TELEDYNE PHILBRICK NEXUS

OPERATIONAL AMPLIFIER TESTER MODEL 5102

OPERATIONS MANUAL

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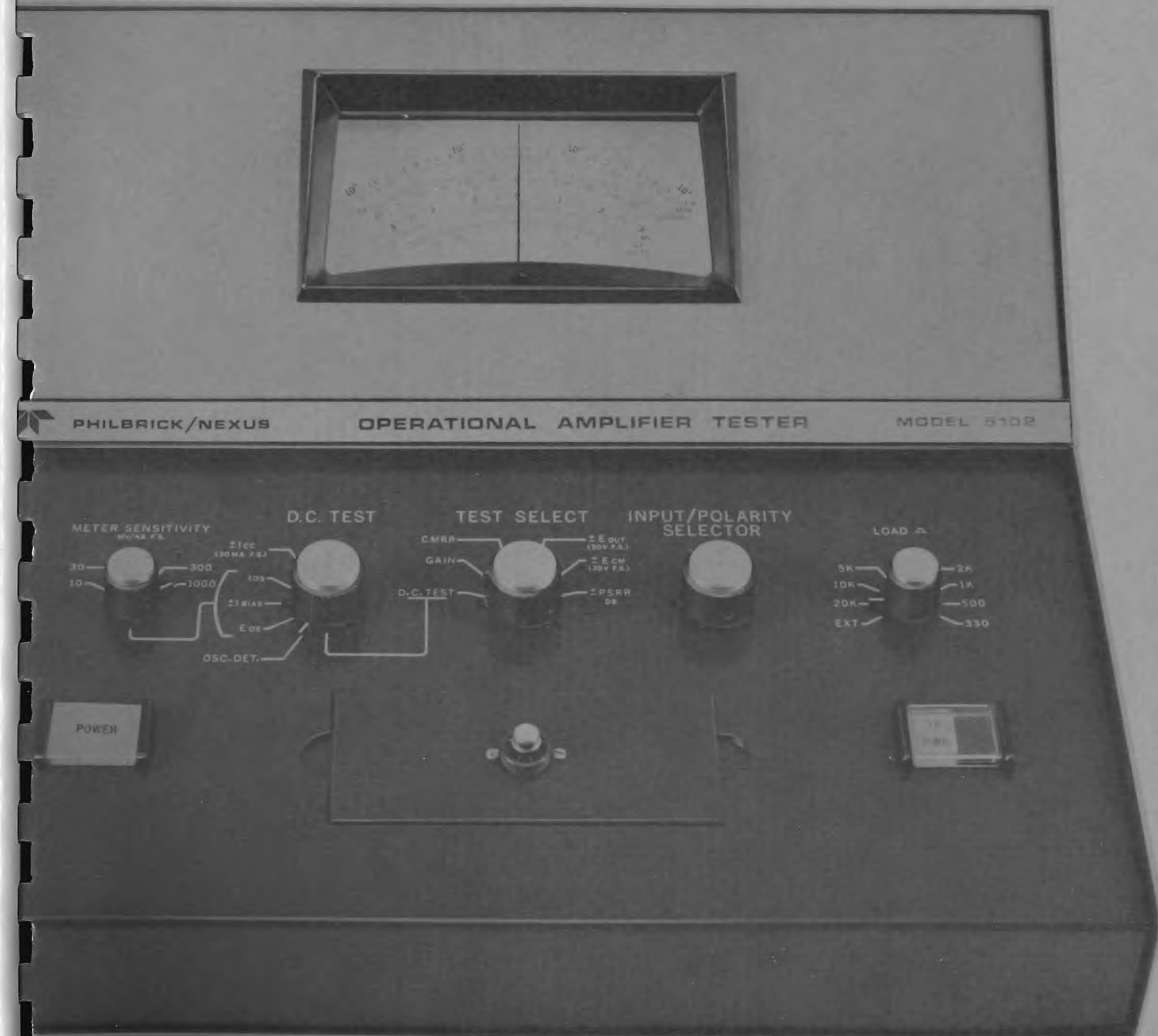

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Teledyne Philbrick Nexus warrants each of its products to be free from defects of material or workmanship and to conform to the applicable published ratings and characteristics in effect at the time of shipment. Our liability under such a warranty is limited to replacement or service, at our option, of any product or part thereof which is found to be defective within one (1) year from the date of shipment. In all instances defective items shall be returned to us, transportation prepaid. In no event shall we be liable for collateral or consequential damages and under no circumstances shall our obligation exceed the original purchase price. This warranty shall not apply to any product that has been subjected to misuse, improper operation, repair, alteration, neglect, accident, inundation, fire or operation outside of its published maximum ratings. We reserve the right of final determination as to the cause and the existence of any defect under this warranty.

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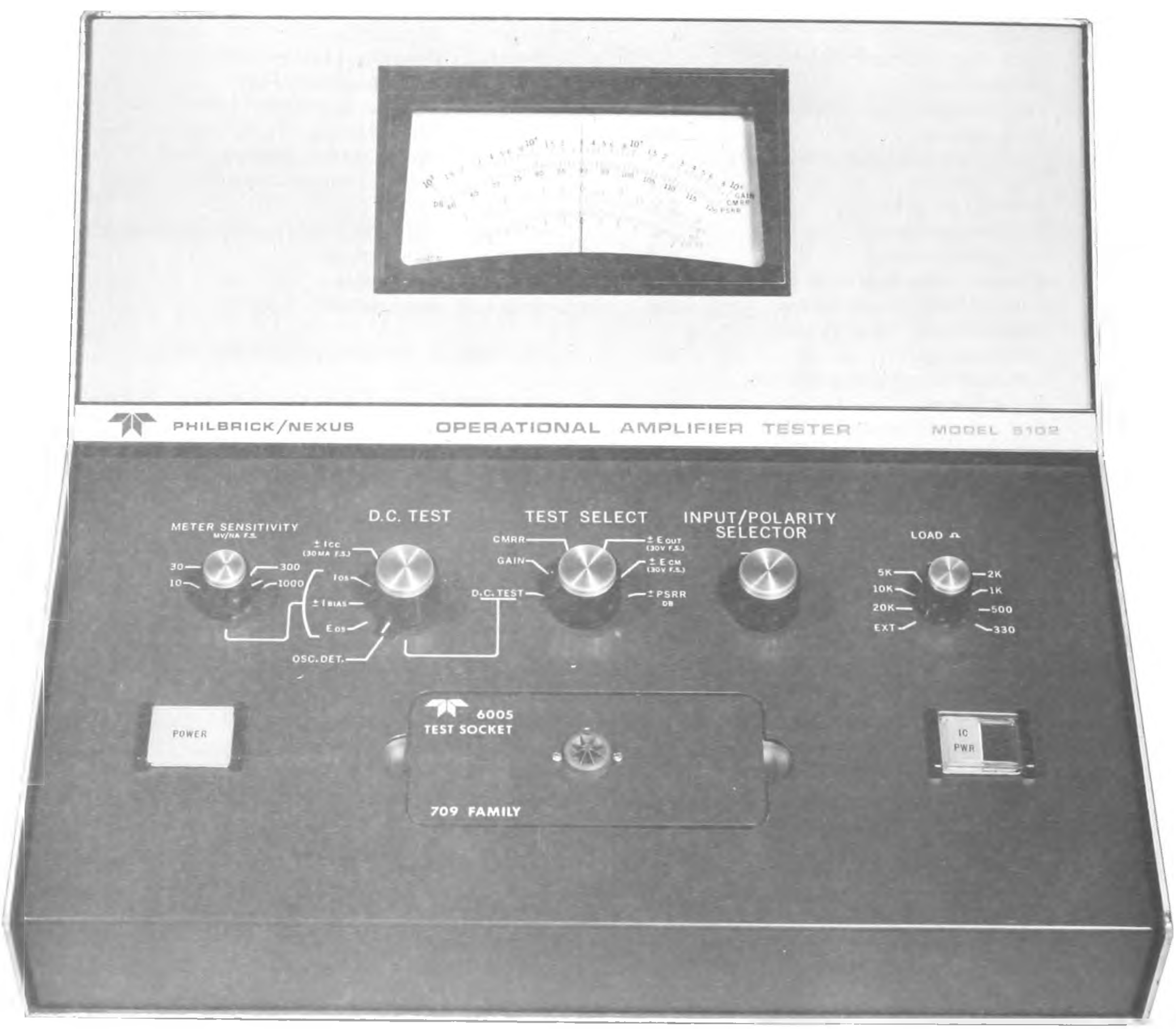

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Table 1-1. Specifications

Quiescent Current ($\pm I_{cc}$)	0 to ±30mA, ±3%, 30mA full-scale	Common Mode Voltage ($\pm E_{cm}$)	0 to ±30V, ±3%, 30V full-scale
Input Offset Current (I_{os})	0 to ±1000nA, ±3%, 10, 30, 100, 300, 1000nA full-scale	Power Supply Rejection Ratio (±PSRR)	60 to 120 dB 60 to 110 dB, ±1dB
Input Bias Current ($\pm I_{bias}$)	0 to ±1000nA, ±3%, 10, 30, 100, 300, 1000nA full-scale	Output Load	Internal: 8 values 330 Ω to 20kΩ External: to 20kΩ
Input Offset Voltage (E_{os})	0 to ±1000mV, ±3%, 10, 30, 100, 300, 1000mV full-scale	Power Supply	Each supply internally programmable from 4 to 24Vdc, short circuit protected, ±100mA at ±15Vdc
Oscillation Detection (OSC DET)	Detects oscillations of 10mV peak from 100Hz to 10MHz	Power Required	115 or 230Vac (specify), 50 to 60 Hz
Gain	60 to 120 dB 60 to 115 dB, ±1dB	Power Consumption	Approx. 10 watts
Common Mode Rejection Ratio (CMRR)	60 to 120 dB 60 to 80 dB, ±1dB 80 to 90 dB, ±2dB 90 to 110 dB, ±3dB	Dimensions	12½"L x 15"W x 11"H
Output Voltage Swing ($\pm E_{out}$)	0 to ±30V, ±3%, 30V full-scale	Weight	Approx. 11 lbs

SECTION 1

GENERAL INFORMATION

1-1. DESCRIPTION

The Teledyne Philbrick Nexus Model 5102 Operational Amplifier Tester, shown in Figure 1-1, is a semi-automatic,precision instrument designed to test most all integrated circuit, hybrid, or discrete operational amplifiers currently available. Housed in a sloping-front cabinet, this instrument provides the capabilities to perform both Static (DC) and Dynamic (AC) testing of most devices. Specifications for these tests are outlined in Table 1-1. A single front panel meter provides measurement indications, expressed in engineering units, without any unnecessary sensitivity adjustments. Human engineering concepts have been fully utilized throughout the development of this unit to assure fast, efficient test sequencing with a minimum of operator training required. Color-coded controls simplify the operation and permit rapid training of unskilled personnel.

1-2. APPLICATIONS

The Model 5102 Operational Amplifier Tester is designed for use in quality control measurements, production line testing, engineering evaluations, and all other applications that require speed, accuracy, and operating convenience. The unit serves as a valuable tool to quality control engineers in obtaining a cross-sectional sampling of data on incoming stock. In production, devices can easily be sorted and matched thereby eliminating those troublesome parameter restrictions pertaining to critical state-of-the-art circuit design. The development engineer can make use of this instrument to reveal the desired characteristics of any operational amplifier he might choose to use. Isolation of defects in substandard devices can readily be determined through the extensive test capabilities of this unit.

Teledyne Philbrick Nexus maintains an applications department to further serve your individual needs. Contact us through our local representative or directly at our facility in Dedham, Massachusetts.

1-3. ACCESSORIES

Full flexibility is designed into the Model 5102 Operational Amplifier Tester in that a complete selection of plug-in test sockets and program cards is available to permit testing of most all integrated circuit, hybrid, or discrete operational amplifiers. Each test socket comes complete with the manufacturers recommended damping networks supplied as a permanent part of the assembly. Two plug-in test sockets, Model's 6005 and 6008, are supplied as standard equipment with each instrument. These test sockets are for use with the 709 integrated circuit and 7-pin discrete types of operational amplifiers, respectively. The layout and circuit configuration of each is shown in Figure 1-2. Program cards, necessary to establish the test conditions particular to a given operational amplifier, are also available. Enclosed within the instrument, these assemblies program the positive and negative power supply limits, the output swing of the amplifier under

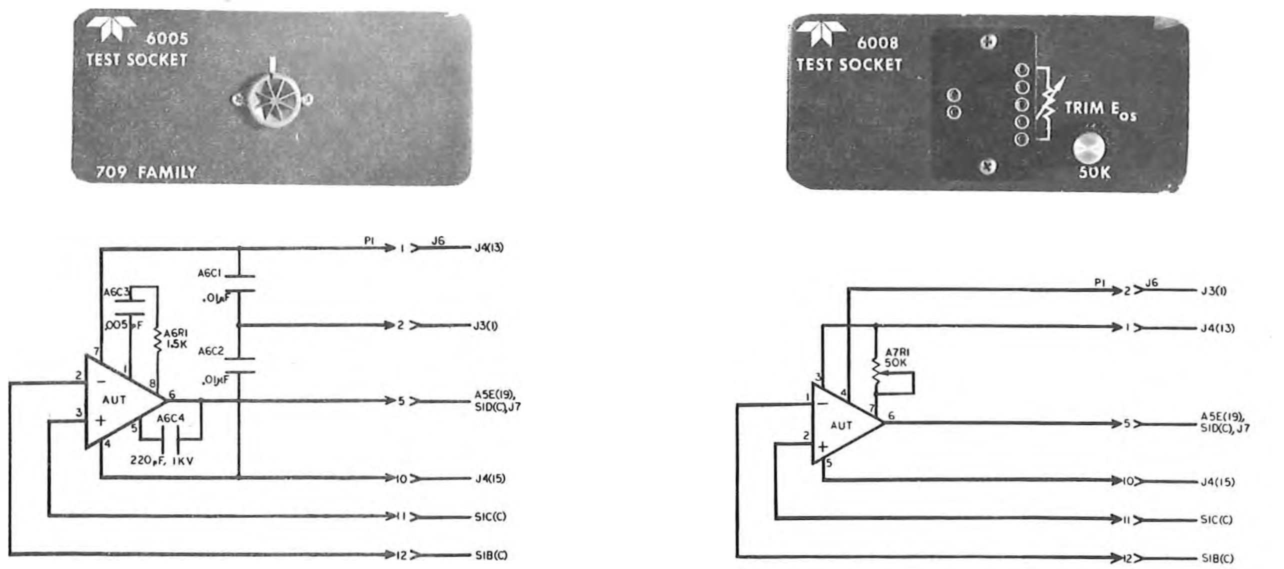


Figure 1-2. Plug-in Test Sockets

test, and the level of common mode voltage for CMRR testing. A Model 6007 program card is supplied with each instrument. Refer to Figure 6-4 in Section 6 of this manual for the schematic diagram and parts location for each program card available.

A list of the program cards designed for this instrument is shown in Table 1-2. Table 1-3 lists the test sockets presently available. A blank program card and test socket are included to provide expansion capabilities for accommodating future developed devices.

Table 1-2. Program Cards

Model	+Vcc	-Vcc	Swing for GAIN Test	CMRR Test Level
6007*	+15Vdc	-15Vdc	±10V	±5V
6016	+ 6Vdc	- 6Vdc	± 4V	±3V
6017	+12Vdc	-12Vdc	± 8V	±5V
6018	+18Vdc	-18Vdc	±14V	±6V
6019	+12Vdc	- 6Vdc	± 5V	±0.5V
6020	+24Vdc	-24Vdc	±20V	±6V
6021	-------BLANK PROGRAM CARD-------			
6022	+ 9Vdc	- 9Vdc	± 6V	±4V

*Supplied with the instrument

Table 1-3. Test Sockets

Model	Socket Description
6005*	709 Family - TO-99
6008*	Philbrick Nexus 7-pin Q
6009	Philbrick Nexus S-52 - DIP
6010	MC1533G - TO-99
6011	Amelco 809C - TO-99
6012	LM101/μA741 Family - TO-99
6013	Philbrick Nexus T-52 - TO-99
6014	----BLANK TEST SOCKET----
6015	Philbrick Nexus 8-pin L
6026	Philbrick Nexus 7-pin Q (high frequency i.e. 1011)
6027	Philbrick Nexus P type
6028	MC1439G - TO-99
6030	MC1437P (Dual 709) - DIP
6031**	Philbrick Nexus 7-pin Q (low current)
6032	MC1433P - TO-116
6033	Philbrick Nexus 9-pin Q
6034	709 Family - DIP

* Supplied with the instrument

** Extends the range of the instrument to the pico-amp measurement region for testing FET-input devices (full scale is ±10pA at reduced accuracy)

SECTION 2

THEORY OF OPERATION

2-1. INTRODUCTION

This section of the manual contains detailed information regarding the test configurations and restraints placed upon the amplifier to be tested. The individual tests performed in the Static (DC) and Dynamic (AC) mode of operation are separately discussed.

2-2. STATIC (DC) TESTING

The Model 5102 Operational Amplifier Tester provides the capabilities to perform four (4) basic static measurements and a stability test on a particular device. They are Quiescent Current (±Icc), Input Offset Current (Ios), Input Bias Current (±Ibias), Input Offset Voltage (Eos), and Oscillation Detection (OSC DET). In the Static mode of operation a simple straightforward approach was taken in that the appropriate source and feedback elements are connected to the amplifier under test and the result of the measurement is displayed on the front panel meter. To activate a Static test, the TEST SELECT switch (S1) must be positioned to DC TEST. The DC TEST selector (S2) in turn is used to set up the desired input, output, and feedback constraints on the amplifier under test. Note the leader which runs from the DC TEST position of the TEST SELECT switch to the DC TEST selector. This along with other similar features is all part of the human engineering that went into the development of this instrument. These input, output, and feedback components are found, for the most part, on the Switch Components Assembly (A5). With the DC TEST selector placed into the Ios, ±Ibias, and Eos positions, the METER SENSITIVITY switch (S4) is then activated. Note that these positions are grouped together by a leader which runs to the METER SENSITIVITY switch. Also, whenever a positive or negative measurement is to be made, the "±" designation has been screened in yellow which corresponds to the color of the screening used on the INPUT/ POLARITY SELECTOR (S3). The addition of these simple but useful features was found to be quite helpful in training test personnel.

2-2.1 QUIESCENT CURRENT (±Icc) MEASUREMENT

Quiescent Current - maximum current drawn by the amplifier under test from either the positive or negative power supply under a no load condition.

The system used to measure the quiescent current delivered from the positive or negative power supply is shown in Figure 2-1.

In this configuration the amplifier under test is connected as a unity gain follower. Normal operating power supply voltages are applied through a 3.3Ω, 1% resistance which is placed in series with each supply line. The meter indicator, with a fixed full-scale sensitivity of ±30mA, is switched across either of the resistances by the INPUT/ POLARITY SELECTOR. The

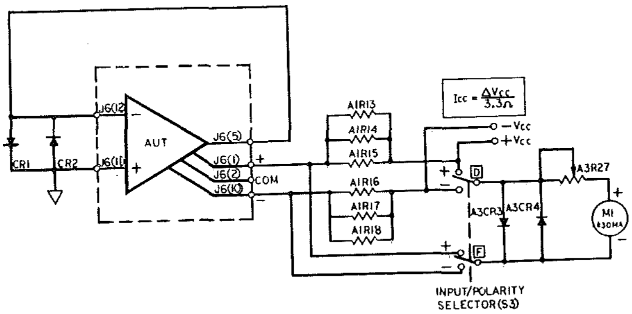


Figure 2-1. Quiescent Current (±Icc) Measurement System

voltage dropped across the resistance is proportional to the current flowing in the circuit. Diodes CR1 and CR2 are connected across the input terminals of the device to prevent "latch-up" with a common mode voltage. This may happen with some operational amplifiers if one supply is turned on before the other.

2-2.2 INPUT OFFSET CURRENT (Ios) MEASUREMENT

Input Offset Current - the difference between the input bias currents flowing into the plus and minus inputs of a device under a no signal condition.

The system used to measure the input offset current of the amplifier under test is shown in Figure 2-2.

In this configuration, the amplifier under test is connected as a unity gain inverter with active feedback and source networks. For the most part, the components that make up this test circuit are found on the Relay & Amplifier Assembly (A3). Amplifiers A1, A2, and A3 are used as current-to-voltage converters and are initially adjusted for a zero offset voltage by the potentiometers R14, R21, and R25, respectively. The QFT-2 amplifiers (A1 and A3) were chosen for their FET inputs so that the bias currents, which are in the picoampere range, will have no significant effect on circuit operation or accuracy. In this configuration the amplifier under test servoes itself to zero volts, plus or minus its offset voltage, through the active feedback network of A1. Amplifier A3 presents an active ground to the non-inverting input terminal of the device.

Under these conditions the voltage appearing at the output of A1 and A3 is as follows:

(1) $E_o\,(A1) = -I_{bias} \cdot R15 \pm E_{os}$

(2) $E_o\,(A3) = +I_{bias} \cdot R26$

As can be seen from the first equation the offset voltage (Eos) of the device enters into the solution. This error term is removed by a subtracter circuit (A2). The output equation of this stage is:

(3) $E_o\,(A2) = -I_{bias} \cdot R15$

A differential measurement is then taken between the output of A3 and A2. This current is representative of the input offset current present in the amplifier under test. The METER SENSITIVITY switch provides a refinement adjustment of the meter indication. Input offset currents in the order of 0 to 1000nA can be measured using this system. The final output equation is:

(4) $I_{os} = \left| +I_{bias} \right| - \left| -I_{bias} \right|$

The potentiometer R27 serves to calibrate the meter movement while diodes CR3 and CR4 protect it from overload.

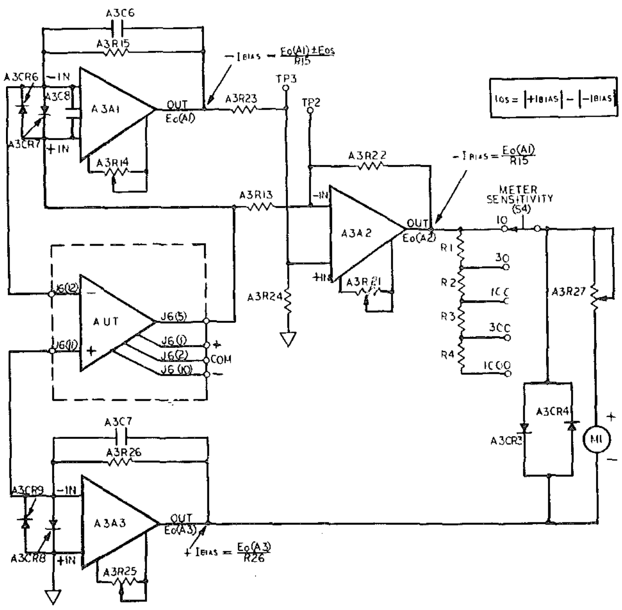


Figure 2-2. Input Offset Current (Ios) Measurement System

2-2.3 INPUT BIAS CURRENT (±Ibias) MEASUREMENT

Input Bias Current - the current flowing into the plus or minus inputs of the device under a no signal condition.

The system used to measure the input bias currents of the amplifier under test is shown in Figure 2-3.

