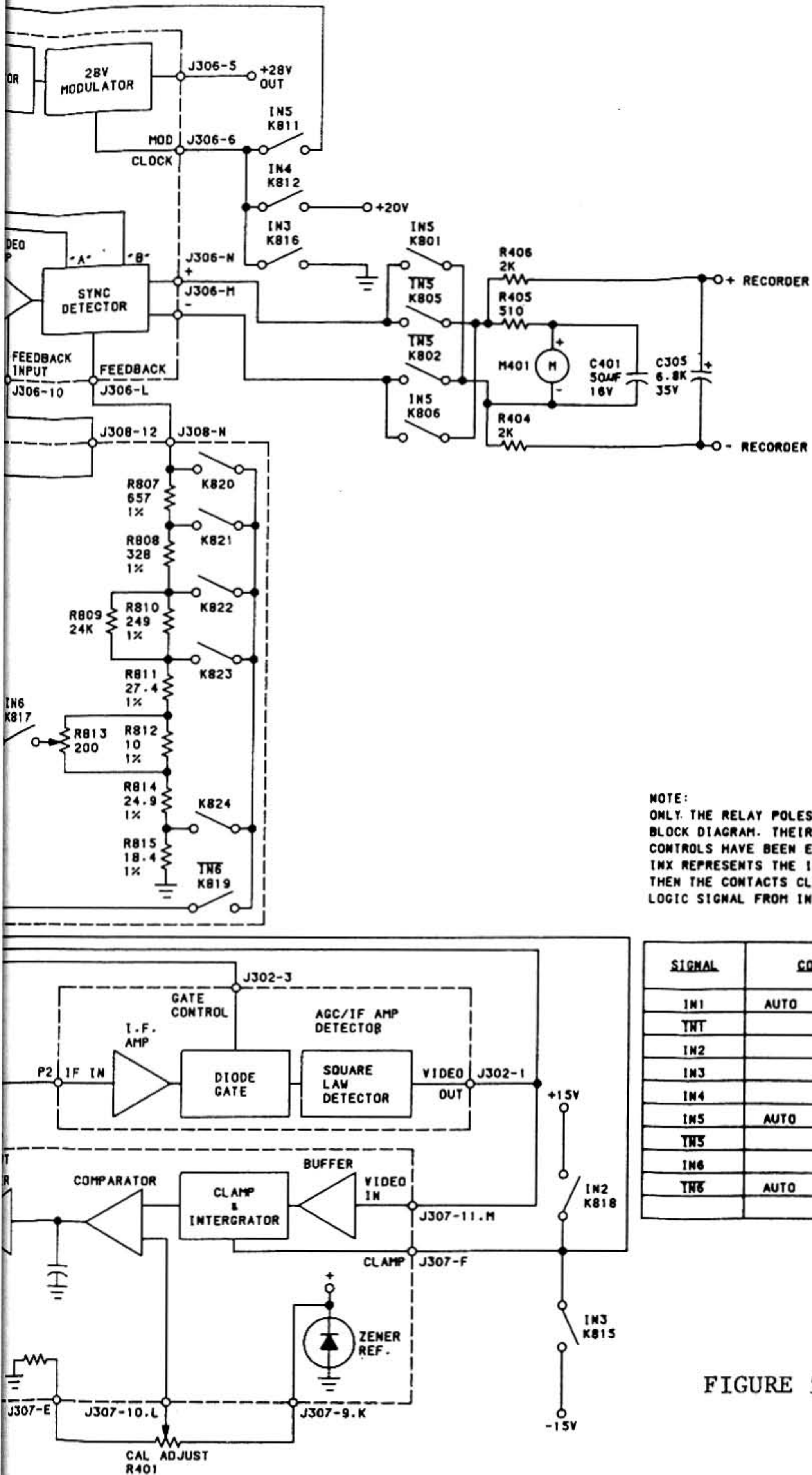
5-41. Should it be necessary to return the equipment for repair or recalibration, please contact Eaton Corporation, or an authorized Sales Representative in your area before shipping a unit. In your communication arranging for a return, please be sure to include model number, serial number, date of purchase, and specific details concerning the problem (in the event of failure), or service desired (in the event of recalibration).

5-42. When an instrument is returned for service, we will proceed to work on the instrument until the charges reach $100. If the total charges exceed $100., an estimate of such charges will be submitted for approval.

5-43. When spare parts are ordered, please indicate a description of the spare part, as well as its part number, and also include the model number and serial number of the instrument being repaired.



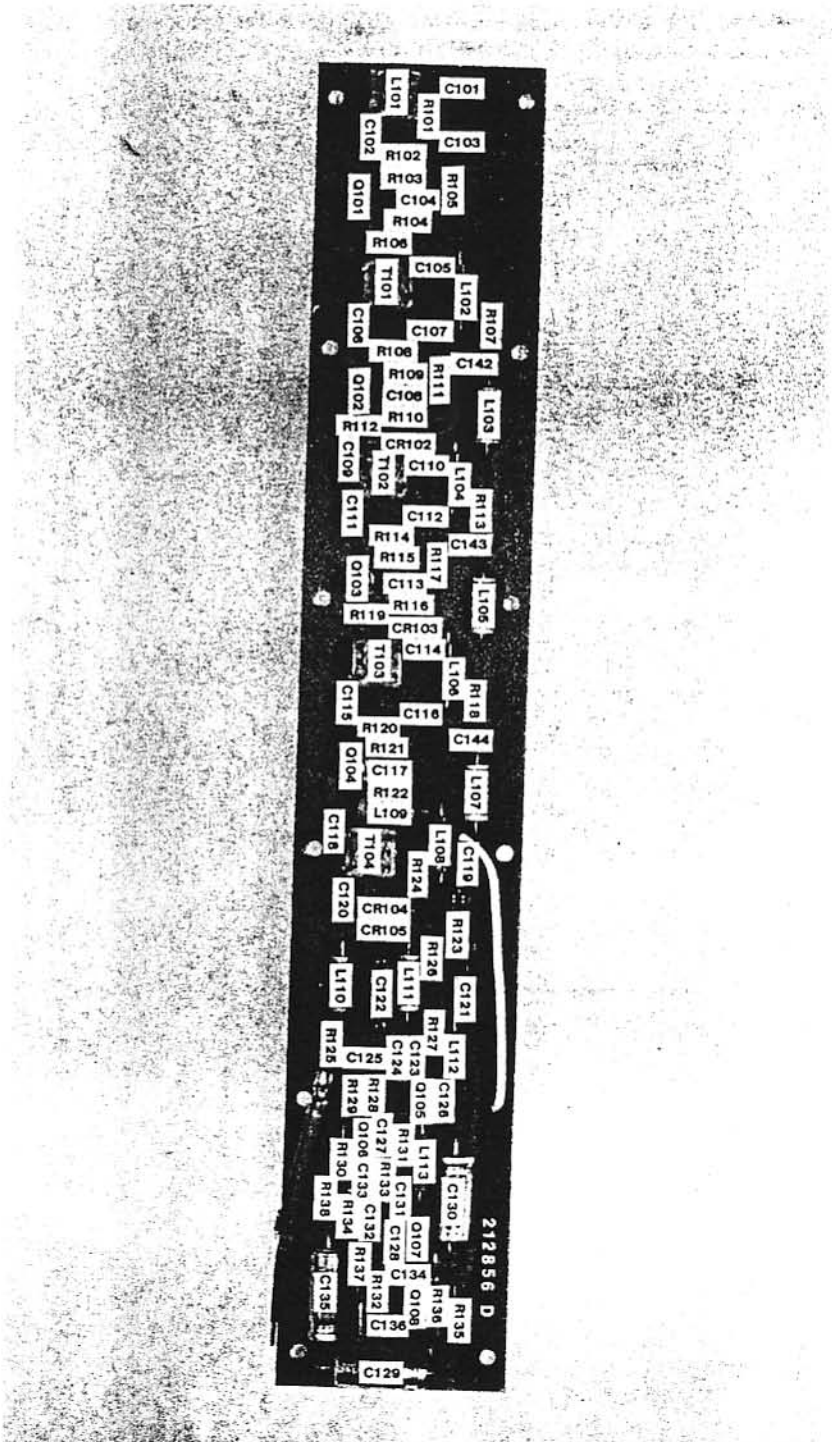
MULTI-METER
J306-11
+40V
REGULATOR
28V MODULATOR
J306-5
MOD CLOCK
J306-6
1600HZ GENERATOR
÷2
÷2
SQUARE WAVE BUFFER
GATE OUT BUFFER
VIDEO AMP
"A"
"B"
SYNC DETECTOR
J306-N
J306-M
GATE OUT
J306-12
IF/AGC GATE OUT
J306-P
VIDEO IN
J306-9
"A"
J306-14.R
FEEDBACK INPUT
J306-10
FEEDBACK
J306-L
IN5 K4
IN5 K3
J303-3
GATE CONTROL
IN1 K809
IN1 K810
J308-12
J308-N
R807 657 1%
K820
R808 328 1%
K821
R809 24K
R810 249 1%
K822
R811 27.4 1%
K823
IN6 K817
R813 200
R812 10 1%
R814 24.9 1%
K824
R815 18.4 1%
IN6 K819
POSTAMPLIFIER
I.F. AMP
J503
I.F. IN
DIODE GATE
SQUARE LAW DETECTOR
INPUT DETECTOR
OVERRANGE DETECTOR
GAIN CONTROL
IF OUT
J307-13
J308-M
J2
IN1 K807
IN1 K808
+15V
GAIN ADJ. R402
GATE CONTROL
I.F. AMP
P2
IF IN
DIODE GATE
J307-13
S/H INPUT
J307-7
AGC OUT
S/H CLOCK
J307-15
SAMPLE /HOLD
BUFFER
BUFFER
COMPARATOR
CLAMP & INTERGRAT
COMPARATOR
POWER SUPPLY
TB101-7
+40V
TB101-5
+20V
TB101-6
TB101-8
-20V
J307-12.N
J308-9
J307-E
J307-10.L
OVERRANGE LED
AGC LOCK LED
CAL ADJUST R401
+15V
+15V



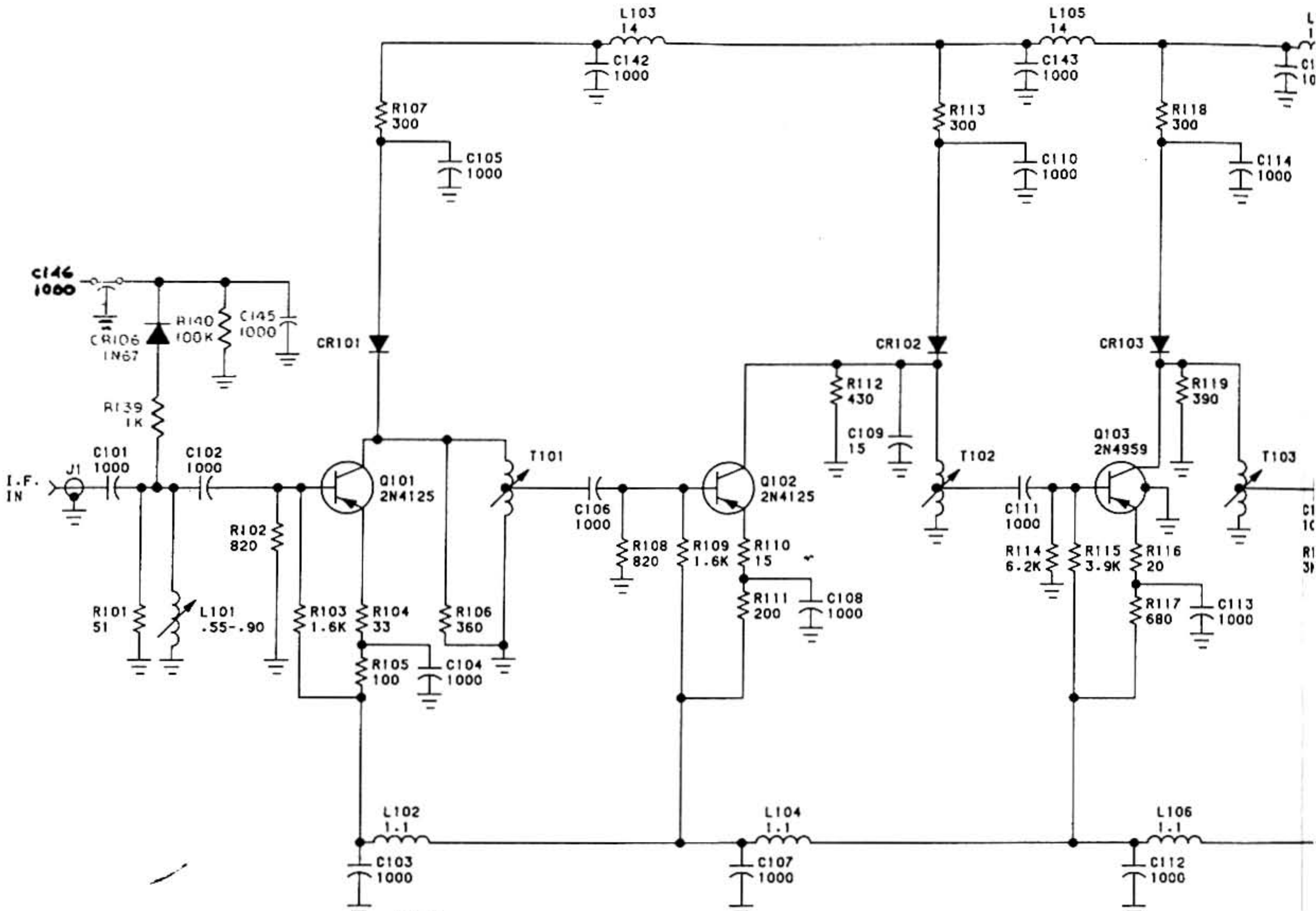
NOTE:
ONLY THE RELAY POLES (SPST) ARE SHOWN IN THIS BLOCK DIAGRAM. THEIR COILS.DRIVERS.AND FRONT PANEL CONTROLS HAVE BEEN ELIMINATED FOR SIMPLICITY.
INX REPRESENTS THE INPUT LOGIC SIGNAL. WHEN INX IS "0" THEN THE CONTACTS CLOSE. $\overline{INX}$ REPRESENTS THE OPPOSITE LOGIC SIGNAL FROM INX.

