

INSTRUCTION MANUAL

AUDIO ANALYZER

Model AA-51

POTOMAC INSTRUMENTS, INC.

**932 PHILADELPHIA AVE.
SILVER SPRING, MD. 20910**



WARNING

This instrument must be used with a 3-prong U-grounded receptacle outlet. Failure to use a grounded outlet may result in improper operation or safety hazard.

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MODEL AA-51
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POTOMAC INSTRUMENTS INC.
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SECTION 1

GENERAL DESCRIPTION

1.1 FUNCTION

1.1.1 The Potomac Instruments Model AA-51 Audio Analyzer is a solid state instrument for measuring ac voltages, total harmonic distortion (THD), intermodulation distortion (IMD), signal plus noise to noise, relative phase, amplitude ratio, and weighted peak flutter (W&F).

1.1.2 The voltmeter contained in the Model AA-51 can be used separately for general purpose voltage and gain measurements. The voltmeter has a frequency range of 5 Hz to 200 kHz and a voltage range of 1 mV to 100 Vrms full scale.

1.1.3 Total harmonic distortion levels of 0.1% to 100% full scale are measured in seven ranges for any fundamental frequency from 20 Hz to 20 kHz: harmonics are indicated to 100 kHz. Input signals between 0.1 Vrms and 80 Vrms are automatically leveled and no manual adjustment is required. Too high or too low input signal levels are indicated by front panel LED's. A scope output is provided for use with an oscilloscope. The instrument is capable of an isolation voltage of ± 200 V above chassis ground.

1.1.4 Intermodulation distortion levels of 0.1% to 100% full scale are measured in seven ranges for an SMPTE standard signal of 60 Hz and 7 kHz (4:1 ratio). Input signals between 0.1 Vrms and 80 Vrms are automatically leveled. Too high or too low input signal levels are indicated by LED's.

1.1.5 Noise levels as low as -75 dBm (600 ohms) are measured in a passband of 20 Hz to 20 kHz.

1.1.6 Relative phase between two signals is measured in two ranges of ± 54 degrees and ± 180 degrees full scale within a frequency range of 20 Hz to 20 kHz. Input signals between 0.3 Vrms and 6 Vrms are fully limited; however, the amplitude ratio should be within ± 6 dB for best accuracy.

1.1.7 Amplitude ratio of two signals is measured over a ± 6 dB range within the frequency range of 20 Hz to 20 kHz. The input signal levels can be between 0.3 Vrms and 6 Vrms.

1.1.8 Weighted peak flutter is measured in two ranges of 0.3% and 1% full scale. The input signal must be 3.15 kHz $\pm 10\%$ within the amplitude range of 0.1 Vrms and 80 rms. A wide band (0.2 Hz to 200 Hz) scope output is provided.

1.2 SPECIFICATIONS, AA-51

AC Voltmeter

Frequency Range:	20 Hz to 200 kHz
Voltmeter Range:	1 mV to 100 Vrms (full scale), 10 dB steps
Voltmeter Accuracy:	$\pm 3\%$ (full scale)
Input Impedance:	330K ohms shunted by 150 pf capacitor
Scope Output:	100 mV p-p (full scale)

THD Distortion Meter

Fundamental Frequency Range:	20 Hz to 20 kHz in 3 decade ranges
Bandwidth:	100 kHz
Distortion Range:	0.1% to 100% full scale
Accuracy:	±5% (full scale)
Dynamic Range:	0.1 Vrms to 80 Vrms automatically leveled
Input Impedance:	500K ohms shunted by 105 pf capacitor
Scope Output:	100 mV p-p (full scale)
Internal Distortion & Noise:	≤0.04%, 50 Hz - 7.5 kHz; ≤.08%, 20 Hz - 20 kHz

IM Distortion Meter

Input Signal Required:	60 Hz & 7 kHz @ 4:1 ratio (SMPTE standard)
Distortion Range:	0.1% to 100%
Accuracy:	±5% (full scale)
Dynamic Range:	0.1 Vrms to 80 Vrms automatically leveled
Input Impedance:	500K ohms shunted by 105 pf capacitor
Scope Output:	100 mV p-p (full scale)
Internal Distortion & Noise:	<.03%

Signal Plus Noise Meter

Frequency Range (-3 dB):	20 Hz to 20 kHz
Voltmeter Range:	1 mV to 100 Vrms (full scale)
Signal Plus Noise-to-Noise Accuracy:	±5% (full scale)
Residual Hum & Noise:	<-80 dBm
Input Impedance:	330K ohms shunted by 150 pf capacitor
Scope Output:	100 mV p-p (full scale)

Phase Meter

Range:	± 54 degrees and ± 180 degrees
Bandwidth:	20 Hz to 20 kHz
Accuracy:	$\pm 5\%$ (full scale)
Dynamic Range:	0.3 V _{rms} to 6 V _{rms}
Input Impedance:	500K ohms shunted by 180 pf capacitor
Scope Output:	Rectangular wave at input frequency, 0.5V p-p, duty cycle proportional to phase angle
Resolution:	3 degrees

Ratio Meter

Range:	± 6 dB
Bandwidth:	20 Hz to 20 kHz
Accuracy:	$\pm 5\%$ (full scale)
Dynamic Range:	0.3 V _{rms} to 6 V _{rms}
Input Impedance:	500K ohms shunted by 180 pf capacitor
Scope Output:	dc voltage proportional to ratio
Resolution:	$\leq \pm 0.25$ dB

W&F Meter

Range:	0.3% and 1% weighted peak flutter in two ranges
Input Frequency:	3.15 kHz $\pm 10\%$
Accuracy:	$\pm 5\%$ (full scale)
Dynamic Range:	0.1 V _{rms} to 80 V _{rms}
Input Impedance:	500K ohms shunted by 150 pf capacitor
Internal Distortion & Noise:	$\leq .01\%$
Scope Output:	Bandwidth .2 to 200 Hz, sensitivity 500 mV p-p (1% full scale)

External Power: 115V or 230V, 50 or 60 Hz, 10W
Weight: 12 lb – with cover
Dimensions (WxHxD) CM (IN): 38.74 x 13.34 x 20.32 (15¼ x 5¼ x 8)

SECTION 2

OPERATING INSTRUCTIONS

2.1 INSTALLATION

The Model AA-51 is ready for operation as delivered and need only be connected to an AC power source.

WARNING

The AA-51 must be used with a 3-prong U-grounded receptacle outlet. Failure to use a grounded outlet may result in improper operation or safety hazard.

2.2 CONTROLS AND INDICATORS

The following controls and indicators are identified on Figure 2-1.

2.2.1 POWER Switch, S1

Applies AC power to the unit when in the ON position.

2.2.2 POWER Indicator, DS1

Illuminates to indicate the presence of main DC (+23V) power.

2.2.3 FREQ Range Switch, S2

The setting of this switch indicates the multiplier for the calibrated FREQ dial.

2.2.4 MODE Switch, S3 (upper)

The upper MODE switch is used to select the 1% W&F, .3% W&F, RATIO, PHX10, PHX3 modes or, in its most counter-clockwise position, to transfer control of mode selection to the lower MODE switch, A7-S1.

2.2.5 MODE Switch A7-S1 (lower)

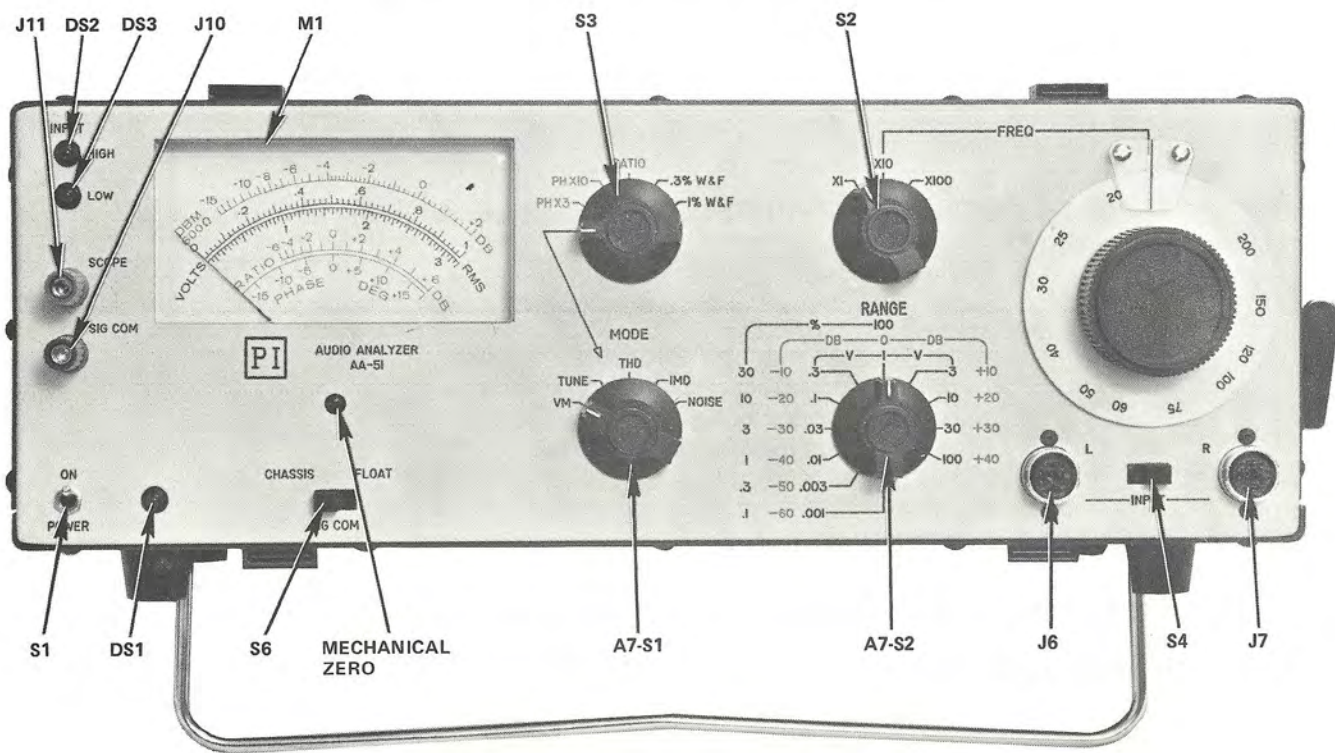
The lower MODE switch is used to select VM, TUNE, THD, IMD or NOISE mode when the upper MODE switch, S3, is in its most counter-clockwise position.

2.2.6 INPUT Switch, S4

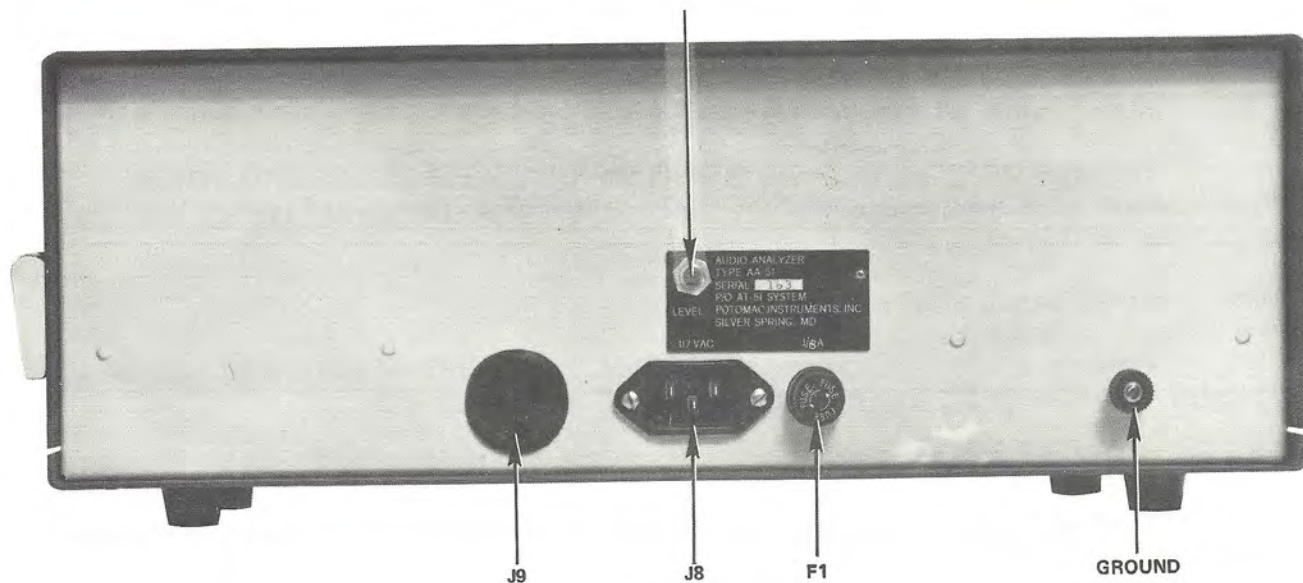
The INPUT switch, S4, is used to select either the L (J6) or R (J7) input in those modes which require only a single input signal.

2.2.7 LEVEL Switch, S5

The LEVEL pushbutton is used to disable the rejection-notch response of the null amplifier for test purposes.



FRONT PANEL



REAR PANEL

Figure 2.1. AA-51 Controls and Indicators

2.2.8 SIG COM Switch, S6

The setting of the SIG COM switch, S6, determines whether the L (J6) and R (J7) signal input grounds (analyzer circuit common) are floating or connected to chassis ground.

2.2.9 RANGE Switch, A7-S2

The RANGE switch is used to select the full scale range in Volts, percent or dB of the meter M1.

2.2.10 FREQ Dial

The FREQ dial is used in conjunction with the FREQ range switch, S2, to tune the notch filter frequency to the input signal fundamental frequency.

2.2.11 Meter, M1

The front panel meter, M1, gives direct readings of amplitude ratio in dB, noise and signal levels in Vrms or dB, signal phase in degrees, and harmonic distortion, intermodulation distortion and weighted peak flutter in percent.

2.2.12 DS2 HIGH Indicator and DS3 LOW Indicator

The HIGH and LOW indicator LEDs illuminate singly in THD, IMD and WF modes to indicate an input signal level which is too high or too low for proper operation of the analyzer. In THD mode, both indicators will illuminate simultaneously to indicate an off-null condition of the null amplifier.

2.3 CONNECTORS

Front and rear panel connectors are identified in Figure 2-1.

2.3.1 L INPUT, J6 and R INPUT, J7

The L and R input connectors, located on the analyzer front panel, are used to apply signals to the analyzer for measurement. In phase and ratio modes both inputs are used, whereas in other modes, one of the two inputs will be selected by INPUT switch S4. The mating connector for J6 and J7 is Switchcraft part no. O5CL3M, available from Switchcraft distributors or Potomac Instruments.

2.3.2 AC IN Connector, J8

Connector J8 is located on the rear panel and receives the line cord connector to provide AC power input to the AA-51.

2.3.3 AC OUT Connector, J9

Connector J9 is located on the rear panel and provides an unfused 115/230 V ac auxiliary output.

2.3.4 SIG COM Output Connector, J10 and SCOPE Output Connector, J11

Connectors J10 and J11 are 3-way binding post connectors which provide a signal output for an oscilloscope.

2.4 FUSE LOCATION

A 1/8 amp, 250V fuse (F1) is accessible in a screw-type holder on the generator rear panel.

2.5 ADJUSTMENT OF MECHANICAL ZERO

Before operating the AA-51 for the first time, check the meter mechanical zero. To do this, if analyzer is on, turn off and allow 2 to 3 minutes for complete capacitor discharge. Turn the meter zero adjust screw, shown in Figure 2-1, using a small-bladed screwdriver until an exact zero indication is achieved.

2.6 GENERAL OPERATING INFORMATION

2.6.1 Input Connections

One or two signal sources may be connected to the AA-51 using the shielded cables provided with the analyzer. In these cables the alligator clip insulators are color coded. Red is the signal high lead; blue is the signal low or common lead; and black is the cable shield and chassis ground. The effect of input and test cable capacitance on frequency response must be considered when the device under test has a high output impedance. The test cable capacitance is approximately 400 pf; this added to the AA-51 input capacitance results in a capacitive reactance load on the device under test of 20,000 ohms at 15 kHz. For a source impedance of 600 ohms this reactance has negligible effect, but for a source impedance of 10,000 ohms the measured voltage is down 1.0 dB from the no-load value at 15 kHz. Low-capacitance test leads can reduce this effect to 0.1 - 0.2 dB. In some cases what is called "output impedance" is not the circuit generator impedance, but the minimum recommended load impedance. The true output impedance, which may be lower, can be measured by finding the resistance that drops the output voltage to half its no-load value at a signal level low enough to maintain linear operation.

2.6.2 Grounding

When the AA-51 power cord is plugged in, the chassis is connected directly to the AC power neutral line through the third wire of the power cord. This may or may not provide minimum pickup of unwanted hum and noise in the measuring circuits. Often the AA-51 must be grounded solidly to the equipment under test to obtain minimum hum pickup. This connection may be made using the test cable shield, which is connected to the chassis, or by using a separate wire from the ground binding post on the rear of the unit. In such cases it may also be necessary to isolate chassis ground from power line ground, using a three-prong-to-two-prong adapter to obtain minimum noise pickup. If this is done be certain to observe the following warning:

WARNING

Be certain that the chassis of the AA-51 is solidly grounded to an earth-grounded point before using an adapter or other means to break the power cord ground connection. Otherwise a dangerous voltage may be present on the AA-51 chassis.

2.6.3 Use of Scope Terminal

The scope terminals provide a 100 mV p-p output for full scale meter deflection. These terminals can be used to monitor the output signal with an oscilloscope. The combination of

the analyzer and oscilloscope provides more significant information about the device under test than the expression of magnitude alone. The impedance at the scope terminals is 2200 ohms and excessive loading should be avoided to maintain the accuracy of meter reading. Watch for a drop in the reading when connecting a load; for high-impedance oscilloscope inputs the effect is negligible.

2.6.4 Signal Common Chassis-Float Switch

For most measurements this switch should be in the CHASSIS position. The FLOAT position is for use when neither of the pair of signal terminals under test is at ground potential. In this mode the signal common may be at up to ± 200 volts dc or peak ac with respect to chassis ground. If the terminals under test are a balanced pair so that signal voltage exists on both AA-51 input leads, the VM and NOISE functions operate normally, but distortion measurements will not be correct. For distortion measurements on a balanced line a balanced-to-unbalanced transformer between the device under test and the AA-51 is recommended.

2.6.5 Balanced Line Measurements

The AA-51 measuring circuits are unbalanced, that is, one of its input terminals (designated Signal Common) is directly connected to the measuring circuit ground. Signal Common may be floated with respect to chassis ground, as explained in 2.6.4, but the measurements possible on balanced lines are limited. Voltage measurements are possible, but the THD measurement circuit does not function well in the FLOAT mode, and a transformer is required.

2.6.6 Equipment Performance Measurements

Equipment Performance Measurements (EPM) to determine a broadcast facility's audio performance are required by the FCC and described in various sections of the FCC Rules, Part 73. These tests are commonly referred to as an "Audio Proof" although the FCC prefers to use the term "Proof" only for measurements to verify the performance of AM directional antenna systems. Useful guides to these EPMs for AM and FM stations have been prepared by Broadcast Engineering Magazine and are available from Broadcast Engineering, P.O. Box 12901, Overland Park, Kansas 66212.

2.7 OPERATING PROCEDURES

2.7.1 GENERAL

The AA-51 audio analyzer should be operated from a 115 volt or 230 volt ac power source according to the rating on the nameplate on the rear of the unit.

CAUTION

Switch (SIG COM) from (CHASSIS) to (FLOAT) when measuring signals between two points which are both above ground potential.

2.7.2 Voltmeter Mode

The AA-51 becomes a general purpose ac voltmeter when the MODE selector is set to VM position (Upper MODE Switch max. CCW). Perform the following steps when making voltage measurements:

- a. Position RANGE selector to a range exceeding the value of the signal to be measured.

- b. Connect signal to either the L or R connector with INPUT switch in proper position to read signal.
- c. Select a meter RANGE to give a reading as close to full scale as possible.
- d. Observe meter indication and meter RANGE setting to obtain signal level.

2.7.3 Total Harmonic Distortion Mode

- a. Position MODE selector to TUNE (Upper MODE Switch max. CCW). The SIG COM switch must be at CHASSIS.
- b. Connect test leads from device under test to either the L or R connector with INPUT switch in proper position to read signal.
- c. See that the HIGH and LOW lights are both out. If the LOW light is on, switch the FREQ switch one step above or below the correct position (or press LEVEL switch S5) and read the meter; if the pointer is at full scale, indicating that signal leveling is effective, the THD reading will be accurate. Normally this occurs for input levels as low as 50 mV RMS. At such low levels, however, the AA-51's residual noise may contribute to the reading.

Accurate readings are also possible for input levels above that which turns on the HIGH light, as high as 100 volts, if leveling is effective and instrument distortion is low.

- d. Position FREQ range selector and frequency dial to fundamental frequency of input signal. Adjust frequency dial to obtain a minimum indication on the meter.
- e. Position MODE selector to THD. HIGH and LOW lights will light together until automatic nulling is nearly completed. If the lights do not go out, recheck the dial setting in TUNE (steps a-c).
- f. Observe meter indication and RANGE switch setting. For example, if meter indicates .8 and the RANGE selector is in 1% position, distortion measured is 0.8%. If the THD reading seems abnormally high, the problem is often power frequency (hum) or other noise pickup, which can be identified by using an oscilloscope at the SCOPE terminal.
- g. If a series of THD measurements is being made at various known frequencies, in most cases the MODE switch can be left at THD and the dial reset by eye to each new frequency. The AA-51 has enough pull-in range to null automatically without using the TUNE step if the dial is set carefully, except that it may be necessary to switch to TUNE and back to THD for nulling near 20 kHz.

2.7.4 Intermodulation Distortion

- a. Position MODE selector to IMD (Upper MODE Switch max. CCW).
- b. Connect test leads from device under test to either the L or R connector with input switch in proper position to read signal.

- c. See that the HIGH and LOW lights are both out. If the LOW light lights, switch the MODE switch to TUNE and FREQ to x10, and read the meter. If the pointer is at full scale, the IMD reading will be accurate (see 2.7.3c).
- d. Observe meter indication and RANGE switch setting to determine the IMD percentage. A dual-trace oscilloscope used to compare the SCOPE output voltage with the input test signal will indicate at what point on the test signal waveform the distortion occurs.

2.7.5 Noise Mode

- a. Position MODE selector to NOISE. (Upper MODE Switch max. CCW).
- b. Connect test leads from device under test to either the L or R connector with INPUT switch in proper position to read signal.
- c. Observe meter indication and RANGE switch setting to determine the noise voltage. The noise voltage may be observed for analysis with an oscilloscope at the SCOPE terminal.
- d. For signal-to-noise ratio measurements (actually signal-plus-noise-to-noise ratio), a reference level may be established by applying the signal in the NOISE mode. An example is, applying modulation to a transmitter to obtain a reference level and then removing it to measure noise. In the NOISE mode, for sine waves, the reference voltage applied must not exceed 8.0 volts RMS up to 7.5 KHz or 4.0 volts at 15 kHz for accurate results. For higher voltages use the VM mode to establish the reference level. The meter sensitivity for VM is the same as for NOISE. If in doubt, look for distortion due to too-high levels in the NOISE circuits using an oscilloscope at the SCOPE terminal.