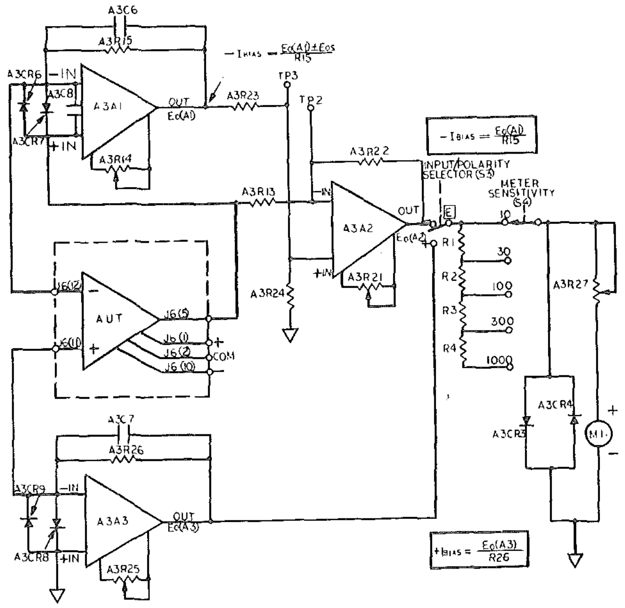


Figure 2-3. Input Bias Current (±Ibias) Measurement System

The test configuration used to measure these parameters is similar to that used to make the input offset current measurement. Refer to Paragraph 2-2.2. Through the use of the INPUT/ POLARITY SELECTOR the current flowing at the output of A2 and A3 can individually be displayed on the front panel meter. The METER SENSITIVITY switch allows for refined input bias current measurements to be made in the order of 0 to 1000nA. The final output equations are:

(1) $+I_{bias} = \dfrac{E_o\,(A3)}{R26}$

(2) $-I_{bias} = \dfrac{E_o\,(A2)}{R15}$

Again the combination of the potentiometer R27 and diodes CR3 and CR4 have been used to calibrate and protect the meter movement.

2-2.4 INPUT OFFSET VOLTAGE (Eos) MEASUREMENT

Input Offset Voltage - the internally generated error voltage which causes a non-zero output. This is referred to the input of the amplifier.

The system used to measure the input offset voltage of the amplifier under test is shown in Figure 2-4.

In this configuration, the amplifier under test is connected as an inverter with a noise voltage gain of ten and an equivalent source impedance of 900 ohms. The gain error is less than 1% for operational amplifiers having gains greater than 60dB. With the METER SENSITIVITY switch set to the most sensitive range

(10mV), one microampere of input offset current will contribute approximately a 10% full-scale error. This circuit does, however, require that the amplifier under test have an output voltage swing of at least ten times the offset voltage to be measured. The final output equation is:

$$(1) \quad E_{os} = \frac{E_o \pm I_{os}R_s}{10} = \frac{E_o \pm 900 I_{os}}{10}$$

Again, the potentiometer R27 and the diodes CR3 and CR4 have been used to provide adjustment and overload protection for the meter movement.

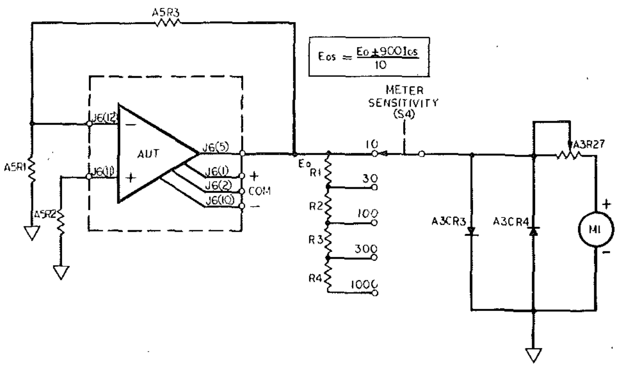


Figure 2-4. Input Offset Voltage (Eos) Measurement System

2-2.5 OSCILLATION DETECTION (OSC DET) MEASUREMENT

The system used to detect an oscillation present in the amplifier under test is shown in Figure 2-5.

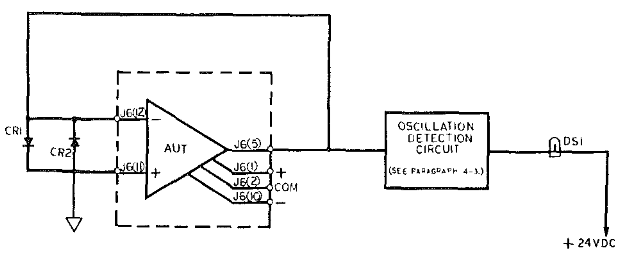


Figure 2-5. Oscillation Detection (OSC DET) Measurement System

In this configuration, the amplifier under test is connected as a unity gain follower. The oscillation detection circuit monitors the output of the device. See Paragraph 4-3. for the discussion of this circuit. Should an oscillation in the frequency range of 100Hz to 10MHz and in excess of 10mV peak be evident, the OSC DET indicator (DS1) will illuminate. Again, diodes CR1 and CR2 are used to prevent "latch-up".

2-3. DYNAMIC (AC) TESTING

The Model 5102 Operational Amplifier Tester provides the capabilities to perform five (5) dynamic measurements on a particular device. They are Gain, Common Mode Rejection Ratio (CMRR), Output Voltage Swing (±Eout), Common Mode Voltage (±Ecm), and Power Supply Rejection Ratio (±PSRR). Measuring the dynamic characteristics of a device presents a more complex problem than did the measurement of the static characteristics. To maintain operating simplicity and the direct readout capability a synchronous demodulation system was developed. See Paragraph 2-3.1 for a discussion on the operation of this system. Through the use of the synchronous demodulator, dynamic measurements are reduced to a simple, straightforward routine, paralleling that used for Static testing. Input, output, and feedback elements are connected to the amplifier under test, and the result of the measurement is displayed on the front panel meter. Again the input, output, and feedback components are found, for the most part, on the Switch Components Assembly (A5). To activate a Dynamic test, the TEST SELECT switch is simply positioned to the desired test. This sets up the proper constraints about the amplifier under test. During Gain and Output Voltage Swing measurements, the LOAD Ω selector (S5) is automatically connected to the output of the device through the energized relay A5K6. It should be noted here that the resistance values shown in conjunction with the LOAD Ω selector, include the parallel, internal effective load of 20,000 ohms. Also, as in Static testing, whenever a positive or negative measurement is to be made, the "±" designation has been screened in yellow to correspond with the screening of the INPUT/POLARITY SELECTOR.

2-3.1 SYNCHRONOUS DEMODULATION

The heart of the dynamic measurement system used in the Model 5102 Operational Amplifier Tester is the synchronous demodulator. To develop a better understanding of this circuit, let us first examine the operation of a basic synchronous detection system, like the one shown in Figure 2-6 in which the gain parameter is measured. Here a signal source is generated to drive the modulator switch S1 in synchronism with the demodulator switch S2. The modulator produces a square-wave signal by switching between two stable dc reference voltages. The magnitude of these voltages should be at least as great as the largest voltage encountered when testing a device over its full dynamic range. Theoretically, the output of the device is:

$$(1) \quad e_{op\text{-}p} = \frac{R2}{R1} \cdot 2\left|V_{ref}\right|$$

In this case, the signal is coupled to the amplifier under test, which is running *in a closed-loop configuration* with a gain-error signal ($e\Sigma$) appearing between the negative terminal and common. The resultant gain-error is:

$$(2) \qquad e\Sigma = -\frac{e_o}{A_o}$$

....where A_O is the open-loop gain of the amplifier under test.

The error signal is then ac coupled and amplified with a precise gain to an appropriate level before being demodulated. It is band-limited to reject dc drift, very low frequency noise (flicker), and any high frequency noise. The amplified signal is demodulated or converted back to a dc signal using a peak-to-peak detector switching in synchronism with the input signal source. Capacitor C1 charges to the level of the Vref output in a negative direction with respect to ground on the first half cycle while on the next half cycle C2 charges in a positive direction. After a few cycles, the dc signal that appears across C2 is equal to the peak-to-peak value of the gain-error signal multiplied by the gain of the ac amplifier. The dc signal is:

$$(3) \qquad Vdc = e\Sigma \cdot A1$$

....where A1 is the gain of the ac amplifier.

The resultant gain equation is:

$$(4) \qquad A_O = A1 \cdot \frac{R2}{R1} \cdot \frac{2|Vref|}{Vdc}$$

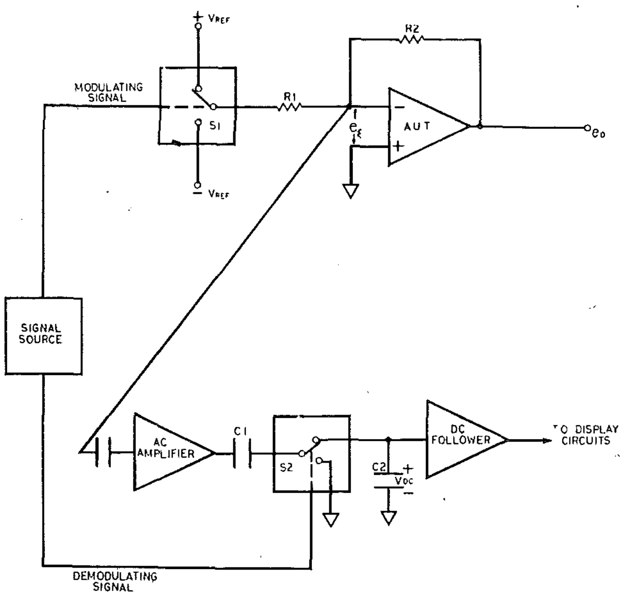


Figure 2-6. Synchronous Demodulation System

Since synchronous demodulators inherently provide improved signal-to-noise ratios, low-level signals in the order of microvolts can easily be detected. Certain basic precautions must be considered, though. First, the switching signal must be low enough in frequency so that the transient spikes on the detected signal introduce a minimal error. The maximum repitition rate will be determined by the low frequency open-loop characteristics of the device. Some form of protection must be provided for the input of the amplifier under test. The ac amplifier must be able to pass the low frequency square-wave input signal and its output impedance must be relatively low to allow the capacitors C1 and C2 to charge quickly. Finally, the dc follower must have a very high input impedance so as not to discharge the capacitor C2 on alternate half cycles.

With these considerations in mind, the actual circuit used in this instrument was developed. A block stage representation of this system is shown in Figure 2-7. It is an improved version, modified to overcome some of the aforementioned problems.

A clock, operating at a frequency of 10Hz, is used to control the modulator and demodulator switching networks. Its output is fed to the frequency divider and monostable multivibrator circuits. The frequency divider, designed to trigger on the negative slope of the clock pulse, produces a signal at one half the frequency of the clock (5Hz). Its outputs are gated by an electronic phase reversing switch and are used to drive the Vref circuit. This electronic switching determines the phase of the modulating signal with respect to the clock. The Vref circuit is used to provide a modulating signal sufficient to drive the amplifier under test through an equivalent source impedance (Req). This impedance corresponds to the resistance of A2R50 on a positive half cycle or to that of A2R51 on a negative half cycle. The output of the individual test circuits is coupled to the ac amplifier A3A1 where it is amplified, band-limited, and then fed to the input of the peak-to-peak demodulator circuit. A monostable multivibrator and FET switch form a dc restorer circuit to discharge the test circuit coupling capacitors where used. The demodulator circuit consists of two junction field-effect transistors operating in a shunt-series chopper configuration. Triggering on the positive slope of the clock pulse, the monostable multivibrator, in conjunction with the ØA and ØB outputs of the frequency divider, causes gates 1 and 2 to function only on the later, positive going half of each clock switching period, by which time nearly all transients on the error signal have been damped out. When gate 1 is turned on, capacitor A3C3 is grounded through the "shunt" FET A2Q18. At the same instant, gate 2 is off, opening the "series" FET A2Q19. This creates a synchronous sample-and-hold, peak-to-peak detector, where the sampling period is set by the timing cycle of the monostable multivibrator. By shorting out capacitor A3C3 and direct coupling the ac amplifier, a synchronous peak reader is formed. Changing the phase of the modulating signal with the electronic switch allows signals of either polarity from the amplifier under test to be measured under dynamic conditions. This feature allows the measurement of maximum output under load as well as the common mode range to be performed. The gate signal for the "shunt" FET is referenced to ground, while the gate signal for the "series" FET is referenced to the dc follower output. This ensures that the FET's are referenced properly. A good FET input operational amplifier is used as the dc follower A3A3 so that signals in the order of a few millivolts to ten volts are accurately demodulated. The only significant error introduced by this circuit is that produced by the dc follower's offset and drift. This circuit has a wide dynamic range that is used to advantage to drive the logarithmic amplifier and display. During ±E out and ±E cm measurements the output of the dc follower is directly displayed on the meter indicator. When a Gain, CMRR or ±PSRR measurement is performed, the output of the dc follower is fed to the log amplifier A3A2. Here the absolute value circuit A2A2 establishes a positive current to the log element A3A4 which is placed in the feedback loop of the log amplifier. The logarithmic resultant is then displayed on the meter movement, which is scaled in dB.

2-3.2 GAIN MEASUREMENT

Gain - the ratio of the change in output voltage with a specified load to the change in the input voltage existing between the inverting and non-inverting terminals of the device.

The system used to meaure the gain of the amplifier under test is shown in Figure 2-8.

In this configuration the amplifier under test is connected as an inverter. Theoretically, the output of the device is:

$$(1)\ eo = -\frac{A5R16}{A4R1 + Req} \cdot \frac{1}{1 + \frac{1}{Ao\beta}} \cdot \left| Vref \right|$$

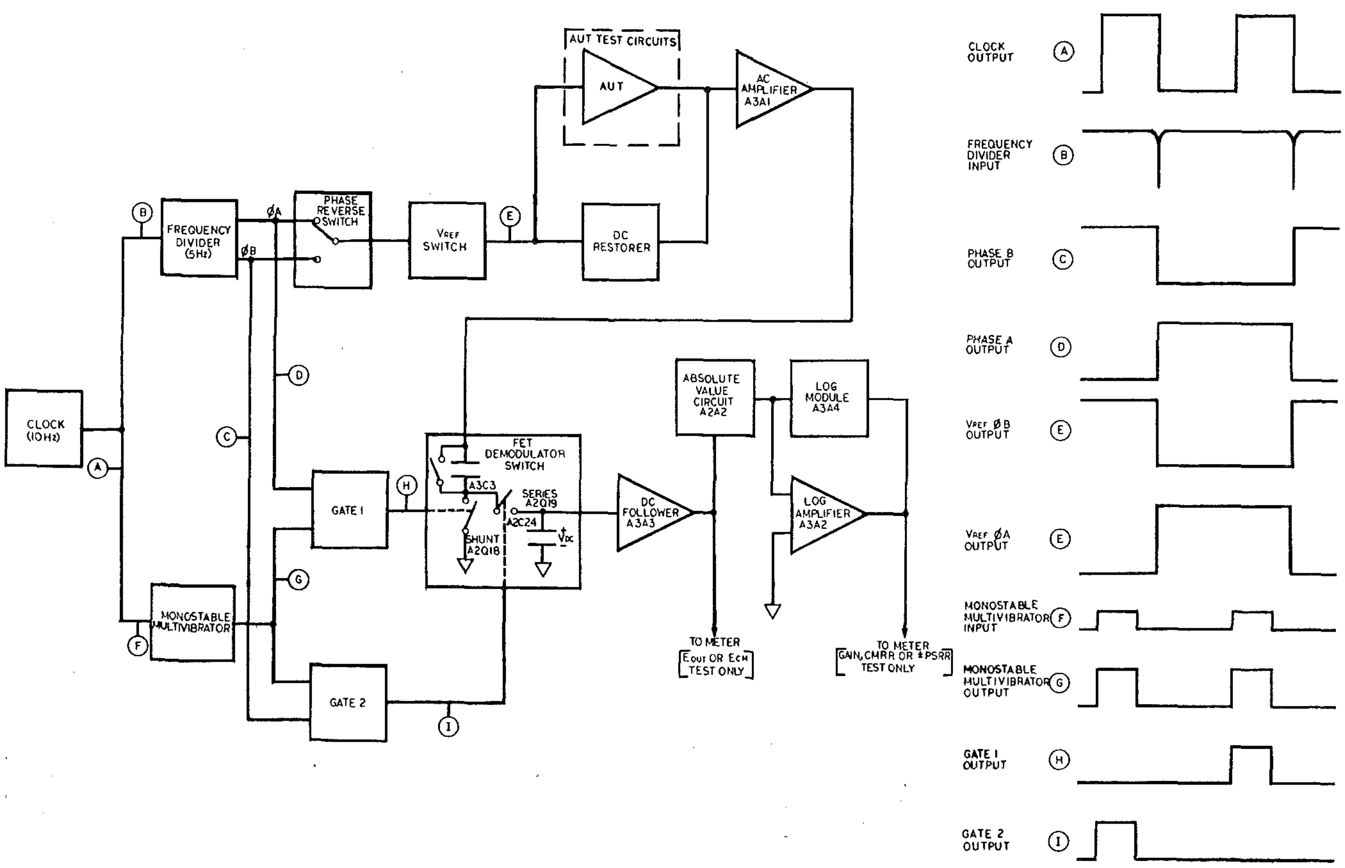


Figure 2-7. Synchronous Demodulation System used in the Model 5102 Operational Amplifier Tester

....where A_o is the open-loop gain of the amplifier under test and Req is the source impedance of the Vref generator and

$$(2)\quad \beta = \frac{1}{(1+\frac{A5R15}{A5R14})\ (1+\frac{A5R16}{A5R16+A4R1}+\frac{A5R16}{A5R15+A5R14})}$$

By a careful choice of values, the term $\frac{1}{A_o\beta}$ is made very small, less than 0.01, therefore resulting in less than a 1% error in the following equation:

$$(3)\qquad e_{op\text{-}p} = 2\left|Vref\right| \cdot \frac{A5R16}{A4R1 + Req}$$

With this in mind, the output level of the amplifier under test can be easily programmed with a single, precisely calibrated resistor, A4R1. This resistor is located on the Program Card Assembly (A4). It allows the same basic circuit to be used to measure the gain of different devices having different swing capabilities.

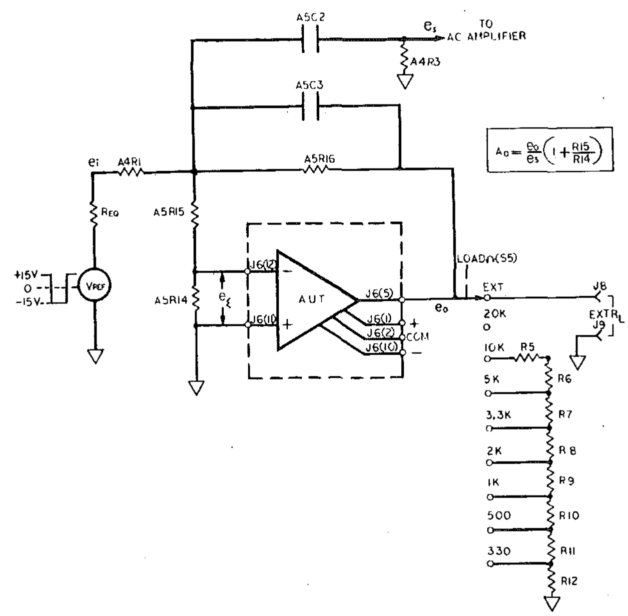


Figure 2-8. Gain Measurement System

The LOAD Ω switch is used to select the proper loading for the device. It should be noted that the resistance shown is the parallel combination of the selected value and the internal feedback resistance of A5R16. An error signal, eΣ, is generated at the input of the device and is increased by the divider network, A5R14 and A5R15, thus eliminating the need for further ac gain. This error signal is then coupled to the synchronous demodulator by the capacitor A5C2 where it is amplified, demodulated, and displayed logarithmically on the front panel meter. The final gain equation is:

$$(4)\qquad Ao = \frac{e_{op\text{-}p}}{e_{sp\text{-}p}}\ (1+\frac{A5R15}{A5R14})$$

A4R3 is used to scale this error signal, e_s, before it is amplified by the ac amplifier stage of A3A1. A device having a higher output level would require a decrease in the resistance of A4R1 together with an increase in the resistance of A4R3. The formulas for calculating these values are found in Section 4-5. of this manual.

2-3.3 COMMON MODE REJECTION RATIO (CMRR) MEASUREMENT

Common Mode Rejection Ratio - the ratio of the change in input common mode voltage to the change in input offset voltage.

The system used to measure the common mode rejection ratio of the amplifier under test is shown in Figure. 2-9.

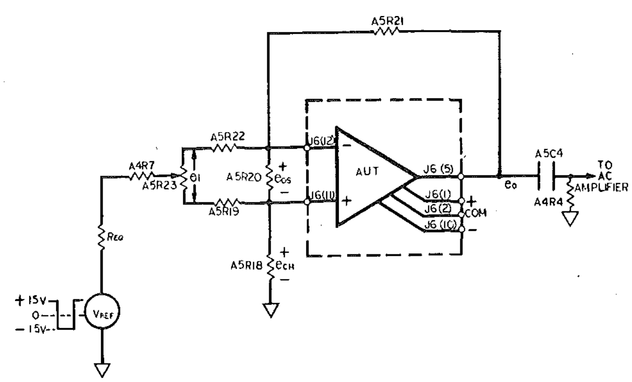


Figure 2-9. Common Mode Rejection Ratio (CMRR) Measurement System

In this configuration the amplifier under test is connected as a perfect subtracter with a balanced bridge in its input circuit. For the purpose of discussion we will neglect the resistor A5R20 for the moment. The common mode rejection is then:

$$(1)\qquad CMRR = \frac{e_{cm}}{\Delta e_{os}} = \frac{e_i}{e_o} \cdot \frac{A5R21}{A5R22}$$

....where e_{cm} is the actual common mode voltage and e_i is the driving function.

This equation holds true when the following condition is satisfied:

$$(2)\qquad \frac{A5R18}{A5R19} = \frac{A5R21}{A5R22}$$

For imbalances in the resistor ratio, the actual expression for e_o vs. e_i becomes:

$$(3)\quad \frac{e_o}{e_i} = \frac{A5R21}{A5R22}\left[\frac{1+\frac{A5R22}{A5R21}}{1+\frac{A5R19}{A5R18}}\cdot\frac{1}{CMRR}+\frac{\frac{A5R22}{A5R21}-\frac{A5R19}{A5R18}}{1+\frac{A5R19}{A5R18}}\right]$$

From this equation one can see how closely the resistor ratios must be matched for the first equation to be valid with any given CMRR, allowable tolerance errors, or environmental changes.

The potentiometer A5R23 is used to balance the input to the bridge circuit to better than 0.5 parts per million while the series combination of A4R7 and the equivalent source impedance of the Vref generator, Req, establishes the level of common mode voltage appearing at both inputs of the device. The noise gain of the test circuit is then increased for better stability by adding the resistor A5R20. The equivalent noise gain is:

$$(4)\quad \text{noise gain} = 1+\frac{A5R21}{A5R22}+\frac{2\cdot A5R21}{A5R20} = 50$$

A4R4 is used to scale the level of the error signal being fed to the input of the synchronous demodulator through the capacitor, A5C4.

The resultant common mode rejection equation is:

$$(5)\quad CMRR = \frac{Ecm}{Eo}\cdot \text{noise gain}$$

2-3.4 OUTPUT VOLTAGE SWING (±Eout) MEASUREMENT

Output Voltage Swing - the maximum positive and negative output voltage, without clipping, developed under a specified load in reference to ground.

The system used to measure the output voltage swing of the amplifier under test is shown in Figure 2-10.

In this configuration the amplifier under test is connected as an inverter. The output voltage swing is:

$$(1)\quad e_o = \frac{A5R8}{A4R2 + Req}\cdot\left|Vref\right|$$

The device is driven into saturation in either a positive or negative direction and the resultant peak level is detected by the synchronous demodulator operating as a peak detector. To accomplish this, the capacitor A3C3 is shorted out in the FET demodulator circuit. The LOAD Ω switch is again used to select the proper loading for the device. Again, the resistance shown is the selected resistance in parallel with the series combination of A5R10 and A5R11, all in parallel with the feedback resistance, A5R8. Diodes CR7 and CR8 are used to protect the input of the amplifier under test from being driven beyond a 0.6 volt limit. The resistor A4R2 is used to program the output of the device. This output is then divided down by the network of A5R10 and A5R11 to a suitable level to drive the input of the amplifier, A3A1. This signal is amplified, peak detected, and the results displayed directly on the front panel meter.