SIGNAL	CONTACT CLOSED IN MODES			
IN1	AUTO	CAL		
$\overline{IN1}$			MAN OFF	MAN ON
IN2			MAN OFF	
IN3				MAN ON
IN4		CAL	MAN OFF	
IN5	AUTO			
$\overline{IN5}$		CAL	MAN OFF	MAN ON
IN6		CAL		
$\overline{IN6}$	AUTO		MAN OFF	MAN ON

FIGURE 5-10. OVERALL BLOCK DIAGRAM, 7514 PANFI



AIL 7514 Postamplifier/Detector Board



NOTES:

UNLESS OTHERWISE SPECIFIED'
ALL RESISTORS ARE IN OHMS 1/4W
ALL DIODES ARE HPA3039
ALL CAPACITORS ARE IN PF
ALL INDUCTORS ARE IN UH

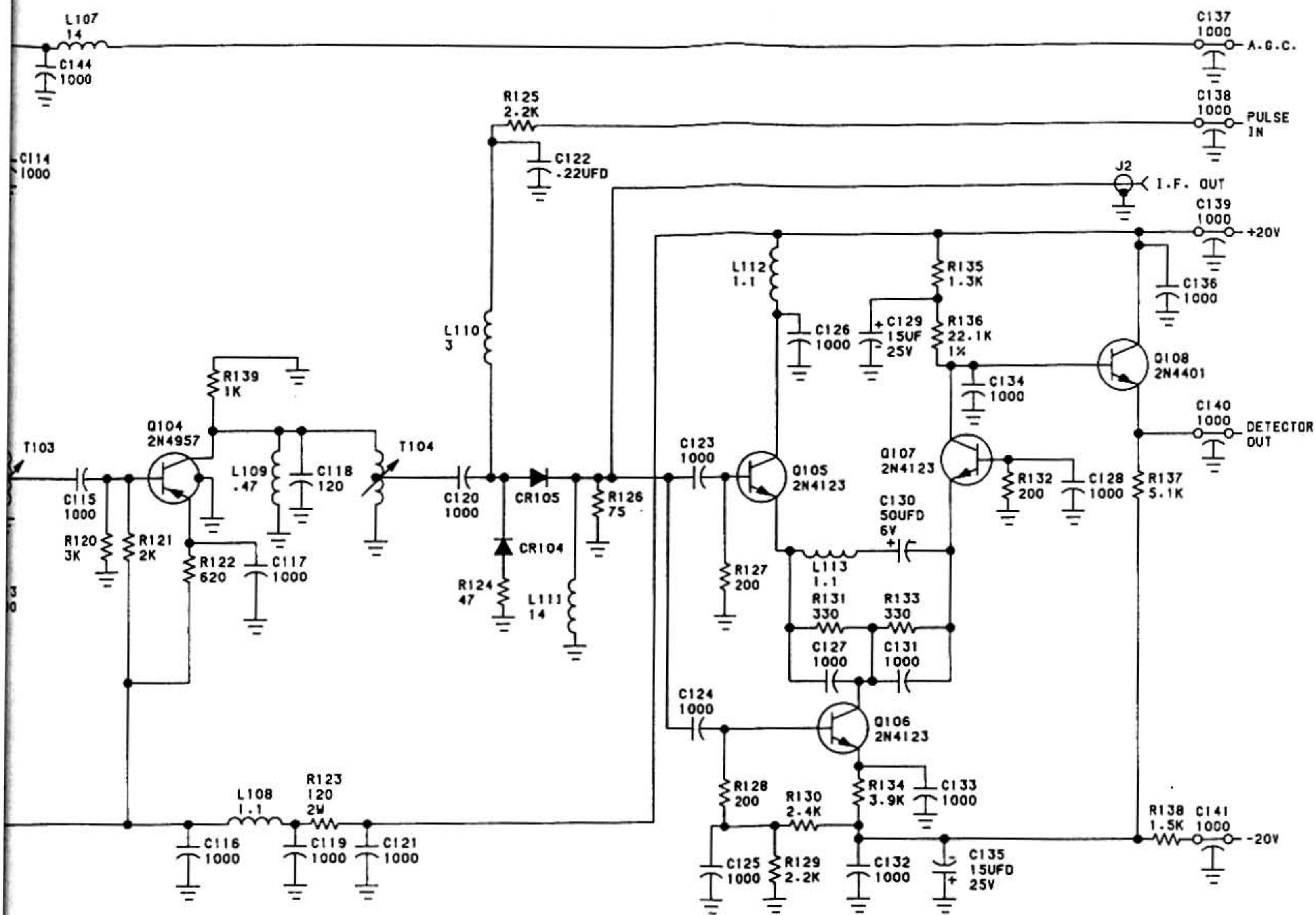
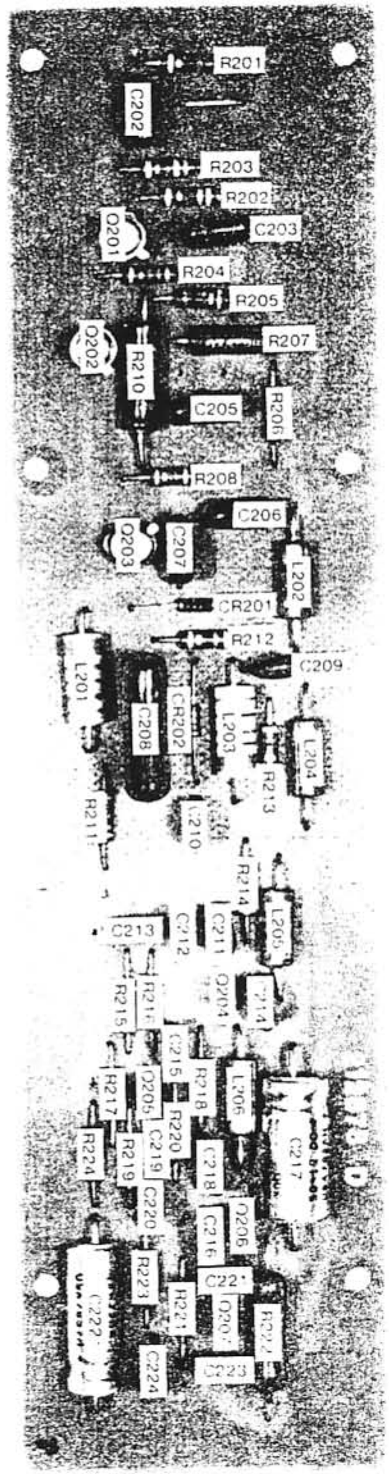
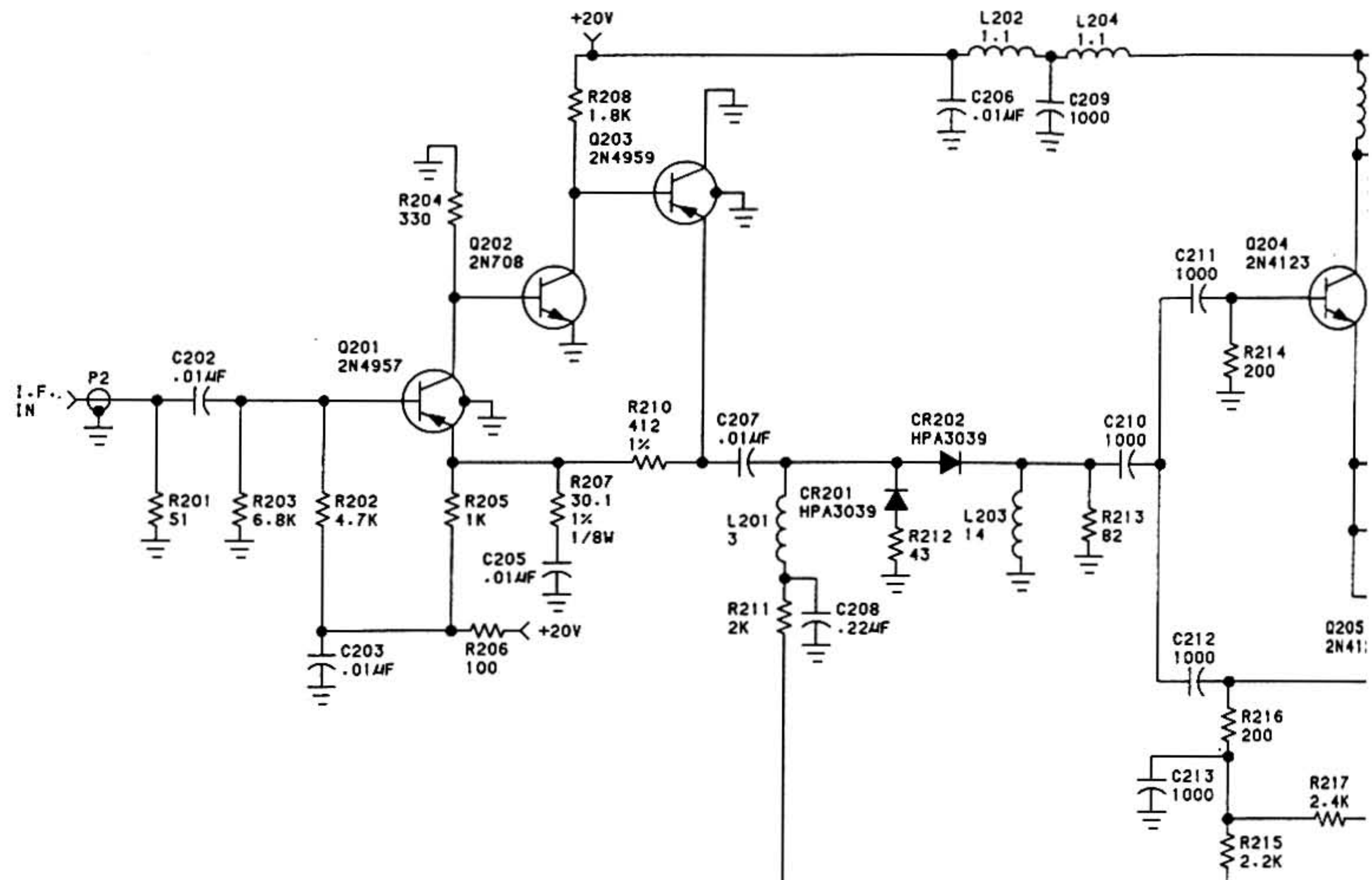


FIGURE 5-11. SCHEMATIC DIAGRAM AND COMPONENT LAYOUT, 7514 PANFI POSTAMPLIFIER/DETECTOR BOARD



AIL 7514 AGC IF AMPLIFIER/DETECTOR Board



NOTES:

UNLESS OTHERWISE SPECIFIED:

ALL RESISTORS ARE IN OHMS 1/4W.

ALL CAPACITORS ARE IN PF

ALL INDUCTORS ARE IN µH

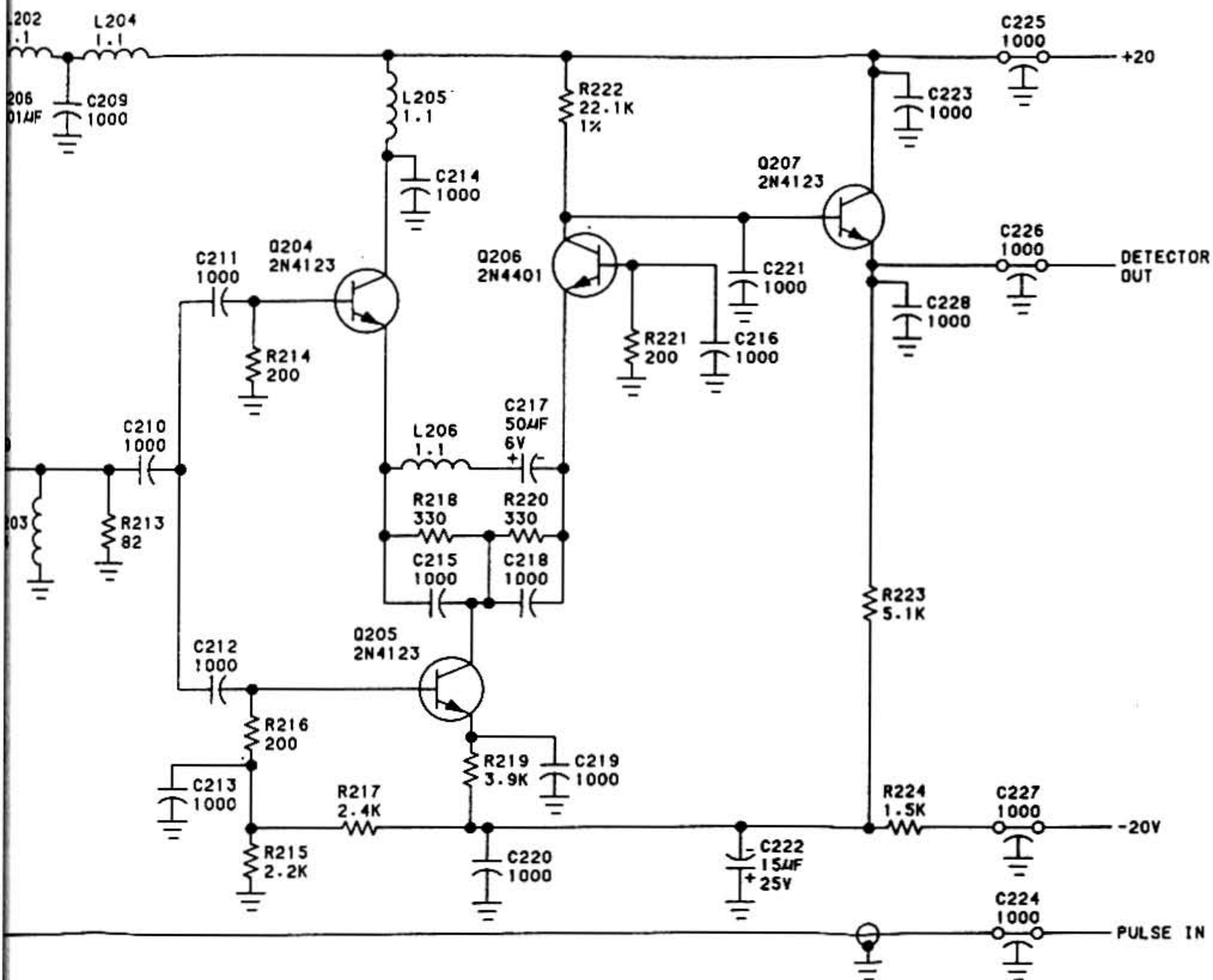
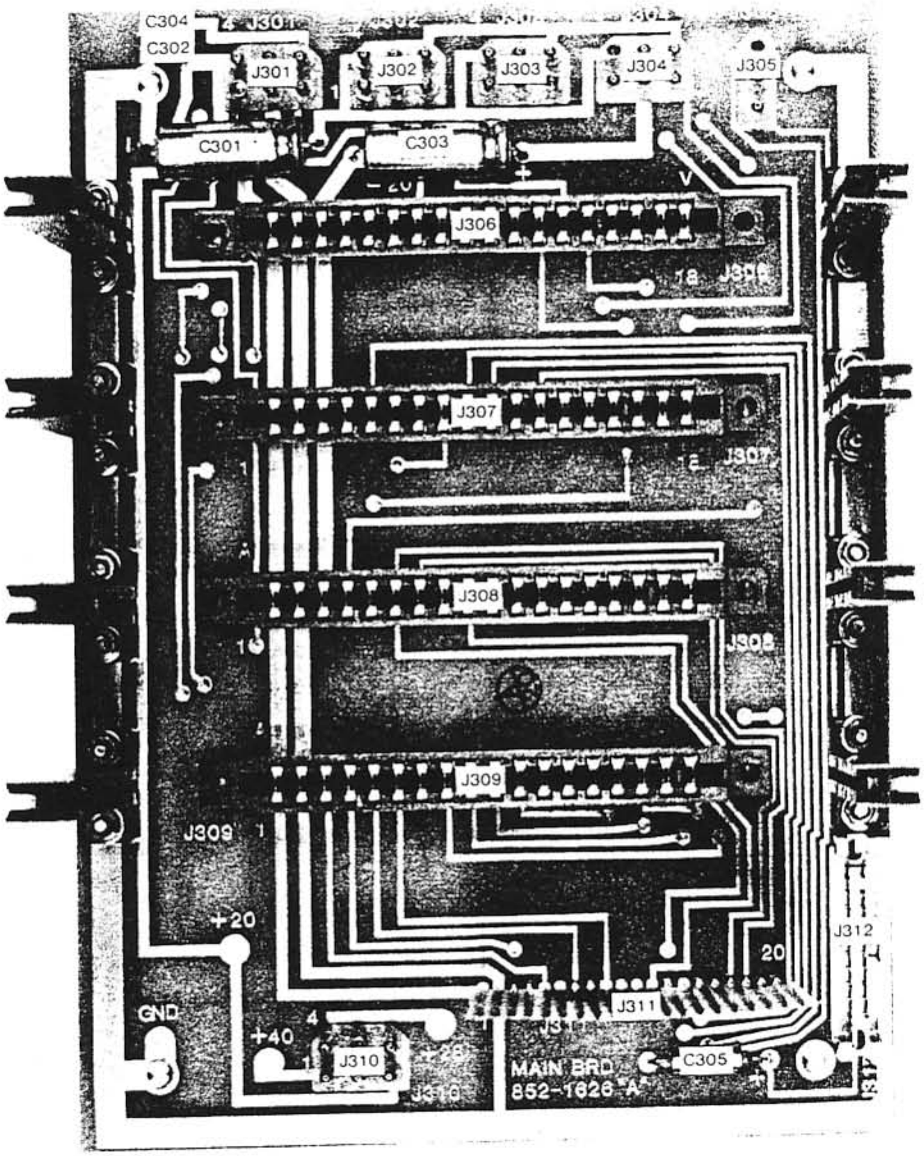
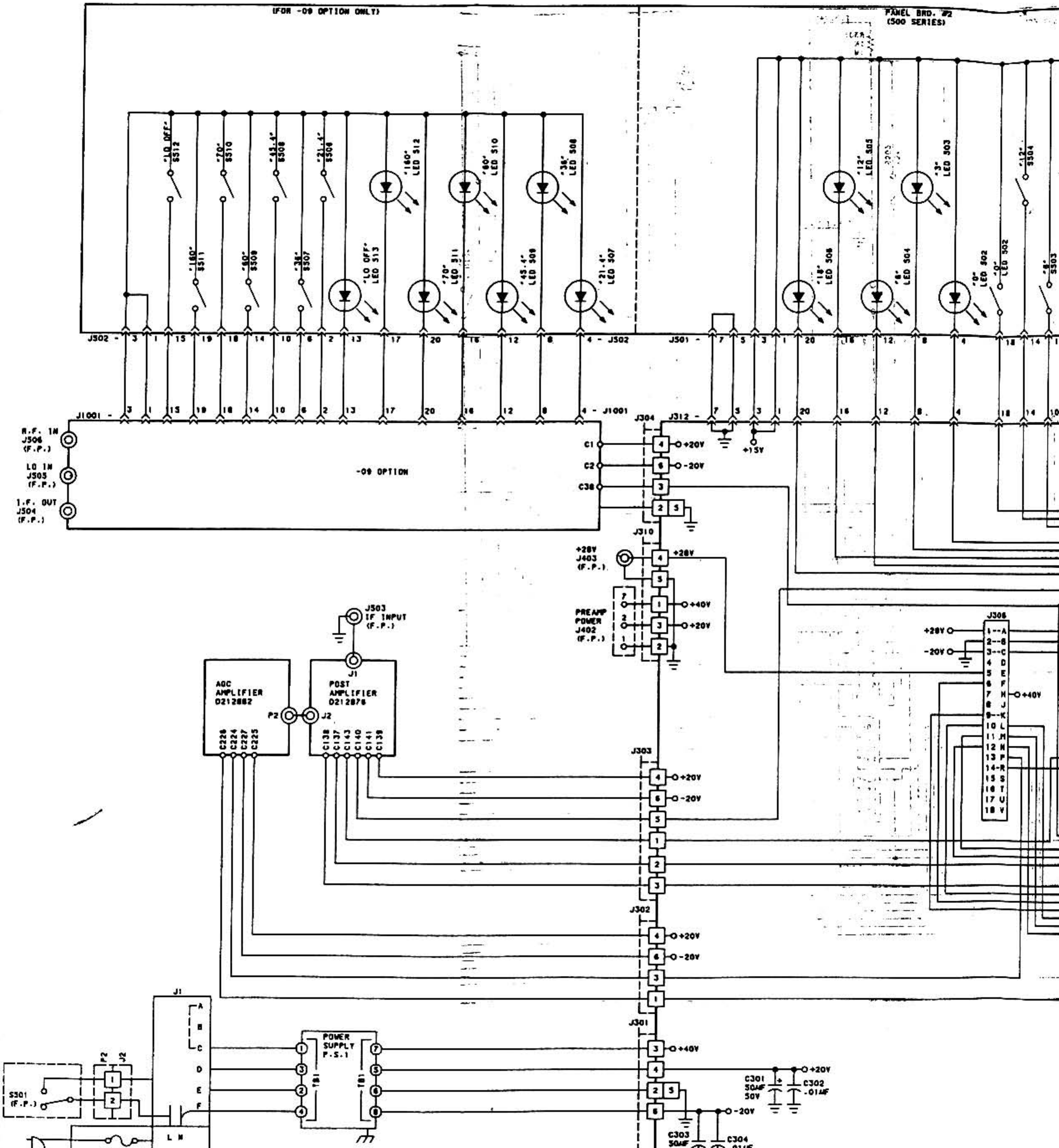