2.7.6 Phase Angle Mode

- a. Position MODE switch (upper) to PHASE x10.
- b. Connect test leads from the L and R input connectors to the points on the device under test between which the phase angle is to be measured.
- c. With signals applied, see that the HIGH and LOW lights are both out. If not or if in doubt, switch to the VM mode and measure the input levels to see that they are within the specified range of 0.3 to 6.0 volts.
- d. Read the meter; if the indication is less than 5 on the PHx10 range, switch to the PHx3 range. Multiply the reading by 10 or 3 to obtain the phase angle. Note the sign of the reading. A positive angle means that the R input lags the L input, or the R input is delayed in time with respect to the L input.
- e. Fast phase changes may be seen by observing the output signal at the SCOPE terminal using an oscilloscope. This signal is a square wave with duty cycle proportional to phase angle; it is symmetrical (50 percent duty cycle) for an angle of zero.

2.7.7 Ratio Mode

- a. Position MODE switch (upper) to RATIO.
- b. Connect test leads from the L and R input connectors to the points on the device under test between which the amplitude ratio is to be measured. The L input is the reference signal in the RATIO circuit, and the meter response time for R voltage changes is faster than for L voltage changes.
- c. With signals applied, see that the HIGH and LOW lights are both out. If not or if in doubt, switch to the VM mode and measure the input levels to see that they are within the specified range of 0.3 to 6.0 volts.
- d. Read the indicated ratio directly in dB. A positive indication means that the R voltage is greater than the L voltage.
- e. A dc voltage proportional to the ratio is available at the SCOPE terminal. This voltage is zero for a ratio of zero dB, and changes +3.0, -1.5 volts for ratios of ± 6 dB.

2.7.8 Wow and Flutter Mode

- a. Position MODE switch (upper) to 1% W&F.
- b. Connect test leads from either the L or R connector to the device under test with input switch in the proper position to read the signal. See that the HIGH and the LOW lights are both out.
- c. Observe percentage of W&F indicated on meter. If meter indication is small, switch MODE selector to .3% W&F for increased sensitivity.
- d. The instantaneous output of the wow and flutter demodulator may be observed on an oscilloscope at the SCOPE terminal. The sensitivity is constant for flutter frequencies from 0.2 to 200 Hz. There is no weighting filter at this point.

SECTION 3

THEORY OF OPERATION

3.1 GENERAL DESCRIPTION

The Model AA-51 Audio Analyzer as shown in the overall block diagram, Figure 3.1, consists basically of a meter with several different input circuits which may be selected for different measuring tasks. The meter itself is driven by the A7 buffer/amplifier and switching assembly which receives its input either directly from the front panel jacks, or from one of the special measurement and demodulation circuits. These circuits consist of the A3 board, used for phase and ratio measurement, the A5 board, used for measuring IM distortion and wow and flutter, and the A4 and A6 circuits which work together to provide automatic measurement of harmonic distortion. The A3 circuit receives its signal input directly from the front panel jacks, while the other measurement circuits receive their input by way of the A2 leveler circuit, which automatically attenuates the input signal to the proper level for measurement.

3.2 BLOCK DIAGRAM DESCRIPTION

3.2.1 AC Voltmeter Mode

In the VM mode of operation, the input signal from either the L or R input connector passes through S4 to the A7 voltmeter assembly. On the noise filter board, A7A1, the signal passes directly through switch S1F to the A7A3 voltmeter buffer where it will be attenuated either 1:1 or 1000:1, depending on the position of range switch S2A. The attenuated signal from the A7A3 board is then further attenuated on the voltmeter amplifier board, A7A2, as it passes through switches S2B and S1C to the voltmeter drive amplifier. The meter drive output current then passes through S3D and E and is applied to the meter.

3.2.2 Noise Measurement Mode

Operation in the NOISE mode is similar to that described above for VM mode, except that the input is bandpass filtered to remove signals lying outside the noise band (20 Hz to 20 kHz). This filtering is accomplished by U1A and U1B on the A7A1 board, through which the signal is routed by switches S1F (on A7A1) and S1B (on A7A3) before it is applied to the circuits on A7A3.

3.2.3 Total Harmonic Distortion Measuring Mode

In the THD mode of operation the input signal from either the L or R connector is applied to the A2 leveler circuit and is attenuated by relay K1 if the signal level is greater than 3 Vrms. After buffering, the input signal is passed through a current controlled attenuator which is feedback controlled to maintain a constant output amplitude from the leveler circuit. The signal level is also monitored by a detector circuit (Q1 etc.) which operates the HI and LO indicators to indicate improper signal level, and activates relay K1.

The levelled output of the A2 board is applied to a rejection amplifier, A6, which when properly tuned suppresses the fundamental component of the tuned signal better than 80 dB. To assure proper tuning of the rejection amplifier and to reduce the time involved in harmonic measurement, automatic null balancing is employed once the operator has rough-tuned the signal frequency. The A4 quadrature detector board performs this null balancing operation by analyzing the null amp output and supplying control signals to adjust null amp parameters. The A4 circuit also has the capability to activate the HI and LO indicators simultaneously to indicate improper null amp tuning. The output of the null amplifier is then applied to the voltmeter circuits of the A7 assembly for measurement of the remaining harmonic components.

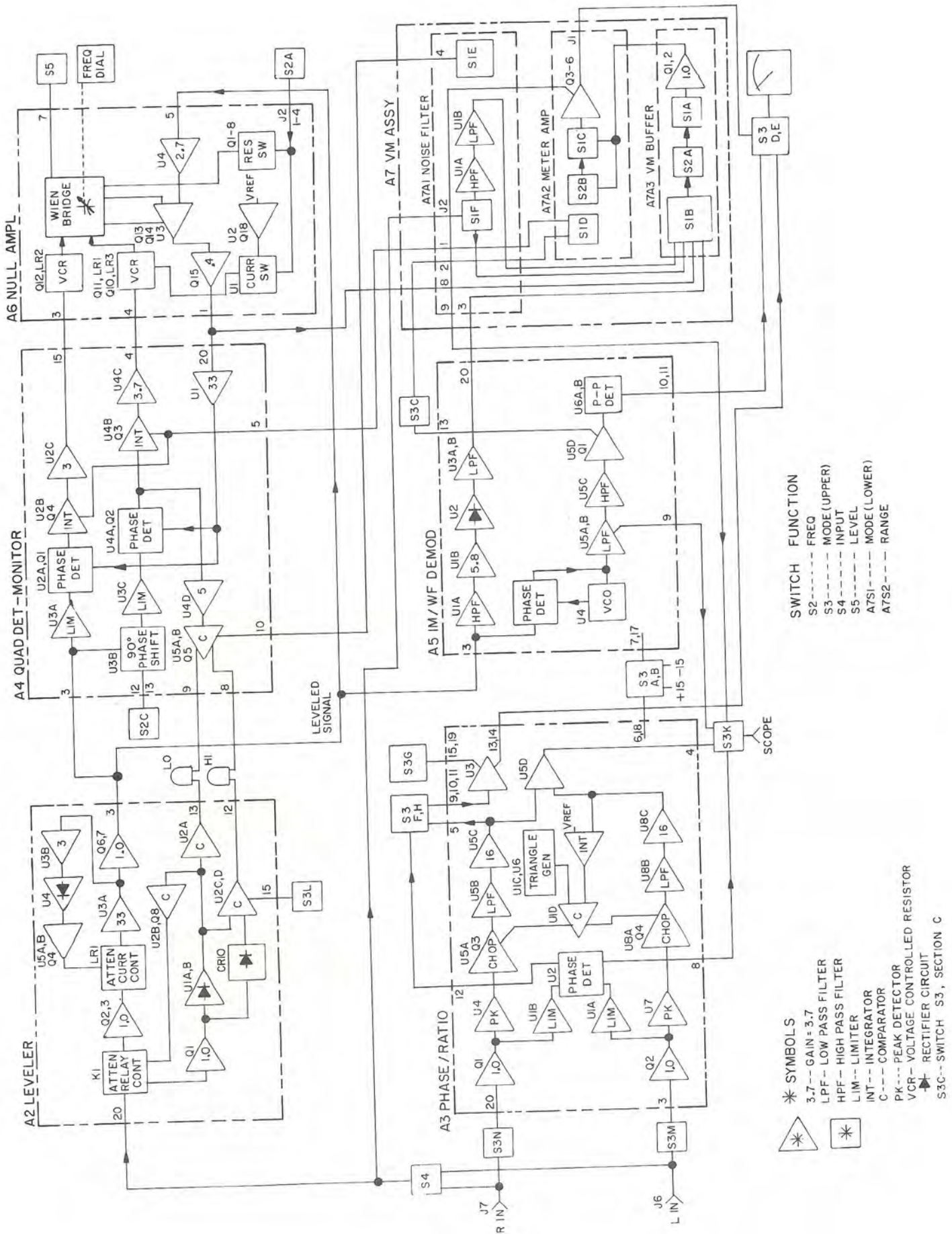


Figure 3.1. AA-51 Block Diagram

Since harmonic distortion is a complex wave and the voltmeter responds to the average value, the reading will deviate from a true RMS value; however, analysis has shown that the amount of error is very small for harmonic content of less than 10%.

3.2.4 Intermodulation Distortion Measuring Mode

In the IMD mode of operation, the input composite signal of 60 Hz and 7 kHz is applied to the signal leveler from either the L or R connector. After being leveled, it is analyzed by the IM/WF demodulator board, A5, which removes the 60 Hz component by high-pass filtering, then rectifies the resultant 7 kHz signal and low-pass filters it to detect any 60 Hz sidebands introduced by intermodulation. The resultant output signal is applied to the voltmeter assembly, A7, where it is read as percent IMD.

3.2.5 Phase Measurement Mode

In the PHX3 and PHX10 modes the input signals from the L and R connectors are applied directly to the phase and ratio detector board, A3. The circuits of the A3 board limit the input signals and compare their phase to produce a DC voltage that is proportional to the phase difference. This signal is applied to the meter circuit to give a meter reading of center scale at 0° and $\pm 54^\circ$ full scale in the PHX3 mode or $\pm 180^\circ$ full scale in the PHX10 mode.

3.2.6 Ratio Measurement Mode

In the RATIO measurement mode, input signals between .3 Vrms and 6 Vrms are applied through the L and R connectors to the phase and ratio detector, A3. The L and R signals are peak rectified by linear detectors and the resultant DC signals are applied to a circuit which divides the L channel signal level by the R channel signal level. This produces a DC signal proportional to the ratio of L and R input amplitudes which is used to drive the meter. The difference in signal amplitudes is read on a zero center scale calibrated for plus and minus 6 dB ratio.

3.2.7 Wow and Flutter Measurement Mode

In the .3% W&F and 1% W&F modes, an input signal of $3.15 \text{ kHz} \pm 10\%$ and with an amplitude between 0.1 Vrms and 80 Vrms is applied to the L or R connector. This signal is applied to a phase locked loop circuit on the A5 board which detects any frequency variations. The resultant demodulated FM signal is filtered by a 200 Hz low-pass filter and made available at the SCOPE output for unweighted wow and flutter analysis. In addition, the low-pass filter output is processed by a weighting filter which peaks at 4 Hz. The output of this filter is rectified by a linear peak-to-peak rectifier whose dynamic response is controlled. Characteristics of the weighting filter and the rectifier circuit are as specified by IEEE STD 193-1971. The rectifier output is applied to the meter where it is read on two scales (0.3% or 1%).

3.3 DETAILED THEORY OF OPERATION

3.3.1 Signal Leveler (BD41) A2 (Ref. Figure 4.6)

The signal leveler circuit divides the analyzer input signal into two paths, a signal path and a monitor path. The signal is input on board pin 20 and is supplied to the monitor path through C1 and a 21.5:1 attenuator consisting of R3 and R4. This attenuation of the input signal allows the first stage of the monitor path, Q1, to operate linearly for input signals up to 80 Vrms. The low output impedance of Q1 drives operational amplifier U1A, which is configured as a linear AC to DC rectifier. The output of the rectifier circuit is applied to a unity gain differential amplifier, U1B, which removes the large common mode term.

After ripple filtering by R38 and C9 the DC level (proportional to input signal amplitude) is applied to several comparators. Comparator U2A compares the DC signal level with a reference level set by R42 and supplies a ground to the LO signal level LED, via board pin 13, when the signal level is lower than the reference. Comparator U2B compares the DC signal level with another reference, set by R47, and outputs a positive voltage to drive Q8 when the DC signal level exceeds the reference. Q8 thus activates relay K1, switching an attenuator (R3, R4) into the signal path whenever the signal amplitude exceeds 3V rms.

Comparator U2C activates the HIGH signal LED for all modes of operation except phase and ratio measurement, when the limit is determined by comparator U2D. U2C is provided with its own monitor signal, which is rectified from the input signal by CR10 and filtered by C3. This DC level is compared with a reference level set by R46 and a current is supplied to the HIGH signal LED, via R27 and board pin 12, when the signal level exceeds the reference. The output of U2C will be asserted when the analyzer input signal amplitude exceeds 80 Vrms. The HIGH signal level LED can also be activated by comparator U2D which is supplied with a signal-derived DC level on pin 6 and an adjustable reference level from R21 on pin 7. In all modes of operation except phase and ratio measurement this reference will be high enough to effectively disable the U20 circuit. In phase and ratio modes, however, a ground is supplied to board pin 15 by switch S3L (on chassis schematic), lowering the reference value so that the HIGH indicator is activated at a signal amplitude of 6 Vrms.

The first stage of the signal path circuit is transistor Q2, which is protected from excessive signal input by CR7 and CR8. Q3 provides negative feedback to assure a high input impedance and low output impedance. The output of the first stage is applied to a variable attenuator consisting of R11 in series and the variable resistance of LR1 in shunt. The low-level attenuator output is amplified by U3A, an operational amplifier in a high gain, wide bandwidth configuration. The output of U3A drives buffer amplifier U3B, which provides isolation for a full-wave rectifier circuit consisting of CR5, CR6 and U4. The DC output of the rectifier is compared to a reference signal established by R25 and the difference is integrated by operational amplifier U5A. This error signal is used to vary the intensity of a sealed incandescent lamp in LR1 via a current amplifier consisting of U5B and Q4. Terminals 1 and 3 of LR1 connect to an internal photocell and thus LR1 and R11 become a variable attenuator whose attenuation is proportional to an input current. Transistor Q5 is used as a diode in the feedback circuit of U5A in order to prevent reverse-polarity voltage from being applied to C8.

The final output of the leveler circuit is through a 100 KHz active low-pass filter consisting of Q6 and Q7 which isolates U3A from loading effects of circuits using the levelled signal.

3.3.2 Phase and Ratio Detector (BD40), A3 (Ref. Figure 4.8)

The phase detection circuits on the A3 module receive signal inputs from the L and R front panel connectors. The L input is applied to the gate of FET Q2, which provides a high impedance input and low impedance output to drive U1A. U1A is a comparator which detects the zero crossing of the input signal and outputs an in-phase square wave. This square wave is applied to the clock input (pin 3) of CMOS D flip-flop U2, where the positive-going edge causes the high D input at pin 5 to be transferred to the Q output. The R input is applied to the gate of FET Q1, which provides a high input impedance and drives U1B. U1B is a comparator which detects the zero crossing of the input signal but, in contrast to U1A, outputs a square wave of opposite phase to the input signal. This square wave is differentiated into a positive pulse by C18 and R52, and is applied to the reset input (pin 4) of flip-flop U2. Thus the flip-flop U2 sets on the positive-going zero crossing of the L input signal and resets on the negative going zero crossing of the R input signal.

In-phase input signals applied to the L and R connectors cause the Q output of the flip-flop to become a 50% duty cycle square wave having an average value of one-half of the flip-flop supply voltage. This signal is output on board pin 12 to switch S3-F, and will be returned to board pin 10 in PHX10 mode or pin 11 in PHX3 mode. Meter amplifier U3 integrates the square wave and supplies current to the panel meter to be read as 0° relative phase (center of meter scale). Potentiometers

R17 and R19 allow separate calibration of the meter drive circuit for $\pm 54^\circ$ and $\pm 180^\circ$ full scale. Diodes CR11 and CR12 limit the voltage output of U3 to protect the meter from overload.

The ratio detection circuits located on the A3 circuit board compare the amplitude of the L and R input signals from Q1 and Q2. To accomplish this, a 1 kHz square wave is first generated, with a duty cycle inversely proportional to the L signal amplitude. This waveform is then used to gate a DC level which is proportional to the R signal amplitude. Thus the final output of the circuit, when integrated, will be proportional to the R input amplitude divided by the L input amplitude.

The DC signal levels for L and R channels are generated by peak detectors U7 and U4 respectively. The L input DC level is applied to buffer U8A which supplies a DC level to FET Q4. The circuit following Q4 produces a square wave of variable duty cycle, as described above, which is then applied to the gate of Q4 as negative feedback. The square wave is produced by comparator U1D, which compares the triangle waveform produced by oscillator U1C/U6 with a DC level output by U8D. As the DC level is raised or lowered, a lesser or greater portion of the triangle waveform will be higher than this DC level, resulting in a narrower or wider positive pulse output of U1D. U8D produces a DC output that is proportional to the difference between a reference voltage, on pin 5, and a DC level on pin 6 which is derived from the integrated output of Q4. The signal from Q4 is integrated by low-pass filter U8B and buffered by U8C before it is applied as a DC level to reference comparator U8D. Q4 connects the left channel peak detector output to the low-pass filter during the positive pulse output of U1D. The filter output at U8C is forced to be equal to U8D's reference voltage because the output of U8D controls the positive pulse width to minimize any error. Therefore, if the peak detector output increases the pulse width must decrease, resulting in a duty cycle inversely proportional to L signal amplitude.

3.3.3 IM/WF Demodulator (BD42) A5 (Ref. Figure 4.12)

3.3.3.1 IM Demodulation

The composite intermodulation test output signal from the leveler is received on board pin 3 of the A5 circuit board. The 60 Hz component of this signal is removed by a high-pass filter consisting of U1A and associated components. The remaining 7 kHz component and any sidebands are amplified by U1B. R5 allows calibration of the signal level supplied to U1B. The amplified signal is full wave rectified by diodes CR1, CR2 and operational amplifier U2. Any 14 kHz ripple is removed by U3A and U3B which are configured as low-pass active filters. The overall bandwidth of the filter circuits is approximately 600 Hz to insure measurement of complex intermodulation distortion by the voltmeter.

3.3.3.2 W F Demodulation

For wow and flutter demodulation, the output signal from the leveler is limited by diodes CR3 and CR4 and is applied to the input of U4, an integrated circuit phase-lock loop, which is tuned to 3.15 kHz by C17, R30 and R31. The output of U4, at pin 10, will be a signal which reflects the variation of the input frequency. This demodulated FM is filtered by active low-pass filters U5A and U5B to remove ripple frequencies introduced by the phase-lock loop. The output of U5B is made available at the front panel SCOPE output via board pin 9, and is routed to additional circuits on the A5 board which provide the frequency weighting and peak rectification required by IEEE standard 193-1971.

Frequency weighting is provided by an active filter consisting of U5C and associated components. FET Q1 accomplishes range switching and is turned off by a negative voltage applied to the gate in all modes except .3 W&F. This control voltage is supplied via board pin 13 from switch S3C (located on chassis wiring diagram). In the 1 W&F mode, the output of U5C is applied to amplifier U5D through calibration potentiometer R26 and R25. When .3 W&F mode is selected, a positive voltage at board pin 13 will reverse-bias diode CR7, allowing Q1 to become a low impedance path for the weighted signal from U5C through calibration potentiometer R23 and R22 to the input of U5D. This increases circuit sensitivity in the .3 W&F mode. The output of amplifier U5D is applied to U6A and U6B, operational amplifiers used as peak rectifiers. The rectifier action of these circuits is linear due to the placement of the diodes in the amplifier feedback loop. The dynamic response characteristic required by the IEEE specification is provided by R17 and R20, which control the charge time of capacitors C13 and C14, and R16 and R52, which control the discharge time of each capacitor, and C26 which speeds up the meter response. Voltage applied to the meter is limited by diode CR8.

3.3.4 Null Amp (BD 49) A6 and Quadrature Detector (BD39) A4

3.3.4.1 Null Amp (Ref. Figure 4.14)

The null amp circuit is controlled by the quadrature detector to reject the fundamental frequency component of the analyzer input signal. The basic principle on which this circuit operates is that if operational amplifier U3 receives identical signals at its + and - inputs, no signal will be produced at its output to drive Q15; the function of the Wien bridge circuit is to cause this condition to occur at the exact fundamental frequency of the input signal. As Wien bridge tuning is changed via C10 (FREQ dial) and the range switch, the frequency at which this null condition occurs changes accordingly. Additional circuitry is introduced to accomplish automatic fine tuning of the Wien bridge (LR1 and LR3 which are part of the Wien bridge resistance) and feedback amplitude adjustment (LR2). These current-controlled resistors are controlled by the Quadrature Detector, based on its analysis of the null amp output, from Q15, to ensure an exact null.

The basic conditions for the null action of U3 are established by a voltage divider consisting of R25 and the series combination of R24 and the variable resistance of LR2 (LR2 is paralleled by R64 to limit the maximum resistance). This divider attenuates the input signal from point A by approximately 3:1 at the - input of U3. At the Wien bridge's tuned frequency, attenuation between points A and B is also 3:1 with no phase shift, while at frequencies other than the tuned frequency, attenuation between points A and B will be greater than 3:1 and the phase of the signal will be shifted. This means that at off tune frequencies the signal at the + input of U3 will not match the signal at the - input and a complex output waveform will be produced which contains a component at 0° due to amplitude difference and a component at either 90° or 270°, due to phase difference. When this output signal is analyzed by the A4 circuits, the 90° or 270° component will be measured and a control current produced to adjust the resistance of LR1 and LR3. This closed-loop process eliminates as much phase error as possible by tuning the Wien bridge, while other A4 circuits measure the 0° component of the output signal and adjust LR2 to eliminate residual amplitude difference. Negative feedback is provided by R23 to sharpen the "rejection notch" produced by the circuit and prevent attenuation at harmonics of the tuned frequency.

The Wien bridge circuit actually contains a large number of components. The top half of the bridge circuit consists of Q1 through Q4, LR1, together with resistors R1 through R7, all in series with the parallel combination of C10A, C11, and C12. Similarly, the bottom half of the Wien bridge consists of Q5 through Q8, LR3, together with R10 through R16, all in parallel with C10B and C19. Q1 through Q8 are FET switches used to select different bridge resistances for the X1, X10, and X100 frequency ranges. In the X100 range, for example, a positive voltage applied to pin 1 of J2 from S2A (on chassis wiring diagram) biases Q2, 4, 6, and 8 on, switching resistors R7, R4, R12, and R16 into the bridge circuit. In the X1 range, all switches are off and the bridge resistance is determined by R1, 2 and 5 on top and R10, 13, and 14 on the bottom. Part of the bridge resistance is paralleled by LR1 on top and LR3 on the bottom. FETs Q16 and Q17 are used to compensate for variations in the gate-to-source

and gate-to-drain capacitance of the other FETs with changes in circuit voltage. Q9, when turned on by a positive voltage at J1-7 (from rear panel LEVEL pushbutton), grounds the center of the bridge network, causing the null amp output response to be flat over its entire frequency range, with no rejection notch. This feature is useful in various test and alignment procedures. Q13 provides a high impedance buffer for the signal from the center of the bridge, and its source current is supplied by Q14.