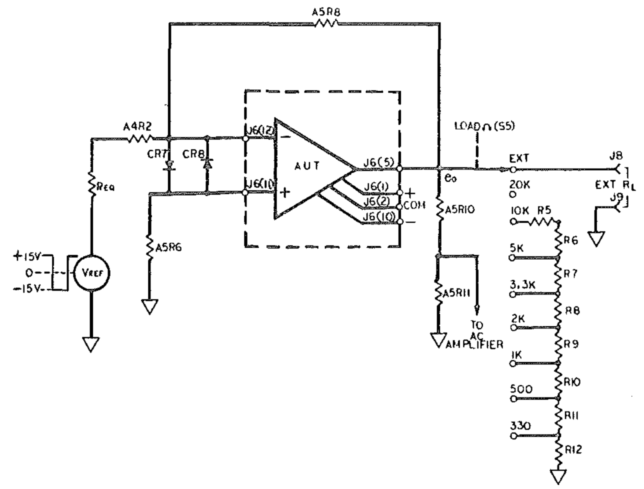


Figure 2-10. Output Voltage Swing (±E out) Measurement System

2-3.5 COMMON MODE VOLTAGE (±Ecm) MEASUREMENT

Common Mode Voltage - the maximum voltage that may be applied to either input with respect to ground and still permit the amplifier to function in the active region.

The system used to measure the common mode voltage of the amplifier under test is shown in Figure 2-11.

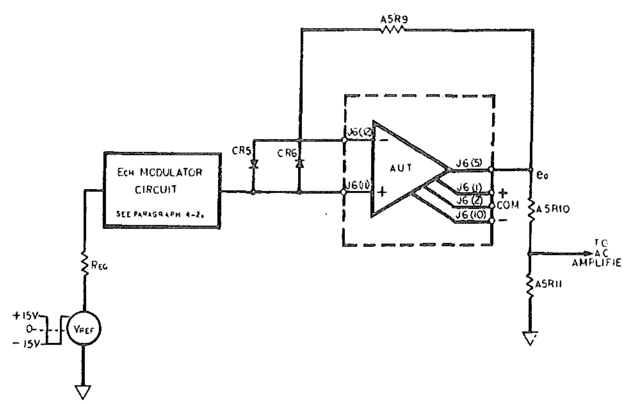


Figure 2-11. Common Mode Voltage (±Ecm) Measurement System

In this configuration the amplifier under test is connected as a follower. The non-inverting terminal of the device is driven, through a large source impedance A1R22, by the Ecm modulator circuit. This circuit receives its input from the Vref generator.

Diodes CR5 and CR6 along with the resistor A5R9 serve to protect the device from "latch-up" with common mode voltage. Under this operation the amplifier under test is driven into saturation as the common mode voltage limit is approached. The output no longer follows the input resulting in a saturated signal appearing at the output. For this reason, it is important to remember that the output voltage swing of the device must be equal to or greater than the level of its common mode voltage range. The signal is then divided by the network of A5R10 and A5R11 to a suitable level to drive the input of the amplifier A3A1. It is amplified, peak detected, and the results displayed directly on the front panel meter, as in the case of the output voltage swing measurement.

2-3.6 POWER SUPPLY REJECTION RATIO (±PSRR) MEASUREMENT

Power Supply Rejection Ratio - the ratio of the change in input offset voltage resulting from a change in either power supply voltage.

The system used to measure the power supply rejection ratio of the amplifier under test is shown in Figure 2-12.

In this configuration the amplifier under test is connected as an inverter, with a noise gain of 25 and an equivalent source impedance of 50Ω. The noise gain is:

$$\text{(1)} \qquad \text{noise gain} = 1 + \frac{A5R4}{A5A5} = 25$$

Here the output of the Vref generator is used to drive the PSRR modulator circuit which introduces a ±0.5 volt fluctuation upon either the positive or negative power supply line. The resulting noise-gained offset voltage is then coupled to the synchronous demodulator by the capacitor A5C1 where it is ac amplified, demodulated, and displayed logarithmically on the front panel meter. The resultant equation for power supply rejection is:

$$\text{(2)} \qquad PSRR = \frac{\Delta Vcc}{e_{os}} = \frac{\Delta Vcc}{e_o} \cdot \frac{A5R4 + A5R5}{A5R5}$$

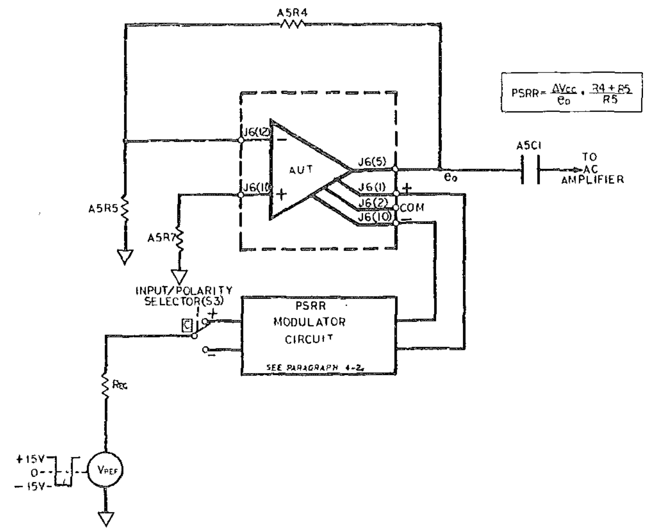


Figure 2-12. Power Supply Rejection Ratio (±PSRR) Measurement System

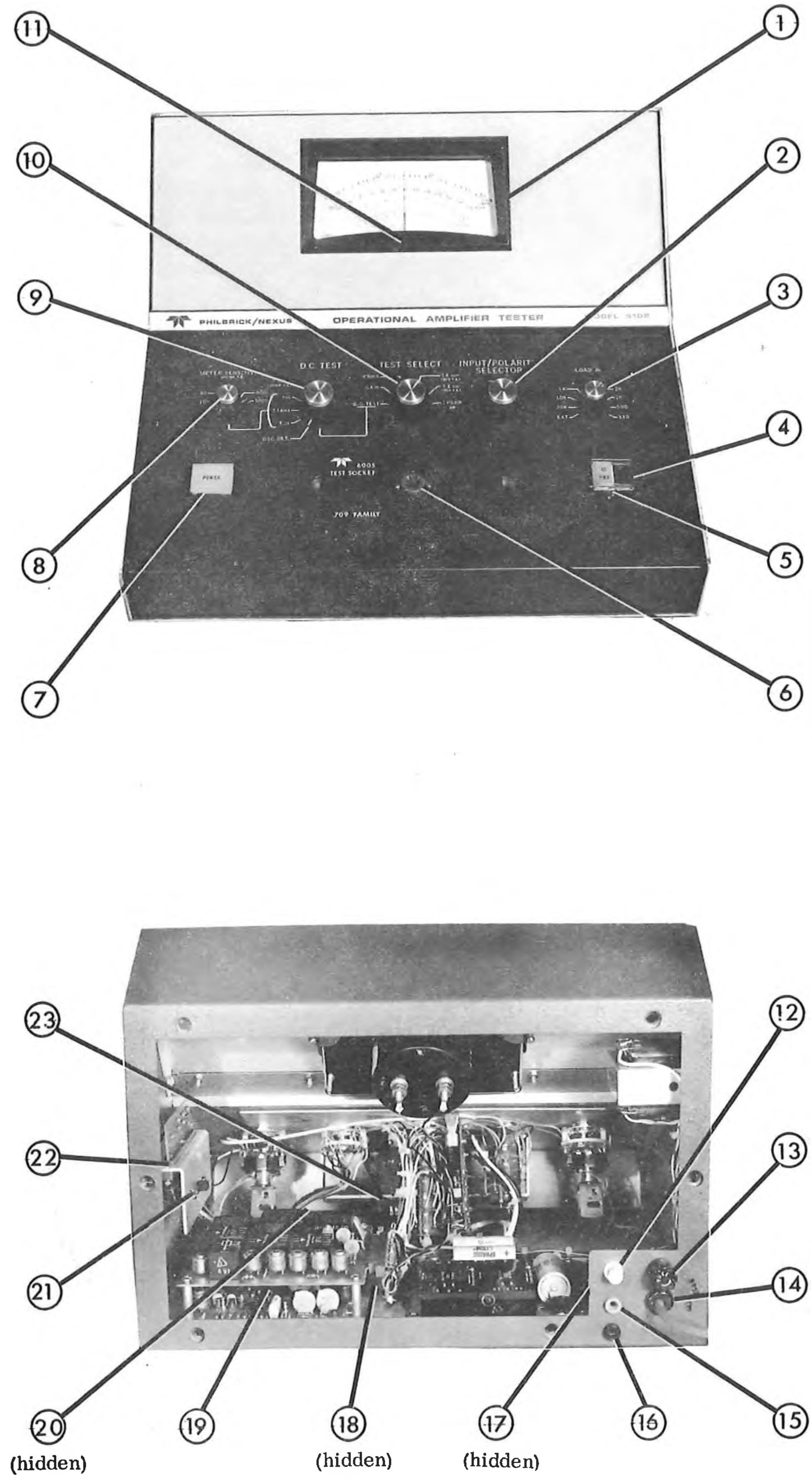


Figure 3-1. Controls, Connectors, and Indicators

SECTION 3

OPERATION

3-1. INTRODUCTION

This section of the manual contains information regarding inspection, installation, controls, connectors, indicators, and a step-by-step operational procedure.

3-2. INSPECTION

The Model 5102 Operational Amplifier Tester was thoroughly inspected for electrical and mechanical perfection prior to shipment. It is recommended that the unit be carefully removed from its packaging and inspected for physical damage that may have resulted during transit. Completeness of your order should be verified at this time to ensure that all purchased accessories have been received. Refer to the warranty in the front of this manual for our Limit of Liability should damage or deficiency be evident. Original packaging should be retained to facilitate a return shipment.

3-3. INSTALLATION

This instrument is designed to operate from a 115Vac, 50 to 60 Hz line source. Should the need arise to operate the unit from a 230Vac, 50 to 60 Hz source, it is recommended that a step-down transformer be used or the instrument be modified as outlined in Paragraph 4-2. A three-conductor power cable is provided for the protection of operating personnel. If a two-contact outlet is all that is available, insure that a two-prong adapter is used and ascertain that the green grounding pigtail is attached to a suitable ground, such as a coldwater pipe. A 3/4-ampere fuse (F1) is incorporated to provide short circuit protection for the instrument. It is advisable to operate the unit under normal ambient conditions (+25°C).

3-4. CONTROLS, CONNECTORS, AND INDICATORS

The function of each front and rear panel control, connector, and indicator is fully described in the following paragraphs. Refer to Figure 3-1 for the location of each item.

(1) Meter Indicator - meter movement (M1) used to display all Static and Dynamic operating parameters of the device under test. Ranges include:

LOG	10^3 - 10^6
dB	60 - 120
mV	±10 - 1000
nA	±10 - 1000
V	±30 (full-scale)
mA	±30 (full-scale)

(2) INPUT/ POLARITY SELECTOR - rotary switch (S3) used to select either the inverting or non-inverting input of the device or the positive or negative power supply line.

(3) LOAD Ω - rotary switch (S5) used to select the load resistance applied to the output of the device being tested.

(4) OSC DET - lamp (DS1) used to indicate detected oscillations in the device under test.

(5) IC PWR - pushbutton switch (S8) used to apply dc power to the device to be tested. The pushbutton indicator lamp (DS2) will illuminate when power is applied.

(6) Test Socket - plug-in test socket. There is a type available for most integrated circuit, hybrid, or discrete operational amplifiers to be tested. See Paragraph 1-3 for a list of these accessories.

(7) POWER - pushbutton switch (S6) used to energize the Model 5102 Operational Amplifier Tester through the application of primary power. The pushbutton indicator lamps (DS3 and DS4) will illuminate when power is applied.

(8) METER SENSITIVITY - rotary switch (S4) used to select the full scale operating range of the meter indicator during the Ios, ±Ibias, and Eos tests. The incorporated sensitivity selection extends the range from 10 to 1000mV or nA depending upon the test to be performed.

(9) DC TEST - rotary switch (S2) used in the selection of all Static tests to be performed by this instrument.

(10) TEST SELECT - rotary switch (S1) used to select all Dynamic tests as well as the Static test mode (DC TEST position).

(11) Meter Zero Adjustment - set screw adjustment used to mechanically zero the meter indicator while the instrument is in an off state of operation.

(12) AMP OUT - BNC connector (J7) used to provice a sampling access to the output of the device under test.

(13) Fuseholder and Fuse - fuseholder (XF1) and 3/4-ampere fuse (F1) used to protect the instrument from an overload.

(14) Power Cable - three-conductor power cable used to connect primary power to the Model 5102 Operational Amplifier Tester.

(15)(16) EXT R_L - banana jacks (J8 and J9) used for connecting an external load resistance to the output of the device under test.

NOTE

In the EXT R_L position, any external load resistance will be in parallel with an internal effective load of 20,000 ohms.

(17) Connector (J1) - 22-pin edge connector used to mate interface circuitry with the Power Supply Assembly (A1).

(18) Connector (J3) - 15-pin edge connector used to mate interface circuitry with the Relay & Amplifier Assembly (A3).

(19) Connector (J2) - 15-pin edge connector used to mate interface circuitry with the Logic Assembly (A2).

(20) Connector (J4) - 22-pin edge connector used to mate interface circuitry with the Relay & Amplifier Assembly (A3).

(21) Calibration Switch - 3PDT slide switch (S7) used to place the instrument into the calibration mode (CMRR test only).

(22) Connector (J5) - 22-pin edge connector used to mate interface circuitry with the Program Card Assembly (A4).

(23) Connector (J6) - 15-pin edge connector used to mate stimuli and response signal lines to the plug-in test socket.

3-5. OPERATIONAL PROCEDURE

The Model 5102 Operational Amplifier Tester is designed to test most integrated circuit, hybrid, or discrete operational amplifiers currently available. A variety of test sockets provide the complete flexibility required to test available devices and those that become available in the future. To aid in the evaluation of these devices, a comprehensive, step-by-step procedure has been prepared in such a manner that any one or all of the Static or Dynamic tests may be performed after the completion of an initial set up.

3-5.1 STATIC TESTS

In the Static test mode of operation, all dc operating parameters of the device (±Icc, Ios, ±Ibias, Eos, and any oscillations detected over a specified bandwidth) are evaluated. The step-by-step procedure for Static evaluation of any operational amplifier is performed as follows:

1. Verify that the correct Program Card Assembly (A4) is inserted into connector J5. See the list of program cards, Table 1-2, for the proper selection.

2. Plug the power cable into a suitable source of 115Vac, 50 to 60 Hz line voltage.

3. Depress to illuminate the POWER pushbutton. A 30-minute warmup period is recommended to allow the circuits of the instrument to stabilize.

NOTE

Depress to extinguish the IC PWR pushbutton if illuminated.

4. Select an appropriate plug-in test socket for the particular device to be tested and insert into connector J6. See the list of test sockets, Table 1-3, for the proper selection.

5. Set the following controls as indicated:

METER SENSITIVITY	1000
TEST SELECT	DC TEST
INPUT/ POLARITY SELECTOR	+
LOADΩ	Not applicable for Static testing

6. Carefully insert the device to be tested into the test socket.

7. Depress to illuminate the IC PWR pushbutton.

8. Perform the ±quiescent current (±Icc) tests as follows:

a. Set the DC TEST selector to the "±Icc" position.

b. Measure the positive power supply quiescent current (+Icc) present at the device being tested. This is displayed on the red current scale (±30mA, full-scale).

c. Set the INPUT/ POLARITY SELECTOR to the " - " position.

d. Measure the negative power supply quiescent current (-Icc) present at the device being tested. This is displayed on the red current scale (±30mA, full-scale).

e. Return the INPUT/ POLARITY SELECTOR to the " + " position.

9. Perform the input offset current (Ios) test as follows:

a. Set the DC TEST selector to the "Ios" position.

b. Adjust the METER SENSITIVITY switch for a suitable meter indication (maximum full-scale).

c. Measure the input offset current (Ios) displayed in nA on the respective red current scale.

d. Return the METER SENSITIVITY switch to 1000.

10. Perform the ±input bias current (±Ibias) tests as follows:

a. Set the DC TEST selector to the "±Ibias" position.

b. Adjust the METER SENSITIVITY switch for a suitable meter indication (maximum full-scale).

c. Measure the input bias current (+Ibias) present at the non-inverting terminal of the device. This is displayed in nA on the respective red current scale.

d. Set the INPUT/ POLARITY SELECTOR to the " - " position.

e. Measure the input bias current (-Ibias) present at the inverting terminal of the device. This is displayed in nA on the respective red current scale.

f. Return the INPUT/ POLARITY SELECTOR to the " + " position and the METER SENSITIVITY switch to 1000.

11. Perform the input offset voltage (Eos) test as follows:

a. Set the DC TEST selector to the "Eos" position.

b. Adjust the METER SENSITIVITY switch for a suitable meter indication (maximum full-scale).

c. Measure the input offset voltage (Eos) displayed in mV on the respective red voltage scale.

d. Return the METER SENSITIVITY switch to 1000.

12. Perform the Oscillation Detection (OSC DET) test as follows:

a. Set the DC TEST selector to the "OSC DET" position.

NOTE

If oscillations are detected in the device, the OSC DET indicator will illuminate, otherwise the indicator will remain extinguished.

13. If Dynamic testing is to be performed, depress to extinguish the IC PWR pushbutton. If no further testing is required, depress both the IC PWR and POWER pushbuttons.

3-5.2 DYNAMIC TESTS

In the Dynamic test mode of operation, the device is evaluated under actual operating conditions. Included in the tests to be performed are Gain, CMRR, ±Eout, ±Ecm, and ±PSRR measurements. The step-by-step procedure for Dynamic evaluation of any operational amplifier is performed as follows:

NOTE

If Dynamic testing is a follow-on to Static testing, omit Steps 1 and 3 of this paragraph, otherwise proceed with the following:

1. Repeat Steps 1 through 4 in Paragraph 3-5.1.

2. Set the following controls as indicated:

METER SENSITIVITY . . .	Not applicable for Dynamic testing
DC TEST.	Not applicable for Dynamic testing
TEST SELECT	GAIN
INPUT/ POLARITY SELECTOR	+
LOAD Ω.	To a corresponding output load impedance specified on the data sheet supplied with the device to be tested.

3. Carefully insert the device to be tested into the test socket.

4. Depress to illuminate the IC PWR pushbutton.

5. Measure the gain of the device under test.

NOTE

The black logarithmic scale on the meter indicates the ratio output to input while the black decibel scale is read directly in dB.

6. Set the TEST SELECT switch to the "CMRR" position.

7. Measure the common mode rejection ratio (CMRR) displayed on either the logarithmic or decibel scale.

8. Set the TEST SELECT switch to the "±Eout" position.

9. Measure the maximum positive output voltage swing (+Eout) displayed on the red voltage scale (±30V, full-scale).

10. Set the INPUT/POLARITY SELECTOR to the " - " position.

11. Measure the maximum negative output voltage swing (-Eout) displayed on the red voltage scale (±30V, full-scale).

12. Set the TEST SELECT switch to the "±Ecm" position.

13. Measure the maximum usable negative common mode voltage limit (-Ecm) displayed on the red voltage scale (±30V, full-scale).

14. Set the INPUT/POLARITY SELECTOR to the " + " position.

15. Measure the maximum usable positive common mode voltage limit (+Ecm) displayed on the red voltage scale (±30V, full-scale).

16. Set the TEST SELECT switch to the "±PSRR" position.

17. Measure the rejection ratio of the positive power supply (+PSRR) on either the logarithmic or decibel scale.

18. Set the INPUT/POLARITY SELECTOR to the " - " position.

19. Measure the rejection ratio of the negative power supply (-PSRR) on either the logarithmic or decibel scale.

20. Return the INPUT/POLARITY SELECTOR to the " + " position.

21. Depress to extinguish both the IC PWR and POWER pushbuttons upon the completion of all tests.

SECTION 4

PRINCIPLES OF OPERATION

4-1. INTRODUCTION

This section of the manual contains information regarding the circuit operation of the individual assemblies that go into the Model 5102 Operational Amplifier Tester. They are the Power Supply Assembly (A1), Logic Assembly (A2), Relay & Amplifier Assembly (A3), Program Card Assembly (A4), and the Switch Components Assembly (A5). Each is separately discussed in the following paragraphs. The interconnection diagram Figure 6-6., shows how each assembly relates to another and to the intricate switching networks of the instrument.

4-2. POWER SUPPLY ASSEMBLY (A1)

Incorporated into the design of the Power Supply Assem-(A1) is a programmable plus and minus supply, a regulated ±15 volt supply, a relay and lamp supply, a modulator circuit for PSRR testing, and a square-wave signal source for Ecm testing. Refer to Figure 6-1. for the schematic diagram of these circuits.

The function of this assembly is straightforward. Upon depressing the POWER pushbutton, lamps DS3 and DS4 will illuminate indicating that line voltage has been applied to the primary winding of the transformer (T1). The primary winding may be wired for both a 115Vac or 230Vac, 50 to 60 Hz line source. To operate the instrument from a 115Vac, 50 to 60 Hz source, terminals T1(2) and T1(4) must be shorted together and connected to the high (white) side of the line while terminals T1(1) and T1(3) are shorted and connected to the low (black) side. For 230Vac, 50 to 60 Hz operation short terminals T1(2) to T1(3) and connect T1(4) to the high (white) side of the line and T1(1) to the low (black) side. The secondary winding then couples voltage to a bridge rectifier comprised of A1CR1 thru A1CR4. The rectified resultant is then filtered by capacitors A1C3 and A1C4 and fed to regulators A1VR1 and A1VR2. Voltage regulator A1VR2 is programmed to supply both a positive and negative voltage from 4 to 24 volts. This voltage level is dependent upon the value of the program resistors A4R5 and A4R6. These resistors are found on the Program Card Assembly (A4). The formulas used to calculate these values are found in Paragraph 4-5. To establish these programmable levels, potentiometers A1R8 and A1R10 are adjusted for the positive supply while A1R7 and A1R12 set the negative supply. A1R10 and A1R12 are used to set the gain of the positive and negative supplies, respectively such that a programmable level of 1 volt/kΩ is established. A1R8 and A1R17 adjust out any offset voltage present in the regulator. Once these adjustments have been made, a 4-volt reference level will have been set up. It is then a matter of determining the desired output voltage, subtracting 4 (reference level) and multiplying the results by one thousand ohms to find the correct value of the program resistors.

Example:

Desired Output Voltage	= 15
less Reference Level	= <u>-4</u>
Result	= 11

Selected Program Resistor = 11 · 1000Ω = 11,000Ω

These programmed levels are used to power the amplifier under test. The positive supply voltage is applied through the parallel combination of A1R13, A1R14, and A1R15 to the positive terminal of the device while the negative supply is fed through the parallel combination of A1R16, A1R17, and A1R18 to the negative terminal. A voltage measurement taken across these parallel resistance combinations indicates the quiescent current being drawn from each supply. The output of voltage regulator A1VR1 is fed directly to the printed circuit connector for distribution to the circuits of the instrument.

Diodes A1CR5 and A1CR6 rectify the voltage from the other secondary winding of the transformer. Capacitor A1C5 filters this rectified voltage while the zener diode A1CR7 and transistor A1Q7 serve to form a zener regulated referenced emitter follower. The regulated output is then transferred to the various relay control and lamp indicator circuits.