FIGURE 5-12. SCHEMATIC DIAGRAM AND COMPONENT LAYOUT, 7514 PANFI AGC IF AMPLIFIER/DETECTOR BOARD



AIL 7514 Main Board



NOTES:

1. J306 REFER TO SCHEMATIC D852-1716 (MULTI-MTR. BRD.)
2. J307 REFER TO SCHEMATIC D852-1717 (AGC/OVERRANGE BRD.)
3. J308 REFER TO SCHEMATIC D852-1718 (RELAY BRD.)
4. J308 REFER TO SCHEMATIC D852-1719 (RELAY DRIVER BRD.)
5. -09 OPTION REFER TO SCHEMATIC D852-1767.

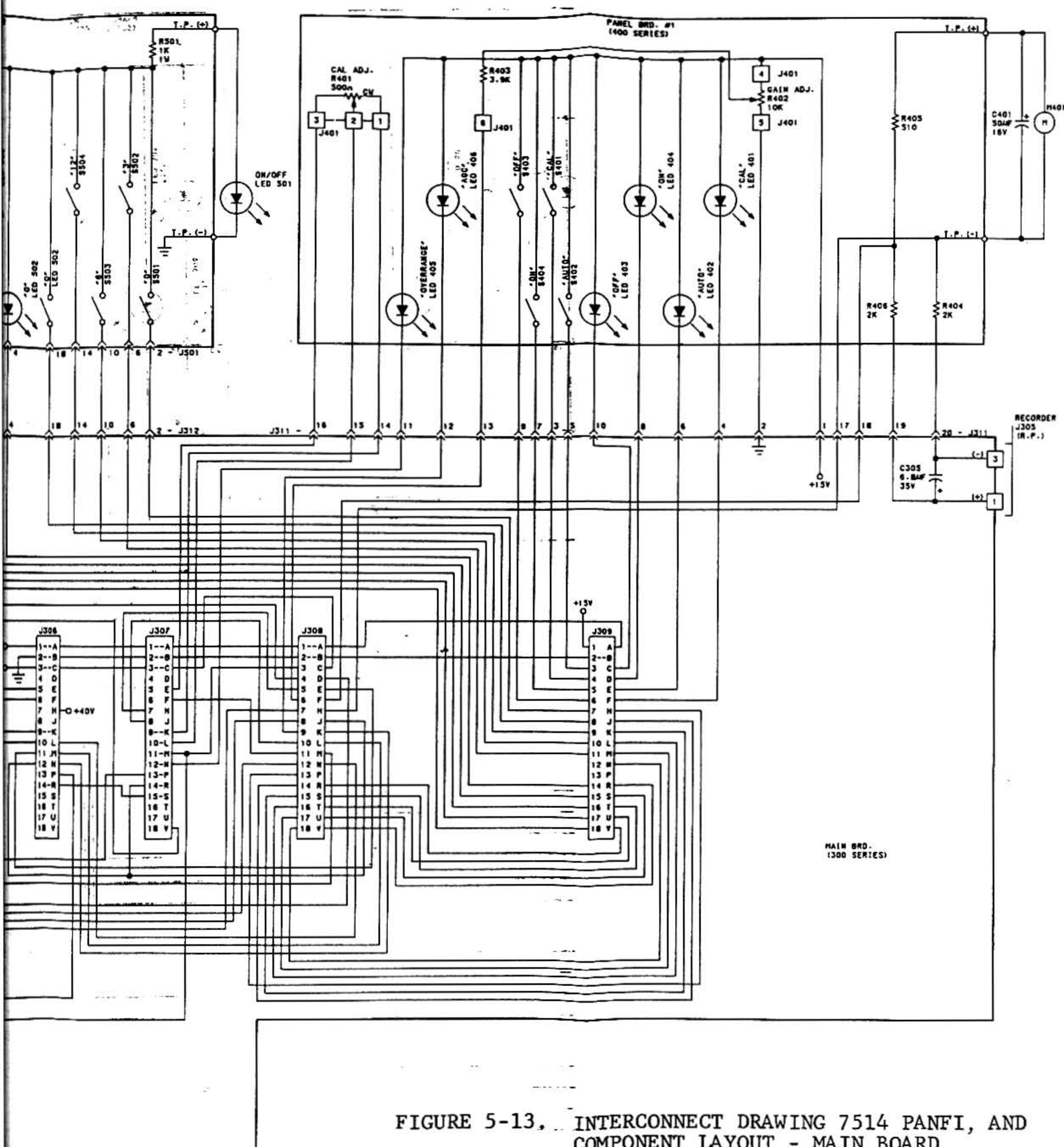
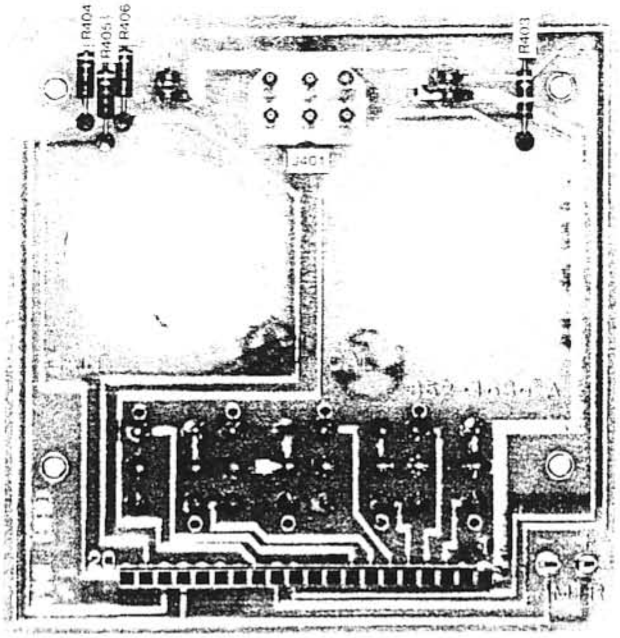
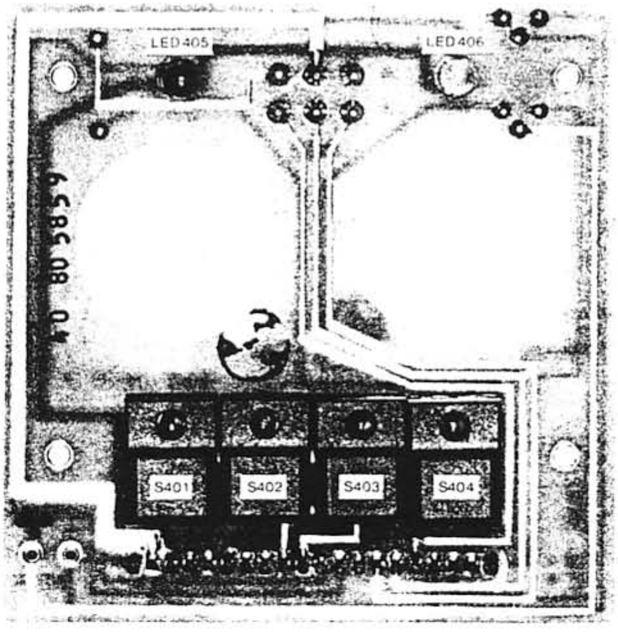