The amplitude correction signal from the Quadrature Detector, which is proportional to the 0° component of the output signal, is applied to the base of Q12 and controls the current supplied to the filament of LR2. This current level is calibrated by adjustment of potentiometer R27, with CR3 supplying temperature compensation. Control current is supplied to LR1 and LR3 by Q11 and Q10, respectively, in response to the " 90° " or phase-sensitive control signal from the Quadrature Detector. The LR1 and LR3 driving circuits are provided with separate calibration potentiometers for each frequency range. The potentiometers which receive supply current in a given range are selected by transistor switches in U1, which are driven by a positive selection voltage at the appropriate pin of J2. Diodes CR4 through CR7 provide progressively greater amounts of temperature compensation as higher frequency ranges are selected. A constant voltage supply for the Q10, Q11 and Q12 circuits is provided by a voltage regulator circuit consisting of Q18 and U2. Operational amplifier U2 is supplied with a reference voltage at the + input by voltage divider R36/R37 and drives Q18. A voltage divider consisting of temperature compensation diode CR2 and R38 supplies the - input of U2 with a voltage proportional to the output voltage at the emitter of Q2. Thus U2 will drive Q18 to maintain the emitter voltage at approximately -7.5 volts regardless of variations in load.

The output stage of the null amplifier, Q15, also functions as a low-pass filter with rolloff at 100 kHz. The low-pass characteristic is imparted by the network consisting of R55, R56, C3 and C15.

3.3.4.2 Quadrature Detector (Ref. Figure 4.10)

The Quadrature Detector circuit receives the output of the null amplifier on board pin 20. This signal is amplified by operational amplifier U1, which provides a high gain (30) for sensitive control circuit operation on the relatively small output of the null amplifier near center frequency. The output of U1 drives two phase detector circuits, U2A/Q1 and U4A/Q2, which detect signal components at 0° and 90° respectively. Amplifiers U2A and U4A are configured to function as inverters (gain of -1) when the associated transistors are turned on or as amplifiers with a gain of $+1$ when the associated transistors are turned off. The square waves which switch Q1 and Q2 are derived from the null amplifier input, which is received on board-pin 3 from the leveler circuit. This input signal is applied to comparator U3A, a zero crossing detector, to produce an in-phase square wave to switch the 0° phase detector, U2A/Q1. To produce the 90° detector switching signal, the input waveform at board-pin 3 is first phase shifted 90° by the circuit consisting of U3B and associated components. U3B is a comparator used in a linear operational amplifier configuration, with a 90° phase shift between input and output introduced by capacitive feedback between board pins 12 and 13. FREQ switch S2 (on chassis wiring diagram) selects different capacitance values to be placed in this feedback loop for different frequency ranges. The RC network consisting of C4 and R25 suppresses a tendency of the U3B circuit to oscillate.

The output of U3B is a sine wave with a 90° phase difference relative to the input. This signal is converted to a square wave by comparator U3C, a zero crossing detector. The resultant 90° shifted square wave is applied to the base of Q2 to control the 90° phase detector. The output of U4A for input signals with no 90° component will be a waveform whose average voltage is 0. For input signals with a 90° component, the output waveform will have a positive average value. For 270° input components, U4A's output will have a negative average value. The operation of U2A is similar for 0° signal components.

The outputs of the phase detectors U2A and U4A are integrated by operational amplifiers U2B and U4B respectively; the operation of the U2B and U4B circuits is identical. Potentiometer R13 compensates for offset voltage in U2B so that the output of U2B stays constant when the phase detector error output is zero. The output of U2B is limited by diodes CR1 and CR2. R10 and C5 provide the long time constant feedback loop which establishes the integrator response of U2B. FET Q4 is used as a switch to connect the output of U2B to the - input through R47 when the analyzer is used in the TUNE, VM or NOISE modes. When Q4 is turned on by a positive voltage (reverse-biasing CR10) the output of U2B is essentially clamped at 0.

Operational amplifiers U2C and U4C are used as inverters with a gain of -3, receiving the DC output of their respective integrators and outputting the control voltages to the null amplifier, A6.

Operational amplifiers U5A and U5B, together with Q5, form a circuit which operates in THD mode to turn on both HIGH and LOW front panel indicators whenever the output of the 90° phase detector is not close to 0 VDC, indicating improper Wien bridge tuning. U5A is provided with a negative reference voltage at the + input, pin 5, of approximately 100 mV, which is developed by voltage divider R39/R42. U5B is provided with a positive 100 mV reference by voltage divider R51/R52. The outputs of U5A and U5B are prevented from going negative by feedback through diodes CR5 and CR8. Thus if the 90° phase detector output from U4D is not within 100 mV of 0, either U5A or U5B will provide a positive output to drive transistor Q5. Q5 in turn supplies current to both front panel LEDs through R59 and R60. Q5 is turned off in all modes except THD by a ground applied to board-pin 10 from switch S1E (on A7 schematic).

3.3.5 Voltmeter Assembly A7 (Ref. Figure 4.18)

The voltmeter circuits are contained on three PC boards; A7A1, A7A2 and A7A3, which are mounted vertically behind the front panel. The switch wafers for the MODE switch, S1 and the RANGE switch, S2, are mounted on these boards and are activated by shafts from the front panel.

3.3.5.1 VM Buffer (BD51) A7A3

The VM buffer circuit, A7A3, is supplied with a signal source selected by S1B, at a level of attenuation determined by S2A in conjunction with S1A. The signal sources which may be selected at S1B are as follows: In VM, the voltmeter mode, the signal is taken directly from the analyzer front panel input, via S4 (on chassis schematic) and J2/S1F on BD43, to pin 1 of S1B. Capacitor C1 provides DC isolation between the front panel input and the circuits of BD51. In TUNE and THD modes (pins 2 and 3 of S1B) the signal source is the output of the Null Amplifier, A6, with DC isolation provided by C2. In the fourth position of S1B, IMD mode, the output of the IM/WF demodulator, A5, is selected as signal source. In NOISE mode the output of the noise filter circuit on A7A3 is selected at pin 5 of S1B.

The signal chosen by S1B is applied to an attenuator network consisting of R1, R2, C3 and C4, and to RANGE switch S2A. S2A selects either the direct output of S1B (pins 1 through 6 of S2A), or the attenuated signal (1000:1) from the middle of the attenuator network (pins 7 through 11 of S2A). The output of S2A is then applied to pins 1, 3, 4 and 5 of S1A. In all modes except TUNE, this signal will be applied to the buffer amplifier Q1/Q2 through S1A; in TUNE mode, however, the selection of S1A pin 2 assures that the attenuated signal is supplied to the buffer amp regardless of the position of RANGE switch S2A.

The buffer amplifier consists of two stages, Q1, which provides a high impedance input and Q2, which develops the output. Limiting of the Q1 base voltage is provided by CR1 and CR2, in conjunction with R3, to prevent damage to Q1 when external signals are applied in voltmeter mode. Negative feedback is supplied from the collector of Q2 to the source of Q1, resulting in a high input impedance at the gate of Q1 and a low output impedance to drive the 10 dB voltage divider located on A7A2.

3.3.5.2 Meter Amp (BD50) A7A2

The voltmeter amplifier circuit on A7A2 receives the output of the buffer amplifier on A7A3. This signal is applied to the 10 dB attenuator network of S2B and also to pin 2 of S1C. S1C selects either the output of the attenuator network or, in TUNE mode, the direct output of the buffer amplifier on S1C pin 2. The signal from S1C is then applied to a two-stage differential amplifier consisting of Q3/Q4 and Q5/Q6. In the first amplifier stage, the input signal is applied to the base of Q3 which shares its current source, R12, with Q4. Negative dc feedback is applied to the base of Q4 from the output rectifier circuit via a voltage divider consisting of R8 and R14. The differential output of the first amplifier stage, at the collectors of Q3 and Q4, is limited by diodes CR7 and CR8 and applied to the second stage, Q5 and Q6. The second stage output current, through R16 and R18, is applied to the meter through rectifiers CR3 and CR4. Diode CR5 limits the meter drive voltage to prevent overload. AC feedback is taken from the rectifier circuit output via capacitors C8 and C9, and voltage divider R25/R26. The level of this feedback applied to Q4 is adjusted by the gain calibration potentiometer R26. A scope signal is also provided from the rectifier output via R29. The final output current to the meter through R23 and R24 is filtered by C11 and C13.

3.3.5.3 Noise Filter (BD43) A7A1

When the analyzer is operated in the NOISE mode, the bandpass filter circuit on the A7A1 board is switched into the voltmeter input circuit by switch S1. The input signal at J2 (A7A1) is routed to operational amplifier U1A which provides high-pass filtering with a cut off frequency of 20 Hz. The output of U1A is then applied to operational amplifier U1B, a low-pass filter with a cut off frequency of 20 kHz. Both filters are Butterworth configurations which feature 12 dB/octave slopes and negligible insertion loss. The bandpass output of U1B is then applied to the buffer and voltmeter amplifier circuits as described above. Switch S2E, also located on A7A1, provides a ground via J1-4 to disable the HIGH/LOW indicator control circuit of the Quadrature Detector, A4, in all modes except THD.

3.3.6 Regulated Power Supply, A1 (Ref. Figure 4.4)

A center tapped transformer (Ref. Figure 4.19) converts the 115 V ac line voltage to 36 Vrms. This secondary voltage is applied to CR1 and CR2 which provide full wave rectification. Capacitor C1 filters the positive 23-volt output. R1 is a bleeder resistor, while R12 provides current to the LED power-on indicator. The decoupling network of R2 and C3 provides input dc to integrated regulator circuit U1. A positive regulated voltage of 15 volts is provided for all analyzer circuits. CR7 prevents negative latch-up. The variable voltage divider circuit composed of R3, R4 and R5 provides an adjustable reference voltage for U1, allowing adjustment of the supply output voltage. C7 filters the reference voltage to ensure stability. The regulated negative 15 volts is derived by an identical circuit except for polarity of components.

SECTION 4 MAINTENANCE

4.1 GENERAL

The troubleshooting procedures given in this section should enable a qualified technician to determine the specific component or adjustment responsible for a malfunction. Replacement of components in a module or performance of alignment procedures should not be attempted unless the equipment specified for performance of the module alignment is available. If there is any doubt as to the advisability of a maintenance operation, factory consultation or service should be sought (REF. title page).

4.2 PERIODIC MAINTENANCE

The AA-51 has no periodic maintenance requirements.

4.3 ALIGNMENT PROCEDURE/PERFORMANCE TEST

The following procedure may be used to perform alignment and calibration of the AA-51 and to verify analyzer performance. Alignment should be attempted only if accurate test equipment of the type specified, and qualified personnel, are available.

Test and adjustment points may be located by referring to Figure 4.2 or to the appropriate component location diagram.

4.3.1 Power Supply, A1

- a. Adjust R5 for +15 V dc ± 20 mV at Pin 6.
- b. Adjust R6 for -15 V dc ± 20 mV at Pin 18.
- c. Check for approximately +22 V dc ± 1 V dc at Pin 8.
- d. Check for approximately -22 V dc ± 1 V dc at Pin 16.

4.3.2 Voltmeter Assembly, A7

- a. Switch power off. After the meter pointer settles down, check it for zero indication. If it is off, adjust it to zero through the hole below the meter with a small screwdriver.
- b. Place analyzer in VM mode. Set meter range to 10 V. Switch power on.
- c. Apply a 1 kHz, +20 dBm signal to analyzer input and adjust R26 on BD-50 for reading of +20.0 dBm. Signal source: distortion $< .5\%$. Level accuracy .1 dBm. Check with meter of known accuracy.
- d. Apply a 100 kHz, +20 dBm signal to the analyzer input, adjust C3 on BD-51 for reading of +20.0 dBm.

- e. Apply a 1 kHz, 300 mV signal to analyzer input. With analyzer in VM mode, note meter reading. Place analyzer in NOISE mode and check that reading remains the same.
- f. With analyzer in NOISE mode and meter range set to .3 V, apply a 300 mV input signal. Vary input signal frequency over range of 18 Hz to 22 kHz and check that meter reading decreases by 3 dB at 20 ± 2 Hz and 20 ± 2 kHz.

4.3.3 Leveler, A2

To perform alignment of the A2 circuit board, the analyzer must be connected to a source of a 1 kHz sine wave of variable amplitude from 0 to 80 Vrms. The voltages specified should be read with an accurate RMS voltmeter.

- a. With analyzer in VM mode and input signal level set at 3.8 Vrms, adjust R47 so that relay K1 just activates.
- b. Place analyzer in VM mode. Set signal source amplitude at 80 Vrms as indicated on analyzer meter. Adjust R46 so that HIGH indicator (front panel) just illuminates.
- c. With analyzer in VM mode, set signal source amplitude at 6 Vrms. Place analyzer in PHASE mode. Adjust R21 so that HIGH indicator just illuminates.
- d. With analyzer in VM mode, set signal source amplitude at 300 m Vrms. Place analyzer in PHASE mode. Adjust R42 so that LOW indicator just illuminates.
- e. Place analyzer in TUNE mode and press rear panel LEVEL pushbutton. Adjust R25 so that the analyzer meter reads 1 V for all input signal levels between .1 and 80 Vrms.

4.3.4 Phase and Ratio Detector, A3

To perform alignment on the A3 circuit board, the L and R analyzer inputs must be supplied with identical 1 kHz sine wave signals from a generator with dual isolated outputs such as the Potomac Instruments AG-51.

- a. Place analyzer in RATIO mode. Connect identical 1 Vrms signals to the L and R inputs. Adjust R21 for a 0 (center scale) meter reading.
- b. Insert 6 dB attenuator in left channel input signal; check meter reading of +6 dB. Insert 6 dB attenuator in right channel input signal; check meter reading of -6 dB.

NOTE

If the Potomac Instruments AG-51 is used as a signal source without terminating resistors, 6 dB attenuation may be provided by placing a 600 ohm resistor from the output signal "hot" lead to ground. For other signal sources the value of this resistor must be chosen according to the output impedance of the generator used.

- c. With identical 1 Vrms signals applied to the L and R inputs, adjust R19 for a 0⁰ meter reading with analyzer in the PHX10 mode.

- d. Insert phase shift network* in right channel and adjust signal frequency until $+180^\circ$ phase reading is obtained. Move phase shift network to left channel and check for -180° phase reading.

***NOTE**

If the Potomac Instruments AG-51 is used as a signal source, a $.1 \mu\text{F}$ capacitor connected between the output signal "hot" lead and ground will provide a phase shift of 45° at 2650 Hz.

- e. With identical signals applied to L and R inputs, adjust R17 for a meter reading of 0° with analyzer in the PHX3 mode.
- f. Insert phase shift network in right channel and adjust signal frequency until $+45^\circ$ phase reading is obtained. Move phase shift network to left channel and check for -45° phase reading.

4.3.5 IM/WF Demodulator, A5

4.3.5.1 IM Demodulator Circuit

To perform alignment of the IM demodulator circuit, a special IMD test signal must be provided consisting of a 60 Hz signal with 7 kHz modulation at an amplitude ratio of 4:1. To provide simulated intermodulation distortion, a 7.2 kHz signal must be added to this composite at an amplitude equal to 10% of the 7 kHz signal. The AG-51 Generator provides a simple means of doing this. This simulated distortion should provide a meter reading of 10%. The required composite signal may be provided by summing the outputs of as many signal generators as necessary through 100 k ohm resistors as shown in Figure 4.1.

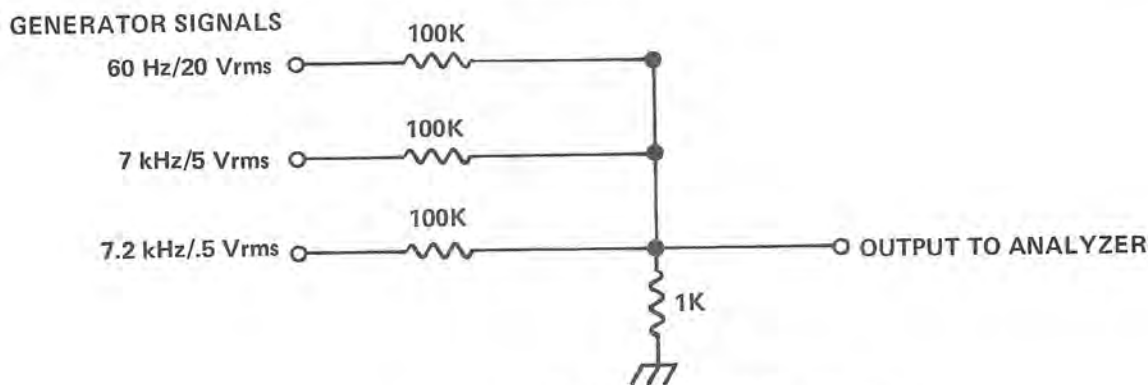


Figure 4.1. IMD Test Signal Network

If the Potomac Instruments AG-51 is used as a signal source, the 7.2 kHz signal may be introduced at TP3 (blue) on the A4 board. Adjust the voltage of this signal to 10% of the voltage at TP1 (orange).

Any signal generator used as a signal source for this procedure must be capable of producing low distortion sine waves having 0.5% or less THD.

- a. Place analyzer in IMD mode with the 60 Hz and 7 kHz signals only applied to the analyzer; check that residual distortion reading on meter is less than .03%.
- b. Add 7.2 kHz component to composite to composite test signal, as described above, and adjust R5 for 10% reading on meter.

4.3.5.2 Wow and Flutter Demodulation Circuit

Normal calibration: at AA-51 input apply 1 V signal at 3150 Hz frequency modulated by 4.0 Hz sine wave, with peak frequency deviation of 1% (31.5 Hz); adjust R26 for meter reading of 1%. Change frequency deviation to 0.3%, mode switch to 0.3%, adjust R23 for meter reading of 0.3%. If such a signal source is not available use steps a-b-c.

- a. Place analyzer in 1% W & F mode. Apply a 4 Hz/100 mV Rms sine wave to the wave to the junction of R35 and R36 through a 1 μ F capacitor. Adjust R26 for a reading of 1% on meter.
- b. Place analyzer in .3% W & F mode. Apply 4 Hz sine wave input as in step A, but with amplitude of 30 mV rms. Adjust R23 for meter reading of .3%.
- c. Check performance of frequency discriminator circuit by applying a 3150 Hz sine wave to the analyzer input and reading voltage at pin 7 of U5. D.C. voltage at this point should vary in a linear manner as frequency of signal is changed slowly, with a slope (voltage change divided by frequency change) of 4.4 mV/Hz.

4.3.6 Null Amp, A6

- a. Place analyzer in TUNE mode with no signal input. Check the DC voltage levels at pins 3 and 4 of connector A6J1; these voltages should be less than .1 Vdc. Check the emitter voltage of Q18, this voltage should be $-7.4 \text{ Vdc} \pm 100 \text{ mV}$.
- b. Using an ohmmeter, measure the resistance between the TP3 (blue) and TP4 (red). Adjust pots R31, R32 and R33 according to the following chart so that in each case the proper resistance is measured between TP3 and TP4.

Set FREQ Range	Adjust Pot	TP3/TP4 Resistance
X1	F R31	2.7 M Ohms
X10	E R32	270 K Ohms
X100	D R33	27 K Ohms

Using an ohmmeter, measure the resistance between TP1 (orange) and TP2 (yellow). Adjust pots R28, R29 and R30 according to the following chart so that in each case the proper resistance is measured between TP1 and TP2.

Set FREQ Range	Adjust Pot	TP1/TP2 Resistance
X1	B R28	2.7 M Ohms
X10	A R29	270 K Ohms
X100	C R30	27 K Ohms

NOTE

When making these adjustments, allow sufficient time for readings to settle (5 - 10 sec.). Tolerance for settings is $\pm 10\%$. The Ohmmeter used for these measurements must be a type which will not pass excessive current through the current-controlled resistor elements. If excessive current is used in measuring the impedance of these elements, the resulting reading will be inaccurate. A digital ohmmeter is preferable, but a Simpson 260 or similar VOM may be used.

- c. Repeat steps b and c to ensure stabilization. The resistance settings are temperature sensitive, but are not very critical for proper operation of the auto-null circuit.
- d. With analyzer in TUNE mode, set FREQ range at X10 and FREQ dial at 20 (200 Hz). Apply a 200 Hz signal to analyzer input. Adjust R27 (G) for minimum reading on meter.
- e. With analyzer in TUNE mode, set FREQ range at X10 and FREQ dial at 200 (2 kHz). Apply a 2 kHz signal to analyzer input. Adjust trimmer capacitor C19 for minimum capacitance (silvered area toward Q9). Adjust trimmer capacitor C11 for minimum meter reading, then carefully adjust FREQ dial to further minimize meter reading; repeat this process until no further improvement can be obtained.
- f. Check analyzer performance in the X1 and X100 frequency ranges (TUNE mode) as follows: Set FREQ range at X1 and FREQ dial to 20. Apply a 20 Hz test signal to analyzer input and tune FREQ dial for null. Check that meter reading is similar to that obtained in step (e). Set FREQ dial to 200, apply a 200 Hz test signal and tune for null. Again note meter reading, which should be as in step (e). Repeat this procedure for the X100 FREQ range, using 2 kHz and 20 kHz test signals.

4.3.7 Quadrature Detector, A4

- a. Place analyzer in TUNE mode, apply a 200 Hz test signal to the analyzer input and set FREQ range to X10; tune for null. Switch generator mode to THD and check for proper automatic null action (meter reading should decrease to minimum). Observe scope output signal with an oscilloscope; if analyzer operation is correct the fundamental frequency should not be visible. Slightly move FREQ dial; meter reading should increase and settle back, and fundamental frequency voltage should appear on the oscilloscope and then decrease to a low level.
- b. Adjust pots R13 and R36 for minimum meter reading, alternating between pots until no further improvement can be achieved. The null is broad; set the pots at the center of the range over which no further decrease in the reading is seen.

4.4 TROUBLESHOOTING, GENERAL

The troubleshooting chart provided in Table 4.1 may be used to isolate AA-51 malfunctions to a circuit card or switch network. Once a malfunction has been isolated to a specific board or switch, reference should then be made to the detailed troubleshooting information for that circuit in Section 4.5.

The following notes and suggestions will be helpful in troubleshooting the AA-51:

- For checking plug-in boards in operation, an extender card is available from Potomac Instruments for \$20.00.
- Always check power supply voltages before checking other circuits.
- To check signal voltages, an oscilloscope with accurate voltage calibration is recommended, as the scope will show oscillations, distortion, hum and other effects not shown by meter readings.
- In case of circuit failure, feel board for hot components.
- Use the AA-51 Block Diagram, Figure 3.1, to follow signal paths through modules and switches to the outputs; it will serve as a guide when tracing the actual circuits on the various schematic diagrams.
- If the correct signal appears at a module output but not at the input of the next module, switch contact failure is a likely cause. The switch circuits to check can be identified on the block diagram and then traced out using the schematic diagram.

TABLE 4.1 AA-51 BOARD-LEVEL TROUBLESHOOTING

SYMPTOM	CHECK
1. Analyzer operation abnormal in all modes	A1; meter; S3D, E
2. VM, NOISE, IMD, THD modes abnormal PHASE, RATIO, W & F modes normal	A7A2; A7A3
3. NOISE mode only abnormal	A7A1
4. W & F or IMD modes only abnormal	A5; S3A, B
5. PHASE and/or RATIO mode only abnormal	A3; S3A, B, G, F, H, M, N
6. IMD, THD, W & F modes abnormal PHASE, RATIO, VM, NOISE modes normal	A2
7. THD mode only abnormal	A4; A6; S2A; S3A, B; S5
8. Improper operation of HIGH/LOW indicators	A2; A4; S1E
9. Scope output only abnormal	S3K
10. PHASE, RATIO modes normal all other modes abnormal	S4

4.5 CIRCUIT MODULE TROUBLESHOOTING

4.5.1 General

All circuit boards and test points may be accessed after removal of the top and bottom covers. The covers are attached by screws and the removal procedure is self-evident. For the location of circuit modules and test points, refer to Figure 4.2. Test points may be accessed without removing circuit boards from the chassis; however, component voltage measurements require the use of a module extender board for those modules on the top of the chassis. IC and transistor pin voltages are listed in Tables 4-2 through 4-7; these readings are taken in TUNE mode with no signal input. Voltage readings are DC voltages read with a voltmeter of 10 Megohm input impedance, with a 22K series resistor at the probe to isolate the probe capacitance from the circuit.