A modulator circuit is designed to inject a known fluctuation upon the positive and negative supply lines during the power supply rejection ratio tests. When a positive power supply rejection ratio test is selected, a ±15 volt square-wave is applied, from the Vref circuit, to a voltage divider A1R1 and A1R3. A ±0.5 volt fluctuation is impressed upon the base of the complementary emitter followers, A1Q1 and A1Q2, and the result is a ±0.5 volt change in the positive supply line. Operation during the negative power supply rejection ratio test is identical to that just described except that the Vref output is applied to a voltage divider, A1R2 and A1R4. The ±0.5 volt divided output is fed to the other pair of emitter followers, A1Q3 and A1Q4, resulting in a ±0.5 volt fluctuation of the negative power supply line.

When a common mode voltage (±Ecm) test is selected the ±15 volt square-wave signal, from the Vref circuit, is used to drive transistor A1Q6 between cutoff and saturation. This in turn drives transistor A1Q5 which switches the raw rectified transformer output to produce a square-wave signal of greater than 30 volts peak-peak. This signal is then impressed upon the non-inverting input of the amplifier under test via the high impedance input resistor A1R22, thus driving it into saturation as the common mode limit is approached.

4-3. LOGIC ASSEMBLY (A2)

The circuits of the Logic Assembly (A2) constitute the major portion of the synchronous demodulation system. They are the clock, frequency divider, electronic phase reverse switch, Vref switch, monostable multivibrator, gates 1 and 2, series-shunt FET demodulator switch, and an absolute value circuit. Also included is a broadband, peak-to-peak oscillation detection circuit. Refer to the Logic Assembly (A2) Block Diagram, Figure 4-1. and the schematic diagram, Figure 6-2. for additional information regarding these circuits.

The timing signal used throughout the synchronous demodulation system is generated by the astable multivibrator clock, consisting of A2Q4 and A2Q5. The clock operates at a frequency of 10 Hz and can be monitored at TP4. It is fed to the input of the frequency divider and monostable multivibrator circuits. The frequency divider A2Q6 and A2Q7 divides the clock frequency to 5Hz. The divided output is then phased by the phase reverse switch. This electronic switching, which is set up by A2Q10 and A2Q11, changes the phase of the signal appearing at the output of the Vref circuit [P1(4)] with respect to the clock. When the FET A2Q10 is energized the ØB output of the frequency divider is fed through the voltage divider A2R44, A2R45, and A2R42 to the input of the Vref circuit. When A2Q11 is turned on the ØA output is coupled to the Vref circuit through a similar voltage divider consisting of A2R40, A2R42, and A2R45. The Vref circuit is driven to generate a low frequency, square-wave with an amplitude of ±15 volts and a source impedance of 4.99k Ω. This signal is generated by switching between two stable dc reference voltages and is then applied to the input of the amplifier under test. As can be seen from the schematic diagram, Figure 6-2., when a positive going signal is applied to the input of the Vref circuit, A2Q12 is turned on and A2Q13 is biased off. This places A2R47 at ground potential causing A2Q14 to conduct resulting in a positive output at P1(4). With a negative going signal applied to the circuit A2Q13 is turned on and A2Q12 is biased off placing A2R48 at ground potential causing A2Q15 to conduct resulting in a negative output at P1(4). When A2Q14 is conducting a

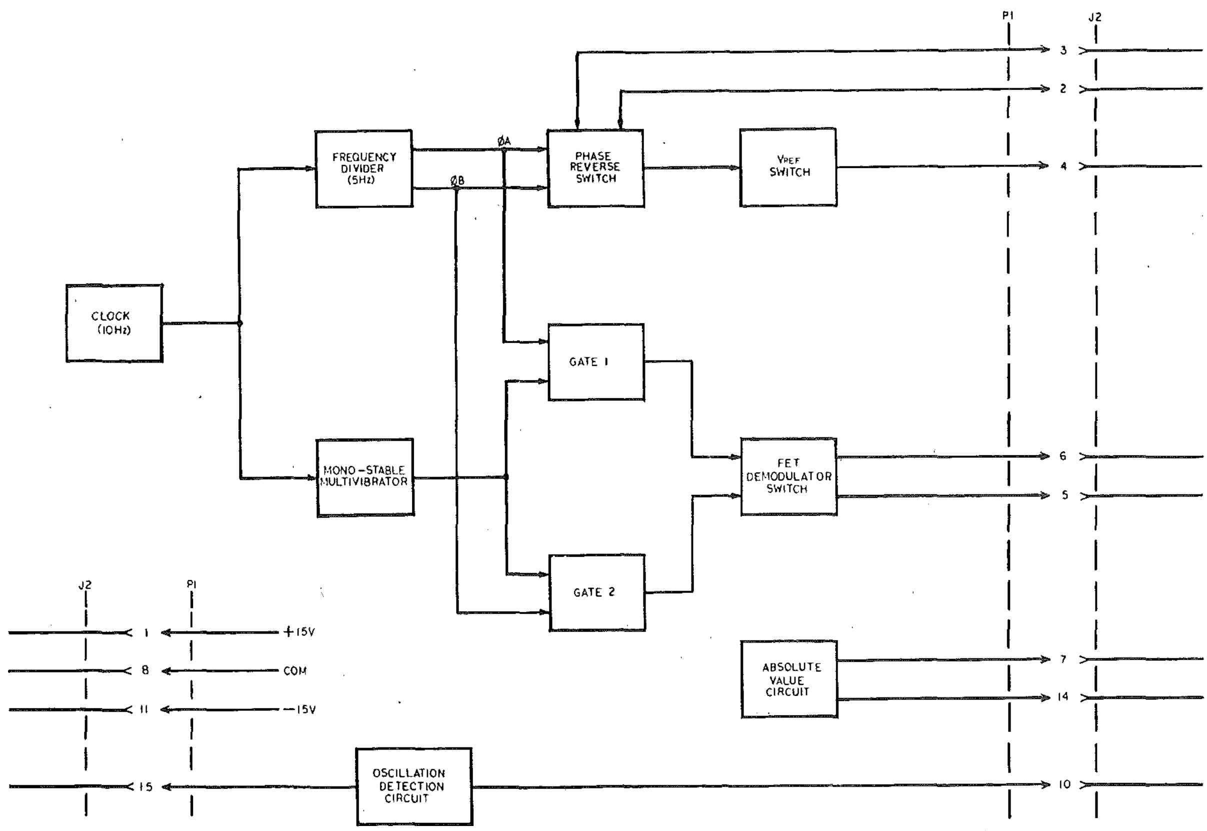


Figure 4-1. Logic Assembly (A2) Block Diagram

positive output is fed through A2R50 while the negative output passes through A2R51 during the conduction of A2Q15.

The output of the clock also drives the monostable multivibrator, A2Q8 and A2Q9, which in turn generates positive pulses in synchronism with the clock. When the output of the monostable multivibrator is coincident with the positive ØB output, gate 1 is turned on. Gate 2 is turned on by a similar coincidence with the positive ØA output. A2CR7 and A2CR8 form gate 1 which is interfaced by A2Q16 and A2Q17 to drive the "shunt" FET A2Q18. Similarly, A2CR9 and A2CR10 form gate 2 and is interfaced by A2Q20, A2Q21 and A2Q22 to drive the "series" FET A2Q19. The FET's A2Q18 and A2Q19, in conjunction with the capacitors A2C24 and A3C3 [on the Relay & Amplifier Assembly (A3)] function as a demodulator working in synchronism with clock output.

The absolute value circuit A2A2 is used to supply a positive current to the inverting input of the log module A3A4 regardless of the signal being detected.

Transistors A2Q1 and A2Q2 function as a broadband, ac amplifier with the output fed to a peak-to-peak detector A2CR1, A2CR2, A2C7 and A2C11. The detected output is used to drive a comparator circuit A2A1. The threshold of this circuit is set by potentiometer A2R11. The output of the comparator is then used to drive the lamp driver A2Q3. During an oscillation detection test the output of the amplifier under test is fed to the input of the detection circuit where it is amplified, detected, and compared to a preset reference level. Should an oscillation exceeding 10mV be detected, the lamp driver A2Q3 will be biased on which places one side of lamp DS1 at ground potential. This causes the lamp to illuminate indicating the presence of an oscillation.

4-4. RELAY & AMPLIFIER ASSEMBLY (A3)

Relays and amplifiers constitute the major portion of the circuitry used in the Relay & Amplifier Assembly (A3). Also incorporated is a monostable multivibrator and FET switch, which is used as a dc restorer, and the meter calibration and protection circuits. When the IC power relay A3K4 is energized, the IC PWR lamp DS2 illuminates to indicate that supply voltages have been applied to the amplifier under test. The three remaining relays A3K1, A3K2, and A3K3 serve to connect the amplifiers A3A1, A3A2, and A3A3, respectively into either a Static (DC) or Dynamic (AC) mode of operation. During Ios or ±Ibias testing these relays are energized and the amplifiers function as current-to-voltage converters. Any initial offset voltage is zeroed by the potentiometers A3R14, A3R21, and A3R25. The proper input, output, and feedback constraints are placed about the amplifiers and the converted result is switched to the monitoring circuit.

In a Dynamic (AC) mode of testing (relays de-energized), amplifier A3A1 functions to amplify the output of the individual test circuits coupled by the capacitors A5C1, A5C2, or A5C4 during ±PSRR, Gain, or CMRR measurements, respectively. When performing the ±Eout or ±Ecm test the amplifier A3A1 is direct coupled to the individual test circuit. The amplified result of either the ±PSRR, Gain, or CMRR test is demodulated and then fed to the dc follower A3A3 and then on to the log amplifier A3A2. The log module A3A4 is placed into the feedback network of the log amplifier. During the ±Eout or ±Ecm test the amplified result is direct coupled to the dc follower A3A3 and displayed directly on the meter movement. The calibration potentiometers A3R17 and A3R19 are used to set the offset and slope of the log amplifier circuit. The meter movement is protected from overload by diodes A3CR3 and A3CR4 while the potentiometer A3R27 sets the full-scale spread.

Transistors, A3Q1 and A3Q2, function as a monostable multivibrator to provide timing pulses necessary to gate the FET switch A3Q3 on once for every frequency divider cycle (5Hz). With the FET switch energized the ac coupling capacitor, A5C1, A5C2, or A5C4, depending upon the test to be performed, is placed at ground potential through the coupling resistor A3R11, thus restoring the charge to a dc level.

4-5. PROGRAM CARD ASSEMBLY (A4)

Program Card assemblies are used to establish the desired operating conditions for a particular device to be tested. A variety of assemblies are available to suit the individual need, see the list of program cards, Table 1-2, for the proper selection. Also refer to the variation table and schematic diagram, Figure 6-4. for information regarding this assembly. Seven (7) precision program resistors are used to establish the parameter restrictions.

Resistors A4R1 and A4R3 are used to program the output swing and scale factor during gain measurements. The output swing may be set between 1 volt and 20 volts peak, symmetrically about zero. The maximum recommended value is limited by the saturated output of the amplifier under test and by its offset voltage, as shown:

$$\text{Peak Output Swing} = E_o = E_{out(sat)} - 21.6\ E_{os}$$

The values of A4R1 and A4R3 may be calculated as follows:

$$A4R1 = \frac{300 - 5E_o}{E_o} \cdot 1k\Omega \qquad A4R3 = \frac{200\ \ E_o}{1000 - E_o} \cdot 1k\Omega$$

....where Eo is the desired peak output swing, and A4R1 and A4R3 are in kilo ohm (1kΩ).

Note: A4R1 and A4R3 should be 0.1%, 1/8 watt resistors.

The maximum output of the device is programmed by A4R2. A 10k ohm resistor provides a swing from ±1 volt to ±24 volts.

The positive and negative power supply limits are set by A4R6 and A4R5 respectively, and may be programmed for any value between 4 and 24 volts. The voltage limits on these supplies need not be equal. The appropriate values may be selected by using the following formulas:

A4R6 = Desired Positive Power Supply Voltage -4 · 1kΩ
A4R5 = Desired Negative Power Supply Voltage-4 · 1kΩ

Note: A4R5 and A4R6 should be 1%, 1/8 watt resistors.

The common mode rejection ratio scale factor and test signal level is programmed by A4R4 and A4R7 respectively, for a limit of 0.5 volts to 6 volts. To calculate the correct value of resistance, use the following formulas:

$$A4R4 = \frac{200\ Ecm}{100\text{-}Ecm} \cdot 1k\Omega \quad A4R7 = \frac{150\text{-}25\ Ecm}{Ecm} \cdot 1k\Omega$$

....where Ecm is the desired test signal, and A4R4 and A4R7 are in kilo ohms (1kΩ).

Note: A4R4 should be a 0.1%, 1/8 watt resistor, while A4R7 should be a 1%, 1/8 watt resistor.

4-6. SWITCH COMPONENTS ASSEMBLY (A5)

The input, output, and feedback constraint components used in the various test circuits are found on the Switch Components Assembly (A5). These components in conjunction with the TEST SELECT switch (S1) and DC TEST selector (S2) establish the operating conditions for the amplifier under test. Referring to the individual test circuits in Section 2 along with the schematic diagram, Figure 6-5. will reveal which components are used for which test. Relay A5K6 is used to connect the LOAD Ω switch (S5) to the output of the device to be tested. A close inspection of the interconnection diagram, Figure 6-6. shows that the LOAD Ω switch is used only during the Eout and Gain tests. Relay A5K5 is used to provide either a meter indication with respect to ground or a differential reading depending upon the test to be performed.

Calibration potentiometer A5R23 is used to balance out the CMRR bridge.

SECTION 5

CALIBRATION AND MAINTENANCE

5-1. INTRODUCTION

This section of the manual contains a list of required test equipment, a recommended step-by-step calibration procedure and information necessary to maintain this instrument.

Voltmeter,	Fluke Model 881 or equivalent
Test Oscillator,	Hewlett Packard Model 651A or equivalent
Oscilloscope,	Tektronix Model 561A or equivalent
2,000 ohm,	1% resistor
11,000 ohm,	1% resistor
249,000 ohm,	1% resistor
47,500 ohm,	1% resistor (2 required)
2.38 ohm,	1% resistor

Table 5-1. List of Required Test Equipment

5-2. CALIBRATION

The Model 5102 Operational Amplifier Tester is designed for ease of calibration within its own enclosure using a minimum of peripheral test equipment. Refer to Table 5-1. for the recommended List of Required Test Equipment. A step-by-step calibration procedure, necessary to verify the operating specifications of the instrument, is performed as follows:

1. Remove the back cover from the unit by loosening the six (6) twist lock screws.

2. Ensure that the Program Card Assembly (A4) is removed from connector J5.

3. Loosen the four (4) retaining screws that hold the Relay & Amplifier Assembly (A3) into place and carefully orient it to provide an access to the Logic Assembly (A2) adjustments.

4. Provide a ground return for the Relay & Amplifier Assembly (A3) by clipping a lead from the outer ground strip to an unpainted surface on the case.

5. Set the following controls as indicated:

METER SENSITIVITY.	1000
DC TEST	±Icc
TEST SELECT.	DC TEST
INPUT/POLARITY SELECTOR	+
LOAD Ω.	EXT

6. Plug the power cable into a 115Vac, 50 to 60 Hz line source.

7. Depress to illuminate the POWER pushbutton and allow a 30-minute warmup period for the circuits of the instrument to stabilize.

NOTE
Depress to extinguish the IC PWR pushbutton if illuminated.

8. Perform the positive power supply calibration adjustments as follows:

   a. Connect a suitable cable from the voltmeter to pins 1 and 2 on connector J6.

   b. Connect a 2,000 ohm, 1% resistor between pins 13 and 16 on connector J5.

   c. Depress to illuminate the IC PWR pushbutton.

   d. Adjust potentiometer R8 for a voltmeter indication of +6V ±100mV. See Figure 5-1. for the location of this adjustment.

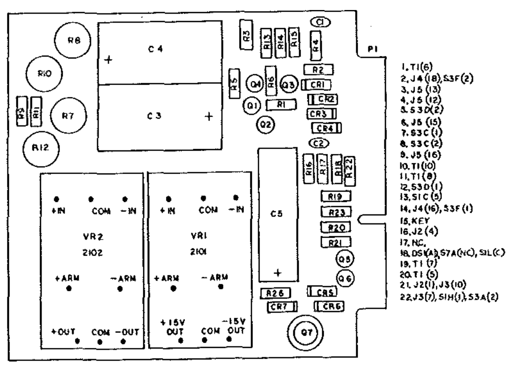


Figure 5-1. Power Supply Assembly (A1) Adjustments

   e. Depress to extinguish the IC PWR pushbutton.

   f. Replace the 2,000 ohm resistor with an 11,000 ohm, 1% resistor between pins 13 and 16 on connector J5.

   g. Depress to illuminate the IC PWR pushbutton.

   h. Adjust potentiometer R10 for a voltmeter indication of +15V ±100mV. See Figure 5-1. for the location of this adjustment.

i. Alternately repeat Steps 8b. thru 8h. until both specifications are achieved.

j. Depress to extinguish the IC PWR push-button.

9. Perform the negative power supply calibration adjustments as follows:

a. Connect a suitable cable from the voltmeter to pins 10 and 2 on connector J6.

b. Connect a 2,000 ohm, 1% resistor between pins 12 and 15 on connector J5.

c. Depress to illuminate the IC PWR push-button.

d. Adjust potentiometer R7 for a voltmeter indication of -6V ±100mV. See Figure 5-1. for the location of this adjustment.

e. Depress to extinguish the IC PWR push-button.

f. Replace the 2,000 ohm resistor with an 11,000 ohm, 1% resistor between pins 12 and 15 on connector J5.

g. Depress to illuminate the IC PWR push-button.

h. Adjust potentiometer R12 for a voltmeter indication of -15V ±100mV. See Figure 5-1. for the location of this adjustment.

i. Alternately repeat Steps 9b. thru 9h. until both specifications are achieved.

j. Depress to extinguish the IC PWR push-button.

10. Remove the resistor from connector J5 and replace the Program Card Assembly (A4).

11. Depress to illuminate the IC PWR push-button.

12. Verify the programmed operation of the positive and negative power supplies as follows:

a. Monitor pins 1 and 2 on connector J6 and verify that the voltmeter indication meets the positive quiescent voltage specification (+Vcc) for the particular Program Card Assembly (A4) being used. Refer to Table 5-2. for the associated Program Card Assembly (A4) specifications.

Model	+Vcc	-Vcc
6007	+15V ±100mV	-15V ±100mV
6016	+ 6V ±100mV	- 6V ±100mV
6017	+12V ±100mV	-12V ±100mV
6018	+18V ±100mV	-18V ±100mV
6019	+12V ±100mV	- 6V ±100mV
6020	+24V ±100mV	-24V ±100mV
6022	+ 9V ±100mV	- 9V ±100mV

Table 5-2. Program Card Assembly (A4) Specifications

b. Monitor pins 10 and 2 on connector J6 and verify that the voltmeter indication meets the negative quiescent voltage specification (-Vcc) for the particular Program Card Assembly (A4) being used. Refer to Table 5-2. for the associated Program Card Assembly (A4) specifications.

13. Perform the clock frequency calibration adjustment as follows:

a. Set the TEST SELECT switch to the "Eout" position.

b. Connect a suitable cable from the vertical input of the oscilloscope to the AMP OUT connector (J7), located at the rear of the instrument.

c. Monitor the square-wave presentation and adjust potentiometer R18 for a 200 ±20 millisecond period. See Figure 5-2. for the location of this adjustment.

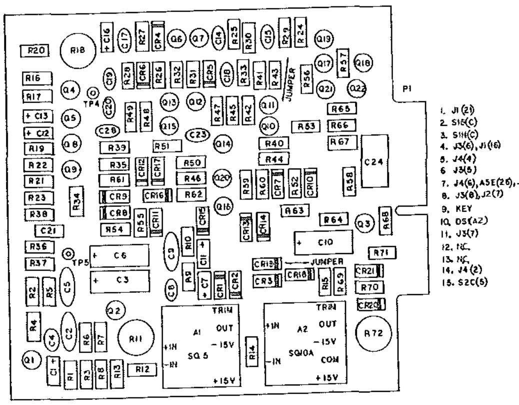


Figure 5-2. Logic Assembly (A2) Adjustments

d. Remove the cable from the AMP OUT connector.

14. Perform the absolute-value circuit calibration adjustment as follows:

a. Set the TEST SELECT switch to the "±PSRR" position.

b. Short together pins 5 and 2 on connector J6.

NOTE
The meter may indicate full-scale since there is no signal present at the input of the demodulator circuit.

c. Connect a suitable cable from the voltmeter to the junction of A2R70 and A2R71, located on the Logic Assembly (A2).

d. Adjust potentiometer R72 for a voltmeter indication of 0V ±300μV. See Figure 5-2. for the location of this adjustment.

e. Remove the short from pins 5 and 2 on connector J6.

15. Perform the oscillation detection circuit calibration adjustment as follows:

a. Set the TEST SELECT switch to the "DC TEST" position and the DC TEST selector to the "OSC DET" position.

b. Connect a suitable cable from the output of the signal generator to the AMP OUT connector.

c. Adjust the signal generator to provide a 20mV peak-peak sine wave, centered about zero, at a frequency of 10kHz.

d. Adjust potentiometer R11 until the OSC DET lamp (DS1) is extinguished. See Figure 5-2. for the location of this adjustment.

e. Readjust potentiometer R11 until the OSC DET lamp just illuminates.

f. Remove the cable from the AMP OUT connector.

16. Depress to extinguish both the IC PWR and POWER pushbuttons.

17. Remove the power cable from the 115Vac line source.

18. Fasten the Relay & Amplifier Assembly (A3) into place ensuring that the four (4) retaining screws are tightened securely.

NOTE
The ground return cliplead may be removed at this time.

19. Plug the power cable into the 115Vac line source.

20. Depress to illuminate both the POWER and IC PWR pushbuttons.

21. Perform the input offset current and input bias current circuit calibration adjustments as follows:

a. With the TEST SELECT switch set to "DC TEST", set the DC TEST selector to the "±Ibias" position.

b. Short together pins 5 and 2 on connector J6.

c. Connect a suitable cable from the voltmeter to pins 12 and 2 on connector J6.

d. Adjust potentiometer R14 for a voltmeter indication of 0V ±300μV. See Figure 5-3. for the location of this adjustment.

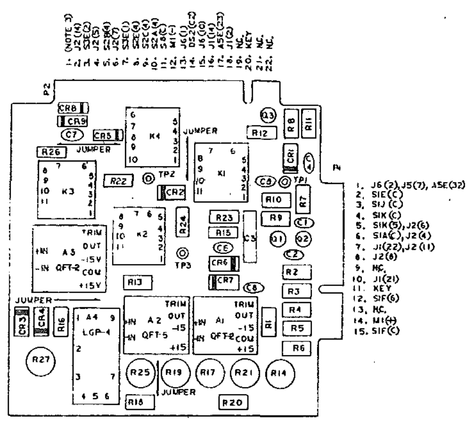


Figure 5-3. Relay & Amplifier Assembly (A3) Adjustments

e. Connect a suitable cable from the voltmeter to pins 11 and 2 on connector J6.

f. Adjust potentiometer R25 for a voltmeter indication of 0V ±300μV. See Figure 5-3. for the location of this adjustment.

g. Connect a suitable cable from the voltmeter to A3TP2, located on the Relay & Amplifier Assembly (A3), and J6 pin 2.

h. Adjust potentiometer R21 for a voltmeter indication of 0V ±300μV. See Figure 5-3. for the location of this adjustment.

i. Remove the short from pins 5 and 2 on connector J6.

22. Perform the meter movement calibration adjustment as follows:

a. Set the following controls as indicated:

TEST SELECT. . . . . . DC TEST
DC TEST. . . . . Eos
METER SENSITIVITY . . 10 (mV)

b. Connect a 249,000 ohm, 1% resistor between pins 1 and 5 on connector J6.

c. Connect a suitable cable from the voltmeter to pins 5 and 2 on connector J6.

d. Adjust potentiometer R27 for a voltmeter indication of 100mV ±1mV. See Figure 5-3. for the location of this adjustment.

e. Remove the 249,000 ohm resistor from pins 1 and 5 on connector J6.