FIGURE 5-13. INTERCONNECT DRAWING 7514 PANFI, AND COMPONENT LAYOUT - MAIN BOARD

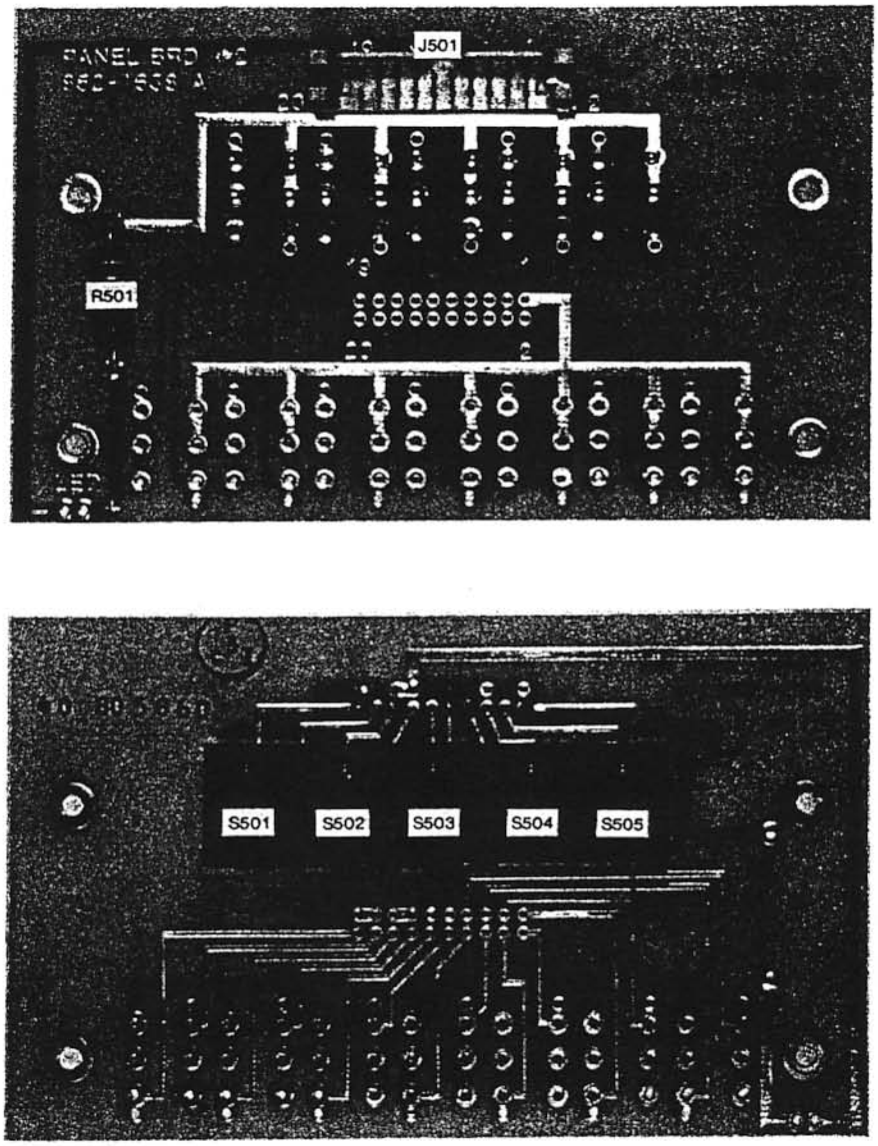


a. Front View



b. Rear View

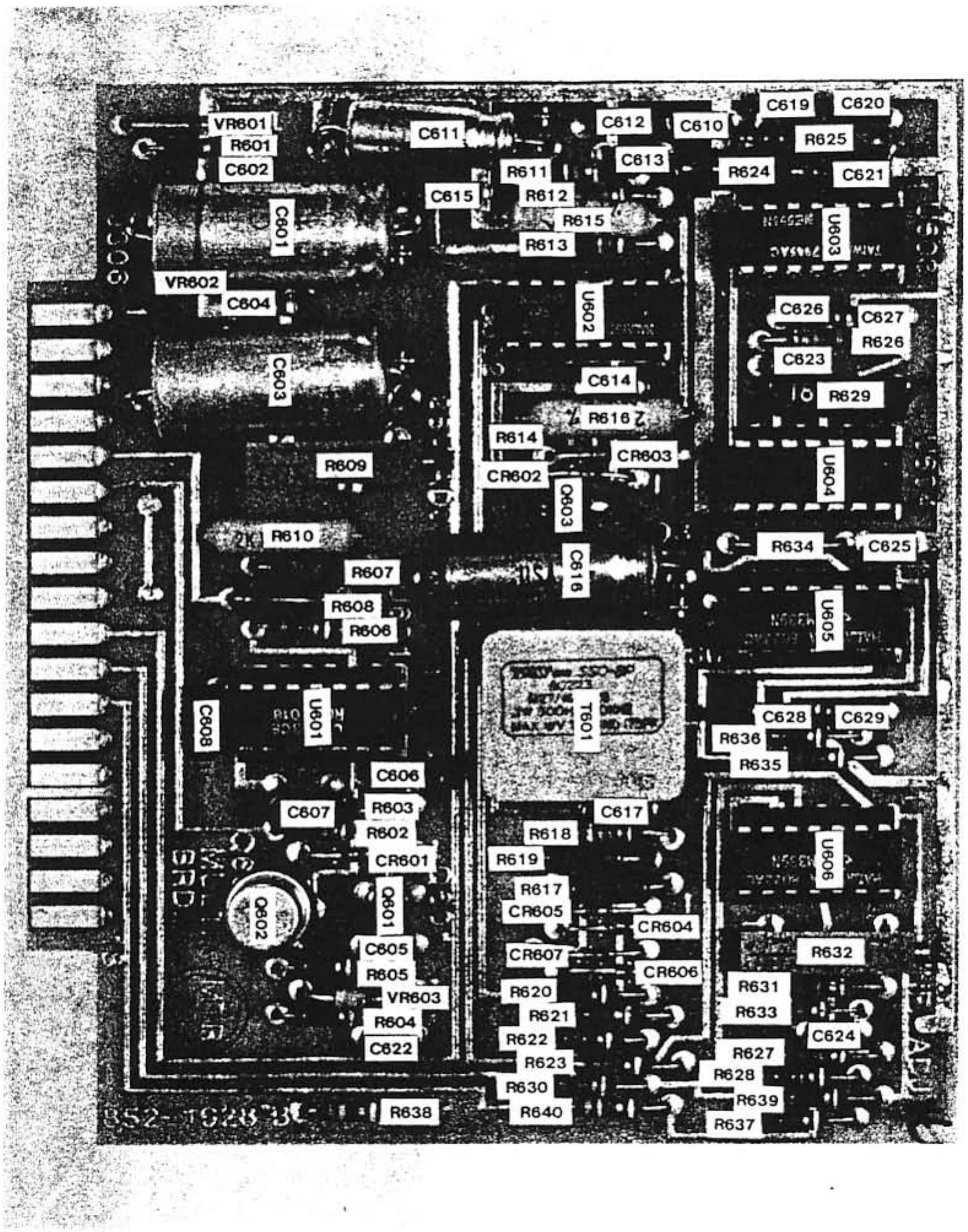
FIGURE 5-14. COMPONENT LAYOUT, PANEL BOARD #1



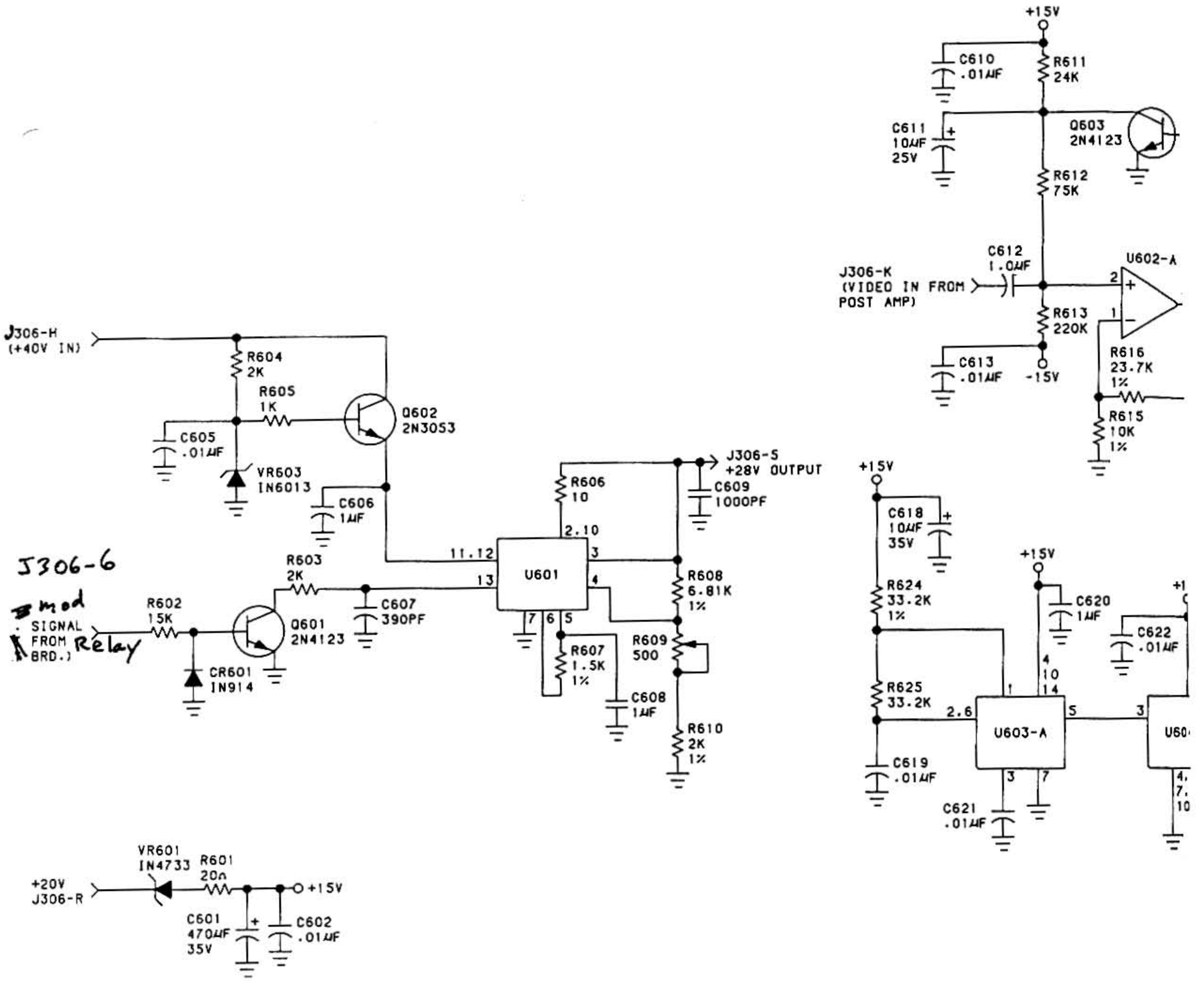
a. Front View

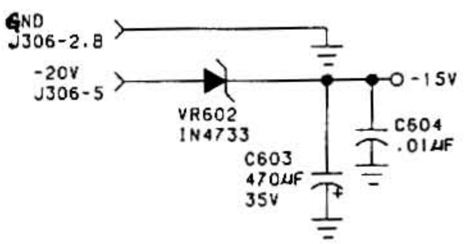
b. Rear View

FIGURE 5-15. COMPONENT LAYOUT, PANEL BOARD #2



AIL 7514 Multimeter Board





SYMBOL	PART NO.	CONNECTION
U601	UA723PC	SHOWN
U602	MC1747CL	SHOWN
U603	LM556	SHOWN
U604	MC14013A	SHOWN
U605.6	LM339N	PIN 3- +15V PIN 12- -15V

NOTES:

1. ALL RESISTORS ARE 1/4W.5% UNLESS OTHERWISE SPECIFIED.

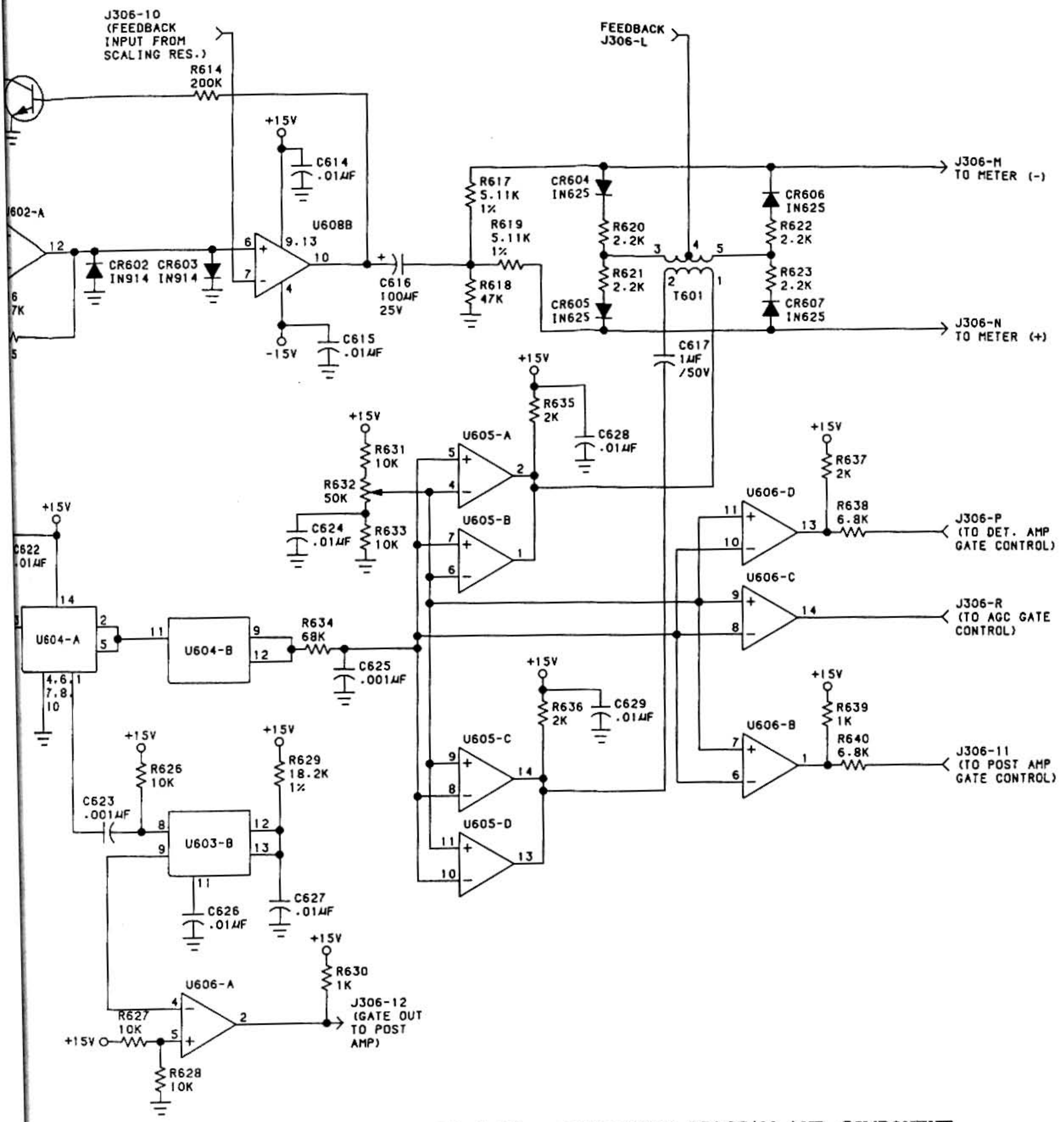
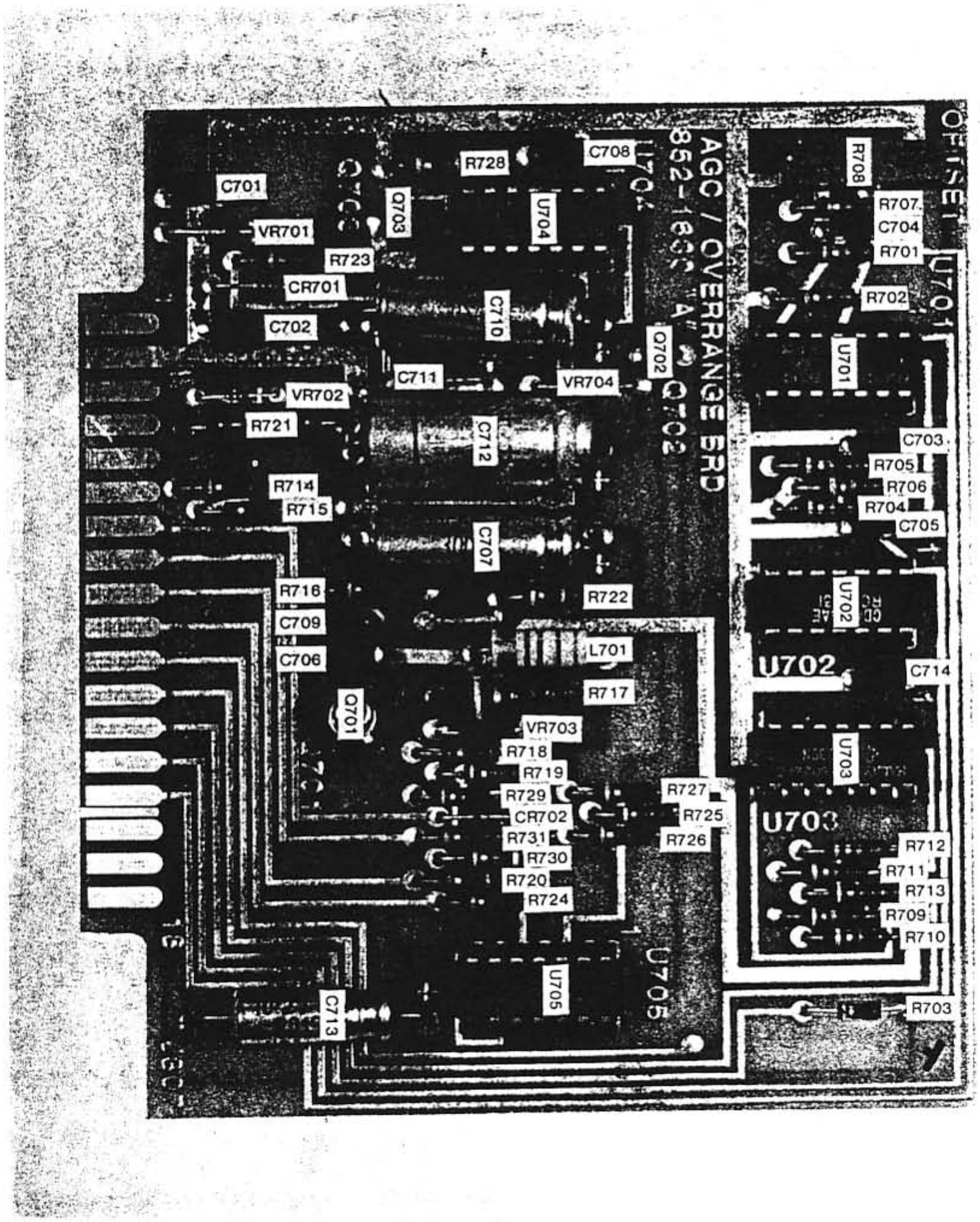
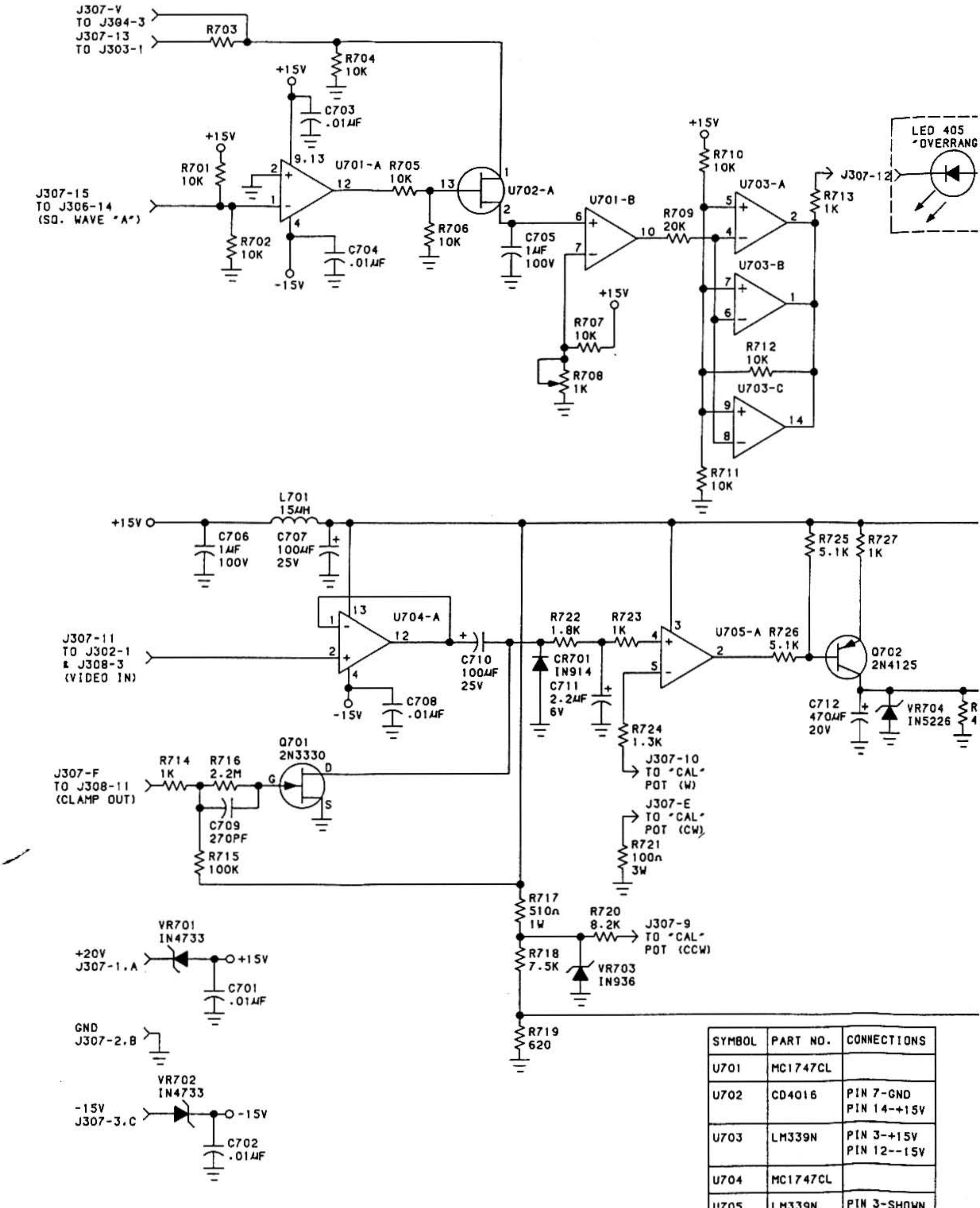