The following procedures may be used to isolate circuit board malfunctions which cannot be corrected by alignment.

4.5.2 Power Supply, A1

If the +15 V regulated output cannot be adjusted to exactly +15 V, U1 or associated components may be faulty or the unregulated voltage at pin 8 may be low or have excessive ripple. If the unregulated voltage is faulty, check the filter components C1, R2, C3, CR2 and the transformer secondary voltage.

If the -15 V regulated output cannot be adjusted to exactly -15 V, U2 or associated components may be faulty or the unregulated voltage at pin 8 may be low or have excessive ripple. If the unregulated voltage is faulty, check the filter components C2, R10, C4, CR3, CR4 and the transformer secondary voltage.

4.5.3 Leveler, A2

4.5.3.1 Signal Path Malfunction

Malfunction of the leveler circuit which involves improper output amplitude or distortion may be isolated by tracing an input signal through successive stages of the circuit with an oscilloscope, observing the proper gain and waveform appearance at each stage. Normal values for stage gain are given on the Analyzer Block Diagram, Figure 3.1. The attenuator circuit associated with relay K1 should be checked by increasing input signal level and noting proper relay action, i.e., 21.5:1 attenuation for signals above 3.8 Vrms. Operation of the current-controlled attenuator feedback loop (U5A, U5B, Q4) may be partially checked by varying input signal amplitude and observing linear response of output signals, allowing for the action of K1. Increasing the input signal should result in an increase in the voltage at the emitter of Q4, indicating a higher control current and lower resistance in LR1.

When the malfunction has been isolated to a stage by signal tracing, or if a malfunction of the current-controlled attenuator feedback loop is suspected, pin voltages of active components may be checked by referring to the voltage charts provided at the end of this section.

4.5.3.2 Monitor Path Malfunctions

If improper operation of the HIGH indicator is noted, check pin voltages of U2C and U2D. If relay K1 is not properly activated, check pin voltages of U2B and Q8. If improper operation of the LOW indicator is observed, check pin voltages of U1A, U1B and U2A. If all the above malfunctions are noted, check transistor Q1.

4.5.4 Phase and Ratio Detector, A3

The following procedures require connection of signal sources to the L and R inputs of the analyzer. The amplitude of one of the sources must be adjustable. If the AG-51 is used, one output may be increased or decreased 6 dB with respect to the other by removing or adding 600 ohm terminating resistors.

4.5.4.1 Phase Detector Malfunctions

Malfunctions which involve phase detection only may be isolated by checking U1A, U1B and U2. An oscilloscope may be used to check for proper input and output waveforms and/or pin voltages may be checked against the voltage tables provided at the end of this section.

4.5.4.2 Ratio Detector Malfunctions

For malfunctions which involve the ratio detector circuits only, the gate signal of Q3 should be checked with an oscilloscope. If a square wave is present, check to see that the duty cycle changes (0.6V approx. V_{rms} input amplitude = 50% duty cycle) with variation of the amplitude of L input signal. If this signal appears normal, check pin voltages of U4, U5A, Q3, U5B and U5C against the voltage tables provided at the end of this section.

If the square wave signal is not present at the gate of Q3 or Q4, check the operation of oscillator U1C/U6 by observing triangle wave output at pin 6 of U6 and checking pin voltages of U1C and U6. If oscillator operation appears normal, check the components of the duty cycle modulation loop; U1D, Q4, U8B, U8C, U8D by checking pin voltages against the tables provided at the end of this section.

If the square wave signal is present at the gate of Q3 but its duty cycle is abnormal, check the pin voltages of U1D, Q4, U8B, U8C and U8D.

4.5.4.3 Phase and Ratio Detector Malfunctions

If both phase and ratio detector operation is abnormal, check pin voltages of U3, A1 and Q2.

4.5.5 Quadrature Detector, A4, and Null Amp, A6

Troubleshooting of the A4 and A6 boards must take into account the interaction between these two circuits. The following procedures treat these two boards as a functional unit for diagnostic purposes. Within this functional unit, the circuit most likely to be at fault may be identified by carefully checking the operation of the analyzer in THD mode on signals with known low harmonic content in various frequency ranges, observing the null circuit output with an oscilloscope at the SCOPE terminal, with external sync to the oscilloscope from the signal source.

In normal operation, as the dial is tuned to the correct frequency in the TUNE mode, the fundamental frequency component should go to a minimum value but still be visible. Upon switching to the THD mode the fundamental should disappear with only harmonics, hum, and noise remaining. If the dial is shifted slightly the fundamental should reappear and then disappear when the automatic nulling circuits are working.

If the automatic nulling does not seem to function normally, the problem may be in the voltage-tuned Wien bridge circuit on board A6, or the controlling circuits on board A4.

Problems on A6 usually show up in the TUNE mode, as inability to obtain the normal dip to 10 - 20 percent of full scale with the dial approximately at the input frequency. Normally the dial setting deviates noticeably from the input frequency only at a setting of 200 on the X1 range, where the setting for a dip is above the 200 mark. Inability to obtain a satisfactory dip may mean that the required settings of pots R27 - R33 (A - G) have drifted and that these pots need to be readjusted as described in Paragraph 4.3.6. This should be done before attempting to replace components. A shallow dip on all frequency ranges indicates that R27 needs adjustment; problems on one range only indicate that the corresponding pots described in 4.3.6 need adjustment. If the pots associated with a particular current-controlled resistor (LR1, 2, or 3) cannot be adjusted, and all voltages are normal, then the LR device must be replaced. Failure of U1, Q10, Q11, or Q12 will

be indicated by dc voltage measurements.

A problem in one range only may also be due to failure of one of the switch transistors Q1 - Q8 in the Wien bridge circuit.

Failure of U3, U4, or Q15 will be indicated by waveform checks.

Problems on the Quad Detector Board A4 will in most cases affect all frequency ranges in the same way. Waveform and voltage checks in the TUNE and THD modes will identify faulty components. If in the THD mode a sharp null does not occur automatically but can be obtained by manual tuning, the fault is in U4 or its associated circuits, or U3B-C and Q2. If the Wien bridge appears to lock on in frequency but does not produce a sharp null indication, free of the fundamental frequency, the fault is in U2 or its associated circuits, or in U3A or Q1. If nulling action is normal but the HI-LO indicator light is not, the fault is in U5 or Q5.

4.5.6 IM/WF Demodulator, A5

Lack of meter indication in either IM or W & F modes can be caused by lack of input signal due to failure of the A2 module. This may be checked by switching to the TUNE mode and looking for the normal full-scale meter indication, with the FREQ controls tuned *away* from 60 Hz, 3.15 kHz, or 7 kHz.

Malfunctions involving the IM demodulator circuit may be isolated by checking the pin voltages and waveforms of U1A, U1B, U2, U3A and U3B.

Malfunctions of the wow and flutter demodulator circuits may be isolated by checking the pin voltages and waveforms of U4, U5A, U5B, U5C, U5D, Q1, U6A and U6B.

4.5.7 Voltmeter Circuit Assembly, A7

If the malfunction is noted in NOISE mode only, check U1A and U1B. If malfunction occurs in VM, IMD and THD modes, determine whether problem affects all meter ranges; if it does not, check switches S2A, S2B and their associated attenuator networks. If all meter ranges are equally affected by the malfunction, check Q1 and Q2 on the A7A3 board, Q3; Q4, Q5 and Q6 on the A7A2 board.

Table 4.2. Voltage Readings, Leveler, A2

Conditions: +10 dBm (2.35V), 1 kHz input. MODE at VM.

Transistor Pin Voltages

PIN	Q1	Q2	Q3	Q4	Q5	Q6	Q7
E/S	+1.3*	-0.67	+15.0	+4.5*	+4.5*	-0.5	+14.5
B/G	0	0	+14.3	+5.1*	+4.5*	+13.8	+13.8
C/D	+15.0	+14.3	-0.67	+13.4	0	0	-0.5

Integrated Circuit Pin Voltages

PIN	U1	U2	U3	U4	U5
1	0	+13.4	0	---	+4.6
2	0	+0.1	+13.8	-1.3	0
3	0	+15.0	+11.3	-1.3	0
4	-15.0	+5.1	+11.3	+15.0	-15.0
5	+0.8	+3.4	0	-15.0	+4.6
6	+0.8	+3.6	0	-2.6	+4.6
7	+3.4	+14.5	-15.0	+15.0	+5.2
8	+15.0	+0.5	0	---	+15.0
9		+3.6	0		
10		+1.1	+11.3		
11		+5.7	+11.3		
12		0	+13.8		
13		+13.4	0		
14		+13.5	+15.0		

*considerable variation

Table 4.3. Voltage Readings, Phase and Ratio Detector, A3

Conditions: Equal signals of +10 dBm (2.35V rms) at 1 kHz to L and R input. MODE at PHX10.

Transistor Pin Voltages

PIN	Q1	Q2	Q3	Q4
E/S	+1.6*	+1.6*	+0.2	+0.2
B/G	0	0	-13	-13
C/D	+15	+15	+3.2	+3.2

Integrated Circuit Pin Voltages

PIN	U1	U2	U3	U4	U5	U6	U7	U8
1	0	+7.4	-15	0	+3.1	-15	0	+3.1
2	-1.4	+7.5	0	+3.2	+0.2	0	+3.2	+0.2
3	+15	+6.4	0	0	+0.2	0	0	+0.2
4	0	+0.1	-15	-15	+15	-15	-15	+15
5	0	+15	-15	0	+1.6	-15	0	+3.1
6	0	0	-0.5	-13	+1.6	+3	-13	+3.1
7	0	0	+15	+15	0	+15	+15	-2.7
8	+0.3	0	--	0	+3.2	--	0	+3.2
9	-2.6	0			+3.2			+3.2
10	0	0			+3.2			+3.2
11	+3	0			-15			-15
12	-15	0			+0.2			+0.2
13	0	+15			+0.2			+0.2
14	-13	+15			+0.2			+0.2

*considerable variation

Table 4.4. Voltage Readings, Quadrature Detector, A4

Conditions: +10 dBm (2.35V) 1 kHz input. MODE at TUNE, FREQ dial adjusted for dip (X10, 100).

Transistor Pin Voltages

PIN	Q1	Q2	Q3	Q4	Q5
E/S	0	0	0	0	0
B/G	-8.5	+6.5	0	0	0
C/D	0	0	0	0	+13

Integrated Circuit Pin Voltages

PIN	U1	U2	U3	U4	U5
1	0	2*	-2.0	+0.4*	-0.6
2	+13.3	1*	0	0.2*	-0.2
3	+11.3	1*	+15	0.2*	-0.2
4	+11.3	+15	0	+15	-15
5	-0.1	0	0	0	-0.1
6	-0.1	0	0	0	-0.2
7	-15	0	0	0	+14
8	---	---	0	0	+15
9	---	---	0	0	
10	---	---	0	0	
11	---	-15	0	-15	
12	---	0	-15	0	
13	---	0	---	0	
14	+15	+0.1	0	+0.03	

*large variation but same ratio, one to another

Table 4.5. Voltage Readings, IM/WF Demodulator, A5

Conditions:

For U1, U2 and U3 – input is IM test signal from AG-51 at +10 dBm. MODE at IM.

For Q1, U4, U5 and U6 – input is 3.15 kHz test signal from AG-51 at +10 dBm. MODE at 1% W & F.

Transistor Pin Voltages

PIN	Q1
S	0
G	-14
D	0

Integrated Circuit Pin Voltages

PIN	U1	U2	U3	U4	U5	U6
1	0	-15	+1.1	0	+7.3	-1 to -14
2	0	+0.6	+1.1	+2.1	+4.6	0
3	0	+0.6	+1.1	+7.5	+4.6	0
4	-15	-15	-15	+7.5	+15	-15
5	0	-15	+1.1	0	+7.3	0
6	0	+1.2	+1.1	+1.9	+7.3	0
7	0	+15	+1.1	+2.1	+7.3	+14
8	+15	---	+15	0	0	+15
9				+6.7	0	
10				+4.6	0	
11				+4.8	-15	
12				+10.6	0	
13				+15	0	
14				+7.1	0	
15				0	---	
16				+15		

Table 4.6. Voltage Readings, Null Amp, A6

Conditions: +10 dBm, 2 kHz input; MODE at TUNE; FREQ X100, Dial at 20

Transistor Pin Voltages

PIN	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
E/S	0	0	0	0	0	0	0	0	0
B/G	-10	0	-10	0	-10	0	-10	0	-10
C/D	0	0	0	0	0	0	0	0	0
	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18
E/S	-.65	-.65	-.65	+1.5*	+1.5*	-0.7	+3.5*	+3.5*	-7.4
B/G	0 ±	0 ±	0 ±	0	-15	+0.1	0	0	-8.1
C/D	+10*	+10*	+8.5	+15	-13*	+15	+15	+15	-15

Integrated Circuit Pin Voltages

PIN	U1	U2	U3	U4
1	-7.3	-0.8	0	0
2	-4.7	-8.6	0	0
3	-11	-8.6	0	0
4	-4.0	-15	-15	-15
5	-15	-0.8	0	0
6	-11	-8.0	0	0
7	-7.3	0	+15	+15
8	-6.6	--	--	--
9	0			
10	-6.9			
11	-11			
12	-4.0			
13	-11			
14	-4.7			
15	-7.4			
16	-6.6			

*considerable variation

Table 4.7. Voltage Readings, Voltmeter, A7

Conditions: +10 dBm, 1 kHz input
 MODE at VM
 RANGE at +10 dB

Integrated Circuit and Transistor Pin Voltages

A7A1		A7A2					A7A3		
PIN	U1	PIN	Q3	Q4	Q5	Q6	PIN	Q1	Q2
1	-0.1	E/S	-0.6	-0.6	+5.2	+5.2	E/S	+2*	+13.7
2	-0.1	B/G	0	0	+4.5	+4.5	B/G	0	+14.4
3	-0.1	C/D	+4.5	+4.5	0	+0.2	C/D	+13.7	+2*
4	-15								
5	-0.1								
6	-0.1								
7	-0.1								
8	+15								