23. Perform the log circuit calibration adjustment as follows:

a. Set the TEST SELECT switch to the "±PSRR" position.

b. Connect one 47,500 ohm, 1% resistor between pins 1 and 5 on connector J6 and another between pins 10 and 5.

c. Adjust potentiometer R17 for a front panel meter indication of 60dB ±0.5dB. See Figure 5-3. for the location of this adjustment.

d. With the resistors of Step 23b. still in place, connect a 2.38 ohm, 1% resistor between pins 5 and 2 on connector J6.

e. Adjust potentiometer R19 for a front panel meter indication of 114dB ±0.5dB. Allow sufficient time for the meter indication to settle. See Figure 5-3. for the location of this adjustment.

f. Alternately repeat Steps 23b. thru 23e. until both specifications are achieved.

g. Remove all resistors from connector J6.

24. Perform the common mode rejection ratio bridge calibration adjustment as follows:

NOTE

The voltmeter must have a true differential input; therefore, both input terminals must be above ground reference.

a. Set the Calibration Switch (S7), located inside the instrument, to "CAL".

b. Set the TEST SELECT switch to the "CMRR" position.

c. Connect a suitable cable from the voltmeter to pins 11 and 12 on connector J6.

d. Adjust potentiometer R23 for a voltmeter indication of 0V $\pm 10\mu V$. See Figure 5-4. for the location of this adjustment.

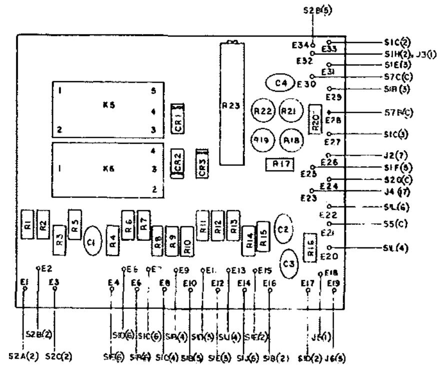


Figure 5-4. Switch Components Assembly (A5) Adjustments

e. Return the Calibration Switch to the "NORMAL" position.

5-3. MAINTENANCE

This section of the manual contains information necessary to isolate and maintain the assemblies of this instrument. Before proceeding with this section be certain that the instrument is truly in need of maintenance and not just out of calibration. Verify calibration as outlined in Section 5-2. If it is determined that a malfunction does exist proceed with a logical troubleshooting analysis of the problem before attempting the actual repair. The following table has been prepared to aid in isolating a particular problem to an individual assembly and then to a stage or component on that assembly. Review this table carefully, as a thorough knowledge of its contents could save many valuable hours of troubleshooting time. Once a problem area is revealed the defective component can easily be located and a suitable replacement part installed. A List of Replaceable Parts is found in Section 7 of this manual.

5-3. Troubleshooting Chart

Trouble	Possible Cause
1. POWER pushbutton does not illuminate when depressed.	1. Open fuse F1 (3/4 A). 2. Open lamps DS3 and DS4.
2. Fuse blows when POWER pushbutton is depressed.	1. Defective regulators A1VR1 or A1VR2. 2. Shorted filter capacitors A1C3, A1C4 or A1C5. 3. Shorted transformer windings.
3. No programmable plus or minus supply output at J1 (5) or J1 (12), respectively.	1. Short at J1 (5) or J1 (12). 2. Check for +20 to +40 Vdc at +IN terminal of A1VR2. 3. Check for -20 to -40 Vdc at -IN terminal of A1VR2.
4. No plus or minus voltage present at +IN or -IN terminals of A1VR2.	1. Shorted diodes A1CR1 thru A1CR4. 2. Shorted filter capacitors A1C3 or A1C4. 3. Defective regulators A1VR1 or A1VR2. 4. Check for 80V peak-peak between J1 (10) and J1 (1). 5. Check for 80V peak-peak between J1 (11) and J1 (1).
5. No peak-peak voltage at J1 (10) and J1 (1) or J1 (11) and J1 (1).	1. Open transformer winding.
6. Unable to program plus or minus supply	1. Open program resistor A4R6 in plus supply. 2. Open program resistor A4R5 in minus supply. 3. Defective potentiometers A1R8 or A1R10 for plus supply. 4. Defective potentiometers A1R7 or A1R12 for minus supply. 5. Defective regulator A1VR2.
7. No plus or minus 15 volt output at J1 (21) or J1 (22), respectively.	1. Defective regulator A1VR1. 2. Check for +20 to +40 Vdc at +IN terminal of A1VR1. 3. Check for -20 to -40 Vdc at -IN terminal of A1VR1.
8. No plus or minus voltage present at +IN or -IN terminals of A1VR1.	1. Shorted diodes A1CR1 thru A1CR4. 2. Shorted filter capacitors A1C3 or A1C4. 3. Defective regulators A1VR1 or A1VR2. 4. Check for 80V peak-peak between J1 (10) and J1 (1). 5. Check for 80V peak-peak between J1 (11) and J1 (1).
9. No peak-peak voltage at J1 (10) and J1 (1) or J1 (11) and J1 (1).	1. Open transformer winding.
10. No relay or lamp driver voltage present at J1 (18).	1. Open diodes A1CR5 or A1CR6. 2. Shorted filter capacitor A1C5. 3. Shorted zener diode A1CR7. 4. Open transistor A1Q7. 5. Check for 80V peak-peak between J1 (19) and J1 (1).

Table 5-3. Troubleshooting Chart continued

Trouble	Possible Cause
	6. Check for 80V peak-peak between J1 (20) and J1 (1). 7. Check for 35Vdc at the collector of A1Q7.
11. No peak-peak voltage at J1 (19) and J1 (1) or J1 (20) and J1 (1).	1. Open transformer winding.
12. No dc voltage at the collector of A1Q7.	1. Open diodes A1CR5 or A1CR6. 2. Shorted filter capacitor A1C5. 3. Shorted zener diode A1CR7. 4. Open transistor A1Q7.
13. No ±0.5 volt fluctuation upon the plus supply voltage at J1 (5) with the TEST SELECT switch set to "±PSRR" and the INPUT/ POLARITY SELECTOR set to "+".	1. Defective transistors A1Q1 or A1Q2. 2. Check for ±10 volt square-wave at J1 (8).
14. No ±10 volt square-wave present at J1 (8).	1. Defective Vref circuit.
15. No ±0.5 volt fluctuation upon the minus supply voltage at J1 (12) with the TEST SELECT switch set to "±PSRR" and the INPUT/ POLARITY SELECTOR set to "-".	1. Defective transistors A1Q3 or A1Q4. 2. Check for ±10 volt square-wave at J1 (7).
16. No ±10 volt square-wave present at J1 (7).	1. Defective Vref circuit.
17. No 35 volt peak-peak square-wave present at the collector of A1Q5 with the TEST SELECT set to "±Ecm" and the INPUT/ POLARITY SELECTOR set to "+".	1. Defective transistors A1Q5 or A1Q6. 2. Check for ±15 volt square-wave at J1 (16).
18. No ±15 volt square-wave present at J1 (16).	1. Defective Vref circuit.
19. No 10Hz clock pulse at A2TP4.	1. Defective transistors A2Q4 or A2Q5.
20. No 5Hz, ØA or ØB outputs from frequency divider.	1. Defective transistors A2Q6 and A2Q7. 2. Check for a ØA, 5Hz pulse at the cathode of A2CR7. 3. Check for a ØB, 5Hz pulse at the cathode of A2CR10.
21. No ØA or ØB, 5Hz pulse at the cathode of A2CR7 or A2CR10, respectively.	1. Defective transistors A2Q6 and A2Q7.
22. No ØA, Vref drive pulse at the bases of A2Q12 and A2Q13 with the TEST SELECT switch set to "±Eout" and the INPUT/ POLARITY SELECTOR set to "+".	1. Defective FET A2Q11.
23. No ØB, Vref drive pulse at the bases of A2Q12 and A2Q13 with the TEST SELECT switch set to "±Eout" and the INPUT/ POLARITY SELECTOR set to "-".	1. Defective FET A2Q10.
24. No positive Vref output pulse at J2 (4).	1. Defective transistors A2Q12 or A2Q14.

Table 5-3. Troubleshooting Chart continued

Trouble	Possible Cause
	2. Check input pulse at bases of A2Q12 and A2Q13.
25. No input pulse at bases of A2Q12 and A2Q13.	1. Defective clock or frequency divider circuits.
26. No negative Vref output pulse at J2 (4).	1. Defective transistors A2Q13 or A2Q15.
	2. Check input pulse at bases of A2Q12 and A2Q13.
27. No input pulse at bases of A2Q12 and A2Q13.	1. Defective clock or frequency divider circuits.
28. No monostable multivibrator output pulse at A2TP5.	1. Defective transistors A2Q8 or A2Q9.
	2. Check for a 10Hz clock pulse at A2TP4.
29. No 10Hz clock pulse at A2TP4.	1. Defective transistors A2Q4 or A2Q5.
30. Gate 1 malfunction.	1. Defective diodes A2CR7 or A2CR8.
	2. Check for ØA, 5Hz pulse at the cathode of A2CR7.
	3. Check for a monostable multivibrator pulse at the cathode of A2CR8.
31. No ØA, 5Hz pulse at A2CR7 cathode.	1. Defective frequency divider stage.
32. No monostable multivibrator pulse at A2CR8 cathode.	1. Defective monostable multivibrator stage.
33. Gate 1 buffer stages inoperative.	1. Defective transistors A2Q16 or A2Q17.
	2. Check for a positive pulse at the collector of A2Q17.
34. No positive pulse at A2Q17 collector.	1. Defective transistor A2Q17.
	2. Check for a negative pulse at the anode of A2CR13.
35. No negative pulse at A2CR13 anode.	1. Defective transistor A2Q16.
36. "Shunt" FET malfunction.	1. Defective FET A2Q18.
	2. With an oscilloscope, check to see that J2 (6) switches to ground potential during the period of time that the collector of A2Q17 goes positive.
37. J2 (6) does not switch to ground potential when the collector of A2Q17 goes positive.	1. Defective FET A2Q18.
38. Gate 2 malfunction.	1. Defective diodes A2CR9 or A2CR10.
	2. Check for a ØB, 5Hz pulse at the cathode of A2CR10.
	3. Check for a monostable multivibrator pulse of the cathode of A2CR9.
39. No ØB, 5Hz pulse at A2CR10 cathode.	1. Defective frequency divider stage.
40. No monostable multivibrator pulse at A2CR9. cathode.	1. Defective monostable multivibrator stage.
41. Gate 2 buffer stages inoperative.	1. Defective transistors A2Q20, A2Q21, or A2Q22.
	2. Check for a positive pulse at the collector of A2Q22.

5-3. Troubleshooting Chart continued

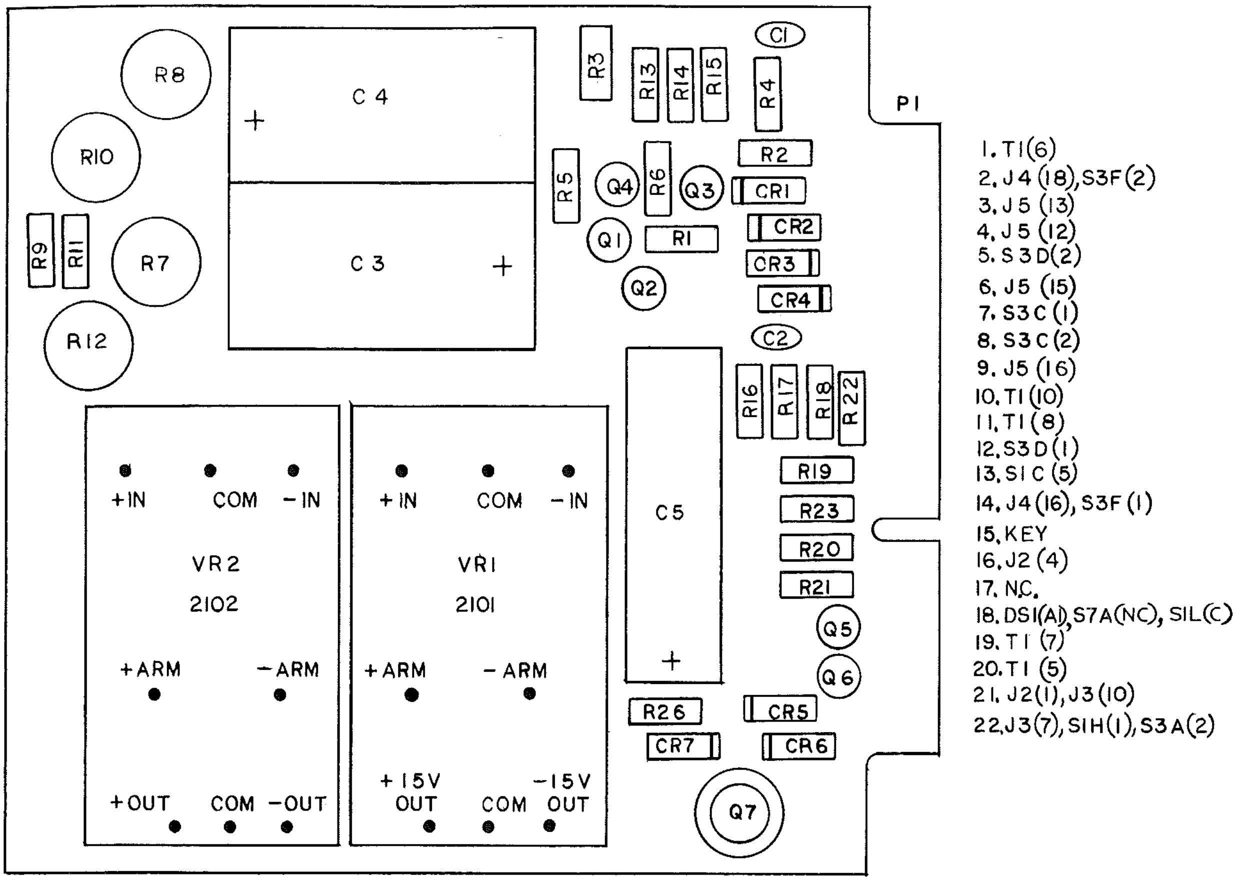
Trouble	Possible Cause
42. No positive pulse at A2Q22 collector.	1. Defective transistor A2Q22. 2. Check for a negative pulse at the collector of A2Q20.
43. Negative pulse present at A2Q20 collector.	1. Defective transistor A2Q21.
44. No negative pulse present at A2Q20 collector.	1. Defective transistor A2Q20.
45. "Series" FET malfunction.	1. Defective FET A2Q19.
46. Oscillation Detection circuit inoperative with the TEST SELECT switch set to "DC TEST", the DC TEST selector set to "OSC DET", and a 20mV peak-peak sine wave, centered about zero, at a frequency of 10kHz applied to the AMP OUT connector (J7).	1. Defective broadband amplifier, peak-to-peak detector, comparator, or lamp driver stages. 2. Check for a 4 to 7 volt peak-peak sine wave at the collector of A2Q2.
47. No peak-peak sine wave at A2Q2 collector.	1. Defective broadband amplifier stage transistors A2Q1 or A2Q2. 2. Check for a negative dc level at the anode of A2CR1.
48. No negative dc level at A2CR1 anode.	1. Defective peak-peak detector stage components A2C7, A2C11, A2CR1 or A2CR2. 2. Check for a positive dc level at the OUT terminal of A2A1.
49. No positive dc level at A2A1 OUT.	1. Defective comparator stage amplifier A2A1. 2. Open potentiometer A2R1. 3. Open input resistor A2R12. 4. Open trim resistor A2R14. 5. Check that J2 (10) switches to ground potential with a positive voltage present at the base of A2Q3
50. J2 (10) does not switch to ground potential with the base of A2Q3 positive.	1. Defective lamp driver transistor A2Q3. 2. Check OSC DET lamp DS1.
51. Absolute value circuit inoperative with the TEST SELECT switch set to "±PSRR" and the AMP OUT connector shorted.	1. Defective absolute value circuit amplifier A2A2.
52. IC PWR pushbutton does not illuminate when depressed.	1. Defective lamp DS2. 2. Defective relay A3K4. 3. Defective relay or lamp driver circuit.
53. No monostable multivibrator pulse at the collector of A3Q1.	1. Defective transistors A2Q1 or A2Q2. 2. Check for ±10 volt square-wave at J3 (6).
54. No ±10 volt square-wave present at J3 (6).	1. Defective Vref circuit.
55. FET switch malfunction.	1. Defective FET A3Q3. 2. Check that the potential on the drain of A3Q3 is at ground reference when the collector of A3Q1 goes positive.
56. Ios or ±Ibias circuit inoperative with the TEST	1. Defective relays, or amplifiers.

5-3. Troubleshooting Chart continued

Trouble	Possible Cause
SELECT switch set to "DC TEST", the DC TEST selector set to "±Ibias", and the AMP OUT connector shorted.	2. Check that the relays activate when an Ios or ±Ibias test is selected.
57. Relays do not activate.	1. Shorted diode A3CR2. 2. Defective relay A3K1, A3K2, or A3K3. 3. Check for 24 Vdc at J4 (8).
58. No voltage at J4 (8).	1. Defective relay or lamp driver circuit. 2. Shorted diode A3CR2. 3. Check the -IN terminal of A3A1, A3A2, or A3A3 for 0V ±300μV adjustable by A3R14, A3R21, or A3R25, respectively.
59. Amplifiers' offset voltage not adjustable.	1. Defective amplifier A3A1, A3A2, or A3A3.
60. Meter movement inoperative.	1. Defective meter movement. 2. Open potentiometer A3R27. 3. Shorted diodes A3CR3 or A3CR4. 4. With the TEST SELECT switch set to "DC TEST", the DC TEST selector set to "Eos", the METER SENSITIVITY switch set to 10 (mV). and a 249k ohm resistor connected between J6 (1) and J6 (5), measure 100mV at J6 (5). Note: 6007 program card must be used.
61. No voltage at J6 (5).	1. Defective positive programmable power supply. 2. Shorted diodes A3CR3 or A3CR4.
62. Meter movement indicates full-scale with less than 100mV at J6 (5).	1. Defective potentiometer A3R27.
63. Logarithmic readout malfunction.	1. Defective log element A3A4. 2. Defective log amplifier A3A2. 3. Absolute value circuit inoperative.
64. Programmable parameter restrictions not functioning.	1. Output swing (Gain) - A4R1 defective. 2. Scale factor (Gain) - A4R3 defective. 3. Maximum output - A4R2 defective. 4. Positive power supply - A4R6 defective. 5. Negative power supply - A4R5 defective. 6. Scale factor (CMRR) - A4R4 defective. 7. Test level (CMRR) - A4R7 defective.
65. LOAD Ω switch malfunction on Gain or ±Eout tests.	1. Defective relay A5K6. 2. Check for 24 Vdc at A5E20 with a Gain or ±Eout test selected.
66. No voltage at A5E20.	1. Defective relay or lamp driver circuit. 2. Shorted diodes A5CR2 or A5CR1 and A5CR3.
67. Meter movement inoperative during all Dynamic tests as well as the Eos and ±Ibias tests.	1. Defective relay or lamp driver circuit. 2. Shorted diodes A5CR1, A5CR2 or A5CR1. 3. Defective relay A5K5.

5-3. Troubleshooting Chart continued

Trouble	Possible Cause
	4. Check for 24 Vdc at A5E20 with a Gain or ±Eout test selected. 5. Check for 24 Vdc at A5E22 with a Gain, CMRR, ±Eout, ±Ecm, ±PSRR, Eos, or ±Ibias test selected.
68. No voltage at A5E20 or A5E22.	1. Defective relay or lamp driver circuit. 2. Shorted diodes A5CR1, A5CR2 or A5CR3.
69. CMRR bridge malfunction.	1. Open potentiometer A5R23. 2. Defective Calibration Switch (S7). 3. Check that A5E30 is at ground potential with the Calibration Switch set to "CAL". 4. Check for 24 Vdc at A5E28 with the Calibration Switch set to "CAL". Note: IC PWR lamp will extinguish when Calibration Switch is set to "CAL".
70. A5E30 is not at ground potential.	1. Defective Calibration Switch.
71. No voltage at A5E28.	1. Defective relay or lamp driver circuit. 2. Defective Calibration Switch.



NOTES:

UNLESS OTHERWISE SPECIFIED:

1. RESISTANCE VALUES ARE EXPRESSED IN OHMS.
   CAPACITANCE VALUES ARE EXPRESSED IN MICROFARADS.
2. ALL RESISTORS ARE 1/4W, 5%.
3. SHIELDED WIRE - SEE FIGURE 6-6 FOR SHIELDING INFORMATION.
4. CONNECT ALL ▽ TO J1P1 (1).