FIGURE 5-16. SCHEMATIC DIAGRAM AND COMPONENT LAYOUT, 7514 PANFI MULTIMETER BOARD



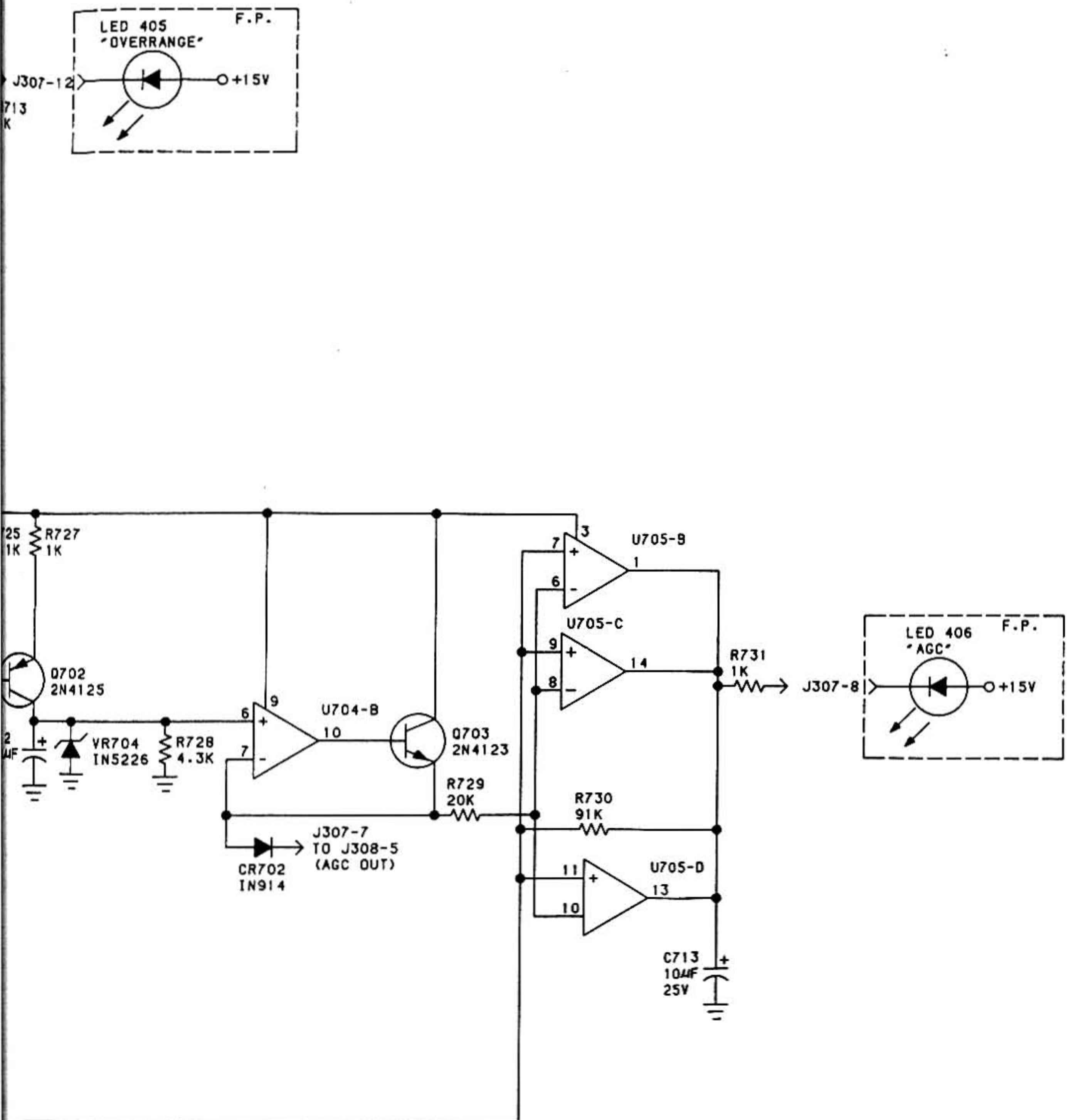
AIL 7514 AGC/overrange Board



SYMBOL	PART NO.	CONNECTIONS
U701	MC1747CL	
U702	CD4016	PIN 7-GND PIN 14-+15V
U703	LM339N	PIN 3-+15V PIN 12--15V
U704	MC1747CL	
U705	LM339N	PIN 3-SHOWN PIN 12-GND

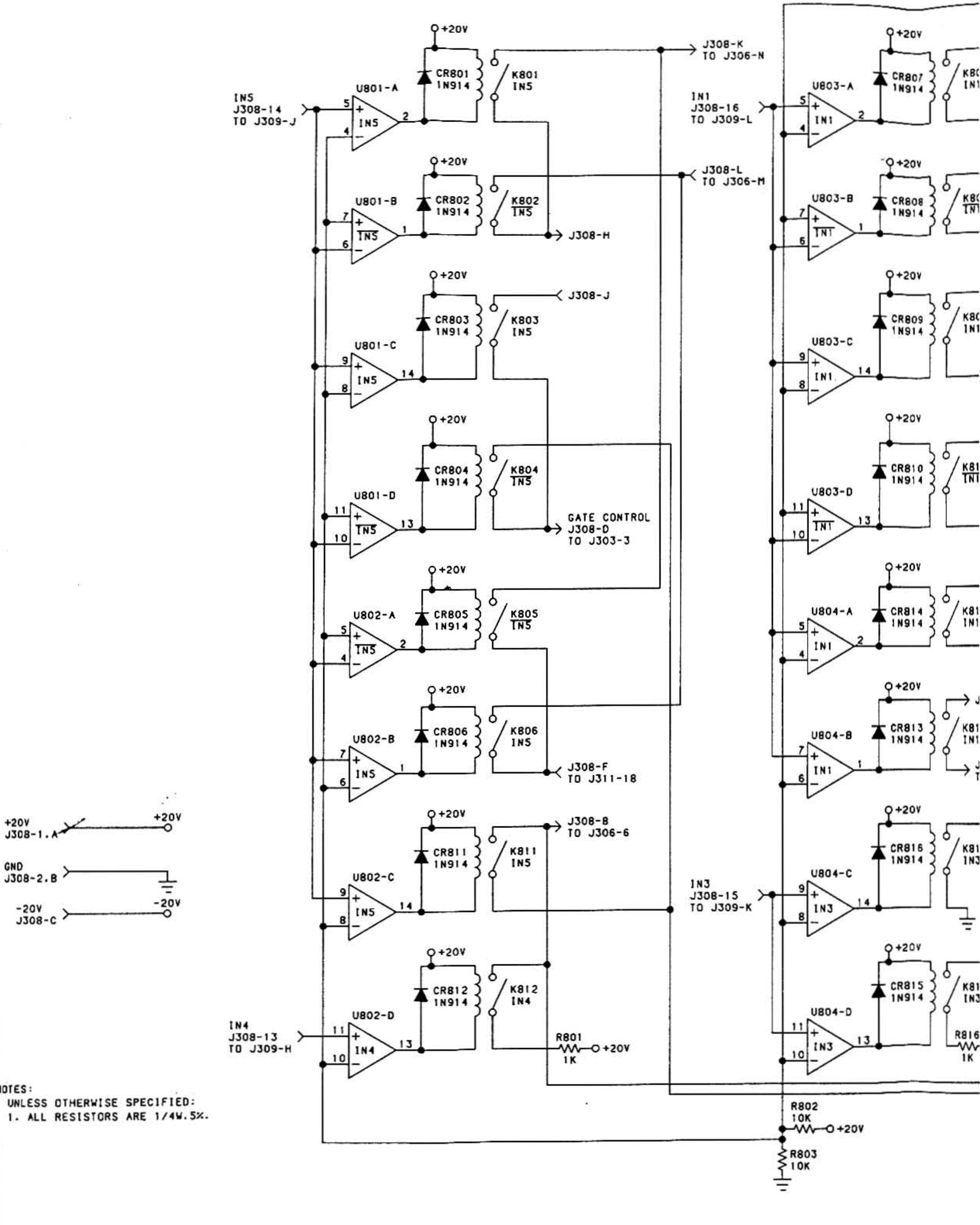
NOTES:

1. ALL RESISTORS ARE 1/4W. 5% UNLESS OTHERWISE SPECIFIED.

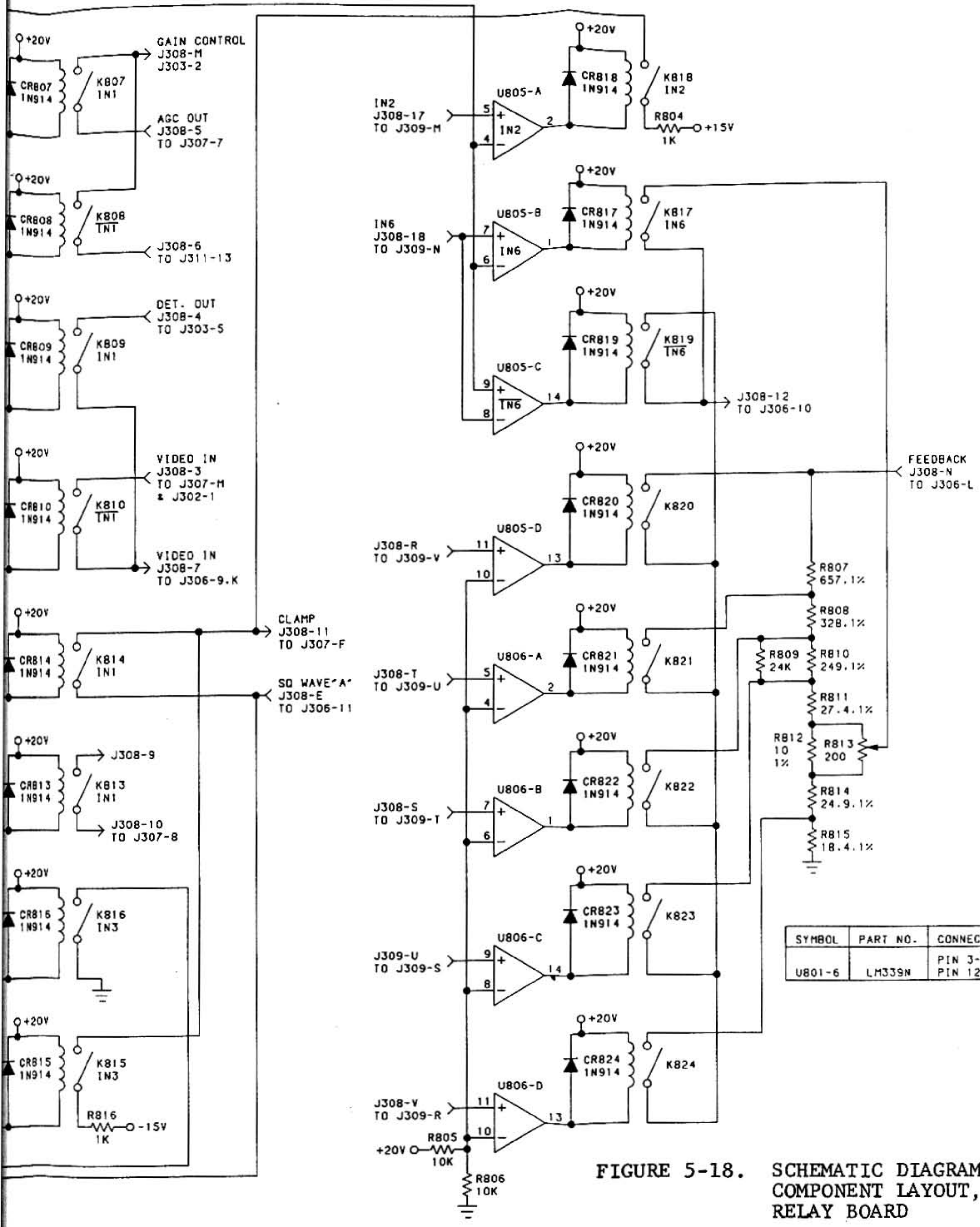


CONNECTIONS
PIN 7-GND PIN 14-+15V
PIN 3-+15V PIN 12--15V
PIN 3-SHOWN PIN 12-GND

FIGURE 5-17. SCHEMATIC DIAGRAM AND COMPONENT LAYOUT, 7514 PANFI AGC/OVERRANGE BOARD

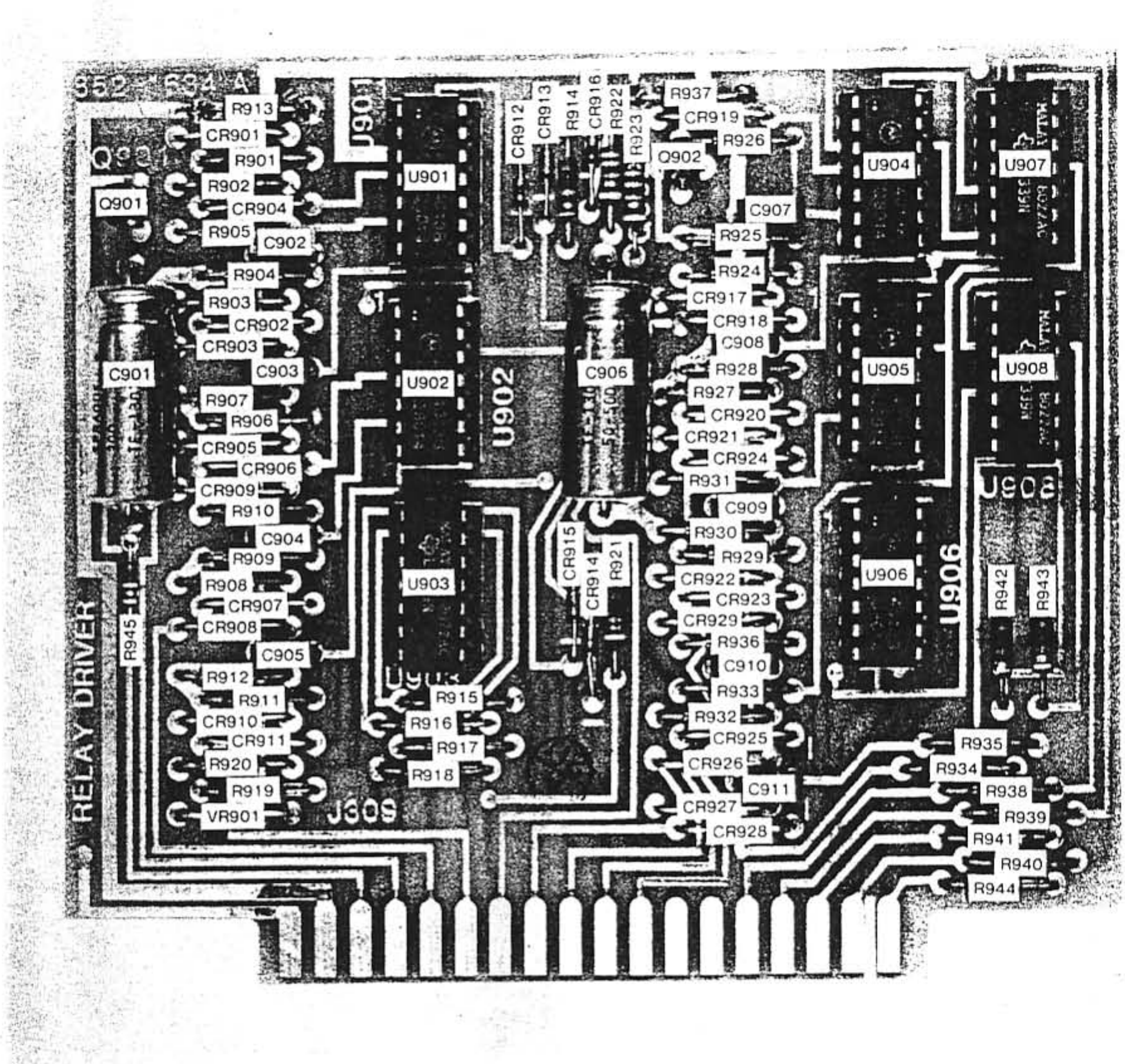


NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE 1/4W.5%.

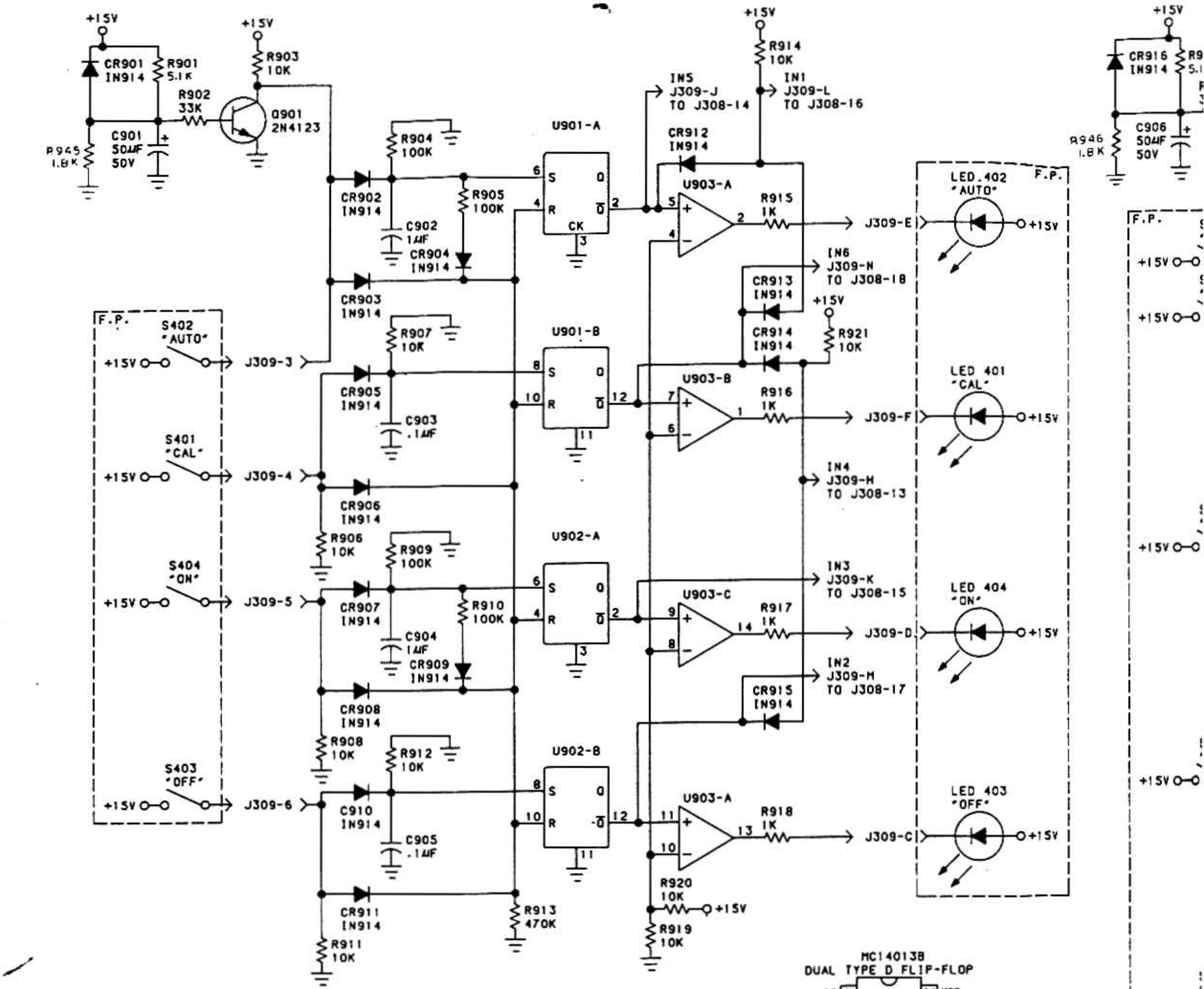


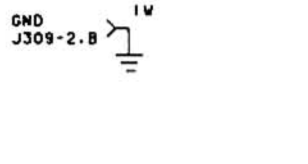
SYMBOL	PART NO.	CONNECTION
U801-6	LM339N	PIN 3-+20V PIN 12-GND

FIGURE 5-18. SCHEMATIC DIAGRAM AND COMPONENT LAYOUT, RELAY BOARD

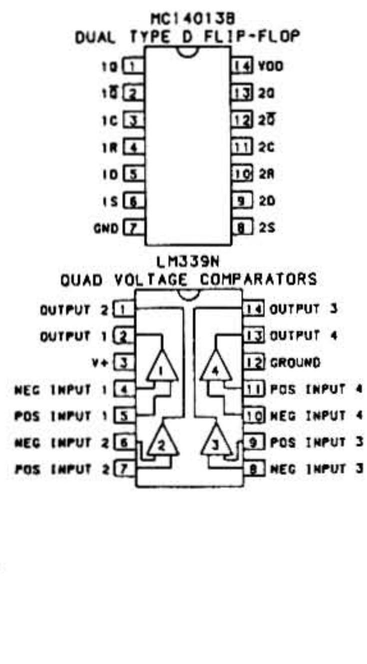


AIL 7514 Relay Driver Board





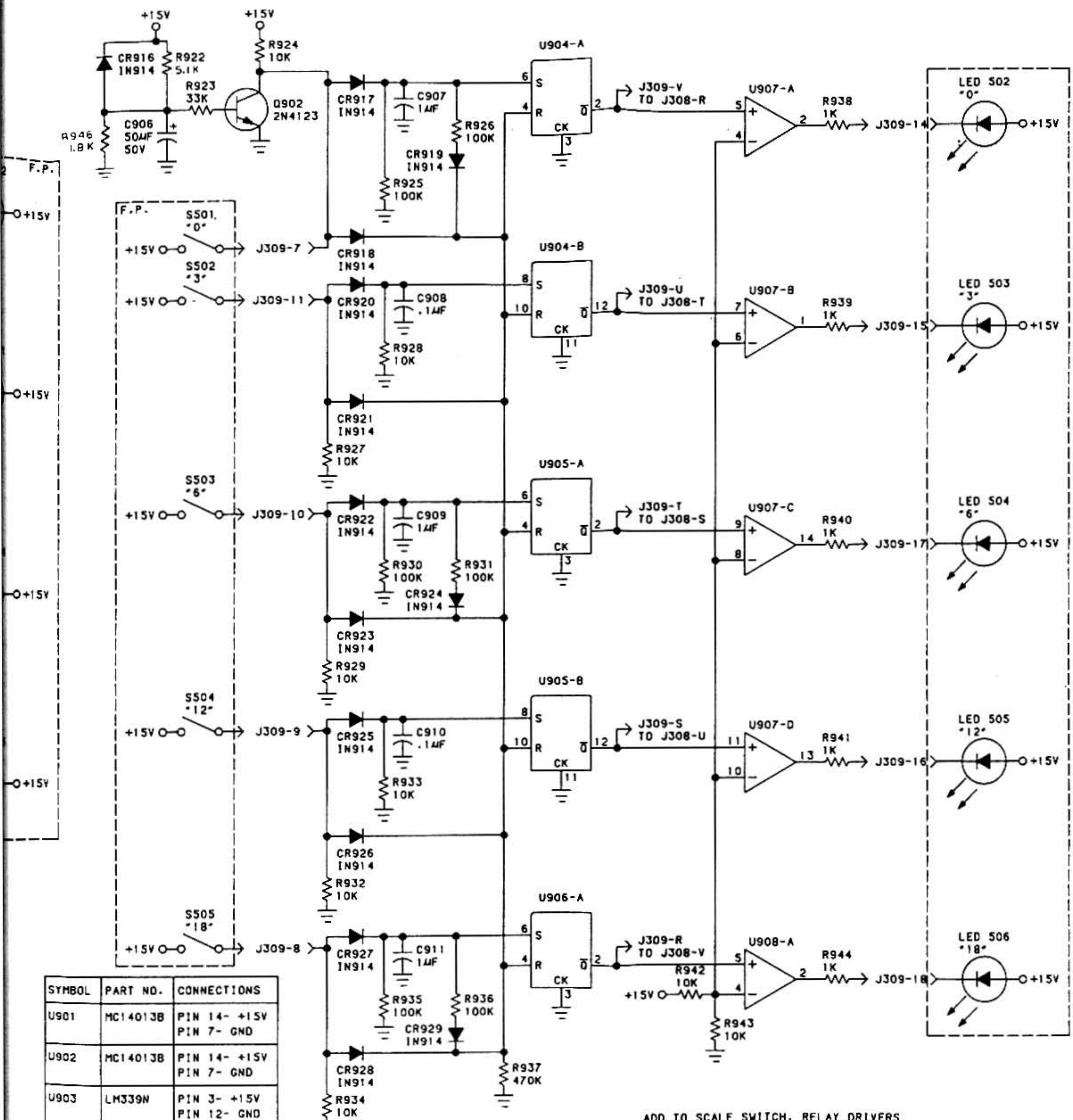
MODE SWITCH RELAY DRIVERS



SYMBOL	PART NO.	C
U901	MC14013B	P
U902	MC14013B	P
U903	LM339N	P
U904	MC14013B	P
U905	MC14013B	P
U906	MC14013B	P
U907	LM339N	P
U908	LM339N	P

NOTES:

1. ALL RESISTORS ARE 1/4W. 5% UNLESS OTHERWISE SPECIFIED.



SYMBOL	PART NO.	CONNECTIONS
U901	MC14013B	PIN 14- +15V PIN 7- GND
U902	MC14013B	PIN 14- +15V PIN 7- GND
U903	LM339N	PIN 3- +15V PIN 12- GND
U904	MC14013B	PIN 14- +15V PIN 7- GND
U905	MC14013B	PIN 7- GND
U906	MC14013B	PIN 7- GND
U907	LM339N	PIN 3- +15V PIN 12- GND
U908	LM339N	PIN 3- +15V PIN 12- GND

FIGURE 5-19. SCHEMATIC DIAGRAM AND COMPONENT LAYOUT, 7514 PANFI RELAY DRIVER BOARD

CHAPTER VI

PARTS LIST

6-1. RECOMMENDED SPARE PARTS LIST

Symbol	Description	Qty.	Part No.	Mfr.
C301	Cap., 50 μF, 50 V	2	TE-1307	Sprague
C302	Cap., 0.01 μF, 100 V	1	CKR05BX103K	Com'l
C303	Cap., 50 μF, 50 V	2	TE-1307	Sprague
C304	Cap., 0.01 μF, 100 V	1	CKR05BX103K	Com'l
C305	Cap., 6.8 μF, 35 V	1	CSR13F685KL	Com'l
C401	Cap., 50 μF, 12 V	1	TE-1133	Sprague
F1	Fuse, 2 amp., Slo-Blo	N/A	313002	Littelfuse
LED405	LED (Red)	1	4304H1	Ind.Devices
LED406	LED (Green)	1	4304H5	Ind.Devices
LED501	LED (Red)	1	RL5054-2	Litronix
M401	Meter	1	C856-5493	Eaton
R401	Pot., 500 ohms	1	73JA-500	Clarostat
R402	Pot., 10k ohms	1	73JA-10k	Clarostat
S401	Switch, Modular	2	SRL-Blk-Red (LED)	IEE Switches
S402	Switch, Modular	2	SRL-Blk-Red (LED)	IEE Switches
S403	Switch, Modular	2	SRL-Blk-Red (LED)	IEE Switches
S404	Switch, Modular	2	SRL-Blk-Red (LED)	IEE Switches
S501	Switch	1	7101-J62ZQ22	C & K
S502	Switch, Modular	3	SRL-Blk-Red (LED)	IEE Switches
S503	Switch, Modular	3	SRL-Blk-Red (LED)	IEE Switches
S504	Switch, Modular	3	SRL-Blk-Red (LED)	IEE Switches