*considerable variation

Top View
Cover Removed

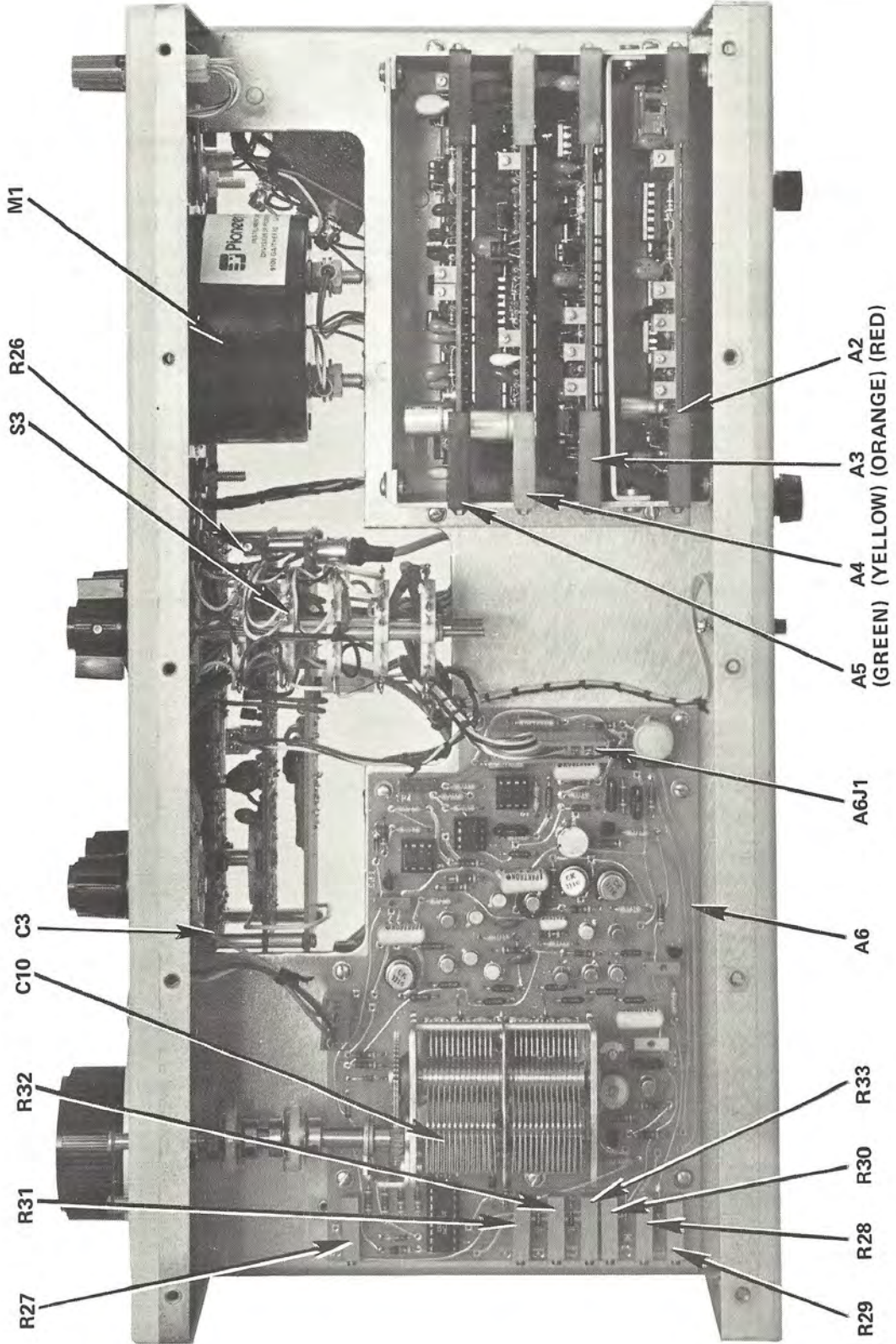


Figure 4.2 Circuit Module and Test Point Location, AA-51, Sheet 1

Bottom View
Cover Removed

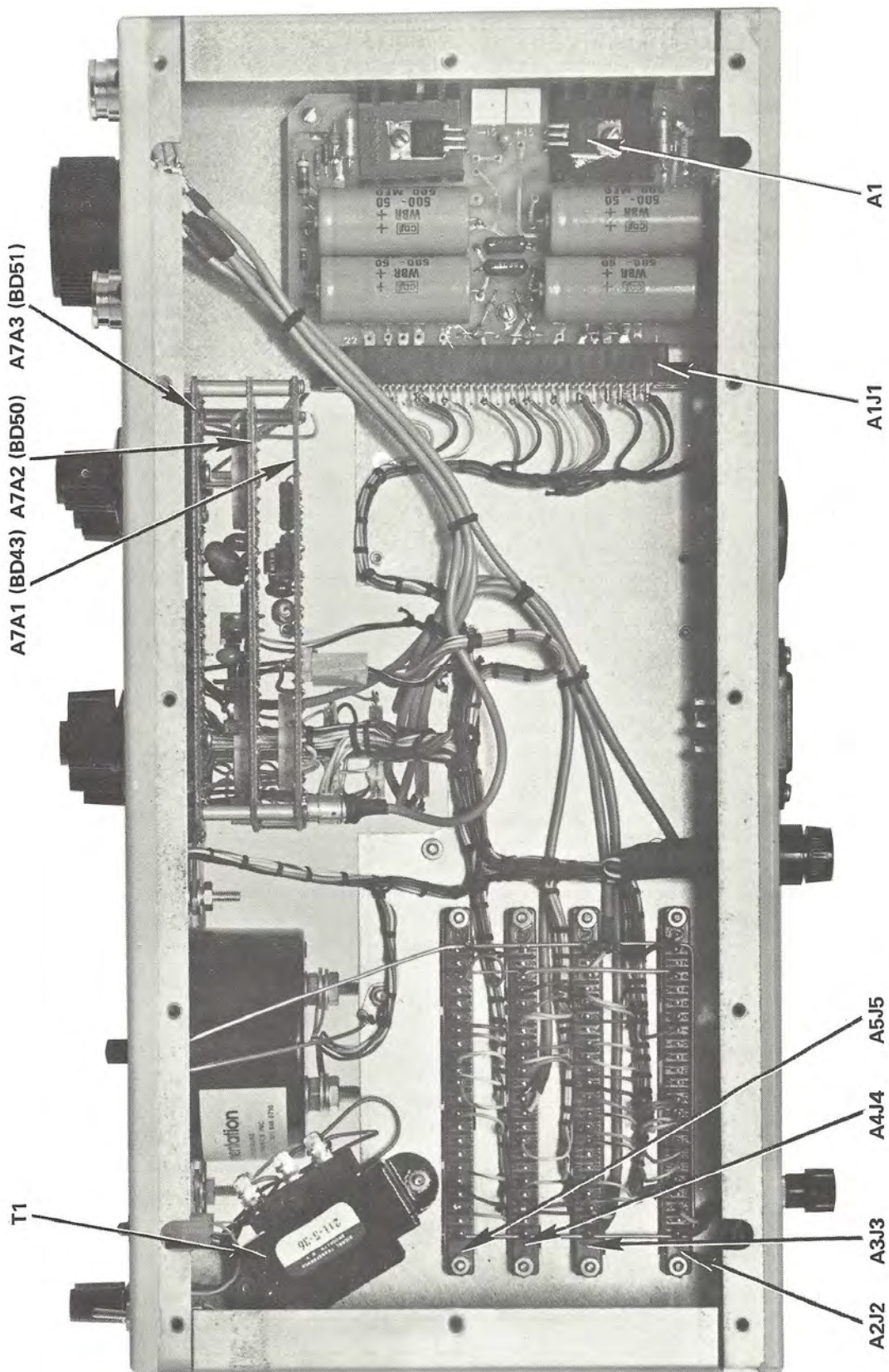


Figure 4.2 Circuit Module and Test Point Location, AA-51, Sheet 2

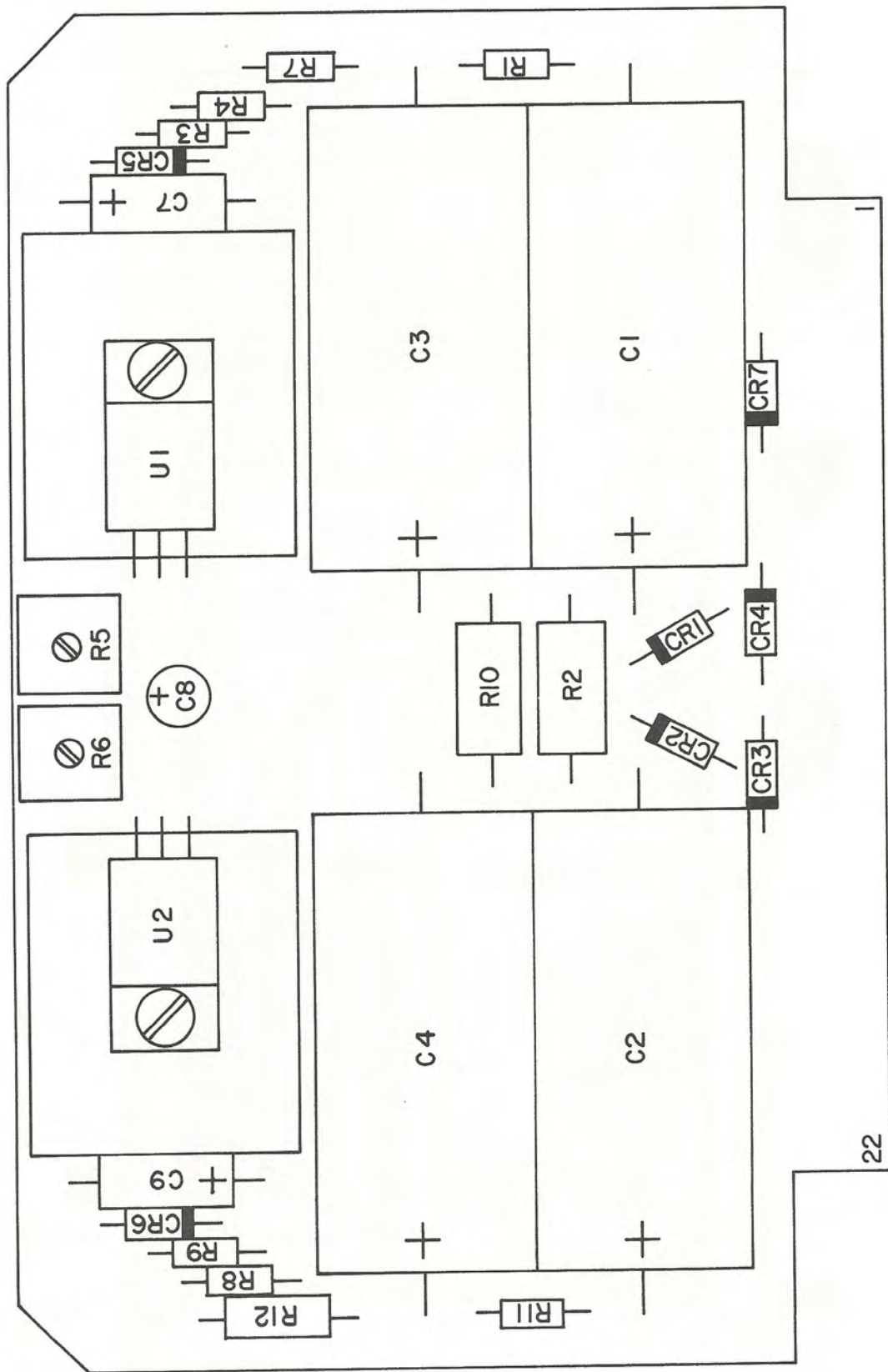
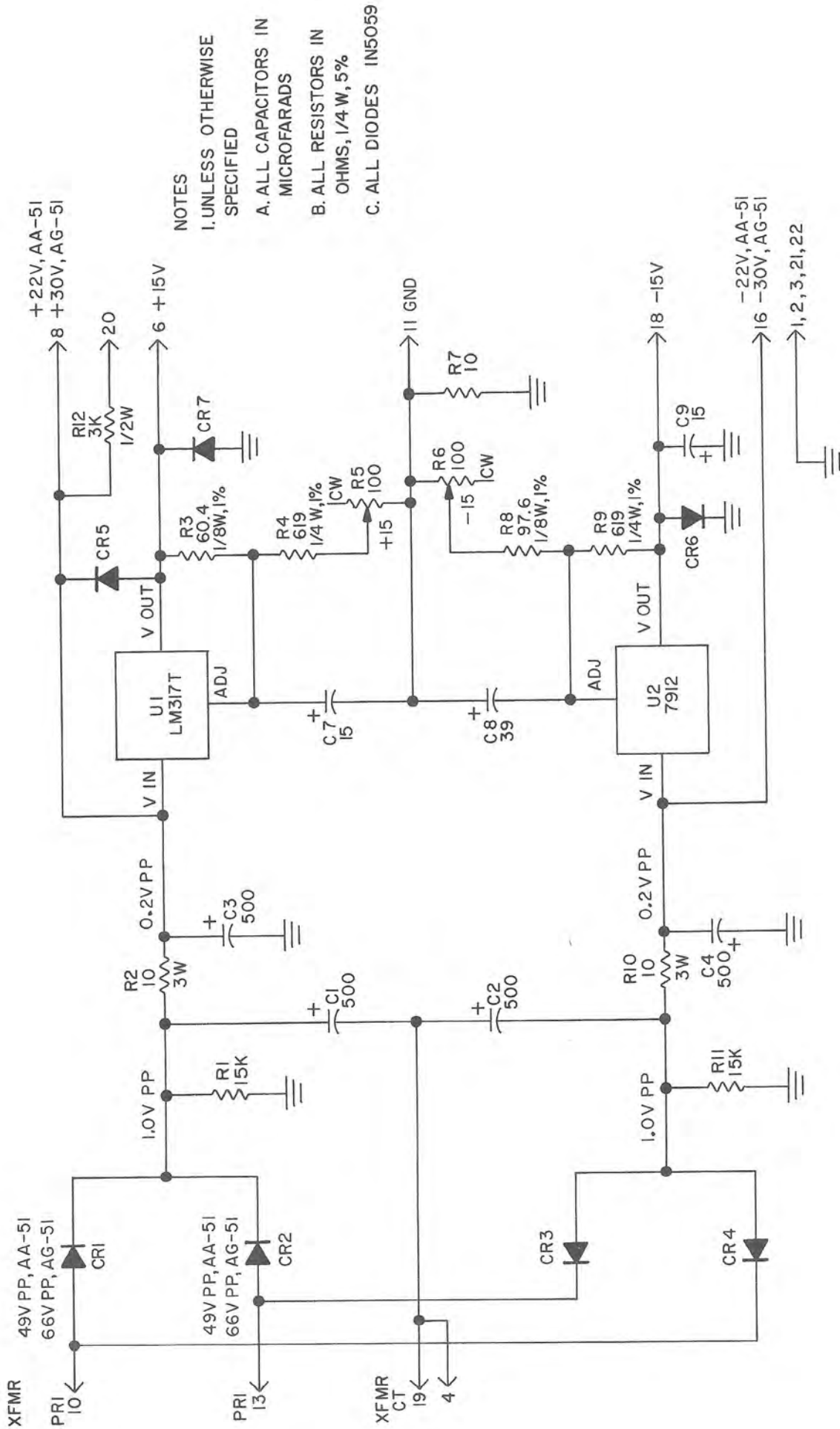


Figure 4.3. Component Location, Power Supply A1



NOTES
 I. UNLESS OTHERWISE SPECIFIED
 A. ALL CAPACITORS IN MICROFARADS
 B. ALL RESISTORS IN OHMS, 1/4 W, 5%
 C. ALL DIODES IN5059