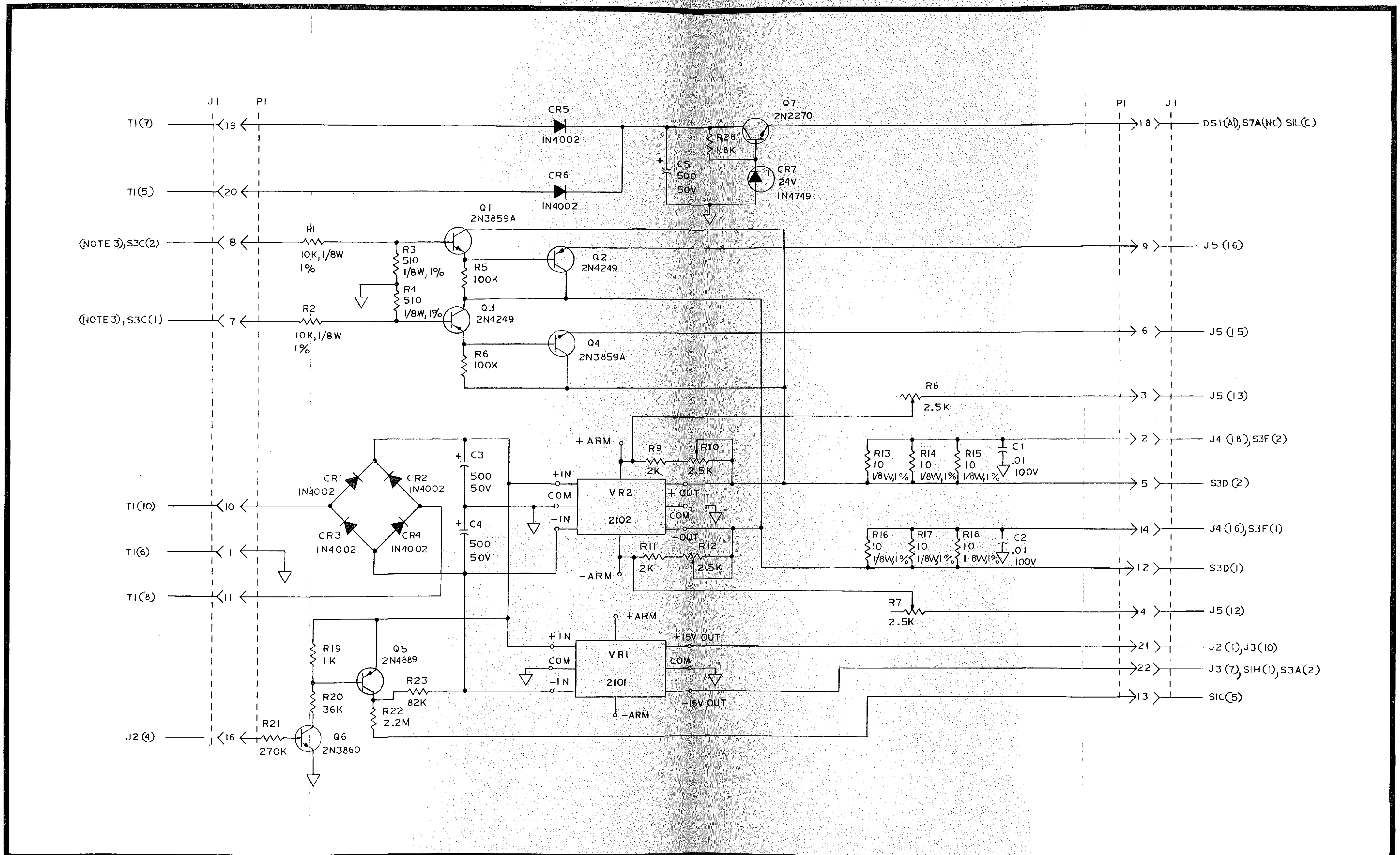
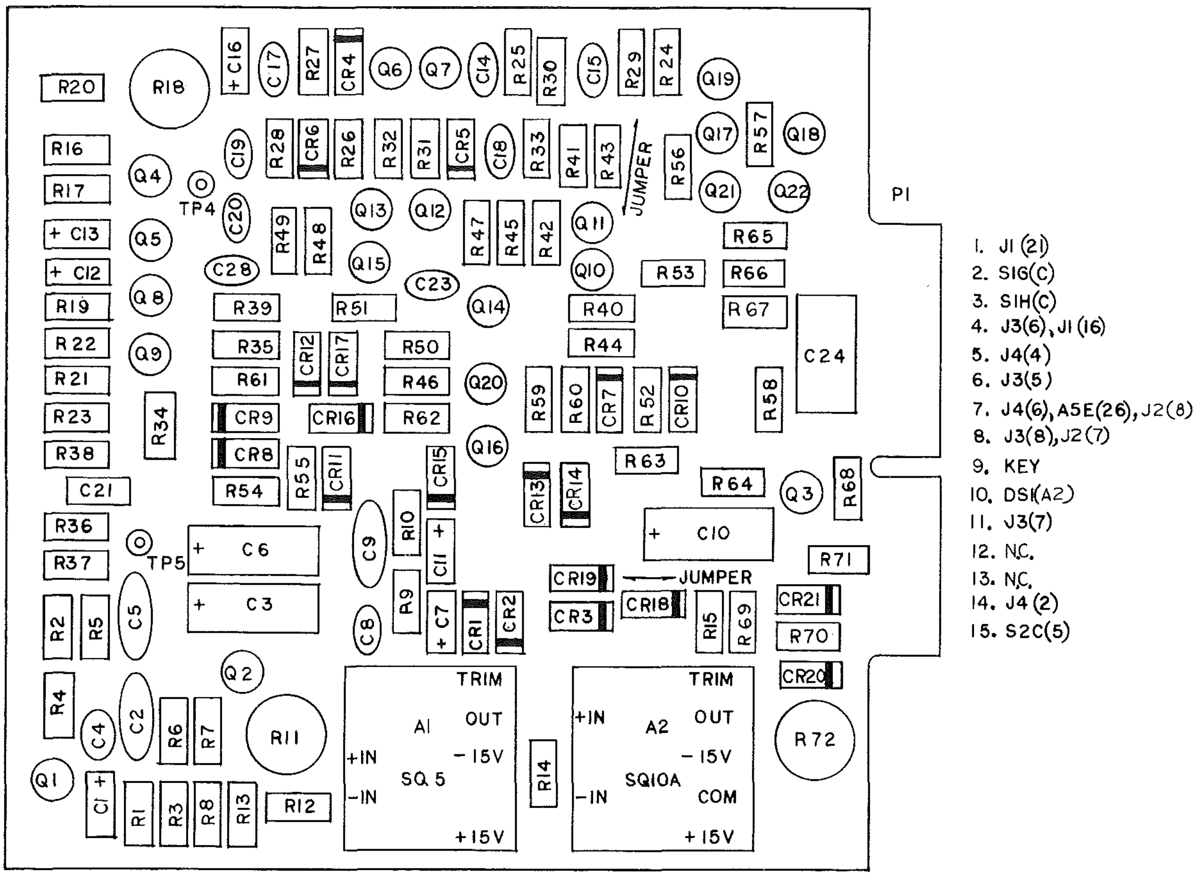


FIGURE 6-1
POWER SUPPLY ASSEMBLY (A1)
SCHEMATIC DIAGRAM



NOTES:

UNLESS OTHERWISE SPECIFIED:

1. RESISTANCE VALUES ARE EXPRESSED IN OHMS.
   CAPACITANCE VALUES ARE EXPRESSED IN MICROFARADS.
2. ALL RESISTORS ARE 1/4W, 5%.
3. SHIELDED WIRE - SEE FIGURE 6-6 FOR SHIELDING INFORMATION
4. CONNECT ALL +15V TO J2P1 (1)
   CONNECT ALL -15V TO J2P1 (11)
   CONNECT ALL ⏚ TO J2P1 (8)

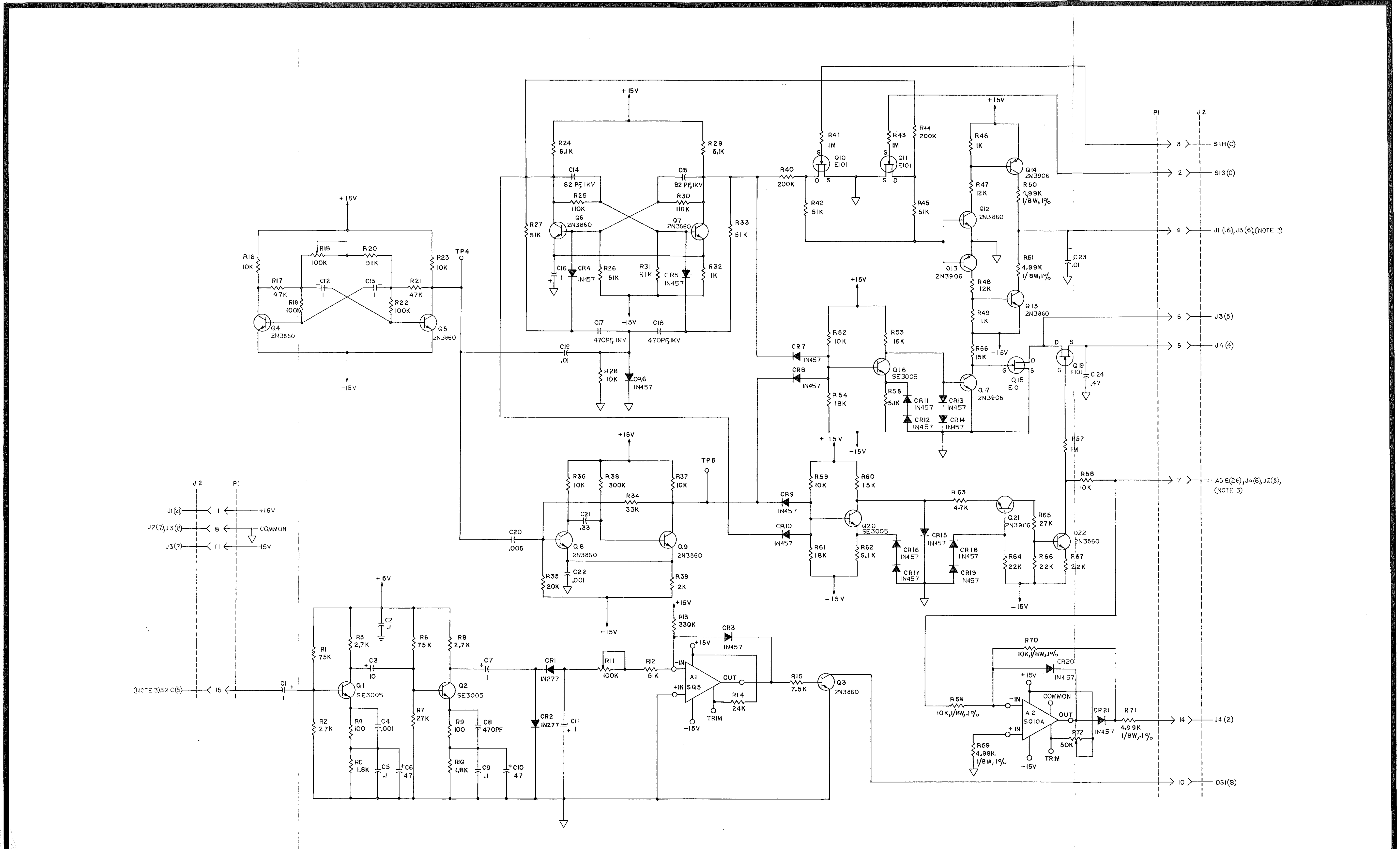
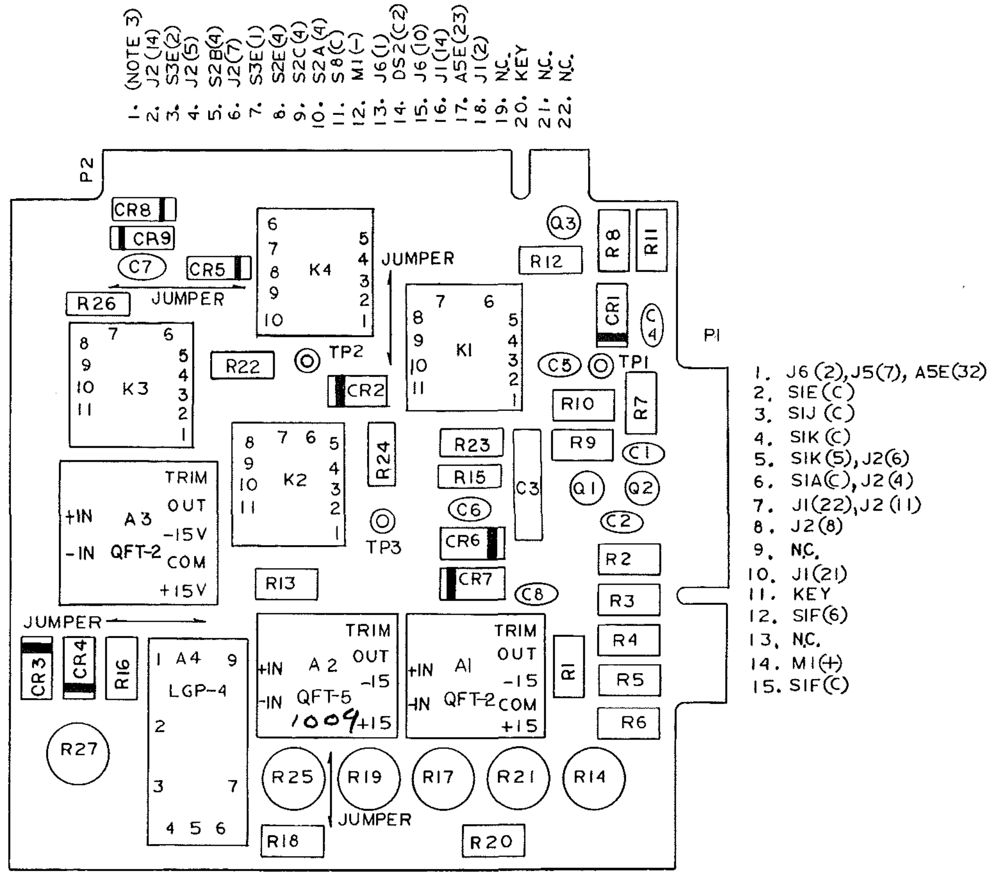


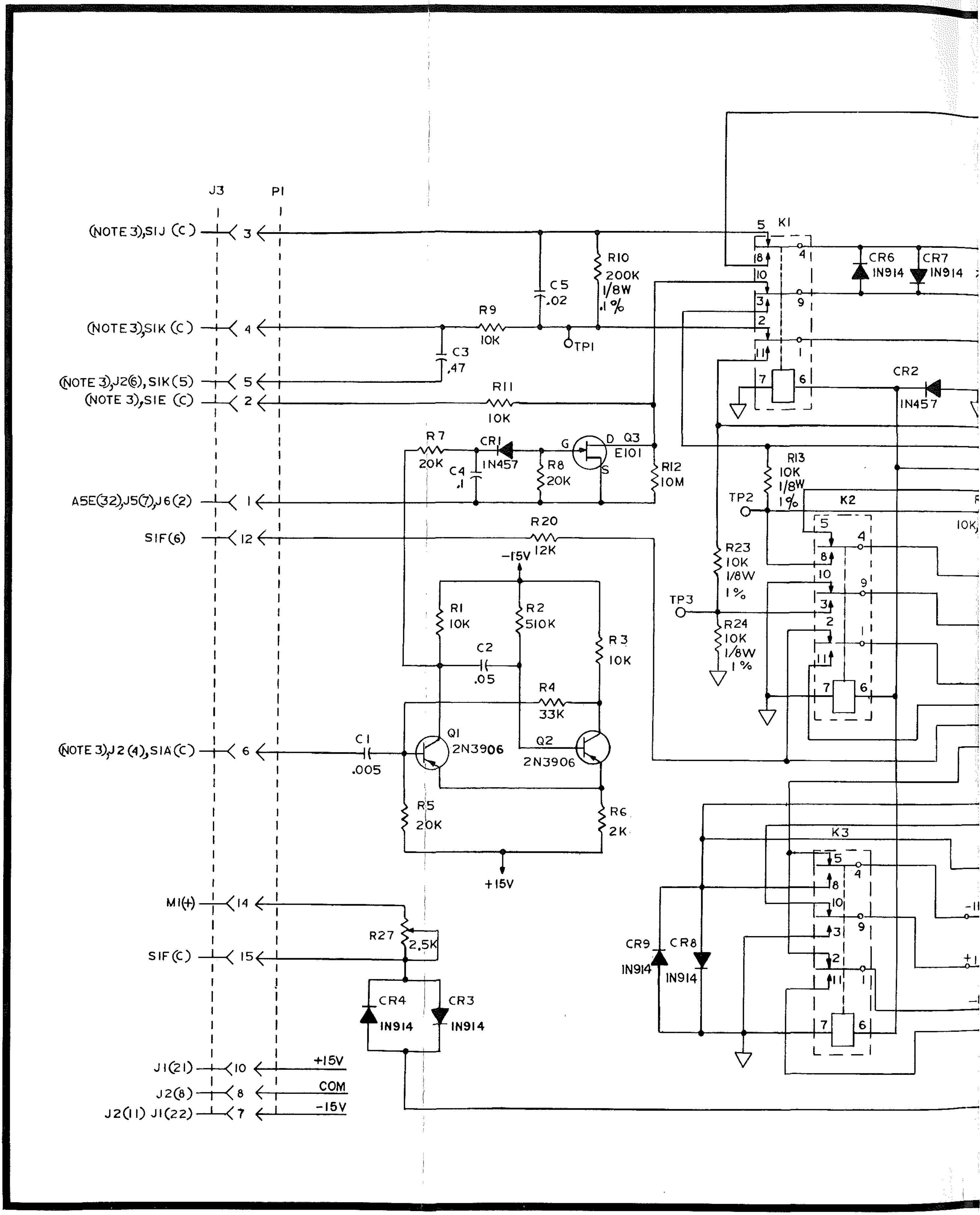
FIGURE 6-2
LOGIC ASSEMBLY (A2)
SCHEMATIC DIAGRAM



NOTES:

UNLESS OTHERWISE SPECIFIED:

1. RESISTANCE VALUES ARE EXPRESSED IN OHMS
   CAPACITANCE VALUES ARE EXPRESSED IN MICROFARADS.
2. ALL RESISTORS ARE 1/4W, 5%.
3. SHIELDED WIRE - SEE FIGURE 6-6 FOR SHIELDING INFORMATION.
4. CONNECT ALL +15V TO J3P1 (10).
   CONNECT ALL -15V TO J3P1 (7).
   CONNECT ALL ⏚ TO J3P1 (8).
5. ALL RELAYS ARE SHOWN DE-ENERGIZED.



J3
P1
(NOTE 3),S1J (C)
(NOTE 3),S1K (C)
(NOTE 3),J2(6),S1K(5)
(NOTE 3),S1E (C)
A5E(32),J5(7),J6(2)
S1F(6)
(NOTE 3),J2(4),S1A(C)
M1(+)
S1F(C)
J1(21)
J2(8)
J2(11) J1(22)
+15V
COM
-15V
K1
K2
K3
C5 .02
R10 200K 1/8W .1%
R9 10K
TP1
C3 .47
R11 10K
R7 20K
CR1 1N457
C4 .1
R8 20K
Q3 E101
R12 10M
R20 12K
R1 10K
R2 510K
R3 10K
C2 .05
R4 33K
C1 .005
Q1 2N3906
Q2 2N3906
R5 20K
R6 2K
R27 2.5K
CR4 1N914
CR3 1N914
CR6 1N914
CR7 1N914
CR2 1N457
R13 10K 1/8W 1%
TP2
TP3
R23 10K 1/8W 1%
R24 10K 1/8W 1%
CR9 1N914
CR8 1N914

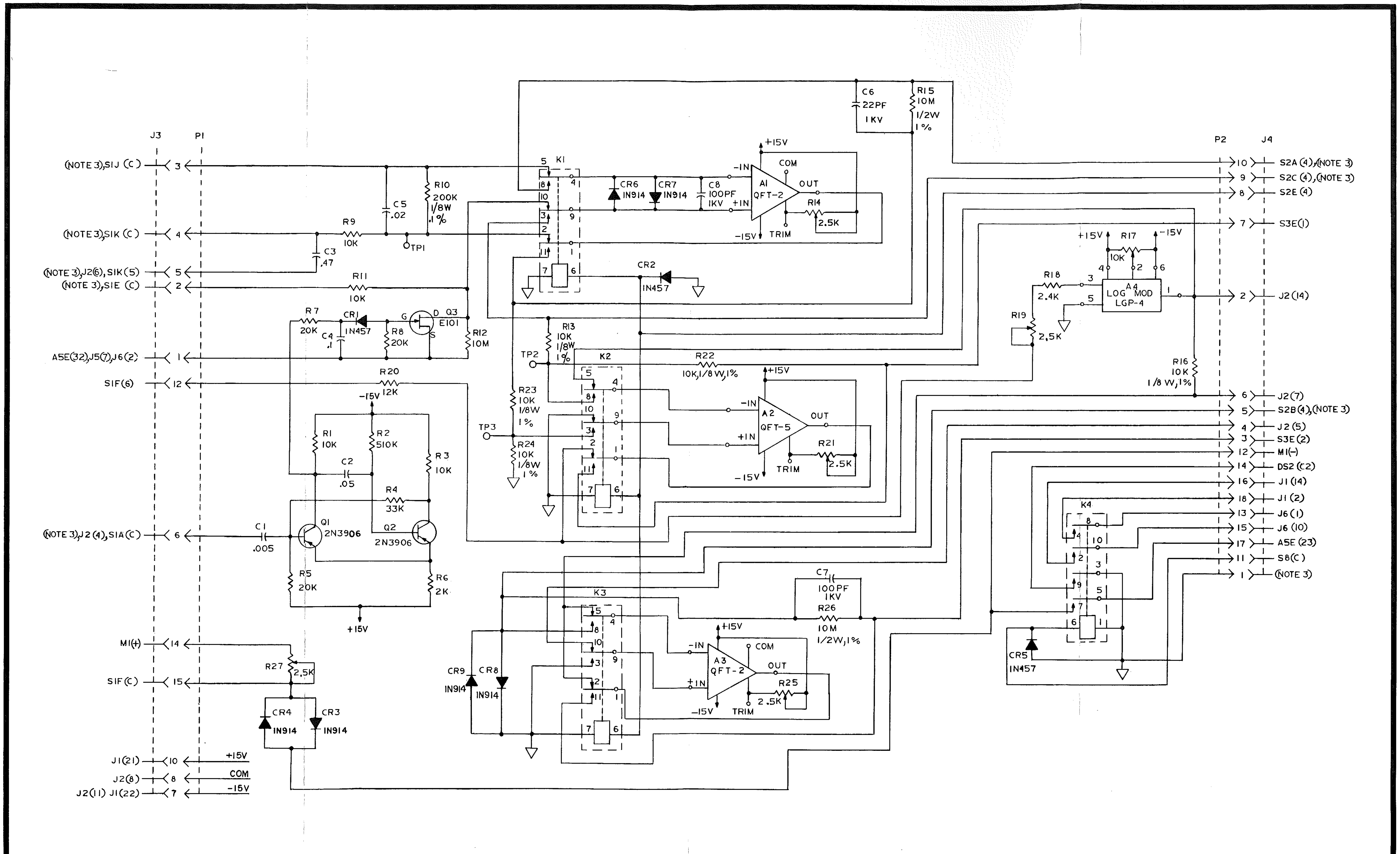
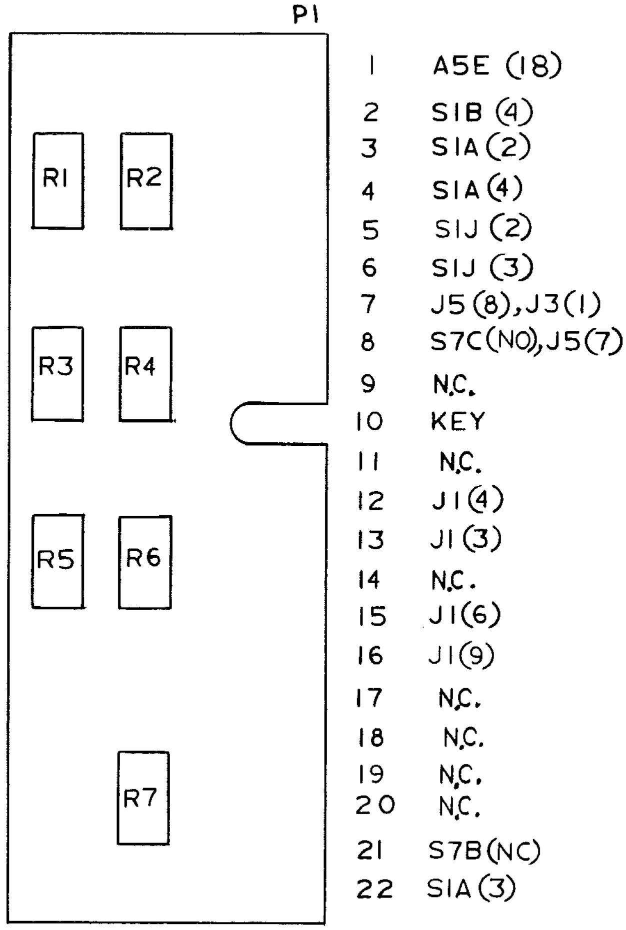


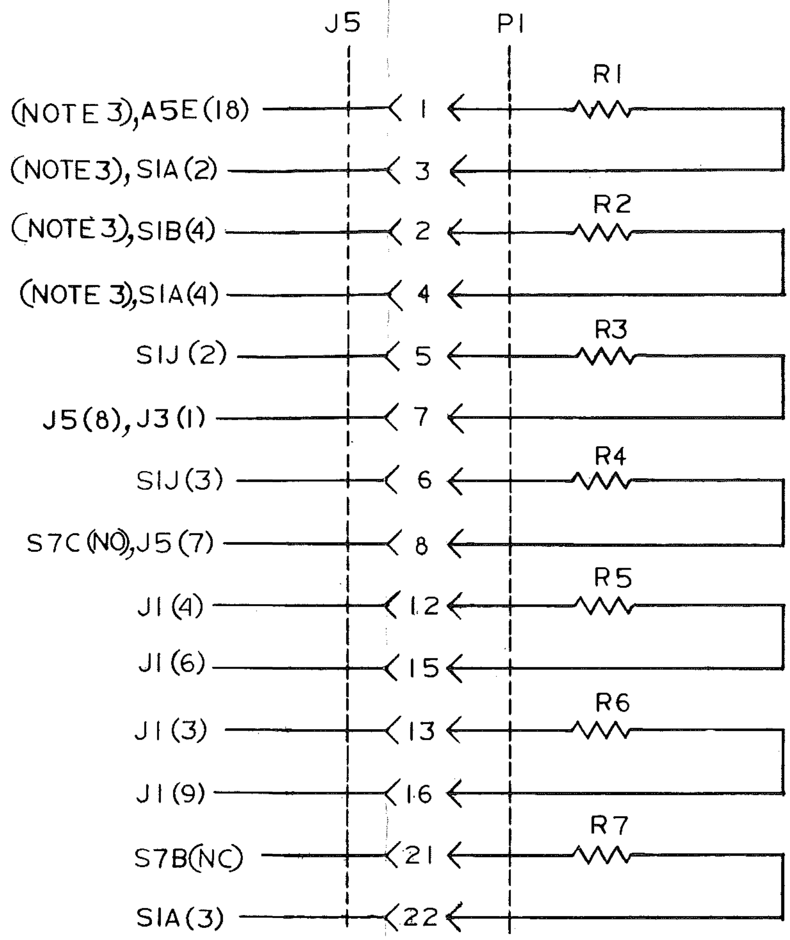
FIGURE 6-3
RELAY & AMPLIFIER ASSEMBLY (A3)
SCHEMATIC DIAGRAM