6-1. RECOMMENDED SPARE PARTS LIST (Continued)

Symbol	Description	Qty.	Part No.	Mfr.
S505	Switch, Modular	3	SRL-Blk-Red (LED)	IEE Switches
S506	Switch, Modular	3	SRL-Blk-Red (LED)	IEE Switches
S507	Switch, Modular	3	SRL-Blk,Red (LED)	IEE Switches
PS1	Power Supply	1	D852-1116	Eaton
-	Postamplifier Assembly	1	D212876	Eaton
-	AGC/IF Amplifier Assembly	1	D212882	Eaton
-	Extender Board Assembly	1	C852-1762	Eaton
-	Power Cord	1	17250	Belden
-	Fuse, 1 amp., 250 V, Slo-Blo	1	3AG313001/S	Littelfuse
-	Multi-Frequency Option (We recommend that the 09 Option be spared as a complete assembly.)	1	Option 09	Eaton

6-2. REPLACEABLE PARTS LIST, POSTAMPLIFIER (P/N 212876)

Symbol	Description	Part No.	Mfr.
C101	Cap., 1000 pF	CKR60AW102M	Com'l
C102	Cap., 1000 pF	CKR60AW102M	Com'l
C103	Cap., 1000 pF	CKR60AW102M	Com'l
C104	Cap., 1000 pF	CKR60AW102M	Com'l
C105	Cap., 1000 pF	CKR60AW102M	Com'l
C106	Cap., 1000 pF	CKR60AW102M	Com'l
C107	Cap., 1000 pF	CKR60AW102M	Com'l
C108	Cap., 1000 pF	CKR60AW102M	Com'l
C109	Cap., 15 pF	CKR05CW150K	Com'l
C110	Cap., 1000 pF	CKR60AW102M	Com'l
C111	Cap., 1000 pF	CKR60AW102M	Com'l
C112	Cap., 1000 pF	CKR60AW102M	Com'l
C113	Cap., 1000 pF	CKR60AW102M	Com'l
C114	Cap., 1000 pF	CKR60AW102M	Com'l
C115	Cap., 1000 pF	CKR60AW102M	Com'l
C116	Cap., 1000 pF	CKR60AW102M	Com'l
C117	Cap., 1000 pF	CKR60AW102M	Com'l
C118	Cap., 120 pF	DD-121	Centralab
C119	Cap., 1000 pF	CKR60AW102M	Com'l
C120	Cap., 1000 pF	CKR60AW102M	Com'l
C121	Cap., 1000 pF	CKR60AW102M	Com'l
C122	Cap., 0.22 μF	115285-9	Eaton
C123	Cap., 1000 pF	CKR60AW102M	Com'l
C124	Cap., 1000 pF	CKR60AW102M	Com'l
C125	Cap., 1000 pF	CKR60AW102M	Com'l
C126	Cap., 1000 pF	CKR60AW102M	Com'l
C127	Cap., 1000 pF	CKR60AW102M	Com'l
C128	Cap., 1000 pF	CKR60AW102M	Com'l
C129	Cap., 15 μF, 25 V	115307-9	Eaton
C130	Cap., 50 μF, 12 V	115307-8	Eaton
C131	Cap., 1000 pF	CKR60AW102M	Com'l
C132	Cap., 1000 pF	CKR60AW102M	Com'l
C133	Cap., 1000 pF	CKR60AW102M	Com'l
C134	Cap., 1000 pF	CKR60AW102M	Com'l
C135	Cap., 15 μF, 25 V	115307-9	Eaton
C136	Cap., 1000 pF	CKR60AW102M	Com'l
C137	Cap., Feedthru, 1000 pF	208674-1	Eaton
C138	Cap., Feedthru, 1000 pF	208674-1	Eaton
C139	Cap., Feedthru, 1000 pF	208674-1	Eaton
C140	Cap., Feedthru, 1000 pF	208674-1	Eaton
C141	Cap., Feedthru, 1000 pF	208674-1	Eaton
C142	Cap., 1000 pF	CKR60AW102M	Com'l
C143	Cap., 1000 pF	CKR60AW102M	Com'l
C144	Cap., 1000 pF	CKR60AW102M	Com'l
C145	Cap., 1000 pF	CKR60AW102M	Com'l
C146	Cap., Feedthru, 1000 pF	208674-1	Eaton

6-2. REPLACEABLE PARTS LIST, POSTAMPLIFIER (Continued)

Symbol	Description	Part No.	Mfr.
CR101	Diode	5082-3039	H-P
CR102	Diode	5082-3039	H-P
CR103	Diode	5082-3039	H-P
CR104	Diode	5082-3039	H-P
CR105	Diode	5082-3039	H-P
CR106	Diode	1N67	Com'l
J1	Connector, Jack, BNC	UG/1094-U	Com'l
J2	Connector, Jack, BNC	UG/1094-U	Com'l
L101	Inductor, Variable, 0.55 - 0.90 μH	212650	Eaton
L102	Inductor, 1.1 μH	115297-3	Eaton
L103	Inductor, 14 μH	115297-2	Eaton
L104	Inductor, 1.1 μH	115297-3	Eaton
L105	Inductor, 14 μH	115297-2	Eaton
L106	Inductor, 1.1 μH	115297-3	Eaton
L107	Inductor, 14 μH	115297-2	Eaton
L108	Inductor, 1.1 μH	115297-3	Eaton
L109	Inductor, 0.47 μH	4411-4M	Jeffers
L110	Inductor, 3 μH	115297-4	Eaton
L111	Inductor, 14 μH	115297-2	Eaton
L112	Inductor, 1.1 μH	115297-3	Eaton
L113	Inductor, 1.1 μH	115297-3	Eaton
Q101	Transistor	2N4125	Com'l
Q102	Transistor	2N4125	Com'l
Q103	Transistor	2N4959	Com'l
Q104	Transistor	2N4957	Com'l
Q105	Transistor	2N4123	Com'l
Q106	Transistor	2N4123	Com'l
Q107	Transistor	2N4123	Com'l
Q108	Transistor	2N4401	Com'l
R101	Res., 51 Ω, 1/4 W, 5%	RC07GF510J	Com'l
R102	Res., 820 Ω, 1/4 W, 5%	RC07GF821J	Com'l
R103	Res., 1.6 k, 1/4 W, 5%	RC07GF162J	Com'l
R104	Res., 33 k, 1/4 W, 5%	RC07GF330J	Com'l
R105	Res., 100 Ω, 1/4 W, 5%	RC07GF101J	Com'l
R106	Res., 360 Ω, 1/4 W, 5%	RC07GF361J	Com'l
R107	Res., 300 Ω, 1/4 W, 5%	RC07GF301J	Com'l
R108	Res., 820 Ω, 1/4 W, 5%	RC07GF821J	Com'l
R109	Res., 1.6 k, 1/4 W, 5%	RC07GF162J	Com'l
R110	Res., 15 Ω, 1/4 W, 5%	RC07GF150J	Com'l
R111	Res., 200 Ω, 1/4 W, 5%	RC07GF201J	Com'l
R112	Res., 430 Ω, 1/4 W, 5%	RC07GF431J	Com'l

6-2. REPLACEABLE PARTS LIST, POSTAMPLIFIER (Continued)

Symbol	Description	Part No.	Mfr.
R113	Res., 300 Ω, 1/4 W, 5%	RC07GF301J	Com'l
R114	Res., 6.2 k, 1/4 W, 5%	RC07GF622J	Com'l
R115	Res., 3.9 k, 1/4 W, 5%	RC07GF392J	Com'l
R116	Res., 20 Ω, 1/4 W, 5%	RC07GF200J	Com'l
R117	Res., 680 Ω, 1/4 W, 5%	RC07GF681J	Com'l
R118	Res., 300 Ω, 1/4 W, 5%	RC07GF301J	Com'l
R119	Res., 390 Ω, 1/4 W, 5%	RC07GF391J	Com'l
R120	Res., 3 k, 1/4 W, 5%	RC07GF302J	Com'l
R121	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
R122	Res., 620 Ω, 1/4 W, 5%	RC07GF621J	Com'l
R123	Res., 120 Ω, 1/4 W, 5%	RC07GF121J	Com'l
R124	Res., 47 Ω, 1/4 W, 5%	RC07GF470J	Com'l
R125	Res., 2.2 k, 1/4 W, 5%	RC07GF222J	Com'l
R126	Res., 75 Ω, 1/4 W, 5%	RC07GF750J	Com'l
R127	Res., 200 Ω, 1/4 W, 5%	RC07GF201J	Com'l
R128	Res., 200 Ω, 1/4 W, 5%	RC07GF201J	Com'l
R129	Res., 2.2 k, 1/4 W, 5%	RC07GF222J	Com'l
R130	Res., 2.4 k, 1/4 W, 5%	RC07GF242J	Com'l
R131	Res., 330 Ω, 1/4 W, 5%	RC07GF331J	Com'l
R132	Res., 200 Ω, 1/4 W, 5%	RC07GF201J	Com'l
R133	Res., 330 Ω, 1/4 W, 5%	RC07GF331J	Com'l
R134	Res., 3.9 k, 1/4 W, 5%	RC07GF392J	Com'l
R135	Res., 1.3 k, 1/4 W, 5%	RC07GF132J	Com'l
R136	Res., 22.1 k, 1/4 W, 1%	RN65C2212F	Com'l
R137	Res., 5.1 k, 1/4 W, 5%	RC07GF512J	Com'l
R138	Res., 1.5 k, 1/4 W, 5%	RC07GF152J	Com'l
R139	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R140	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
T101	Transformer	212567-2	Eaton
T102	Transformer	212567-2	Eaton
T103	Transformer	212567-2	Eaton
T104	Transformer	212567-1	Eaton

6-3. REPLACEABLE PARTS LIST, AGC/IF AMPLIFIER (P/N 212882)

Symbol	Description	Part No.	Mfr.
C201	Not Used		
C202	Cap., 0.01 μF	115285-6	Eaton
C203	Cap., 0.01 μF	115285-6	Eaton
C204	Not Used		
C205	Cap., 0.01 μF	115285-6	Eaton
C206	Cap., 0.01 μF	115285-6	Eaton
C207	Cap., 0.01 μF	115285-6	Eaton
C208	Cap., 0.22 μF	115285-9	Eaton
C209	Cap., 1000 pF	CKR60AW102M	Com'l
C210	Cap., 1000 pF	CKR60AW102M	Com'l
C211	Cap., 1000 pF	CKR60AW102M	Com'l
C212	Cap., 1000 pF	CKR60AW102M	Com'l
C213	Cap., 1000 pF	CKR60AW102M	Com'l
C214	Cap., 1000 pF	CKR60AW102M	Com'l
C215	Cap., 1000 pF	CKR60AW102M	Com'l
C216	Cap., 1000 pF	CKR60AW102M	Com'l
C217	Cap., 50 μF, 12 V	115307-8	Eaton
C218	Cap., 1000 pF	CKR60AW102M	Com'l
C219	Cap., 1000 pF	CKR60AW102M	Com'l
C220	Cap., 1000 pF	CKR60AW102M	Com'l
C221	Cap., 1000 pF	CKR60AW102M	Com'l
C222	Cap., 15 μF, 25 V	115307-9	Eaton
C223	Cap., 1000 pF	CKR60AW102M	Com'l
C224	Cap., Feedthru, 1000 pF	208674-1	Eaton
C225	Cap., Feedthru, 1000 pF	208674-1	Eaton
C226	Cap., Feedthru, 1000 pF	208674-1	Eaton
C227	Cap., Feedthru, 1000 pF	208674-1	Eaton
C228	Cap., 1000 pF	CKR60AW102M	Com'l
CR201	Diode	5082-3039	H-P
CR202	Diode	5082-3039	H-P
L201	Inductor, 3 μH	115297-4	Eaton
L202	Inductor, 1.1 μH	115297-3	Eaton
L203	Inductor, 14 μH	115297-2	Eaton
L204	Inductor, 1.1 μH	115297-3	Eaton
L205	Inductor, 1.1 μH	115297-3	Eaton
L206	Inductor, 1.1 μH	115297-3	Eaton
P2	Cable Assembly	B852-1771	Eaton
Q201	Transistor	2N4957	Com'l
Q202	Transistor	2N708	Com'l
Q203	Transistor	2N4959	Com'l
Q204	Transistor	2N4123	Com'l
Q205	Transistor	2N4123	Com'l

6-3. REPLACEABLE PARTS LIST, AGC/IF AMPLIFIER (P/N 212882) (Continued)

Symbol	Description	Part No.	Mfr.
Q206	Transistor	2N4123	Com'l
Q207	Transistor	2N4401	Com'l
R201	Res., 51 Ω, 1/4 W, 5%	RC07GF510J	Com'l
R202	Res., 4.7 k, 1/4 W, 5%	RC07GF472J	Com'l
R203	Res., 6.8 k, 1/4 W, 5%	RC07GF682J	Com'l
R204	Res., 330 Ω, 1/4 W, 5%	RC07GF331J	Com'l
R205	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R206	Res., 100 Ω, 1/4 W, 5%	RC07GF101J	Com'l
R207	Res., 20.1 Ω, 1/8 W, 1%	RN60D30R1F	Com'l
R208	Res., 1.8 k, 1/4 W, 5%	RC07GF182J	Com'l
R209	Not Used		
R210	Res., 412 Ω, 1/4 W, 1%	RN65C4120F	Com'l
R211	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
R212	Res., 43 Ω, 1/4 W, 5%	RC07GF430J	Com'l
R213	Res., 82 Ω, 1/4 W, 5%	RC07GF820J	Com'l
R214	Res., 200 Ω, 1/4 W, 5%	RC07GF201J	Com'l
R215	Res., 2.2 k, 1/4 W, 5%	RC07GF222J	Com'l
R216	Res., 200 Ω, 1/4 W, 5%	RC07GF201J	Com'l
R217	Res., 2.4 k, 1/4 W, 5%	RC07GF242J	Com'l
R218	Res., 330 Ω, 1/4 W, 5%	RC07GF331J	Com'l
R219	Res., 3.9 k, 1/4 W, 5%	RC07GF392J	Com'l
R220	Res., 330 Ω, 1/4 W, 5%	RC07GF331J	Com'l
R221	Res., 200 Ω, 1/4 W, 5%	RC07GF201J	Com'l
R222	Res., 22.1 k, 1/4 W, 1%	RN65C2212F	Com'l
R223	Res., 5.1 k, 1/4 W, 5%	RC07GF501J	Com'l
R224	Res., 1.5 k, 1/4 W, 5%	RC07GF152J	Com'l

6-4. REPLACEABLE PARTS LIST, MAIN BOARD (P/N 852-1755)