Figure 4.4. Schematic Diagram, Power Supply A1

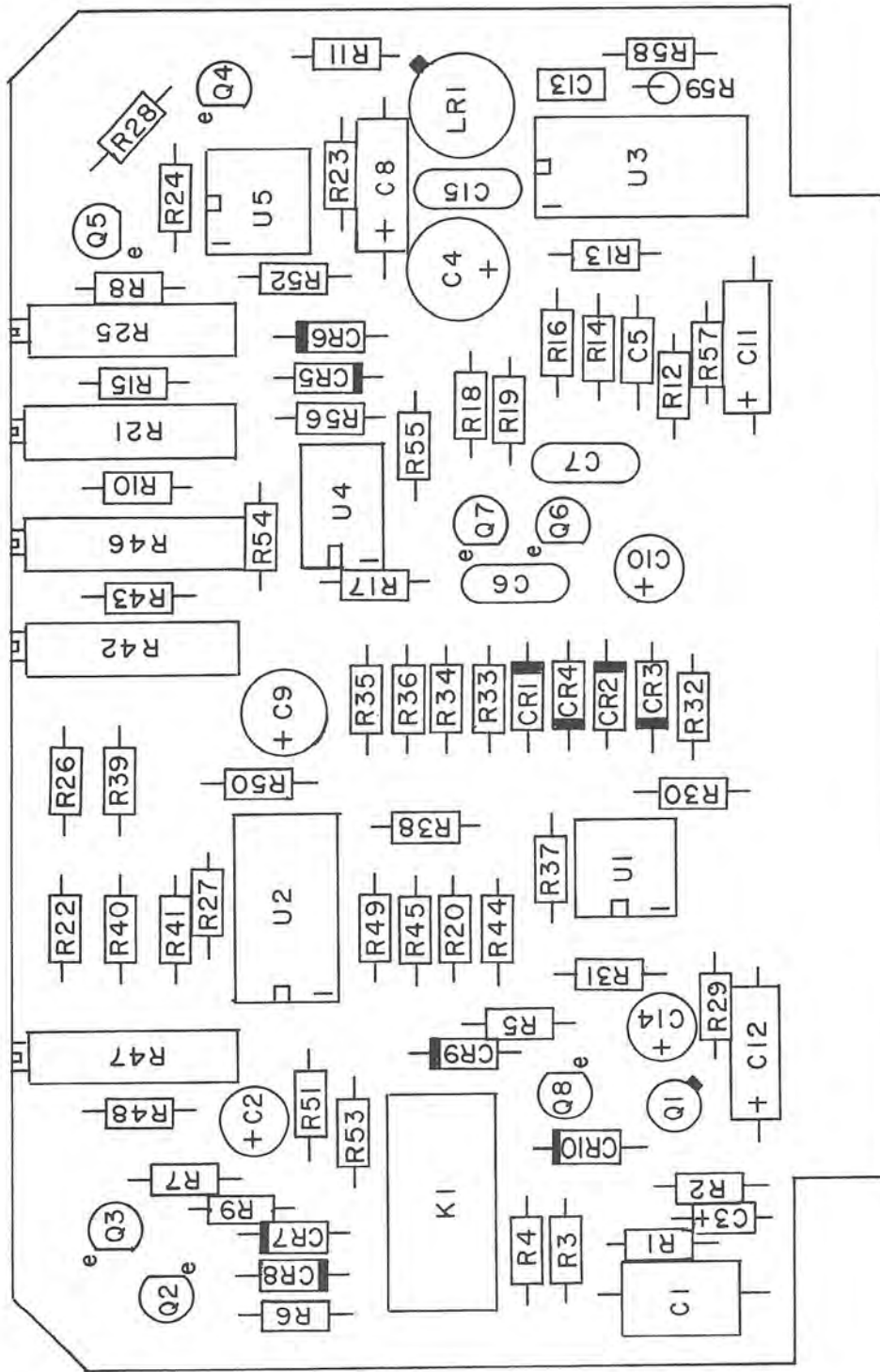


Figure 4.5. Component Location, Signal Leveler A2

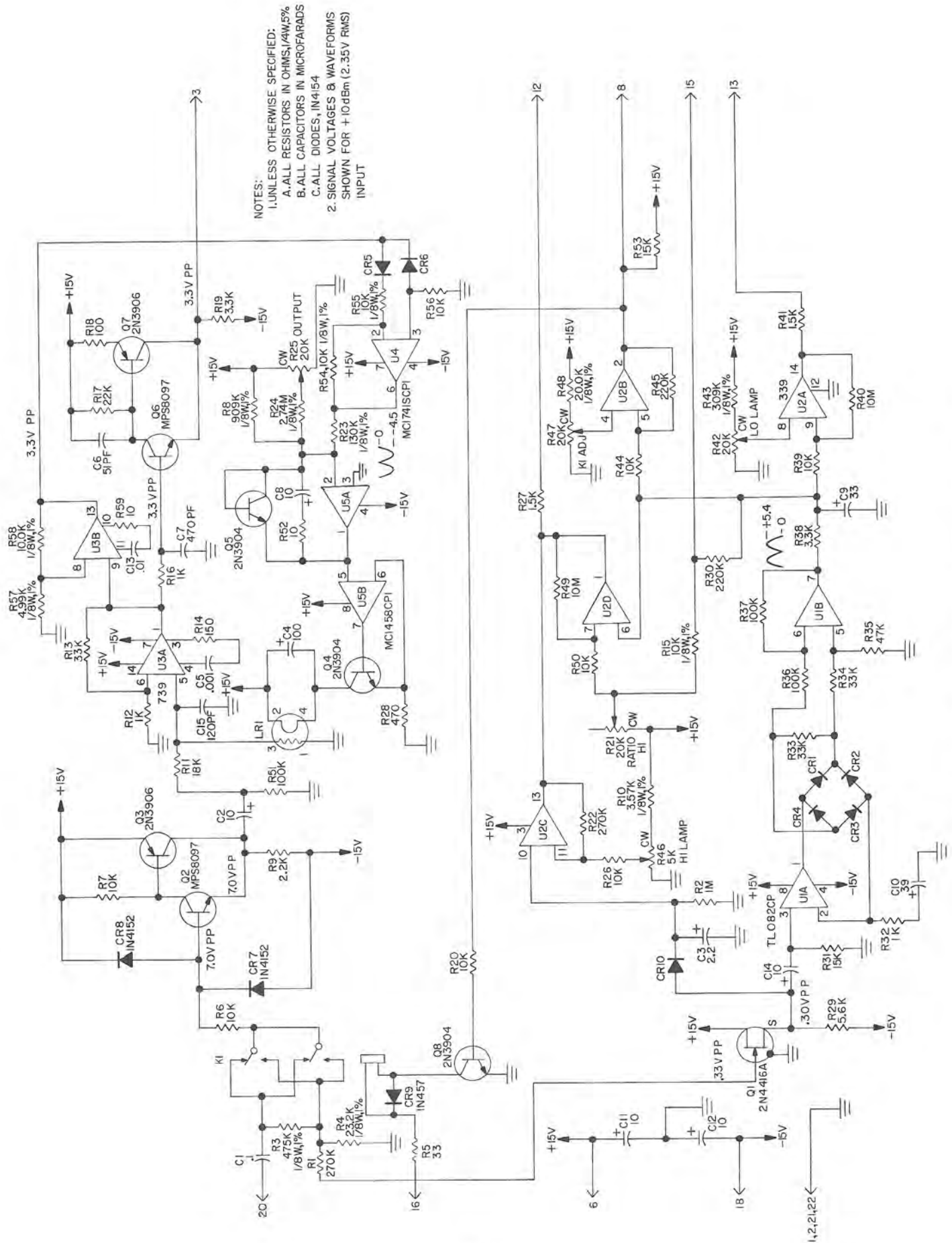


Figure 4.6. Schematic Diagram, Signal Leveler A2

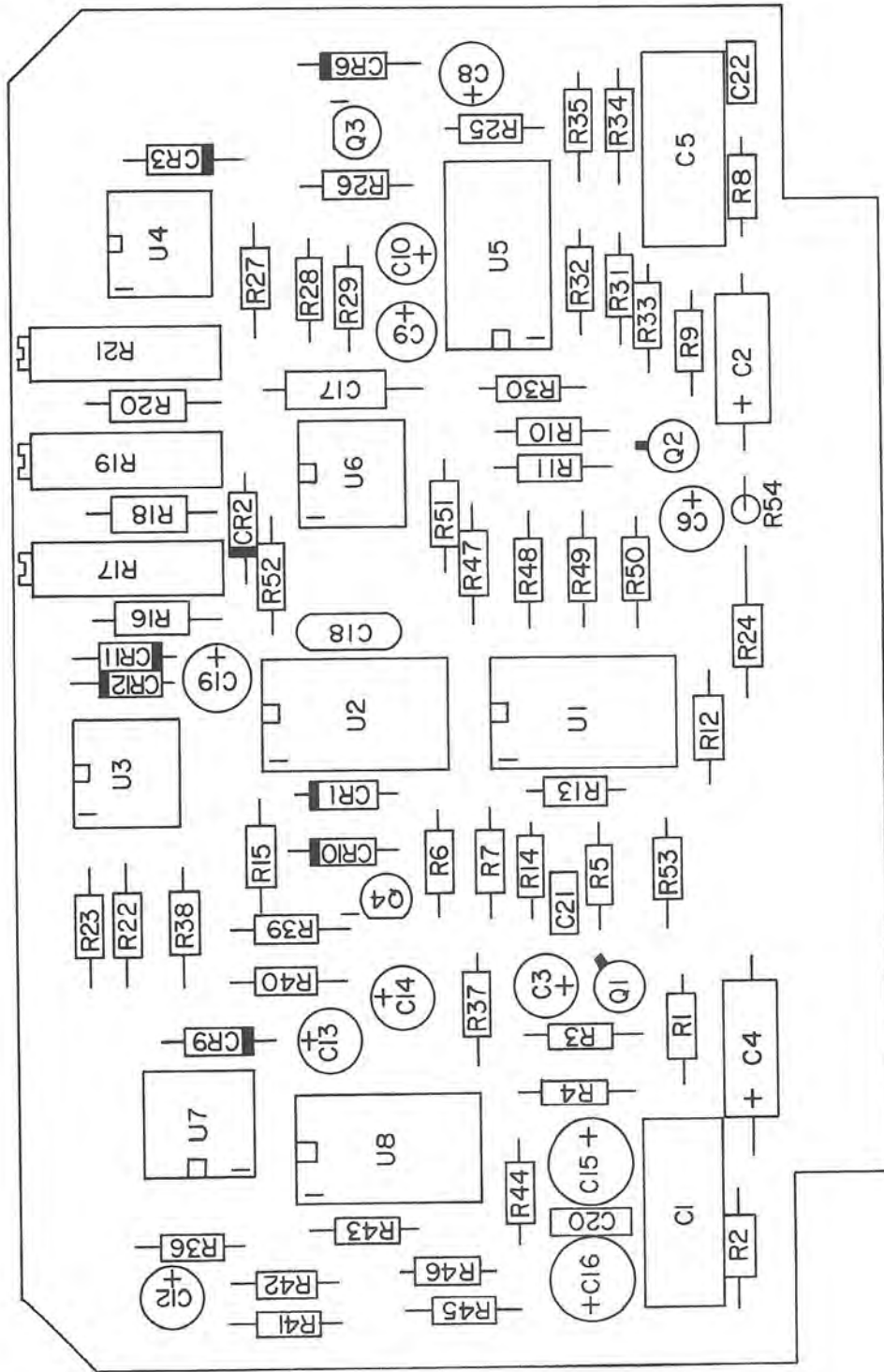


Figure 4.7. Component Location, Phase and Ratio Detector A3

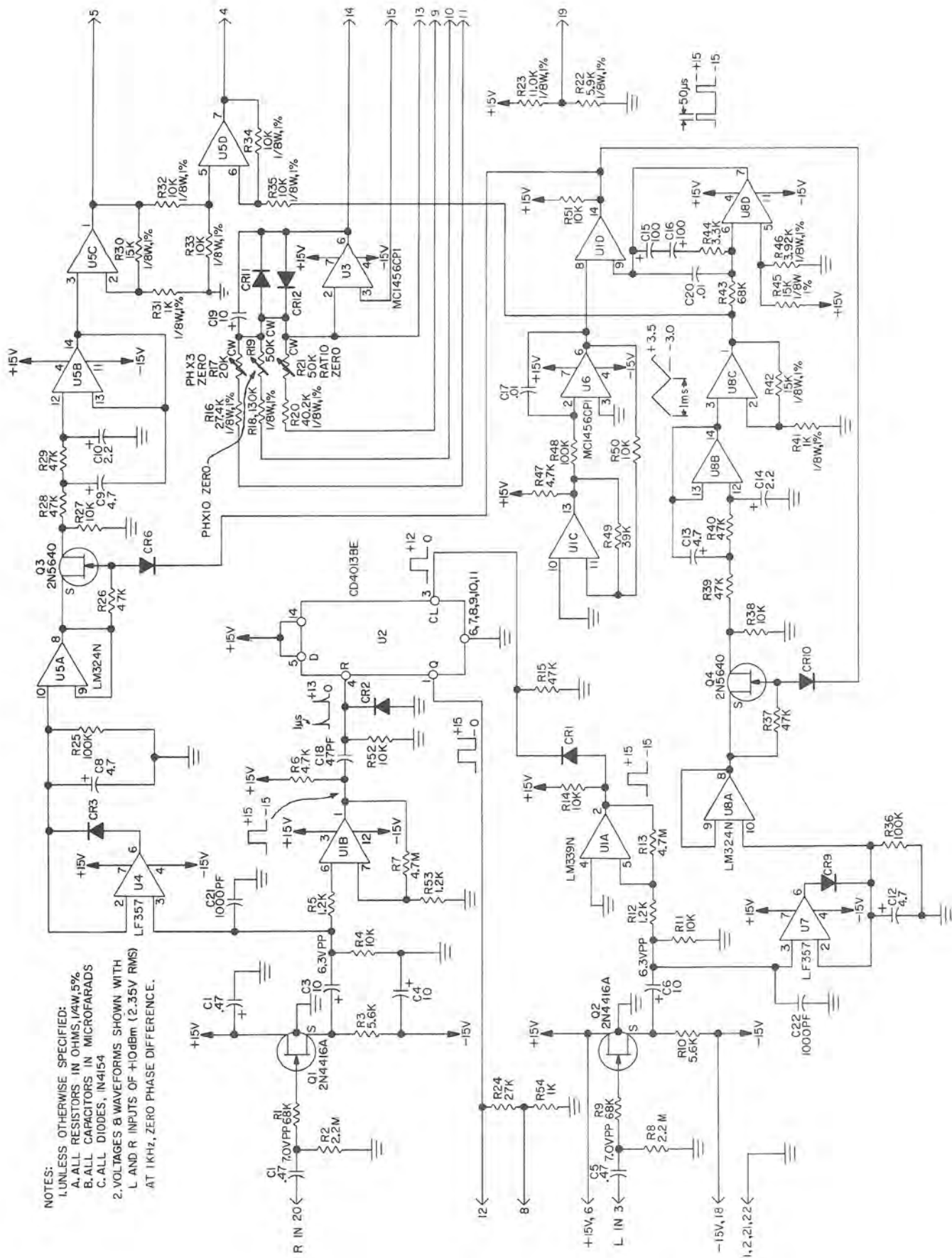


Figure 4.8. Schematic Diagram, Phase and Ratio Detector A3

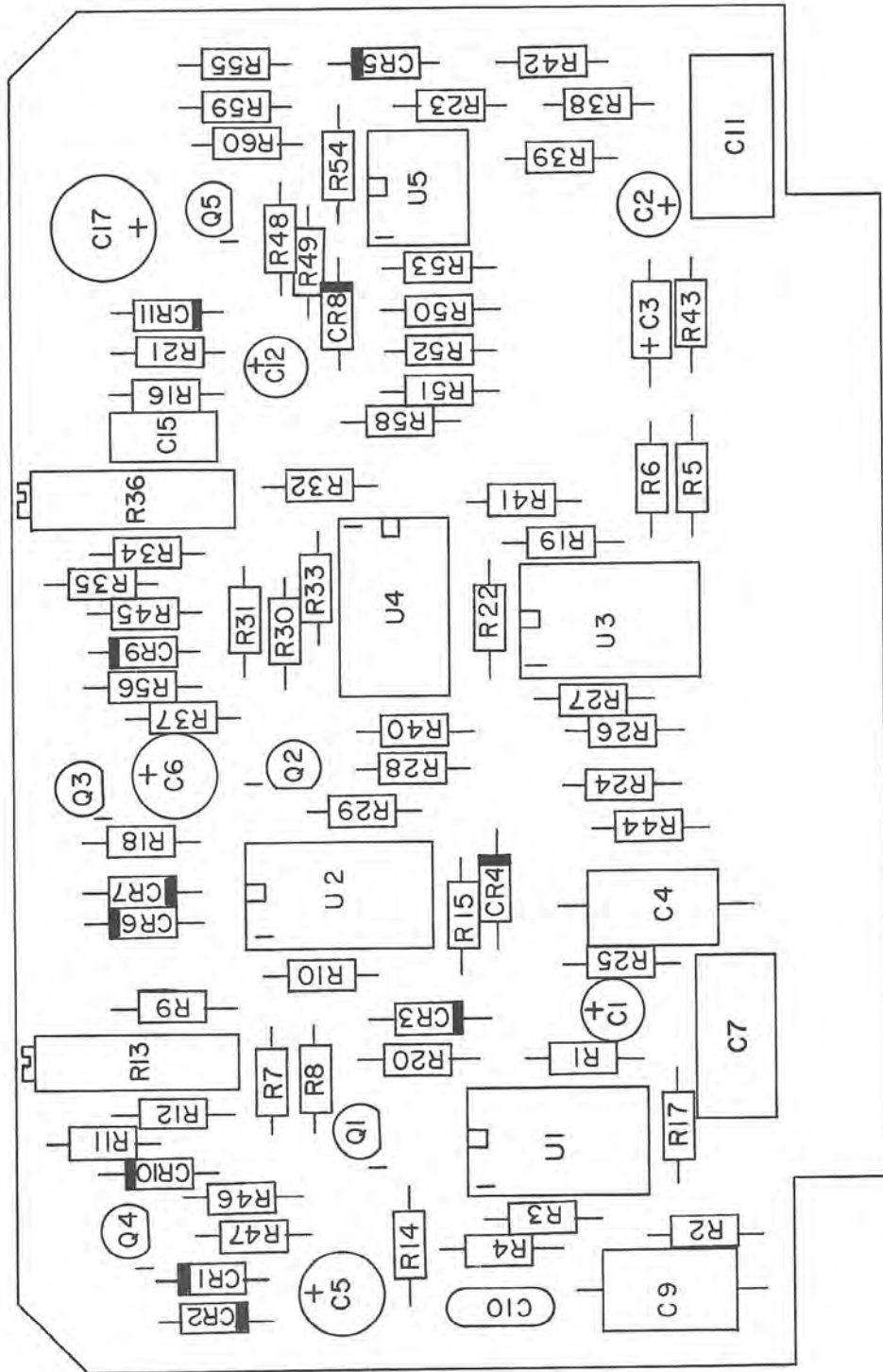
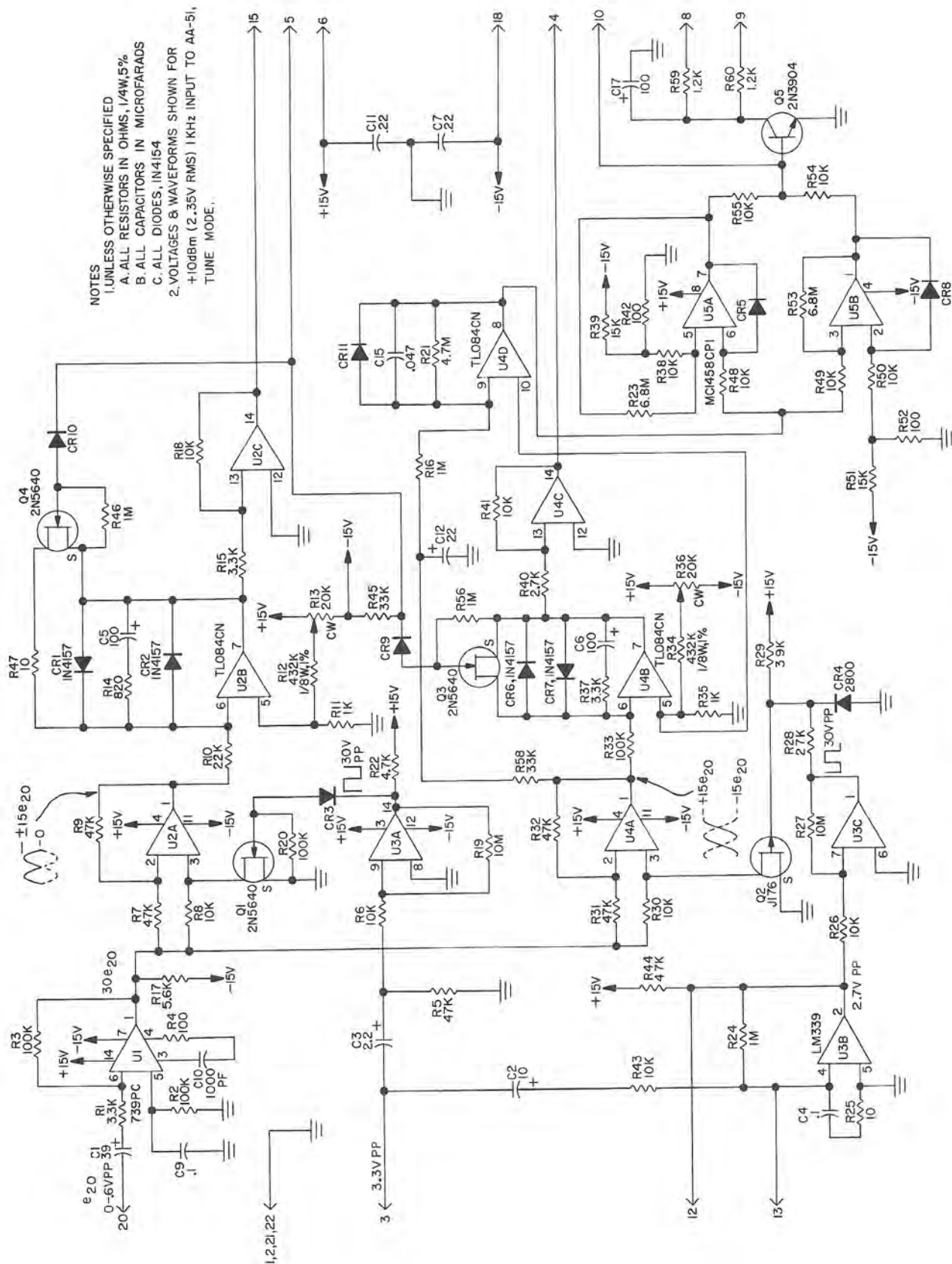


Figure 4.9. Component Location, Quadrature Detector A4



NOTES
 1. UNLESS OTHERWISE SPECIFIED
 A. ALL RESISTORS IN OHMS, 1/4W, 5%
 B. ALL CAPACITORS IN MICROFARADS
 C. ALL DIODES, IN4154
 2. VOLTAGES & WAVEFORMS SHOWN FOR
 +10dBm (2.35V RMS) 1 KHz INPUT TO AA-51,
 TUNE MODE.

Figure 4.10. Schematic Diagram, Quadrature Detector A4

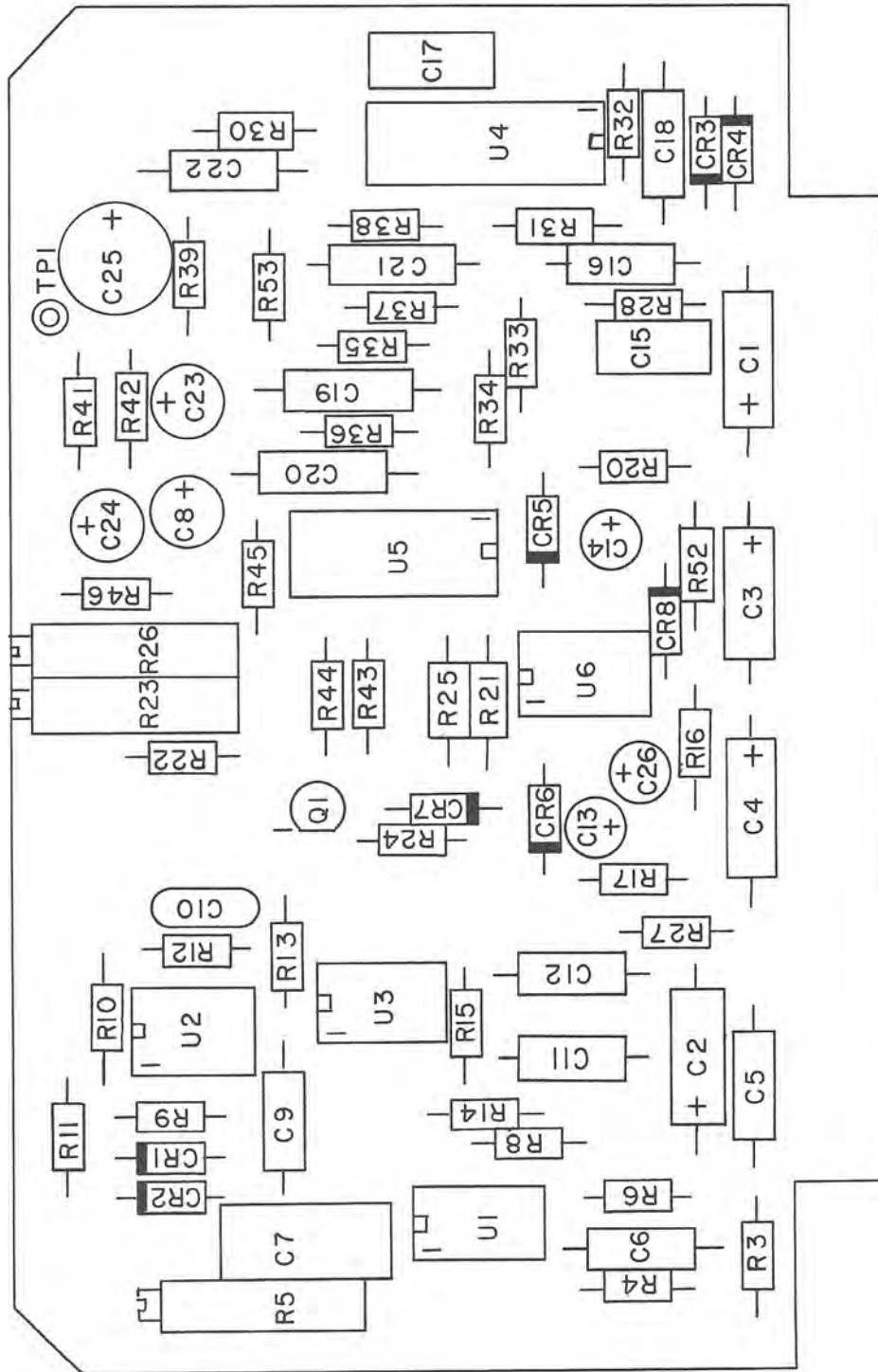
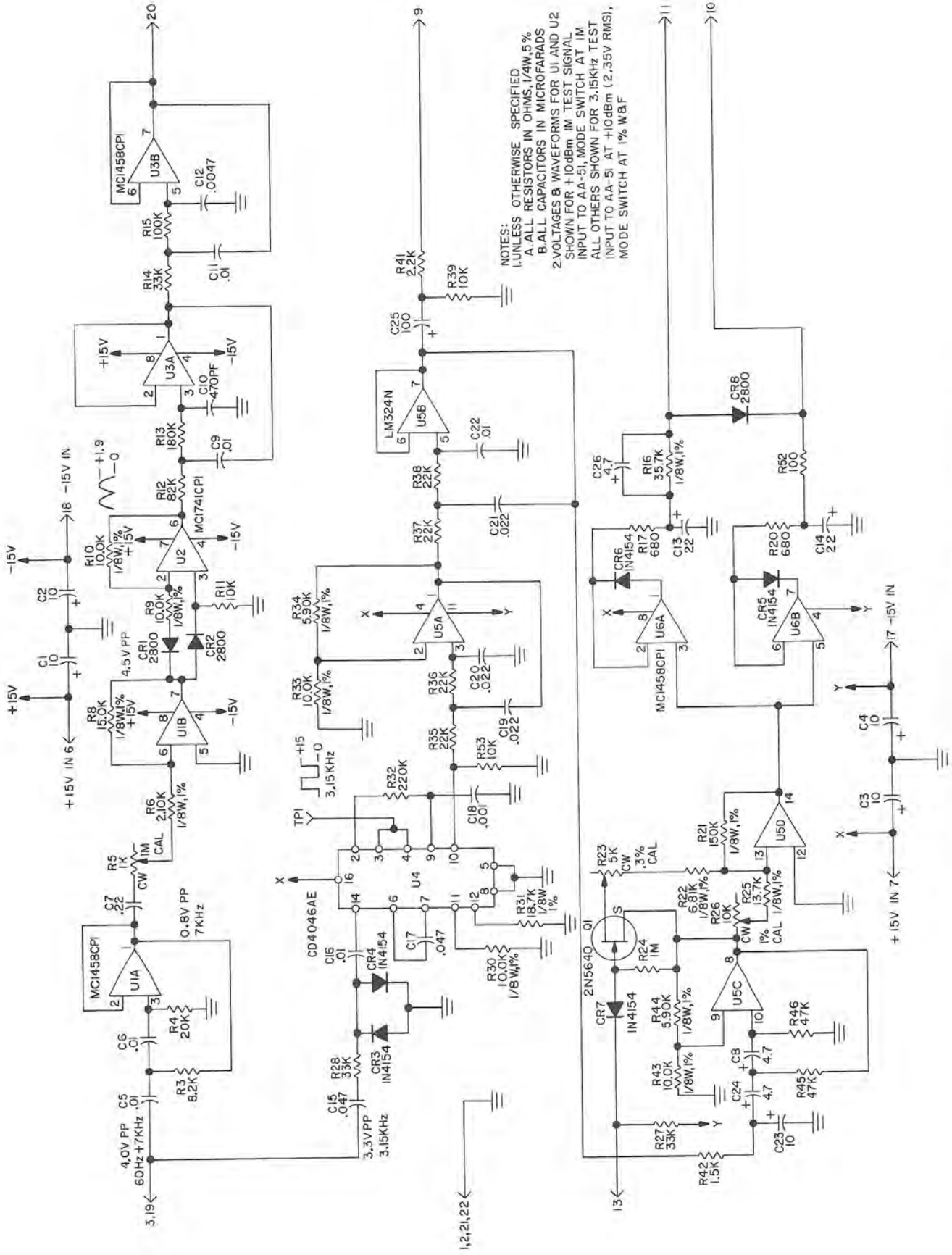


Figure 4.11. Component Location, IM/WF Demodulator A5



NOTES:
 1. UNLESS OTHERWISE SPECIFIED
 A. ALL RESISTORS IN OHMS, 1/4W, 5%
 B. ALL CAPACITORS IN MICROFARADS
 2. VOLTAGES & WAVEFORMS FOR U1 AND U2
 SHOWN FOR +10dBm IM TEST SIGNAL
 ALL OTHERS SHOWN FOR 3.15kHz TEST
 INPUT TO AA-51 AT +10dBm (2.35V RMS),
 MODE SWITCH AT 1% WBF

Figure 4.12. Schematic Diagram, IM/WF Demodulator A5

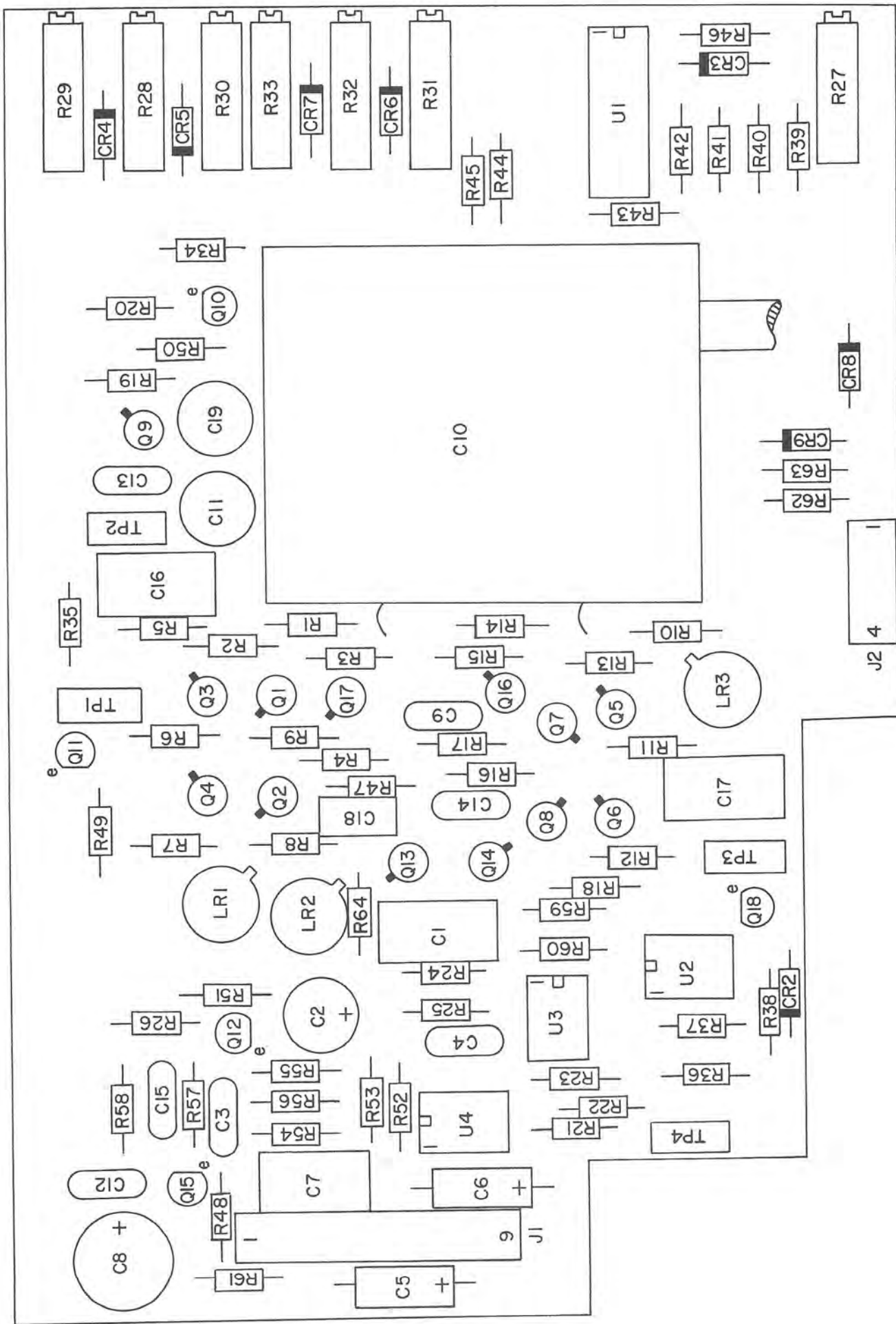
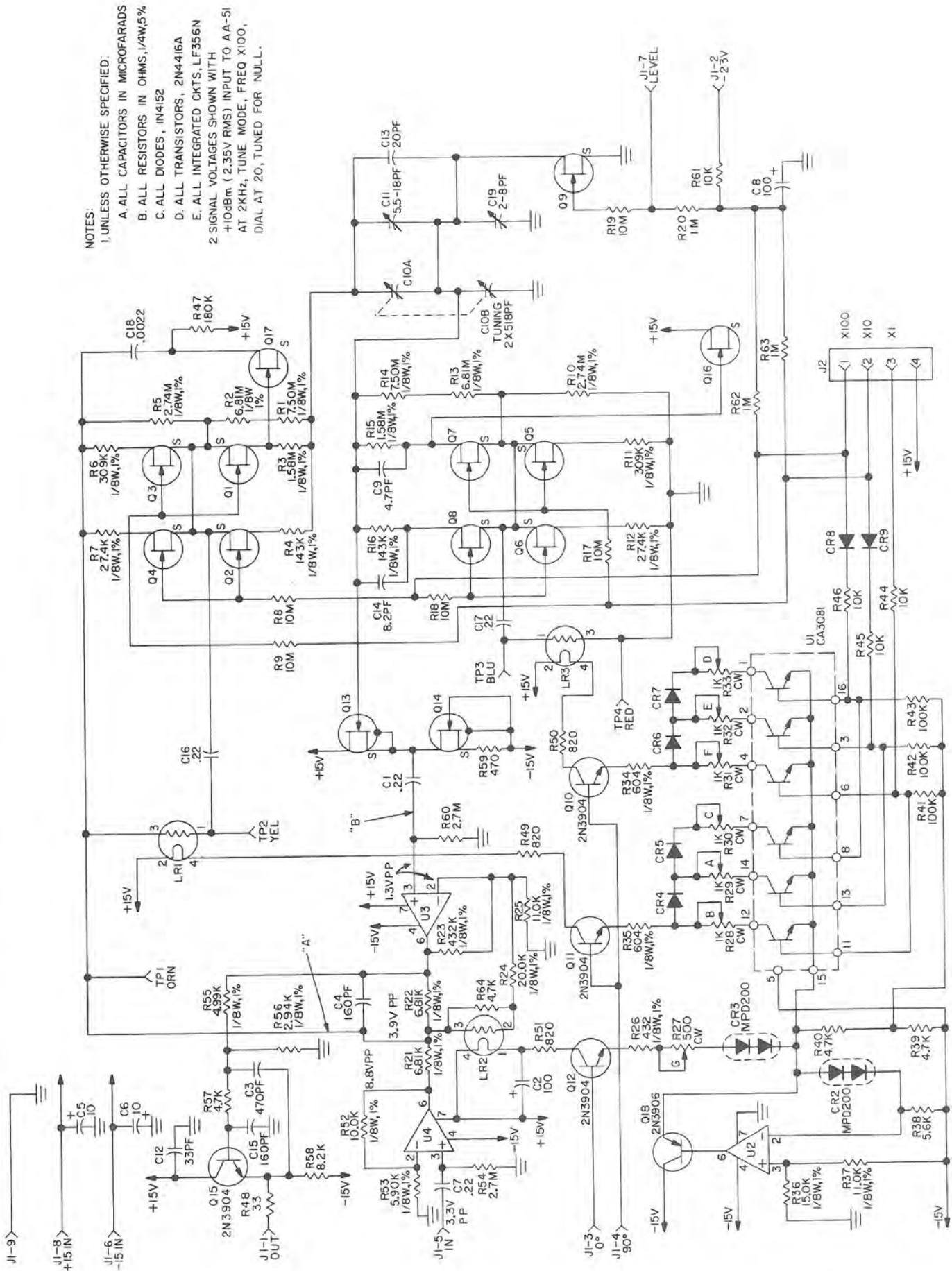


Figure 4.13. Component Location, Null Amp A6



- NOTES:
 1. UNLESS OTHERWISE SPECIFIED:
 A. ALL RESISTORS IN OHMS, 1/4W, 5%
 B. ALL CAPACITORS IN MICROFARADS
 C. ALL DIODES, IN4152
 D. ALL TRANSISTORS, 2N4416A
 E. ALL INTEGRATED CKTS, LF356N
 2. SIGNAL VOLTAGES SHOWN WITH
 +10dBm (2.35V RMS) INPUT TO AA-51
 AT 2KHz, TUNE MODE, FREQ X100,
 DIAL AT 20, TUNED FOR NULL.