NOTES:

UNLESS OTHERWISE SPECIFIED:

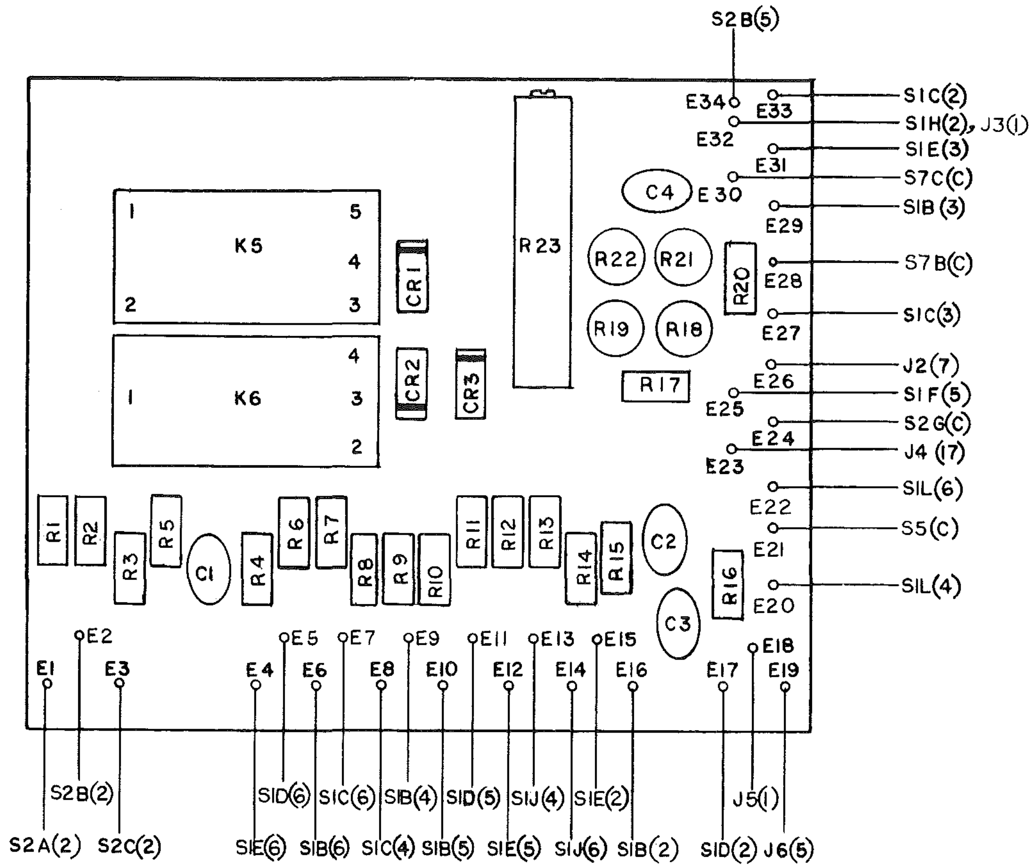
1. RESISTANCE VALUES ARE EXPRESSED IN OHMS.
2. ALL RESISTORS ARE 1/8W, 1%
3. SHIELDED WIRE - SEE FIGURE 6-6 FOR SHIELDING INFORMATION.



VARIATION TABLE														
MODEL NO.	R1		R2		R3		R4		R5		R6		R7	
6007	25K	1%	10K 1/4W 5%		2K	.1%	10.5K	.1%	11K	1%	11K	1%	4.99K	1%
6016	69.8K	1%	10K 1/4W 5%		806	.1%	6.19K	.1%	2K	1%	2K	1%	25K	1%
6017	32.4K	1%	10K	1%	1.620K	.1%	10.5K	.1%	8.06K	1%	8.06K	1%	4.99K	1%
6018	16.5K	1%	10K 1/4W 5%		2.87K	.1%	12.7K	.1%	14K	1%	14K	1%		
6019	54.9K	1%	10K 1/4W 5%		1.05K	.1%	1.05K	.1%	8.06K	1%	2K	1%	124K	1%
6020	10K	1%	10K 1/4W 5%		4.02K	.1%	12.70K	.1%	20K	1%	20K	1%		
6022	45.3K	1%	10K 1/4W 5%		1.21K	.1%	8.25K	.1%	4.99K	1%	4.99K	1%	12.4K	1%

FIGURE 6-4
PROGRAM CARD ASSEMBLY (A4)
SCHEMATIC DIAGRAM

5-14



NOTES:

UNLESS OTHERWISE SPECIFIED:

1. RESISTANCE VALUES ARE EXPRESSED IN OHMS; CAPACITANCE VALUES ARE EXPRESSED IN MICROFARADS.
2. ALL RESISTORS ARE 1/8W.
3. SHIELDED WIRE - SEE FIGURE 6-6 FOR SHIELDING INFORMATION.
4. ALL RELAYS ARE SHOWN DE-ENERGIZED.

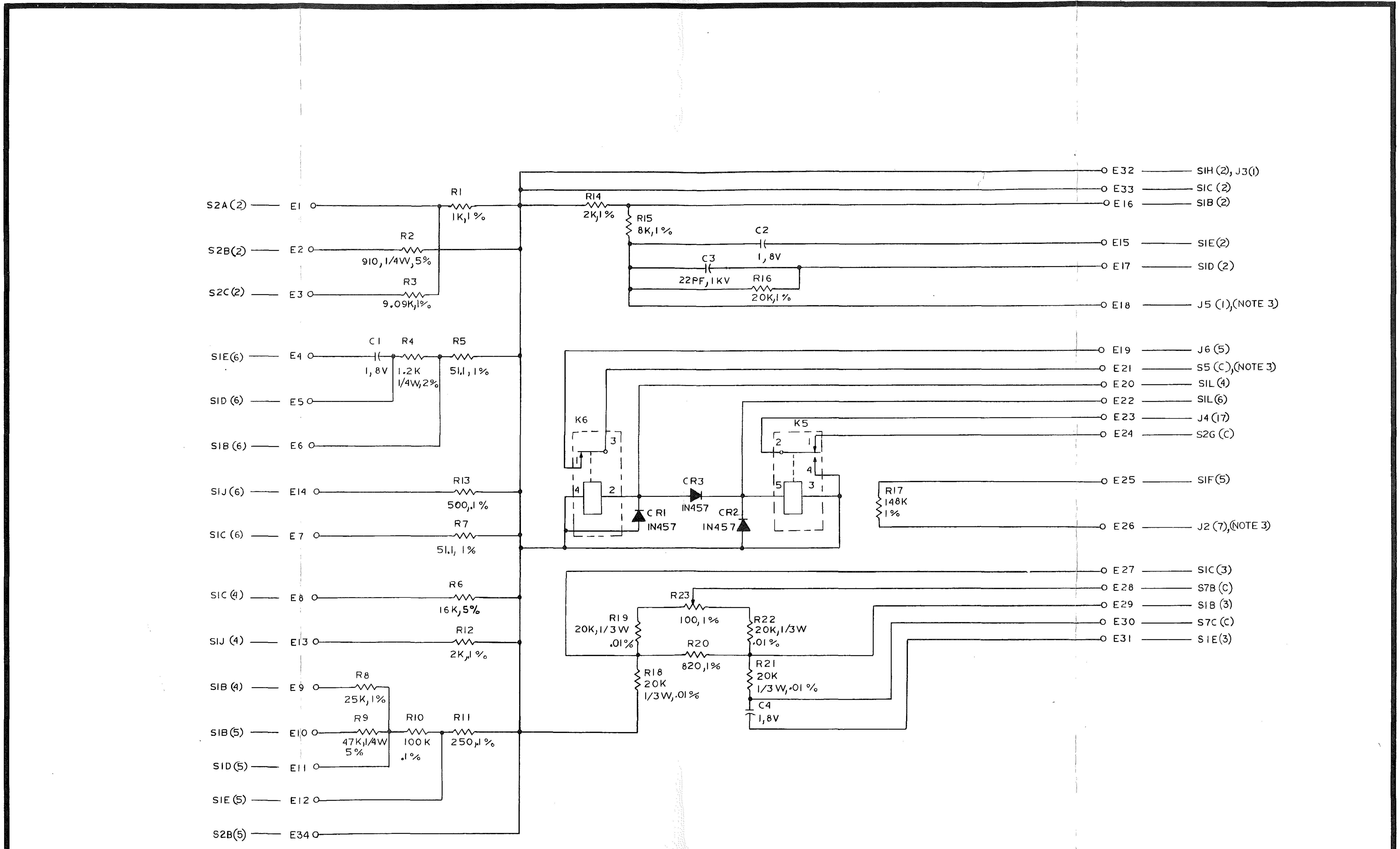
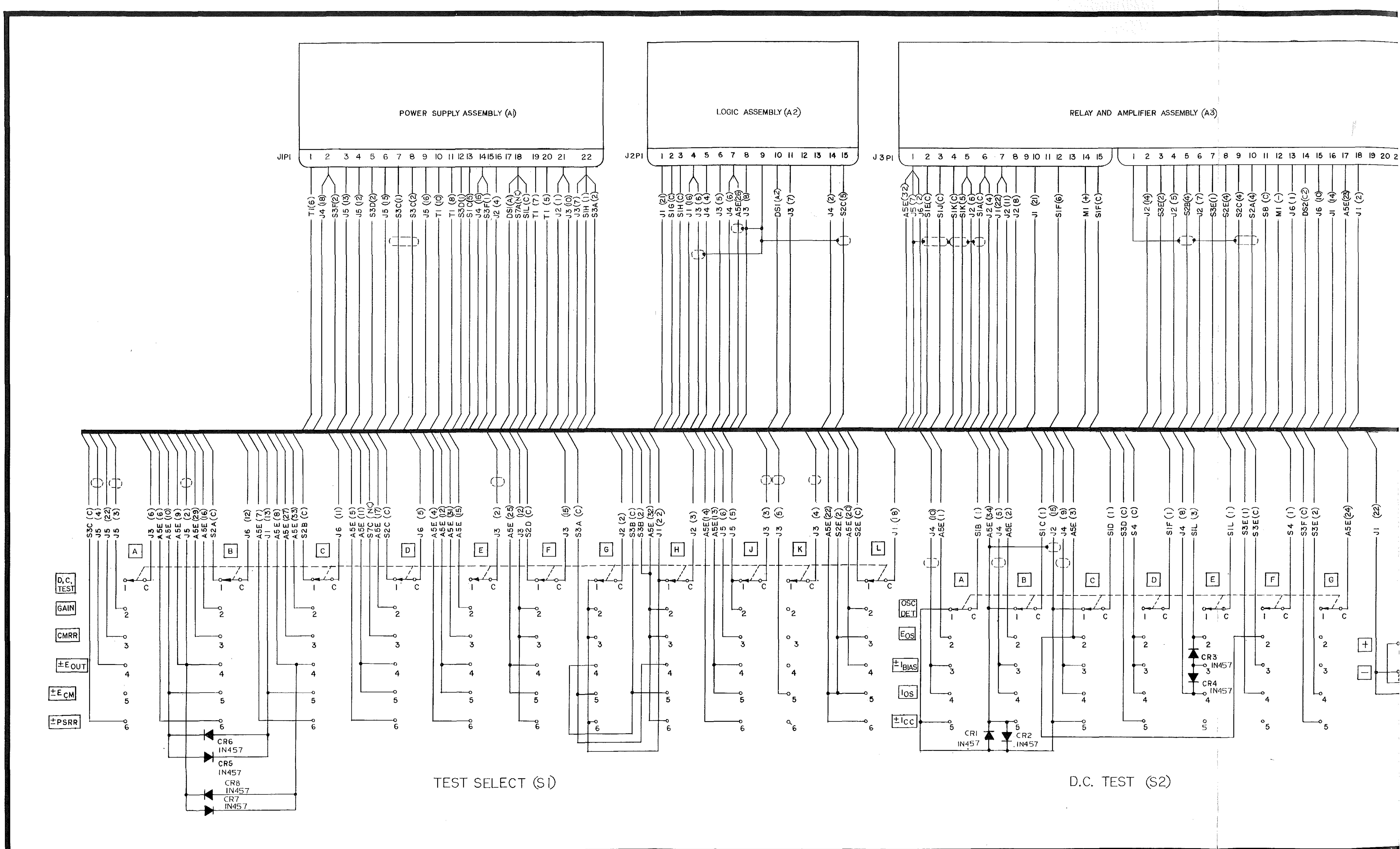
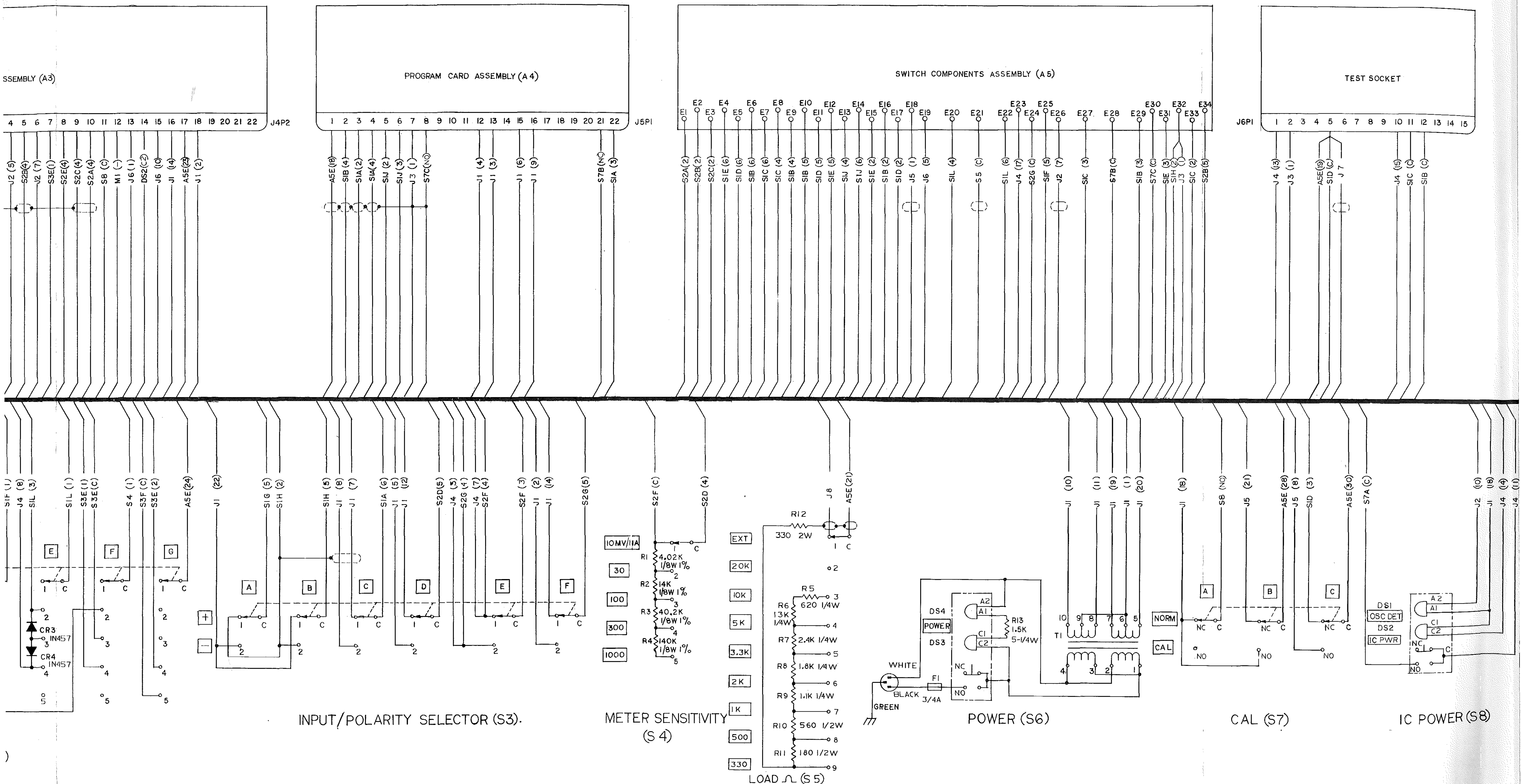


FIGURE 6-5
SWITCH COMPONENTS ASSEMBLY (A5)
SCHEMATIC DIAGRAM

5-15



POWER SUPPLY ASSEMBLY (A1)
LOGIC ASSEMBLY (A2)
RELAY AND AMPLIFIER ASSEMBLY (A3)
J1P1
J2P1
J3P1
D.C. TEST
GAIN
CMRR
±E OUT
±E CM
±PSRR
OSC DET
E OS
±I BIAS
I OS
±I CC
CR1 IN457
CR2 IN457
CR3 IN457
CR4 IN457
CR5 IN457
CR6 IN457
CR7 IN457
CR8 IN457
TEST SELECT (S1)
D.C. TEST (S2)



F
MODEL 5102 OPERA
INTERCON

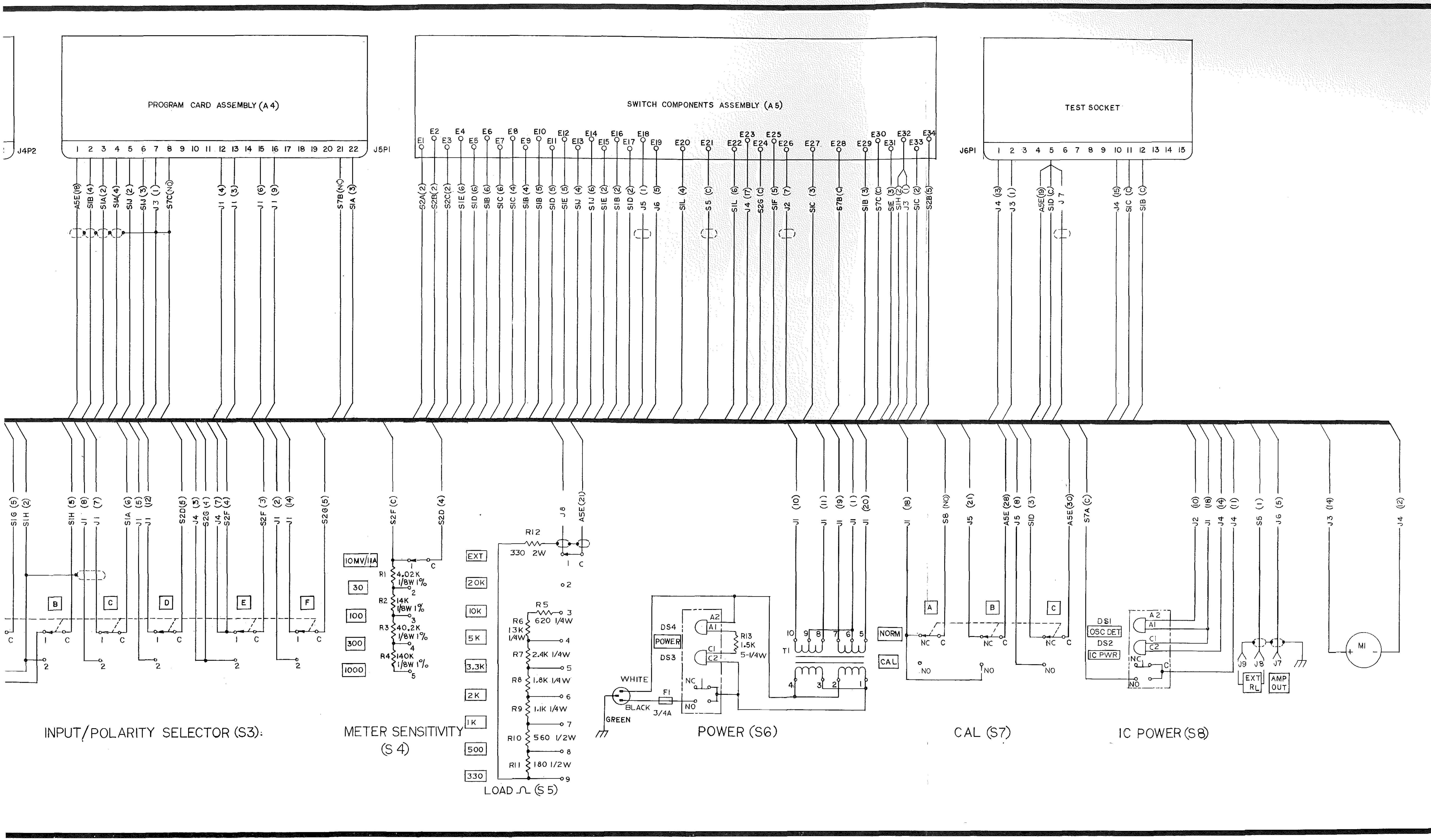


FIGURE 6-6
MODEL 5102 OPERATIONAL AMPLIFIER TESTER
INTERCONNECTION DIAGRAM

SECTION 7

REPLACEABLE PARTS

7-1. INTRODUCTION

This section of the manual contains an alphanumeric listing of the replaceable component parts available for the Model 5102 Operational Amplifier Tester. Given is the reference designation, Teledyne Philbrick Nexus part number, part description, total quantity, and the suggested manufacturer and his part number of each item used in the manufacture of the unit. Items such as machine parts, hardware, etc., are not included although they may be ordered directly through us upon special request. A listing of manufacturers and their addresses, arranged in numeric order by the Federal Supply Code, is provided in Table 7-1.

7-2. ORDERING REPLACEABLE PARTS

Replacement parts for the Model 5102 Operational Amplifier Tester may be ordered through your local Teledyne Philbrick Nexus representative, or directly from:

Teledyne Philbrick Nexus
Allied Drive at Route 128
Dedham, Massachusetts 02026

When placing your order, give our representative complete information regarding the part required including the Teledyne Philbrick Nexus part number, part description, and total quantity desired. We will endeavor to provide you with the latest and most improved components as they become available.