Symbol	Description	Part No.	Mfr.
C301	Cap., 50 μF, 30 V	TE1307	Sprague
C302	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C303	Cap., 50 μF, 50 V	TE1307	Sprague
C304	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C305	Cap., 6.8 μF, 35 V	CSR13F685KL	Com'l
J301	Connector, 6 Pin	09-18-5061	Molex
J302	Connector, 6 Pin	09-18-5061	Molex
J303	Connector, 6 Pin	09-18-5061	Molex
J304	Connector, 6 Pin	09-18-5061	Molex
J305	Connector, 3 Pin	09-18-5031	Molex
J306	Connector, 18 Position	530655-5	AMP
J307	Connector, 18 Position	530655-5	AMP
J308	Connector, 18 Position	530655-5	AMP
J309	Connector, 18 Position	530655-5	AMP
J310	Connector, 6 Pin	09-18-5061	Molex
J311	Jumper, 20 Position	FST-23A-20	Ansley
J312	Header, 20 Position, Scotchflex	3492-2003	3M

6-5. REPLACEABLE PARTS LIST, FRONT PANEL (P/N 852-1783)

Symbol	Description	Part No.	Mfr.
C401	Cap., 50 μF, 12 V	TE1133	Sprague
J401	Connector, 6 Pin	09-18-5061	Molex
J402	Receptacle, Panel	RA2.308NYL	Lemo
J403	Jack, Bulkhead	UG/1094-2	Com'l
LED405	LED (Red)	4304H1	Ind.Devices
LED406	LED (Green)	4304H5	Ind.Devices
M401	Meter	856-5493	Eaton
R401	Pot., 500 Ω	73JA-500	Clarostat
R402	Pot., 10 k	73JA-10k	Clarostat
R403	Res., 3.9 k, 1/4 W, 5%	RC07GF392J	Com'l
R404	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
R405	Res., 510 Ω, 1/4 W, 5%	RC07GF511J	Com'l
R406	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
S401	Switch, Modular	SRL-Blk-Red(LED)	IEE Switches
S402	Switch, Modular	SRL-Blk-Red(LED)	IEE Switches
S403	Switch, Modular	SRL-Blk-Red(LED)	IEE Switches
S404	Switch, Modular	SRL-Blk-Red(LED)	IEE Switches

6-6. REPLACEABLE PARTS LIST, PANEL BOARD #2 (P/N 852-1761)

Symbol	Description	Part No.	Mfr.
J501	Header, 20 Position, Scotchflex	3492-2003	3M
J503	Jack, Bulkhead	UG/1094-U	Com'l
R501	Res., 1 k, 1 W, 5%	RC32GF102J	Com'l
S501	Switch	7101-J62ZQ22	C & K
S502	Switch, Modular	SLR-Blk-Red(LED)	IEE Switches
S503	Switch, Modular	SLR-Blk-Red(LED)	IEE Switches
S504	Switch, Modular	SLR-Blk-Red(LED)	IEE Switches
S505	Switch, Modular	SLR-Blk-Red(LED)	IEE Switches
S506	Switch, Modular	SLR-Blk-Red(LED)	IEE Switches
S507	Switch, Modular	SLR-Blk-Red(LED)	IEE Switches

6-7. REPLACEABLE PARTS LIST, MULTIMETER BOARD (P/N 852-1756)

Symbol	Description	Part No.	Mfr.
C601	Cap., 470 μF, 25 V	TH-CSF470	Ducati
C602	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C603	Cap., 470 μF, 25 V	TH-CSF470	Ducati
C604	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C605	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C606	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C607	Cap., 390 pF	DM10-391	Elmenco
C608	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C609	Cap., 0.001 μF, 200 V	CKR05BX102K	Com'l
C610	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C611	Cap., 10 μF, 25 V	TE1204	Sprague
C612	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C613	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C614	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C615	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C616	Cap., 100 μF, 25 V	TE1211	Sprague
C617	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C618	Cap., 10 μF, 25 V	TE1204	Sprague
C619	Cap., 0.01 μF, 100 V	CKR06BX103K	Com'l
C620	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C621	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C622	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C623	Cap., 0.001 μF, 200 V	CKR05BX102K	Com'l
C624	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C625	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C626	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C627	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C628	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
C629	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
CR601	Diode	1N914	Com'l
CR602	Diode	1N914	Com'l
CR603	Diode	1N914	Com'l
CR604	Diode	1N625	Com'l
CR605	Diode	1N625	Com'l
CR606	Diode	1N625	Com'l
CR607	Diode	1N625	Com'l
VR601	Diode, Zener	1N4733	Com'l
VR602	Diode, Zener	1N4733	Com'l
VR603	Diode, Zener	1N6013	Com'l
Q601	Transistor	2N4123	Com'l
Q602	Transistor	2N3053	Com'l
Q603	Transistor	2N4123	Com'l
R601	Res., 20Ω, 1/4 W, 5%	RC07GF200J	Com'l
R602	Res., 15 k, 1/4 W, 5%	RC07GF153J	Com'l

REPLACEABLE PARTS LIST, MULTIMETER BOARD (Continued)

Symbol	Description	Part No.	Mfr.
R603	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
R604	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
R605	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R606	Res., 10 Ω, 1/4 W, 5%	RC07GF100J	Com'l
R607	Res., 1.5 k, 1/4 W, 1%	RN65D1501F	Com'l
R608	Res., 6.81 k, 1/4 W, 1%	RN65D6811F	Com'l
R609	Res., Var., 500 Ω	3006W-501	Bourns
R610	Res., 2 k, 1/4 W, 1%	RN65D2001F	Com'l
R611	Res., 24 k, 1/4 W, 5%	RC07GF243J	Com'l
R612	Res., 75 k, 1/4 W, 5%	RC07GF753J	Com'l
R613	Res., 220 k, 1/4 W, 5%	RC07GF224J	Com'l
R614	Res., 200 k, 1/4 W, 5%	RC07GF204J	Com'l
R615	Res., 10 k, 1/4 W, 1%	RN65D1002F	Com'l
R616	Res., 23.7 k, 1%	RN65C2372F	Com'l
R617	Res., 5.11 k, 1/4 W, 1%	RN65D5111J	Com'l
R618	Res., 47 k, 1/4 W, 5%	RC07GF473J	Com'l
R619	Res., 5.11 k, 1/4 W, 1%	RN65D5111J	Com'l
R620	Res., 2.2 k, 1/4 W, 5%	RC07GF222J	Com'l
R621	Res., 2.2 k, 1/4 W, 5%	RC07GF222J	Com'l
R622	Res., 2.2 k, 1/4 W, 5%	RC07GF222J	Com'l
R623	Res., 2.2 k, 1/4 W, 5%	RC07GF222J	Com'l
R624	Res., 33.2 k, 1/4 W, 1%	RN65D3322K	Com'l
R625	Res., 33.2 k, 1/4 W, 1%	RN65D3322K	Com'l
R626	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R627	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R628	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R629	Res., 18.2 k, 1%	RN65C1822F	Com'l
R630	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R631	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R632	Res., Var., 50 kΩ	3006W-503	Bourns
R633	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R634	Res., 68 k, 1/4 W, 5%	RC07GF683J	Com'l
R635	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
R636	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
R637	Res., 2 k, 1/4 W, 5%	RC07GF202J	Com'l
R638	Res., 6.8 k, 1/4 W, 5%	RC07GF682J	Com'l
R639	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R640	Res., 6.8 k, 1/4 W, 5%	RC07GF682J	Com'l
T601	Transformer	SSO-8P	UTC
U601	Integrated Circuit	UA723PC	Signetics
U602	Integrated Circuit	MC1747CL	Motorola
U603	Integrated Circuit	LM556	T.I.
U604	Integrated Circuit	MC14013B	Motorola
U605	Integrated Circuit	LM339N	T.I.
U606	Integrated Circuit	LM339N	T.I.

6-8. REPLACEABLE PARTS LIST, AGC/OVERRANGE BOARD (P/N 852-1757)

Symbol	Description	Part No.	Mfr.
C701	Cap., 0.01 μF, 100 V	CKR06BX103K	Com'l
C702	Cap., 0.01 μF, 100 V	CKR06BX103K	Com'l
C703	Cap., 0.01 μF, 100 V	CKR06BX103K	Com'l
C704	Cap., 0.01 μF, 100 V	CKR06BX103K	Com'l
C705	Cap., 1 μF, 100 V	CKR06BX105K	Com'l
C706	Cap., 1 μF, 100 V	CKR06BX105K	Com'l
C707	Cap., 100 μF, 25 V	TE1211	Sprague
C708	Cap., 0.01 μF, 100 V	CKR06BX103K	Com'l
C709	Cap., 270 pF	DM10F-271J	Elmenco
C710	Cap., 100 μF, 25 V	TE1211	Sprague
C711	Cap., 2.2 μF, 6 V	CSR13BE225K	Com'l
C712	Cap., 470 μF, 25 V	TH-CSF470	Ducati
C713	Cap., 10 μF, 25 V	TE1204	Sprague
C714	Cap., 0.01 μF, 100 V	CKR05BX103K	Com'l
CR701	Diode	1N914	Com'l
CR702	Diode	1N914	Com'l
VR701	Diode, Zener	1N4733	Com'l
VR702	Diode, Zener	1N4733	Com'l
VR703	Diode, Zener	1N936	Com'l
VR704	Diode, Zener	1N5226	Com'l
L701	Inductor, 15 μH	WEE-15μH	Nytronics
Q701	Transistor	2N3330	Com'l
Q702	Transistor	2N4125	Com'l
Q703	Transistor	2N4123	Com'l
R701	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R702	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R703	Test Select	RC07GFXXXX	Com'l
R704	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R705	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R706	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R707	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R708	Res., Var., 1 k	3006W-102	Bourns
R709	Res., 20 k, 1/4 W, 5%	RC07GF203J	Com'l
R710	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R711	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R712	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R713	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R714	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R715	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R716	Res., 2.2 MΩ, 1/4 W, 5%	RC07GF225J	Com'l
R717	Res., 510 Ω, 1 W, 5%	RC32GF511J	Com'l

6-8. REPLACEABLE PARTS LIST, AGC/OVERRANGE BOARD (Continued)

Symbol	Description	Part No.	Mfr.
R718	Res., 7.5 k, 1/4 W, 5%	RC07GF752J	Com'l
R719	Res., 620 Ω, 1/4 W, 5%	RC07GF621J	Com'l
R720	Res., 8.2 k, 1/4 W, 5%	RC07GF822J	Com'l
R721	Res., 100 Ω, 3 W	242E1015	Sprague
R722	Res., 1.8 k, 1/4 W, 5%	RC07GF182J	Com'l
R723	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R724	Res., 1.3 k, 1/4 W, 5%	RC07GF103J	Com'l
R725	Res., 5.1 k, 1/4 W, 5%	RC07GF512J	Com'l
R726	Res., 5.1 k, 1/4 W, 5%	RC07GF512J	Com'l
R727	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R728	Res., 4.3 k, 1/4 W, 5%	RC07GF432J	Com'l
R729	Res., 20 k, 1/4 W, 5%	RC07GF203J	Com'l
R730	Res., 91 k, 1/4 W, 5%	RC07GF913J	Com'l
R731	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
U701	Integrated Circuit	MC1747C1	Motorola
U702	Integrated Circuit	CD4016	National
U703	Integrated Circuit	LM339N	T.I.
U704	Integrated Circuit	MC1747C1	Motorola
U705	Integrated Circuit	LM339N	T.I.

6-9. REPLACEABLE PARTS LIST, RELAY BOARD (P/N 852-1758)

Symbol	Description	Part No.	Mfr.
CR801 thru CR824	Diode	1N914	Com'l
K801 thru K824	Relay	RA31541241	Elec-Trol
R801	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R802	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R803	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R804	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R805	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R806	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R807	Res., 687 Ω, 1%	RN60D6870F	Com'l
R808	Res., 328 Ω, 1%	RN60D3280F	Com'l
R809	Res., 24 k, 1/4 W, 5%	RC07GF243J	Com'l
R810	Res., 249 Ω, 1%	RN60D2490F	Com'l
R811	Res., 27.4 Ω, 1%	RN60D27R4F	Com'l
R812	Res., 10 Ω, 1%	RN65D18R4F	Com'l
R813	Res., Var., 200 Ω	66X-200	Helipot
R814	Res., 24.9 Ω, 1%	RN60D24R9F	Com'l
R815	Res., 18.4 Ω, 1%	RN65D18R4F	Com'l
R816	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
U801	Integrated Circuit	LM339N	T.I.
U802	Integrated Circuit	LM339N	T.I.
U803	Integrated Circuit	LM339N	T.I.
U804	Integrated Circuit	LM339N	T.I.
U805	Integrated Circuit	LM339N	T.I.
U806	Integrated Circuit	LM339N	T.I.

6-10. REPLACEABLE PARTS LIST, RELAY DRIVER BOARD (P/N 852-1759)

Symbol	Description	Part No.	Mfr.
C901	Cap., 50 μF, 50 V	TE1307	Sprague
C902	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C903	Cap., 0.1 μF, 100 V	CKR06BX104K	Com'l
C904	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C905	Cap., 0.1 μF, 100 V	CKR06BX104K	Com'l
C906	Cap., 50 μF, 50 V	TE1307	Sprague
C907	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C908	Cap., 0.1 μF, 100 V	CKR06BX104K	Com'l
C909	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
C910	Cap., 0.1 μF, 100 V	CKR06BX104K	Com'l
C911	Cap., 1.0 μF, 200 V	CKR06BX105K	Com'l
CR901 thru CR929	Diode	1N914	Com'l
VR901	Diode, Zener	1N4733	Com'l
Q901	Transistor	2N4123	Com'l
Q902	Transistor	2N4123	Com'l
R901	Res., 5.1 k, 1/4 W, 5%	RC07GF512J	Com'l
R902	Res., 33 k, 1/4 W, 5%	RC07GF333J	Com'l
R903	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R904	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R905	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R906	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R907	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R908	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R909	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R910	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R911	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R912	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R913	Res., 470 k, 1/4 W, 5%	RC07GF474J	Com'l
R914	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R915	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R916	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R917	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R918	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R919	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R920	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R921	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R922	Res., 5.1 k, 1/4 W, 5%	RC07GF512J	Com'l
R923	Res., 33 k, 1/4 W, 5%	RC07GF512J	Com'l
R924	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R925	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l

6-10. REPLACEABLE PARTS LIST, RELAY DRIVER BOARD (Continued)

Symbol	Description	Part No.	Mfr.
R926	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R927	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R928	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R929	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R930	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R931	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R932	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R933	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R934	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R935	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R936	Res., 100 k, 1/4 W, 5%	RC07GF104J	Com'l
R937	Res., 470 k, 1/4 W, 5%	RC07GF474J	Com'l
R938	Res., 1k, 1/4 W, 5%	RC07GF102J	Com'l
R939	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R940	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R941	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R942	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R943	Res., 10 k, 1/4 W, 5%	RC07GF103J	Com'l
R944	Res., 1 k, 1/4 W, 5%	RC07GF102J	Com'l
R945	Res., 1.8 k, 1/4 W, 5%	RC07GF182J	Com'l
R946	Res., 1.8 k, 1/4 W, 5%	RC07GF182J	Com'l
U901	Integrated Circuit	MC14013B	Motorola
U902	Integrated Circuit	MC14013B	Motorola
U903	Integrated Circuit	LM339N	T.I.
U904	Integrated Circuit	MC14013B	Motorola
U905	Integrated Circuit	MC14013B	Motorola
U906	Integrated Circuit	MC14013B	Motorola
U907	Integrated Circuit	LM339N	T.I.
U908	Integrated Circuit	LM339N	T.I.