Figure 4.14. Schematic Diagram, Null Amp A6

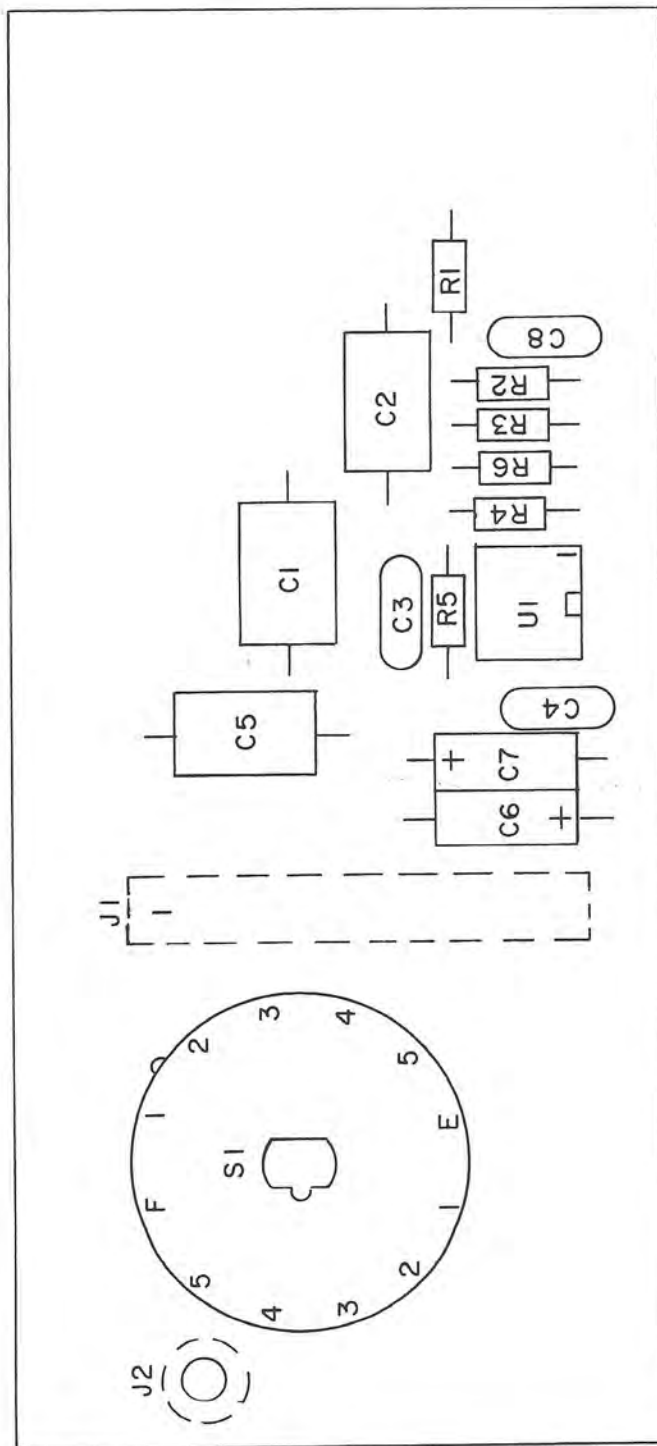


Figure 4.15. Component Location, Noise Filter A7A1

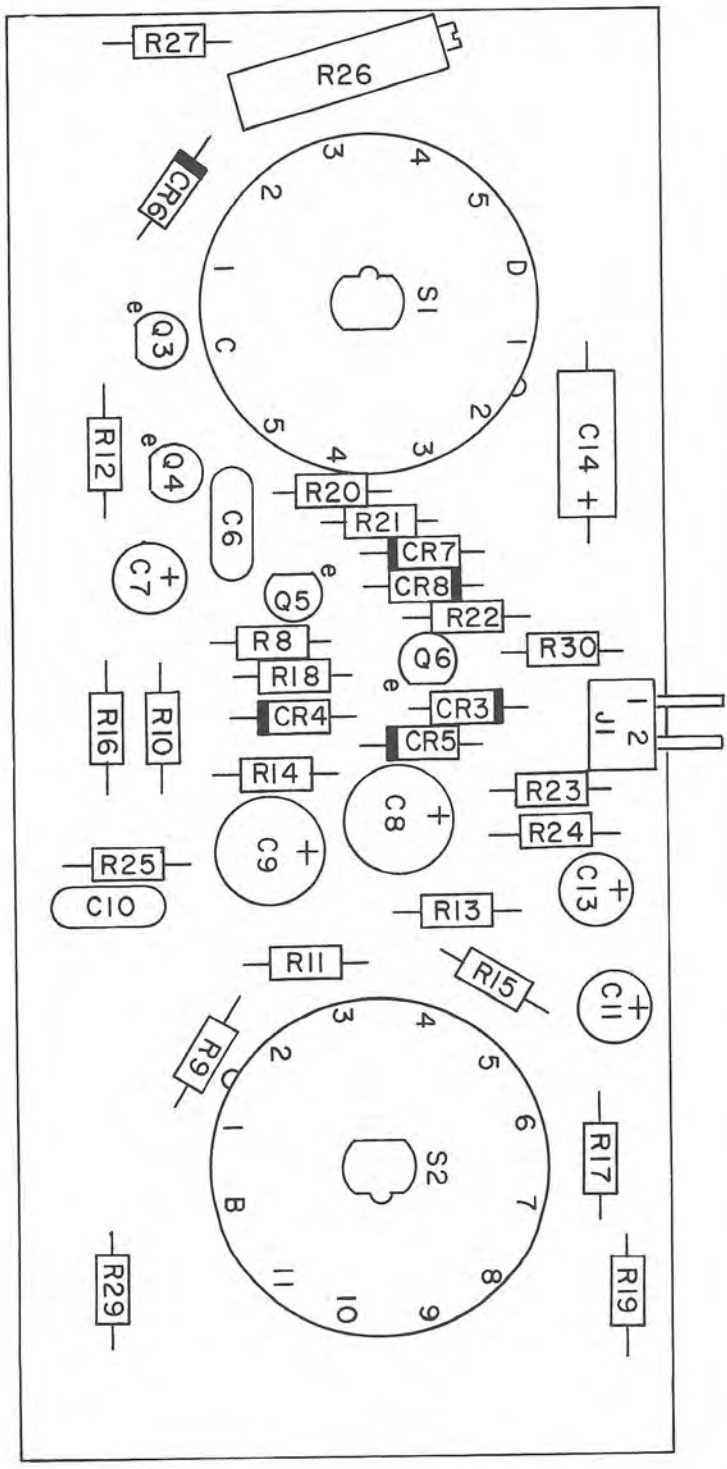


Figure 4.16. Component Location, Voltmeter Amplifier A7A2

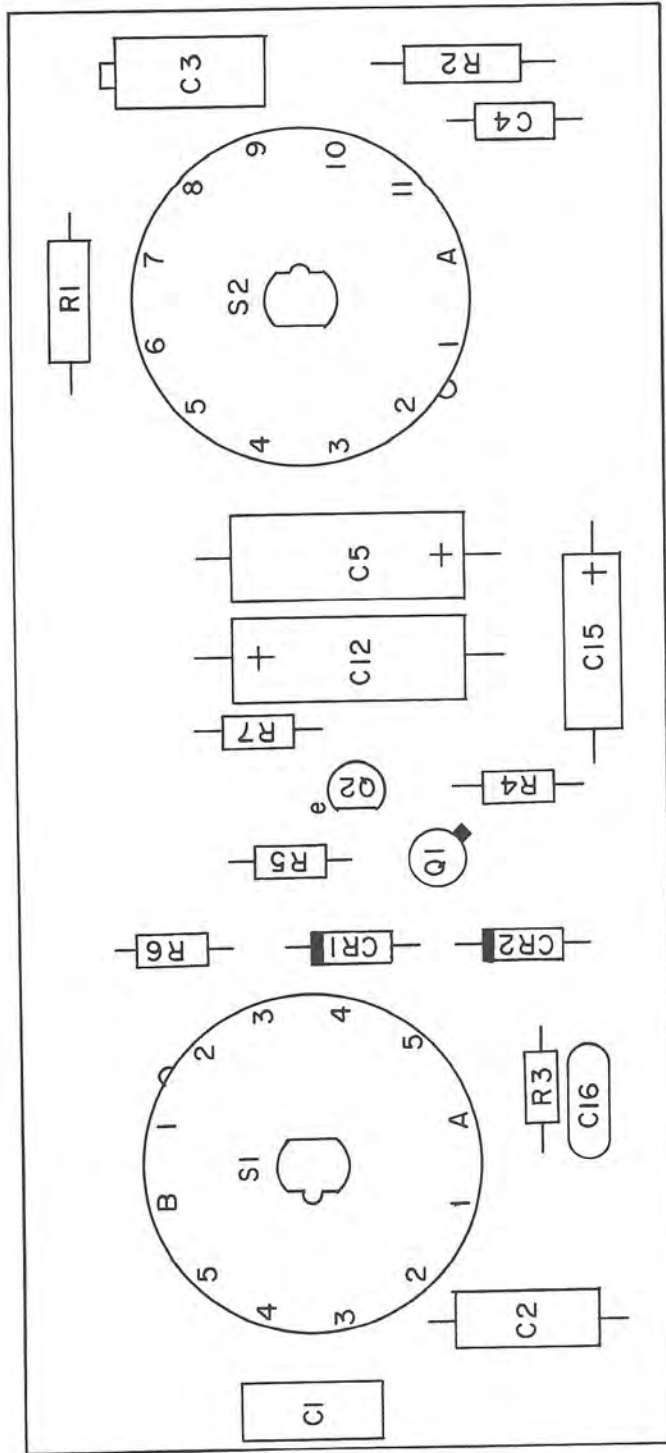


Figure 4.17. Component Location, Voltmeter Buffer A7A3

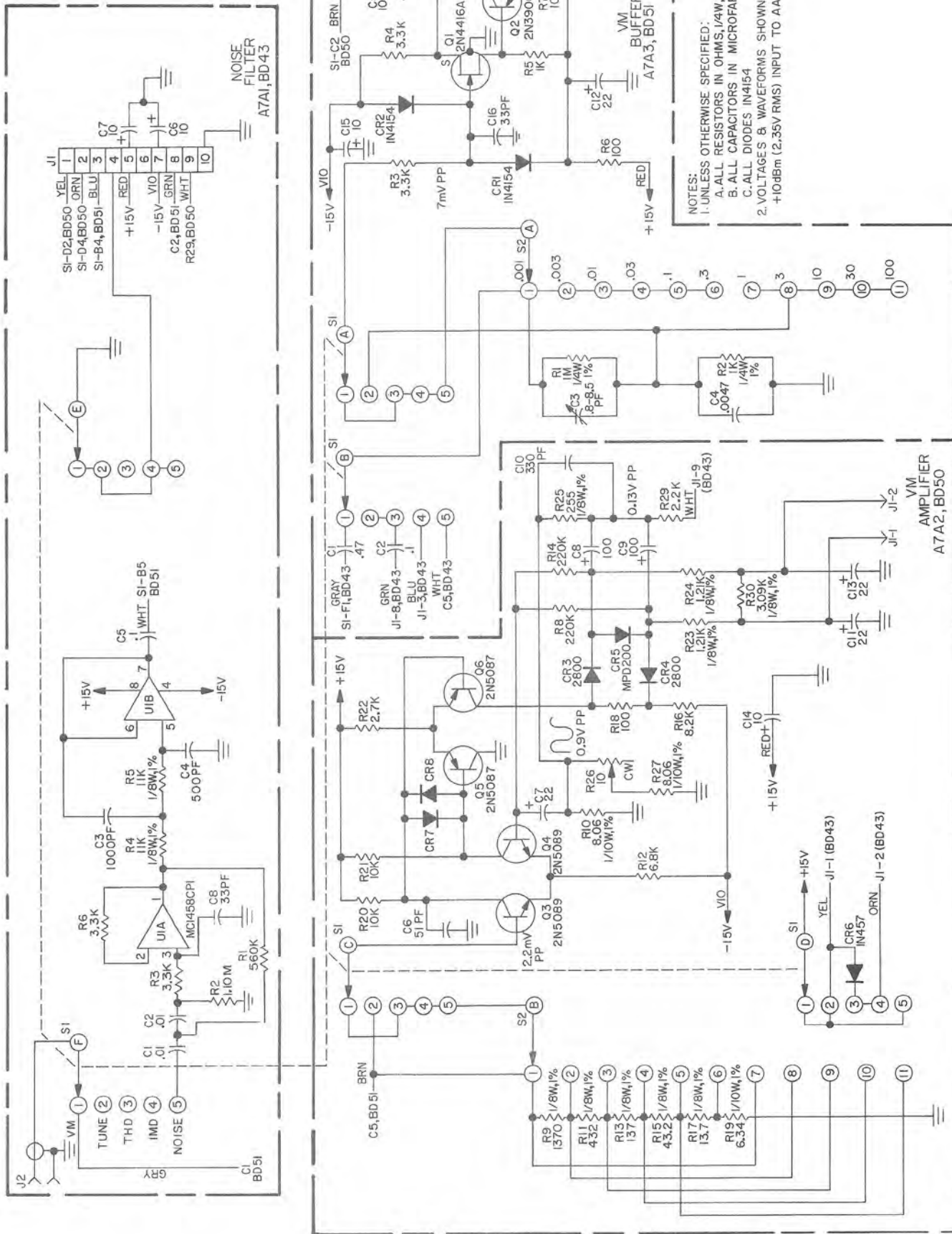


Figure 4.18. Schematic Diagram, Voltmeter Assembly A7

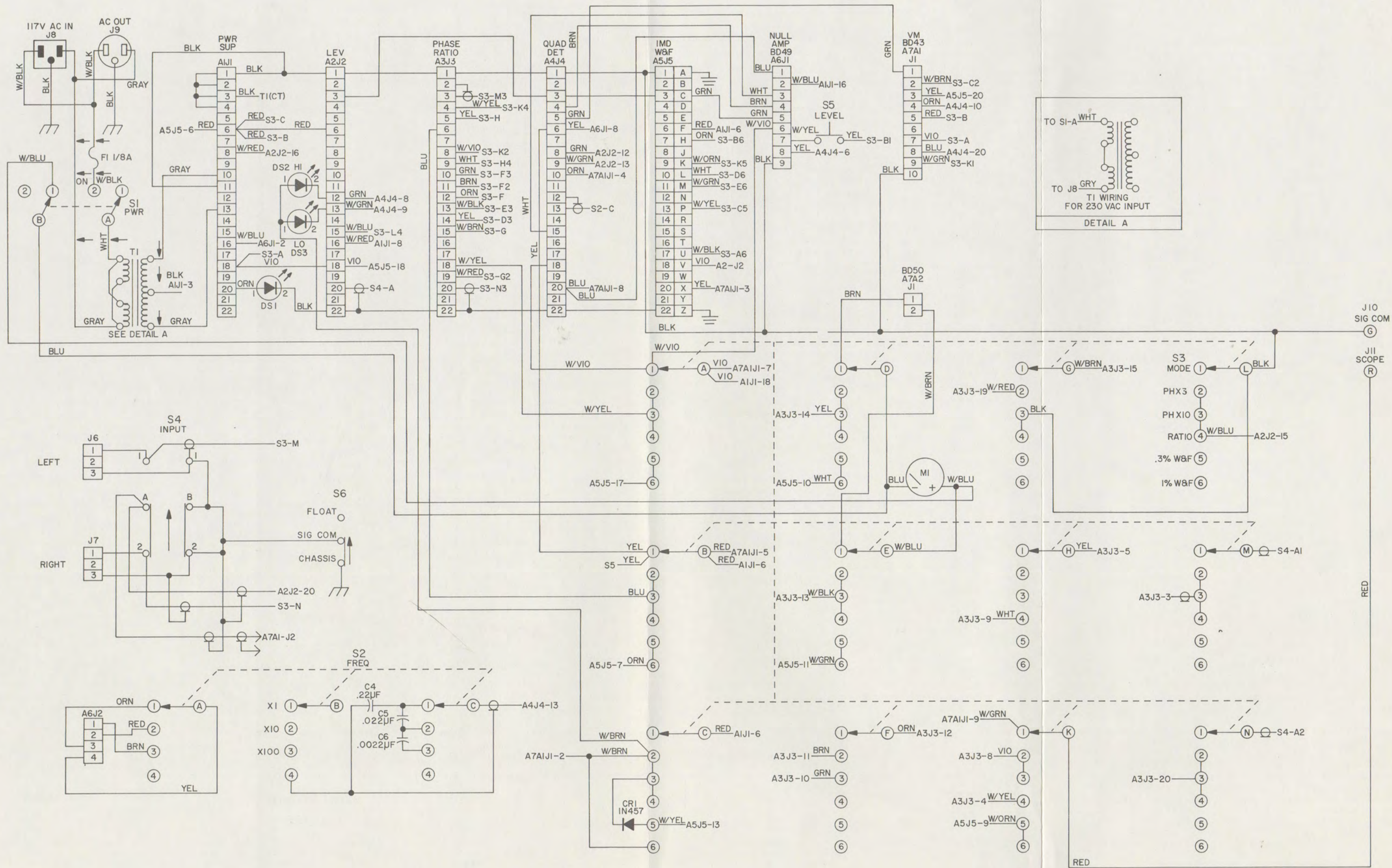


Figure 4.19. Wiring Diagram, AA-51

TABLE 4.8. PARTS LIST, AA-51 CHASSIS

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
A1	Power Supply PCB Assembly (see Table 4-13)	Potomac	BLM 20166
A2	Signal Leveler PCB Assembly (see Table 4-14)	Potomac	BLM 20171
A3	Phase and Ratio Detector PCB Assembly (see Table 4-15)	Potomac	BLM 20161
A4	Quadrature Detector PCB Assembly (see Table 4-16)	Potomac	BLM 20168
A5	IM/WF Demodulator PCB Assembly (see Table 4-17)	Potomac	BLM 20169
A6	Null Amp PCB Assembly (see Table 4-18)	Potomac	BLM 20167
A7	Voltmeter Assembly (see Tables 4-19, 4-20 and 4-21)	Potomac	30084
C1, 2, 3	Not used		
C4	Capacitor, .22 uf, 200 V, 10%	Paktron	224K02MY600L1
C5	Capacitor, .022 uf, 200 V, 10%	Paktron	223K02MY400L1
C6	Capacitor, .0022 uf, 200 V, 10%	Paktron	222K02MY400L1
CR1	Diode		1N457
DS1, 2, 3	LED, red	Litronix	L2000
F1	Fuse, 1/8 amp SLO BLO		MDL 1/8
J1, 2, 3, 4, 5	Connector, P.C.	Amphenol	143-022-01
J6, 7	Connector, receptacle	Switchcraft	57HA3F
J8	AC receptacle, male	Switchcraft	EAC-301
J9	AC receptacle, female	Amphenol	160-2N
J10	Binding post, nylon, green	H.H. Smith	517-104
J11	Binding post, nylon, red	H.H. Smith	517-102
M1	Meter	Potomac	30068

TABLE 4.8. PARTS LIST, AA-51 CHASSIS. (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
S1	Switch, toggle, DPDT	C & K	7201
S2	Switch, modified	Potomac	20187-7
S3	Switch assembly	Potomac	20182-1
S4, 6	Switch, slide, DPDT	Switchcraft	6206 LR
S5	Switch, pushbutton, SPST	Grayhill	3-4
T1	Transformer	Signal	DP241-5-36
XF1	Fuse holder	Bussman	HKP
	Cable assembly (test)	Potomac	20190
	LED mounting clip and collar	Litronix	004-9002
	AC power cord	Belden	17250

TABLE 4.9. PARTS LIST, POWER SUPPLY PCB ASSEMBLY, A1

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1, 2, 3, 4	Capacitor, 500 uf, 50V	Cornell Dublier	WBR500-50
C5, 6	Not used		
C7, 9	Capacitor, 15 uf, 20V, 10%		C513BE156K
C8	Capacitor, 39 uf, 10V, 10%	Sprague	196D396X9010KA1
CR1, 2, 3, 4, 5, 6, 7	Diode		1N5059
R1, 11	Resistor, 15K Ohm, ¼W, 5%		RCR07G153JM
R2, 10	Resistor, 10 Ohms, 3W, 5%	Clarostat	VC3D
R3	Resistor, 60.4 Ohms, 1/8W, 1%		RN55D60R4F
R4, 9	Resistor, 619 Ohms, ¼W, 1%	Allen Bradley	CC6190F
R5, 6	Potentiometer, 100 Ohms	Beckman	72PR100
R7	Resistor, 10 Ohms, ¼W, 5%		RCR07G100JM
R8	Resistor, 97.6 Ohms, 1/8W, 1%		RN55D97R6F
R12	Resistor, 3K Ohms, ½W, 5%		RCR20G302JM
U1	I.C., pos. voltage reg.	National	LM317T
U2	I.C., neg. voltage reg.	Fairchild	uA7912UC

TABLE 4.10. PARTS LIST, LEVELER PCB ASSEMBLY, A2

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1	Capacitor, .1 uf, 80V, 10%	Sprague	192P1049R8
C2, 14	Capacitor, 10 uf, 25V, 10%	Sprague	196D106X9025KA1
C3	Capacitor, 2.2 uf, 20V, 10%		CS13BE225K
C4	Capacitor, 100 uf, 16V -0, +100%	Arco	RME-E-E-100
C5	Capacitor, .001 uf, 200V, 10%	Sprague	192P10292
C6	Capacitor, 51 pf, 500V, 5%		DM15 510
C7	Capacitor, 470 pf, 100V, 5%		DM15471J
C8, 11, 12	Capacitor, 10 uf, 20V, 10%		CS13BE106K
C9	Capacitor, 33 uf, 25V, 10%		196D336X9025PE4
C10	Capacitor, 39 uf, 10V, 10%	Sprague	96D396X9010KA1
C13	Capacitor, .01 uf, 100V, 10%		CK06BX103K
C15	Capacitor, 120 pf, 500V, 5%		DM 15121J
CR1-6, 10	Diode		1N4154
CR7, 8	Diode		1N4152
CR9	Diode		1N457
K1	Relay, DPDT	ITT Components	RZ-24
LR1	Resistor	Raytheon	CK1118
Q1	Transistor	T.I.	2N4416A
Q2, 6	Transistor	Motorola	MPS8097
Q3, 7	Transistor		2N3906
Q4, 5, 8	Transistor		2N3904
R1, 22	Resistor, 270K Ohm, ¼ W, 5%		RCR07G274JM
R2	Resistor, 1M Ohm, ¼W, 5%		RCR07G105JM
R3	Resistor, 475K Ohm, 1/8W, 1%		RN55D4753F

TABLE 4.10. PARTS LIST, LEVELER PCB ASSEMBLY, A2 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
R4	Resistor, 23.2K Ohm, 1/8W, 1%		RN55D2322F
R5, 28	Resistor, 470 Ohm, ¼W, 5%		RCR07G471JM
R6, 7, 20, 26, 39 44, 50, 56	Resistor, 10K Ohm, ¼W, 5%		RCR07G103JM
R8	Resistor, 909K Ohm, 1/8W, 1%	Allen Bradley	CC9093F
R9	Resistor, 2.2K Ohm, ¼W, 5%		RCR07G222JM
R10	Resistor, 3.57K Ohm, 1/8W, 1%		RN55D3571F
R11	Resistor, 18K Ohm, ¼W, 5%		RCR07G183JM
R12, 16, 32	Resistor, 1K Ohm, ¼W, 5%		RCR07G102JM
R13, 33, 34	Resistor, 33K Ohm, ¼W, 5%		RCR07G333JM
R14	Resistor, 150 Ohm, ¼W, 5%		RCR07G151JM
R15, 54, 55, 58	Resistor, 10K Ohm, 1/8W, 1%		RN55D1002F
R17	Resistor, 22K Ohm, ¼W, 5%		RCR07G223JM
R18	Resistor, 100 Ohm, ¼W, 5%		RCR07G101JM
R19, 38	Resistor, 3.3K Ohm, ¼W, 5%		RCR07G332JM
R21, 25, 47, 42	Potentiometer, 20K Ohm		89PR20K
R23	Resistor, 130K Ohm, 1/8W, 1%		RN55D1303F
R24	Resistor, 2.74M Ohm, 1/8W, 1%	Allen Bradley	CC2744
R27, 41	Resistor, 1.5K Ohm, ¼W, 5%		RCR07G152JM
R29	Resistor, 5.6K Ohm, ¼W, 5%		RCR07G562JM
R30, 45	Resistor, 220K Ohm, ¼W, 5%		RCR07G224JM
R31, 53	Resistor, 15K Ohm, ¼W, 5%		RCR07G153JM
R35	Resistor, 47K Ohm, ¼W, 5%		RCR07G473JM
R36, 37, 51	Resistor, 100K Ohm, ¼W, 5%		RCR07G104JM

TABLE 4.10. PARTS LIST, LEVELER PCB ASSEMBLY, A2 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
R40, 49	Resistor, 10M Ohm, ¼W, 5%		RCR07G106JM
R43	Resistor, 309K Ohm, 1/8W, 1%		RN55D3093F
R46	Potentiometer, 5K Ohm		89PR5K
R48	Resistor, 20K Ohm, 1/8W, 1%		RN55D2002F
R52, 59	Resistor, 10 Ohm, ¼W, 5%		RCR07G100JM
R57	Resistor, 4.99K Ohm, 1/8W, 1%		RN55D4991F
U1	I.C.	TI	TL082CP
U2	I.C.	National	LM339N
U3	I.C.	Fairchild	739PC
U4	I.C.	Motorola	MC1741SCP1
U5	I.C.	Motorola	MC1458CP1

TABLE 4.11. PARTS LIST, PHASE AND RATIO DETECTOR PCB ASSEMBLY, A3

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1, 5	Capacitor, .47 uf, 200V, 10%	Paktron	474K02MY800L1
C2, 4	Capacitor, 10 uf, 20V, 10%		CS13BE106K
C3, 6, 19	Capacitor, 10 uf, 25V, 10%	Sprague	96D106X9025KA1
C7	Not used		
C8, 9, 12, 13	Capacitor, 4.7 uf, 35V, 10%	Sprague	96D475X9035JA1
C10, 14	Capacitor, 2.2 uf, 25V, 10%	Sprague	96D225X9025HA1
C11	Not used		
C15, 16	Capacitor, 100 uf, 10V, 10%	Sprague	96D107X9010PE4
C17	Capacitor, .01 uf, 80V, 10%	Sprague	92P1039R8
C18	Capacitor, 47 pf, 500V, 5%		DM15470J
C20	Capacitor, .01 uf, 100V, 10%		CK06BX103K
C21, 22	Capacitor, 1000 pf, 200V, 10%		CK05BX102K
CR1, 2, 3, 6, 9-12	Diode		1N4154
CR4, 5, 7, 8	Not used		
Q1, 2	Transistor		2N4416A
Q3, 4	Transistor		2N5640
R1, 9, 43	Resistor, 68K Ohm, ¼W, 5%		RCR07G683JM
R2, 8	Resistor, 2.2M Ohm, ¼W, 5%		RCR07G225JM
R3, 10	Resistor, 5.6K Ohm, ¼W, 5%		RCR07G562JM
R4, 11, 14, 27, 38 50, 51, 52	Resistor, 10K Ohm, ¼W, 5%		RCR07G103JM
R5, 12, 53	Resistor, 1.2K Ohm, ¼W, 5%		RCR07G122JM
R6, 47	Resistor, 4.7K Ohm, ¼W, 5%		RCR07G472JM
R7, 13	Resistor, 4.7M Ohm, ¼W, 5%		RCR07G475JM
R15, 26, 28, 29 37, 39, 40	Resistor, 47K Ohm, ¼W, 5%		RCR07G473JM

TABLE 4.11. PARTS LIST, PHASE AND RATIO DETECTOR PCB ASSEMBLY, A3 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
R16	Resistor, 27.4K Ohm, 1/8W, 1%		RN55D2742F
R17	Potentiometer, 20K Ohm		89PR20K
R18	Resistor, 130K Ohm, 1/8W, 1%		RN55D1303F
R19, 21	Potentiometer, 50K Ohm		89PR50K
R20	Resistor, 40.2K Ohm, 1/8W, 1%		RN55D4022F
R22	Resistor, 5.90K Ohm, 1/8 W, 1%		RN55D5901F
R23	Resistor, 11K Ohm, 1/8 W, 1%		RN55D1102F
R24	Resistor, 27K Ohm, ¼W, 5%		RCR07G273JM
R25, 36, 48	Resistor, 100K Ohm, ¼W, 5%		RCR07G104JM
R30, 42, 45	Resistor, 15K Ohm, 1/8 W, 1%		RN55D1502F
R31, 41	Resistor, 1K Ohm, 1/8 W, 1%		RN55D1001F
R32-35	Resistor, 10K Ohm, 1/8 W, 1%		RN55D1002F
R44	Resistor, 3.3K Ohm, ¼W, 5%		RCR07G332JM
R46	Resistor, 3.92K Ohm, 1/8W, 1%		RN55D3921F
R49	Resistor, 39K Ohm, ¼W, 5%		RCR07G393JM
R54	Resistor, 1K Ohm, ¼W, 5%		RCR07G102JM
U1	I.C.	National	LM339N
U2	I.C.	RCA	CD 4013BE
U3, 6	I.C.	Motorola	MC 1456P1
U4, 7	I.C.	National	LF357N
U5, 8	I.C.	National	LM324N

TABLE 4.12. PARTS LIST, QUADRATURE DETECTOR PCB ASSEMBLY, A4

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1	Capacitor, 39 uf, 10 V, 10%	Sprague	19D396X9010KA1
C2	Capacitor, 10 uf, 25 V, 10%	Sprague	196D106X9025KA1
C3	Capacitor, 2.2 uf, 20 V, 10%		CS13BE225K
C4, 9	Capacitor, .1 uf, 80 V, 10%	Sprague	192P1049R8
C5, 6	Capacitor, 100 uf, 10 V, 10%	Sprague	196D107X9010PE4
C7, 11	Capacitor, .22 uf, 200 V, 10%	Paktron	224K02MY600L1
C8	Not used		
C10	Capacitor, 1000 pf, 100 V, 5%		DM15102J
C12	Capacitor, 22 uf, 10 V, 10%	Sprague	196D226X9010JA1
C13, 14	Not used		
C15	Capacitor, .047 uf, 200 V, 10%	Paktron	473K02MY400L1
C16	Not used		
C17	Capacitor, 100 uf, 16 V+100,-0%	Arco	RME-E-E-100
CR1, 2, 6, 7	Diode		IN4157
CR3,5,8, 9-11	Diode		IN4154
CR4	Diode		5082-2800
Q1, 3, 4	Transistor		2N5640
Q2	Transistor	Silconix	J176
Q5	Transistor		2N3904
R1, 15, 37	Resistor, 3.3K ohms, ¼ W, 5%		RCR07G332JM
R2, 3, 20, 33	Resistor, 100 K ohms, ¼ W, 5%		RCR07G104JM
R4, 42, 52	Resistor, 100 ohms, ¼ W, 5%		RCR07G101JM
R5, 7, 9, 31, 32,44	Resistor, 47 K ohms, ¼W, 5%		RCR07G473JM

TABLE 4.12. PARTS LIST, QUADRATURE DETECTOR PCB ASSEMBLY, A4 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
R6, 8, 10, 18, 26 30, 38, 41, 43, 48 49, 50, 54, 55	Resistor, 10 K ohms, ¼ W, 5%		RCR07G103JM
R11, 35	Resistor, 1 K ohms, ¼ W, 5%		RCR07G102JM
R12, 34	Resistor, 432 K ohms, 1/8 W, 1%		RN55D4323F
R13, 36	Potentiometer, 20 K ohms	Beckman	89PR20K
R14	Resistor, 820 ohms, ¼ W, 5%		RCR07G821JM
R16, 46, 56	Resistor, 1 M ohms, ¼ W, 5%		RCR07G105JM
R17	Resistor, 5.6 K ohms, ¼ W, 5%		RCR07G562JM
R19, 27	Resistor, 10 M ohms, ¼ W, 5%		RCR07G106JM
R21	Resistor, 4.7 M ohms, ¼ W, 5%		RCR07G475JM
R22	Resistor, 4.7 K ohms, ¼ W, 5%		RCR07G472JM
R23, 53	Resistor, 6.8 M ohms, ¼ W, 5%		RCR07G685JM
R25, 47	Resistor, 10 ohms, ¼ W, 5%		RCR07G100JM
R28	Resistor, 27 K ohms, ¼ W, 5%		RCR07G273JM
R29	Resistor, 39 K ohms, ¼ W, 5%		RCR07G393JM
R39, 51	Resistor, 15 K ohms, ¼ W, 5%		RCR07G153JM
R40	Resistor, 2.7 K ohms, ¼ W, 5%		RCR07G272JM
R45, 58	Resistor, 33 K ohms, ¼ W, 5%		RCR07G333JM
R57	Not used		
R59, 60	Resistor, 1.2 K ohms, ¼ W, 5%		RCR07G122JM
U1	I.C.	Fairchild	739 PC
U2, 4	I.C.	T.I.	TL084CN
U3	I.C.	National	LM339N
U5	I.C.	Motorola	MC1458CP1

TABLE 4.13. PARTS LIST, IM/WF DEMODULATOR PCB ASSEMBLY, A5

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1-4	Capacitor, 10 uf, 20 V, 10%		CS13BE106K
C5, 6, 9, 11, 16,22	Capacitor, .01 uf, 80V, 10%	Sprague	192P1039R8
C7	Capacitor, .22 uf, 200 V, 10%	Paktron	224K02MY600L1
C8, 24, 26	Capacitor, 4.7 uf, 35 V, 10%	Sprague	196D475X9035JA1
C10	Capacitor, 470 pf, 500 V, 5%		DM 15471J
C12	Capacitor, .0047 uf, 80 V, 10%	Sprague	192P4729R8
C13, 14	Capacitor, 22 uf, 10 V, 10%	Sprague	196D226X9010JA1
C15, 17	Capacitor, .047 uf, 200 V, 10%	Paktron	473K02MY400L1
C18	Capacitor, .001 uf, 200 V, 10%	Sprague	192P10292
C19, 20, 21	Capacitor, .022 uf, 80 V, 10%	Sprague	192P2239R8
C23	Capacitor, 10 uf, 25 V, 10%	Sprague	196D106X9025KA1
C25	Capacitor, 100 uf, 16 V +0,-100%	Arco	RME-E-E-100
CR1, 2, 8	Diode	Hewlett-Packard	5082-2800
CR3-7	Diode		IN4154
Q1	Transistor		2N5640
R1, 2	Not used		
R3	Resistor, 8.2 K ohms, ¼W, 5%		RCR07G822JM
R4	Resistor, 20 K ohms, ¼W, 5%		RCR07G203JM
R5	Potentiometer, 1 K ohms	Beckman	89PR1K
R6	Resistor, 2.10 K ohms, 1/8 W, 1%		RN55D2101F
R7	Not used		
R8	Resistor, 15 K ohms, 1/8 W, 1%		RN55D1502F
R9, 10, 30, 33, 43	Resistor, 10 K ohms, 1/8 W, 1%		RN55D1002F
R11, 53, 39	Resistor, 10 K ohms, ¼ W, 5%		RCR07G103JM

TABLE 4.13. PARTS LIST, IM/WF DEMODULATOR PCB ASSEMBLY, A5 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
R12	Resistor, 82 K ohms, ¼ W, 5%		RCR07G823 JM
R13	Resistor, 180 K ohms, ¼ W, 5%		RCR07G184JM
R14, 27, 28	Resistor, 33 K ohms, ¼ W, 5%		RCR07G333JM
R15	Resistor, 100 K ohms, ¼ W, 5%		RCR07G104JM
R16	Resistor, 35.7 K ohms, 1/8 W, 1%		RN55D3572F
R17, 20	Resistor, 680 ohms, ¼ W, 5%		RCR07G681JM
R18, 19	Not used		
R21	Resistor, 150 K ohms, 1/8 W, 1%		RN55D1503F
R22	Resistor, 6.81 K ohms, 1/8 W, 1%		RN55D6811F
R23	Potentiometer, 5 K ohms	Beckman	89PR5K
R24	Resistor, 1 M ohm, ¼ W, 5%		RCR07G105JM
R25	Resistor, 13.7 K ohms, 1/8 W, 1%		RN55D1372F
R26	Potentiometer, 10 K ohms	Beckman	89PR10K
R29	Not used		
R31	Resistor, 18.7 K ohms, 1/8 W, 1%		RN55D1872F
R32	Resistor, 220 K ohms, ¼ W, 5%		RCR07G224JM
R34, 44	Resistor, 5.90 K ohms, 1/8 W, 1%		RN55D5901F
R35-38	Resistor, 22 K ohms, ¼ W, 5%		RCR07G223JM
R40	Not used		
R41	Resistor, 2.2 K ohms, ¼ W, 5%		RCR07G222JM
R42	Resistor, 1.5 K ohms, ¼ W, 5%		RCR07G152JM
R45, 46	Resistor, 47 K ohms, ¼ W, 5%		RCR07G473JM
R47-51	Not used		
R52	Resistor, 100 ohms, ¼ W, 5%		RCR07G101JM

TABLE 4.13. PARTS LIST, IM/WF DEMODULATOR PCB ASSEMBLY, A5 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
U1, 3, 6	I.C.	Motorola	MC1458CP1
U2	I.C.	Motorola	MC1741CP1
U4	I.C.	RCA	CD4046BE
U5	I.C.	National	CM324N

TABLE 4.14. PARTS LIST, NULL AMPLIFIER PCB ASSEMBLY, A6

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1, 7, 16, 17	Capacitor, .22 uf, 200 V, 10%	Paktron	224K02MY600L1
C2	Capacitor, 100 uf, 16 V -0,+100%	Arco	RME-E-E-100
C3	Capacitor, 470 pf, 500 V, 5%		DM15471J
C4, 15	Capacitor, 160 pf, 500 V, 5%		DM15161J
C5, 6	Capacitor, 10 uf, 20 V, 10%		CS13BE106K
C8	Capacitor, 100 uf, 50V,-10,+50%	Sprague	502D107F050DG1C
C9	Capacitor, 4.7 pf, 1000 V ±.5 pf	Sprague	10TCC-V47
C10	Capacitor, 2x518 pf	Jackson Bros.	5084/2/518/G2S
C11	Capacitor, var. 5.5-18 pf	JFD	DV11 PS18A
C12	Capacitor, 33 pf, 500 V, 5%		DM15330J
C13	Capacitor, 20 pf, 500 V, 5%		DM15200J
C14	Capacitor, 8.2 pf, 1000 V, ± .5 pf	Sprague	10TCC-V82
C18	Capacitor, .0022 uf, 200 V ±10%	Paktron	222K02MY400L1
C19	Capacitor, variable, 2-8 pf	JFD	DV11PS8A
CR1	Not used		
CR2, 3	Diode	G.E.	MPD200
CR4-9	Diode		IN4152
J1	Connector, wafer	Molex	09-64-1091
J2	Connector, wafer	Molex	09-64-1041
LR1, 2, 3	Resistor	Raytheon	CK1118
Q1-9, 13, 14, 16, 17	Transistor	T.I.	2N4416A
Q10, 11, 12, 15	Transistor		2N3904
Q18	Transistor		2N3906
R1, 14	Resistor, 7.5 M ohms, 1/8 W, 1%	Allen Bradley	CC7504F

TABLE 4.14. PARTS LIST, NULL AMPLIFIER PCB ASSEMBLY, A6 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
R2, 13	Resistor, 6.81 M ohms, 1/8 W, 1%	Allen Bradley	CC6814F
R3, 15	Resistor, 1.58 M ohms, 1/8 W, 1%	Allen Bradley	CC1584F
R4, 16	Resistor, 143 K ohms, 1/8 W, 1%		RN55D1433F
R5, 10	Resistor, 2.74 M ohms, 1/8 W, 1%	Allen Bradley	CC2744F
R6, 11	Resistor, 309 K ohms, 1/8 W, 1%		RN55D3093F
R7, 12	Resistor, 27.4 K ohms, 1/8 W, 1%		RN55D2742F
R8, 9, 17, 18, 19	Resistor, 10 M ohms, ¼ W, 5%		RCR07G106JM
R20, 62, 63	Resistor, 1 M ohms, ¼ W, 5%		RCR07G105JM
R21, 22	Resistor, 6.81 K ohms, 1/8 W, 1%		RN55D6811F
R23	Resistor, 432 K ohms, 1/8 W, 1%		RN55D4323F
R24	Resistor, 20 K ohms, 1/8 W, 1%		RN55D2002F
R25, 37	Resistor, 11 K ohms, 1/8 W, 1%		RN55D1102F
R26	Resistor, 432 ohms, 1/8 W, 1%		RN55D4320F
R27	Potentiometer, 500 ohm	Beckman	89PR500
R28-33	Potentiometer, 1 K ohms	Beckman	89PR1K
R34, 35	Resistor, 604 ohms, 1/8 W, 1%		RN55D6040F
R36	Resistor, 15 K ohms, 1/8 W, 1%		RN55D1502F
R38	Resistor, 5.6 K ohms, ¼ W, 5%		RCR07G562JM
R39, 40, 57, 64	Resistor, 4.7 K ohms, ¼ W, 5%		RCR07G472JM
R41, 42, 43	Resistor, 100 K ohms, ¼ W, 5%		RCR07G104JM
R44, 45, 46, 61	Resistor, 10 K ohms, ¼ W, 5%		RCR07G103JM
R47	Resistor, 180 K ohms, ¼ W, 5%		RCR07G184JM
R48	Resistor, 33 ohms, ¼ W, 5%		RCR07G330JM
R49, 50, 51	Resistor, 820 ohms, ¼ W, 5%		RCR07G821JM

TABLE 4.14. PARTS LIST, NULL AMPLIFIER PCB ASSEMBLY, A6 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
R52	Resistor, 10 K ohms, 1/8 W, 1%		RN55D1002F
R53	Resistor, 5.90 K ohms, 1/8 W, 1%		RN55D5901F
R54, 60	Resistor, 2.7 M ohms, 1/4 W, 5%		RCR07G275JM
R55	Resistor, 4.99 K ohms, 1/8 W, 1%		RN55D4991F
R56	Resistor, 2.94 K ohms, 1/8 W, 1%		RN55D2941F
R58	Resistor, 8.2 K ohms, 1/4 W, 5%		RCR07G822JM
R59	Resistor, 470 ohms, 1/4 W, 5%		RCR07G471JM
U1	I.C.	RCA	CA3081
U2, 3, 4	I.C.	National	LF356N

TABLE 4.15. PARTS LIST, NOISE FILTER PCB ASSEMBLY, A7A1

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1, 2	Capacitor, .01 uf, 200 V, 10%	Sprague	192P10392
C3	Capacitor, 1000 pf, 100 V, 5%		DM15102J
C4	Capacitor, 500 pf, 500 V, 5%		DM15501J
C5	Capacitor, .1 uf, 80 V, 10%	Sprague	192P1049R8
C6, 7	Capacitor, 10 uf, 20 V, 10%		CS13BE106K
C8	Capacitor, 33 pf, 500 V, 5%		DM15330J
J1	Connector, wafer, 10-pin	Molex	09641101
J2	Jack, phone	Keystone	572
R1	Resistor, 560 K ohms, ¼ W, 5%		RCR07G564JM
R2	Resistor, 1.10 M ohms, ¼ W, 5%		RCR07G115JM
R3, 6	Resistor, 3.3 K ohms, ¼ W, 5%		RCR07G332JM
R4, 5	Resistor, 11 K ohms, 1/8 W, 1%		RN55D1102F
S1	Switch, wafer		20163
U1	I.C.	Motorola	MC1458CP1

TABLE 4.16. PARTS LIST, VOLTMETER AMPLIFIER, A7A2

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1-5	Not used		
C6	Capacitor, 51 pf, 500 V, 5%		DM15510J
C7, 11, 13	Capacitor, 22 uf, 10 V, 10%	Sprague	196D226X9010JA1
C8, 9	Capacitor, 100 uf, 10 V, 10%	Sprague	196D107X9010PE4
C10	Capacitor, 330 pf, 500 V, 5%		DM15331J
C12	Not used		
C14	Capacitor, 10 uf, 20 V, 10%		CS13BE106K
CR1, 2	Not used		
CR3, 4	Diode	Hewlett-Packard	5082-2800
CR5	Diode		MPD200
CR6	Diode		IN457
CR7, 8	Diode		IN4154
J1	Connector, right-angle wafer	Molex	09-66-1021
Q1, 2	Not used		
Q3, 4	Transistor,		2N5089
Q5, 6	Transistor		2N5087
R1-7	Not used		
R8, 14	Resistor, 220 K ohms, ¼ W, 5%		RCR07G224JM
R9	Resistor, 1.37 K ohms, 1/8 W, 1%		RN55D1371F
R10, 27	Resistor, 8.06 ohms, 1/10 W, 1%		LMF1/10
R11	Resistor, 432 ohms, 1/8 W, 1%		RN55D432OF
R12	Resistor, 6.8 K ohms, ¼ W, 5%		RCR07G682JM
R13	Resistor, 137 ohms, 1/8 W, 1%		RN55D1370F
R15	Resistor, 43.2 ohms, 1/8 W, 1%		RN55D43R2F

TABLE 4.16. PARTS LIST, VOLTMETER AMPLIFIER, A7A2 (Contd.)

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
R16	Resistor, 8.2 K ohms, ¼ W, 5%		RCR07G822JM
R17	Resistor, 13.7 ohms, 1/8 W, 1%		RN55D13R7F
R18	Resistor, 100 ohms, ¼ W, 5%		RCR07G101JM
R19	Resistor, 6.34 ohms, 1/10 W, 1%		LMF 1/10
R20, 21	Resistor, 10 K ohms, ¼ W, 5%		RCR07G103JM
R22	Resistor, 2.7 K ohms, ¼ W, 5%		RCR07G272JM
R23, 24	Resistor, 1.21 K ohms, 1/8 W, 1%		RN55D1211F
R25	Resistor, 255 ohms, 1/8 W, 1%		RN55D2550F
R26	Potentiometer, 10 ohms	Beckman	89PR10
R28	Not used		
R29	Resistor, 2.2 K ohms, ¼ W, 5%		RCR07G222JM
R30	Resistor, 3.09 K ohms, 1/8 W, 1%		RN55D3091F
S1	Switch, wafer		20163
S2	Switch, wafer		212-34453W0

TABLE 4.17. PARTS LIST, VOLTMETER BUFFER ASSEMBLY, A7A3

REFERENCE DESIGNATION	DESCRIPTION	MFR.	PART NO.
C1	Capacitor, .47 uf, 200 V, 10%	Paktron	474K02MY800L1
C2	Capacitor, .1 uf, 80 V, 10%	Sprague	92P1049R8
C3	Capacitor trimmer, .8-8.5 pf	JFD	PC41J8R5
C4	Capacitor, .0047 uf, 80 V, 10%	Sprague	92P4729R8
C5	Capacitor, 100 uf, 16V, -10, +75%	Sprague	500D107G016DC7
C6-11	Not used		
C12	Capacitor, 22 uf, 35 V, 10%		CS13BF226K
C13, 14	Not used		
C15	Capacitor, 10 uf, 20 V, 10%		CS13BE106K
C16	Capacitor, 33 pf, 500 V, 5%		DM15330J
CR1, 2	Diode		1N4154
Q1	Transistor		2N4416A
Q2	Transistor		2N3906
R1	Resistor, 1 M ohm, ¼ W, 1%		RN60D1004F
R2	Resistor, 1 K ohms, ¼ W, 1%		RN60D1001F
R3, 4	Resistor, 3.3 K ohms, ¼ W, 5%		RCR07G332JM
R5	Resistor, 1 K ohms, ¼ W, 5%		RCR07G102JM
R6	Resistor, 100 ohms, ¼ W, 5%		RCR07G101JM
R7	Resistor, 10 ohms, ¼ W, 5%		RCR07G100JM
S1	Switch, wafer		20163
S2	Switch, wafer		212-34453W0