TABLE 7-1. LIST OF MANUFACTURERS

Code No.*	Manufacturer	Address
01121	Allen & Bradley Co.	Milwaukee, Wisconsin
01295	Texas Instrument, Inc.	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, New Hampshire
02660	Amphenol Corp.	Broadview, Illinois
02735	Radio Corp. of America	Somerville, New Jersey
03877	Transitron Electronic Corp.	Wakefield, Massachusetts
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, New Jersey
04713	Motorola Semiconductor Products, Inc.	Phoenix, Arizona
06751	Components, Inc.	Phoenix, Arizona
07263	Fairchild Camera and Instrument Corp.	Mountain View, California
14433	ITT Semiconductor, Inc.	West Palm Beach, Florida
14655	Cornell & Dubilier Electric Corp.	Newark, New Jersey
14674	Corning Glass Works	Corning, New York
17856	Siliconix, Inc.	Sunnyvale, California
23020	General Reed Company	Clark, New Jersey
24455	General Electric Co., Lamp Division	Cleveland, Ohio
29604	Stackpole Components Co.	Raleigh, North Carolina
29832	Teledyne Philbrick Nexus	Dedham, Massachusetts
44655	Ohmite Mfg. Co.	Skokie, Illinois
56289	Sprague Electric Co.	North Adams, Massachusetts
71400	Bussman Mfg. Co.	St. Louis, Missouri
71590	Centralab Div. of Globe Union, Inc.	Milwaukee, Wisconsin
71785	Cinch Mfg. Co.	Chicago, Illinois
74970	E. F. Johnson Co.	S. W. Waseca, Minnesota
75915	Littelfuse, Inc.	Des Plains, Illinois
83332	TECH Laboratories	Palisades Park, New Jersey
84411	TRW Capacitor Division	Ogallala, Nebraska
91929	Honeywell, Inc., Micro Switch Division	Freeport, Illinois

* Federal Supply Code for Manufacturers Cataloging Handbook H4-1 (Name to Code)

7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Description	Total Quantity	Mfgr.	Mfgr. Part No.
End Item	99005102	Operational Amplifier Tester, Model 5102, Figure 1-1.	1	29832	
A1	98000106	Power Supply Assembly, Figure 6-1.	1	29832	
A2	98000107	Logic Assembly, Figure 6-2.	1	29832	
A3	98000108	Relay & Amplifier Assembly, Figure 6-3.	1	29832	
A4	99006007	Program Card Assembly, Figure 6-4.	1	29832	
A5	98000110	Switch Components Assembly, Figure 6-5.	1	29832	
A6	99006005	709 Plug-In Test Socket, Figure 1-2.	1	29832	
A7	99006008	7-Pin Q Plug-In Test Socket, Figure 1-2.	1	29832	
CR1 thru CR8	10191253	Diode, 1N457	8	03877	1N457
DS1 thru DS4	12090327	Lamp, Switch, Midget 28V	4	24455	327
XF1	11891301	Fuseholder	1	75915	342014
F1	11890750	Fuse, AGC 3/4 amp	1	71400	AGC 3/4
J1	12591704	Connector, 22-pin edge	3	71785	250-22-30-170
J2, J3	12591695	Connector, 15-pin edge	3	71785	250-15-36-170
J4, J5	12591704	Connector, 22-pin edge	-	71785	250-22-30-170
J6	12591695	Connector, 15-pin edge	-	71785	250-15-36-170
J7	12591831	Connector, BNC	1	02660	UG1094/U
J8	14591404	Jack, Banana, Blue	1	74970	108-910
J9	14591417	Jack, Banana, Black	1	74970	108-903
M1	51630002	Meter	1	29832	
R1	02134021	Res., 4.02kΩ 1/8W 1% T-1 MF	1	03888	PME-55
R2	02141402	Res., 14.0kΩ 1/8W 1% T-1 MF	1	03888	PME-55
R3	02144022	Res., 40.2kΩ 1/8W 1% T-1 MF	1	03888	PME-55
R4	02151403	Res., 140 kΩ 1/8W 1% T-1 MF	1	03888	PME-55
R5	00326215	Res., 620 Ω 1/4W 5% comp	1	01121	CB6215
R6	00341335	Res., 13 kΩ 1/4W 5% comp	1	01121	CB1335
R7	00332425	Res., 2.4kΩ 1/4W 5% comp	1	01121	CB2425
R8	00331825	Res., 1.8kΩ 1/4W 5% comp	1	01121	CB1825
R9	00331125	Res., 1.1kΩ 1/4W 5% comp	1	01121	CB1125
R10	00525615	Res., 560 Ω 1/2W 5% comp	1	01121	EB5615

7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Description	Total Quantity	Mfgr.	Mfgr. Part No.
R11	00521815	Res., 180 Ω 1/2W 5% comp	1	01121	EB1815
R12	00923315	Res., 330 Ω 2W 5% comp	1	01121	HB3315
R13	03430857	Res., 1.5kΩ 5-1/4W 5%	1	44655	2898
S1	11590116	Switch, Rotary, 11 pole-6 pos	1	83332	3A-2N6-6
S2	11590075	Switch, Rotary, 7 pole-5 pos	1	83332	3A-2N5-4
S3	11592019	Switch, Rotary, 6 pole-2 pos	1	71590	PA-2019 Sil Con
S4	11592001	Switch, Rotary, 1 pole-5 pos	2	71590	PA-2001 Sil Con
S5	11592001	Switch, Rotary, 1 pole-9 pos	-	71590	PA-2001 Sil Con
S6	11690005	Switch, Pushbutton, SPDT	2	91929	2D118
	11690004	Operator Indicator, 2 Lamp	2	91929	2C201
	11690003	Barrier, Switch Mounting	4	91929	2B3
S7	11491346	Switch, Slide, 3PDT	1	29604	SS-34
S8	11690005	Switch, Pushbutton, SPDT	-	91929	2D118
	11690004	Operator Indicator, 2 Lamp	-	91929	2C201
	11690003	Barrier, Switch Mounting	-	91929	2B3
T1	52910002	Transformer	1	29832	
A1	98000106	Power Supply Assembly, Figure 6-1.	1	29832	
A1C1, A1C2	06040949	Cap., 0.01μF 100V 20% disc	2	56289	C023B101F103M
A1A3 thru A1C5	07081038	Cap., 500 μF 50V electrolytic	3	56289	TVA-1315
A1CR1 thru A1CR6	10191245	Diode, 1N4002	6	04713	1N4002
A1CR7	10591240	Diode, 1N4749 24V Zener	1	04713	1N4749
A1Q1	08293859	Transistor, 2N3859A NPN Si	2	56289	2N3859A
A1Q2, A1Q3	09191858	Transistor, 2N4249 PNP Si	2	07263	2N4249
A1Q4	08293859	Transistor, 2N3859A NPN Si	-	56289	2N3859A
A1Q5	09094889	Transistor, 2N4889 PNP Si	1	07263	2N4889
A1Q6	55510002	Transistor, 2N3860 NPN Si	1	56289	2N3860
A1Q7	08091860	Transistor, 2N2270 NPN Si	1	02735	2N2270
A1R1, A1R2	02141002	Res., 10k Ω 1/8W 1% T-1 MF	2	03888	PME-55
A1R3, A1R4	02125100	Res., 510 Ω 1/8W 1% T-1 MF	2	03888	PME-55
A1R5, A1R6	00351045	Res., 100kΩ 1/4W 5% comp	2	01121	CB1045
A1R7, A1R8	17231611	Pot., 2.5kΩ	4	01121	FR252M

7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Description	Total Quantity	Mfgr.	Mfgr. Part No.
A1R9	00332025	Res., 2k Ω 1/4W 5% comp	2	01121	CB2025
A1R10	17231611	Pot., 2.5k Ω	-	01121	FR252M
A1R11	00332025	Res., 2k Ω 1/4W 5% comp	-	01121	CB2025
A1R12	17231611	Pot., 2.5k Ω	-	01121	FR252M
A1R13 thru A1R18	02110100	Res., 10 Ω 1/8W 1% T-1 MF	6	03888	PME-55
A1R19	00331025	Res., 1k Ω 1/4W 5% comp	1	01121	CB1025
A1R20	00343635	Res., 36k Ω 1/4W 5% comp	1	01121	CB3635
A1R21	00352745	Res., 270k Ω 1/4W 5% comp	1	01121	CB2745
A1R22	00362255	Res., 2.2MΩ 1/4W 5% comp	1	01121	CB2255
A1R23	00348235	Res., 82k Ω 1/4W 5% comp	1	01121	CB8235
A1R26	00331825	Res., 1.8k Ω 1/4W 5% comp	1	01121	CB1825
A1VR1	2101	Voltage Regulator	1	29832	
A1VR2	2102	Voltage Regulator	1	29832	
A2	98000107	Logic Assembly, Figure 6-2.	1	29832	
A2A1	0581	Amplifier, Model SQ-5	1	29832	
A2A2	0305	Amplifier, Model SQ-10A	1	29832	
A2C1	07161026	Cap., 1μF 25V tantalum	6	06751	CT-105
A2C2	06050963	Cap., .1μF 50V 20% disc	3	56289	33C41A3
A2C3	07171071	Cap., 10μF 35V tantalum	1	56289	150D106X9035R2
A2C4	06030939	Cap., .001μF 600V 20% disc	2	71590	LG102M
A2C5	06050963	Cap., .1μF 50V 20% disc	-	56289	33C41A3
A2C6	07171037	Cap., 47μF 50V tantalum	2	14433	CL64BJ47OUP3
A2C7	07161026	Cap., 1μF 25V tantalum	-	06751	CT-105
A2C8	06020906	Cap., 470pF 1kV 10% disc	3	71590	DD-471
A2C9	06050963	Cap., .1μF 50V 20% disc	-	56289	33C41A3
A2C10	07171037	Cap., 47μF 50V tantalum	-	14433	CL64BJ47OUP3
A2C11 thru A2C13	07171026	Cap., 1μF 25V tantalum	-	06751	CT-105
A2C14, A2C15	06010992	Cap., 82pF 1kV 20% disc	2	71590	DD-820
A2C16	07161026	Cap., 1μF 25V tantalum	-	06751	CT-105
A2C17, A2C18	06020906	Cap., 470pF 1kV 10% disc	-	71590	DD-471
A2C19	06040949	Cap., .01μF 100V 20% disc	2	56289	CO23B101F103M
A2C20	06030945	Cap., .005μF 100V 20% disc	1	56289	40C172
A2C21	06741053	Cap., .33μF 100V 10% mylar	1	84411	X663FR
A2C22	06030939	Cap., .001μF 600V 20% disc	-	71590	LG102M
A2C23	06040949	Cap., .01μF 100V 20% disc	-	56289	CO23B101F103M
A2C24	06754710	Cap., .47μF 100V 10% mylar	1	84411	X663FR
A2CR1, A2CR2	10091278	Diode, 1N277	2	14433	1N277

7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Description	Total Quantity	Mfgr.	Mfgr. Part No.
A2CR3 thru A2CR21	10191253	Diode, 1N457	19	03877	1N457
A2Q1, A2Q2	08193005	Transistor, SE 3005 NPN Si	4	07263	SE3005
A2Q3 thru A2Q9	55510002	Transistor, 2N3860 NPN Si	10	56289	2N3860
A2Q10, A2Q11	08491875	Transistor, E101 FET Si	4	17856	E101
A2Q12	55510002	Transistor, 2N3860 NPN Si	-	56289	2N3860
A2Q13, A2Q14	09393906	Transistor, 2N3906 PNP Si	4	14713	2N3906
A2Q15	55510002	Transistor, 2N3860 NPN Si	-	56289	2N3860
A2Q16	08193005	Transistor, SE3005 NPN Si	-	07263	SE3005
A2Q17	09393906	Transistor, 2N3906 PNP Si	-	04713	2N3906
A2Q18, A2Q19	08491875	Transistor, E101 FET Si	-	17856	E101
A2Q20	08193005	Transistor, SE3005 NPN Si	-	07263	SE3005
A2Q21	09393906	Transistor, 2N3906 PNP Si	-	04713	2N3906
A2Q22	55510002	Transistor, 2N3860 NPN Si	-	56289	2N3860
A2R1	00347535	Res., 75kΩ 1/4W 5% comp	2	01121	CB7535
A2R2	00342735	Res., 27kΩ 1/4W 5% comp	3	01121	CB2735
A2R3	00332725	Res., 2.7kΩ 1/4W 5% comp	2	01121	CB2725
A2R4	00321015	Res., 100kΩ 1/4W 5% comp	2	01121	CB1015
A2R5	00331825	Res., 1.8kΩ 1/4W 5% comp	2	01121	CB1825
A2R6	00347535	Res., 75kΩ 1/4W 5% comp	-	01121	CB7535
A2R7	00342735	Res., 27kΩ 1/4W 5% comp	-	01121	CB2735
A2R8	00332725	Res., 2.7kΩ 1/4W 5% comp	-	01121	CB2725
A2R9	00321015	Res., 100kΩ 1/4W 5% comp	-	01121	CB1015
A2R10	00331825	Res., 1.8kΩ 1/4W 5% comp	-	01121	CB1825
A2R11	17251580	Pot., 100kΩ	2	01121	FR104M
A2R12	00345135	Res., 51kΩ 1/4W 5% comp	7	01121	CB5135
A2R13	00353345	Res., 330kΩ 1/4W 5% comp	1	01121	CB3345
A2R14	00342435	Res., 24kΩ 1/4W 5% comp	1	01121	CB2435
A2R15	00337525	Res., 7.5kΩ 1/4W 5% comp	1	01121	CB7525
A2R16	00341035	Res., 10kΩ 1/4W 5% comp	8	01121	CB1035
A2R17	00344735	Res., 47kΩ 1/4W 5% comp	2	01121	CB4735
A2R18	17251580	Pot., 100kΩ	-	01121	FR104M
A2R19	00351045	Res., 100kΩ 1/4W 5% comp	2	01121	CB1045
A2R20	00349135	Res., 91kΩ 1/4W 5% comp	1	01121	CB9135
A2R21	00344735	Res., 47kΩ 1/4W 5% comp	-	01121	CB4735
A2R22	00351045	Res., 100kΩ 1/4W 5% comp	-	01121	CB1045
A2R23	00341035	Res., 10kΩ 1/4W 5% comp	-	01121	CB1035

7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Description	Total Quantity	Mfgr.	Mfgr. Part No.
A2R24	00335125	Res., 5.1kΩ 1/4W 5% comp	4	01121	CB5125
A2R25	00351145	Res., 110kΩ 1/4W 5% comp	2	01121	CB1145
A2R26, A2R27	00345135	Res., 51kΩ 1/4W 5% comp	-	01121	CB5135
A2R28	00341035	Res., 10kΩ 1/4W 5% comp	-	01121	CB1035
A2R29	00335125	Res., 5.1kΩ 1/4W 5% comp	-	01121	CB5125
A2R30	00351145	Res., 110kΩ 1/4W 5% comp	-	01121	CB1145
A2R31	00345135	Res., 51kΩ 1/4W 5% comp	-	01121	CB5135
A2R32	00331025	Res., 1kΩ 1/4W 5% comp	3	01121	CB1025
A2R33	00345135	Res., 51kΩ 1/4W 5% comp	-	01121	CB5135
A2R34	00343335	Res., 33kΩ 1/4W 5% comp	1	01121	CB3335
A2R35	00342035	Res., 20kΩ 1/4W 5% comp	1	01121	CB2035
A2R36, A2R37	00341035	Res., 10kΩ 1/4W 5% comp	-	01121	CB1035
A2R38	00353045	Res., 300kΩ 1/4W 5% comp	1	01121	CB3045
A2R39	00332025	Res., 2kΩ 1/4W 5% comp	1	01121	CB2025
A2R40	00352045	Res., 200kΩ 1/4W 5% comp	2	01121	CB2045
A2R41	00361055	Res., 1MΩ 1/4W 5% comp	3	01121	CB1055
A2R42	00345135	Res., 51kΩ 1/4W 5% comp	-	01121	CB5135
A2R43	00361055	Res., 1MΩ 1/4W 5% comp	-	01121	CB1055
A2R44	00352045	Res., 200kΩ 1/4W 5% comp	-	01121	CB2045
A2R45	00345135	Res., 51kΩ 1/4W 5% comp	-	01121	CB5135
A2R46	00331025	Res., 1kΩ 1/4W 5% comp	-	01121	CB1025
A2R47, A2R48	00341235	Res., 12kΩ 1/4W 5% comp	2	01121	CB1235
A2R49	00331025	Res., 1kΩ 1/4W 5% comp	-	01121	CB1025
A2R50, A2R51	02134991	Res., 4.99kΩ 1/8W 1% T-1 MF	3	03888	PME-55
A2R52	00341035	Res., 10kΩ 1/4W 5% comp	-	01121	CB1035
A2R53	00341535	Res., 15kΩ 1/4W 5% comp	3	01121	CB1535
A2R54	00341835	Res., 18kΩ 1/4W 5% comp	2	01121	CB1835
A2R55	00335125	Res., 5.1kΩ 1/4W 5% comp	-	01121	CB5125
A2R56	00341535	Res., 15kΩ 1/4W 5% comp	-	01121	CB1535
A2R57	00361055	Res., 1MΩ 1/4W 5% comp	-	01121	CB1055
A2R58, A2R59	00341035	Res., 10kΩ 1/4W 5% comp	-	01121	CB1035
A2R60	00341535	Res., 15kΩ 1/4W 5% comp	-	01121	CB1535
A2R61	00341835	Res., 18kΩ 1/4W 5% comp	-	01121	CB1835
A2R62	00335125	Res., 5.1kΩ 1/4W 5% comp	-	01121	CB5125
A2R63	00334725	Res., 4.7kΩ 1/4W 5% comp	1	01121	CB4725
A2R64	00342235	Res., 22kΩ 1/4W 5% comp	2	01121	CB2235
A2R65	00342735	Res., 27kΩ 1/4W 5% comp	-	01121	CB2735
A2R66	00342235	Res., 22kΩ 1/4W 5% comp	-	01121	CB2235
A2R67	00332225	Res., 2.2kΩ 1/4W 5% comp	1	01121	CB2225
A2R68	04641002	Res., 10kΩ 1/8W 0.1% T-1 MF	2	03888	PME-55

7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Description	Total Quantity	Mfgr.	Mfgr. Part No.
A2R69	02134991	Res., 4.99kΩ 1/8W 1% T-1 MF	-	03888	PME-55
A2R70	04641002	Res., 10kΩ 1/8W 0.1% T-1 MF	-	03888	PME-55
A2R71	04634991	Res., 4.99kΩ 1/8W 0.1% T-1 MF	1	03888	PME-55
A2R72	17241589	Pot., 50kΩ	1	01121	FR503M
A3	98000108	Relay & Amplifier Assembly Figure 6-3.	1	29832	
A3A1	0555	Amplifier, QFT-2	2	29832	
A3A2	0581	Amplifier, QFT-5	1	29832	
A3A3	0555	Amplifier, QFT-2	-	29832	
A3A4	0362	Logarithmic Module, LGP-4	1	29832	
A3C1	06030945	Cap., .005μF 100V 20% disc	1	56289	40C172
A3C2	06040959	Cap., .05μF 50V 20% disc	1	56289	55C23A1
A3C3	06754710	Cap., .47μF 100V 10% mylar	1	84411	X663FR
A3C4	06050963	Cap., .1μF 50V 20% disc	1	56289	33C41A3
A3C5	06040898	Cap., .02μF 50V 20% disc	1	56289	TG-S20
A3C6	06010931	Cap., 22pF 1kV 20% disc	1	56289	CO48B102E220M
A3C7, A3C8	06020922	Cap., 100pF 1kV 10% disc	2	71590	DD-101
A3CR1, A3CR2	10191253	Diode, 1N457	3	03877	1N457
A3CR3, A3CR4	10091274	Diode, 1N914	6	01295	1N914
A3CR5	10191253	Diode, 1N457	-	03877	1N457
A3CR6 thru A3CR9	10091274	Diode, 1N914	-	01295	1N914
A3K1 thru A3K3	16790203	Relay, 3PDT 28V reed	3	23020	203-28
A3K4	16790240	Relay, 4PST 28V reed	1	23020	240-28
A3Q1, A3Q2	09393906	Transistor, 2N3906 PNP Si	2	04713	2N3906
A3Q3	08491875	Transistor, E101 FET Si	1	17856	E101
A3R1	00341035	Res., 10kΩ 1/4W 5% comp	4	01121	CB1035
A3R2	00355145	Res., 510kΩ 1/4W 5% comp	1	01121	CB5145
A3R3	00341035	Res., 10kΩ 1/4W 5% comp	-	01121	CB1035
A3R4	00343335	Res., 33kΩ 1/4W 5% comp	1	01121	CB3335
A3R5	00342035	Res., 20kΩ 1/4W 5% comp	3	01121	CB2035
A3R6	00332025	Res., 2kΩ 1/4W 5% comp	1	01121	CB2025
A3R7, A3R8	00342035	Res., 20kΩ 1/4W 5% comp	-	01121	CB2035
A3R9	00341035	Res., 10kΩ 1/4W 5% comp	-	01121	CB1035
A3R10	04652003	Res., 200kΩ 1/8W 0.1% T-1 MF	1	03888	PME-55

7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Description	Total Quantity	Mfgr.	Mfgr. Part No.
A3R11	00341035	Res., 10kΩ 1/4W 5% comp	-	01121	CB1035
A3R12	00371065	Res., 10MΩ 1/4W 5% comp	1	01121	CB1065
A3R13	02141002	Res., 10kΩ 1/8W 1% T-1 MF	4	03888	PME-55
A3R14	17231611	Pot., 2.5kΩ	5	01121	FR252M
A3R15	01471005	Res., 10MΩ 1/2W 1% T-1 MF	2	03888	PME-65
A3R16	04641002	Res., 10kΩ 1/8W 0.1% T-1 MF	1	03888	PME-55
A3R17	17241599	Pot., 10kΩ	1	01121	FR103M
A3R18	00332425	Res., 2.4kΩ 1/4W 5% comp	1	01121	CB2425
A3R19	17231611	Pot., 2.5kΩ	-	01121	FR252M
A3R20	00341235	Res., 12kΩ 1/4W 5% comp	1	01121	CB1235
A3R21	17231611	Pot., 2.5kΩ	-	01121	FR252M
A3R22 thru A3R24	02141002	Res., 10kΩ 1/8W 1% T-1 MF	-	03888	PME-55
A3R25	17231611	Pot., 2.5kΩ	-	01121	FR252M
A3R26	01471005	Res., 10MΩ 1/2W 1% T-1 MF	-	03888	PME-65
A3R27	17231611	Pot., 2.5kΩ	-	01121	FR252M
A4	99006007	Program Card Assembly, Figure 6-4.	1	29832	
A4R1	02142502	Res., 25kΩ 1/8W 1% T-1 MF	1	03888	PME-55
A4R2	00341035	Res., 10kΩ 1/4W 5% comp	1	01121	CB1035
A4R3	04630350	Res., 2kΩ 1/8W 0.1% T-1 MF	1	03888	PME-55
A4R4	04641052	Res., 10.5kΩ 1/8W 0.1% T-1 MF	1	03888	PME-55
A4R5, A4R6	02141102	Res., 11kΩ 1/8W 1% T-1 MF	2	03888	PME-55
A4R7	02134991	Res., 4.99kΩ 1/8W 1% T-1 MF	1	03888	PME-55
A5	98000110	Switch Components Assembly, Figure 6-5.	1	29832	
A5C1, A5C2	07161058	Cap., 1μF 8V NP tantalum	3	06751	NF105A
A5C3	06010931	Cap., 22pF 1kV 20% disc	1	56289	CO481B102E220M
A5C4	07161058	Cap., 1μF 8V NP tantalum	-	06751	NF105A
A5CR1 thru A5CR3	10191253	Diode, 1N457	3	03877	1N457
A5K5	16790201	Relay, SPDT 28V reed	1	23020	201-28
A5K6	16790210	Relay, SPST 28V reed	1	23020	210-28
A5R1	02130757	Res., 1kΩ 1/8W 1%	1	14674	RN55D
A5R2	00329115	Res., 910 Ω 1/4W 5% comp	1	01121	CB9115
A5R3	02139091	Res., 9.09kΩ 1/8W 1% T-1 MF	1	03888	PME-55
A5R4	02430122	Res., 1.2kΩ 1/4W 2%	1	14674	C4
A5R5	02110474	Res., 51.1Ω 1/8W 1% T-1 MF	2	03888	PME-55
A5R6	00341635	Res., 16kΩ 1/4W 5% comp	1	01121	CB1635

7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Description	Total Quantity	Mfgr.	Mfgr. Part No.
A5R7	02110474	Res., 51.1Ω 1/8W 1% T-1 MF	-	03888	PME-55
A5R8	02142502	Res., 25kΩ 1/8W 1% T-1 MF	1	03888	PME-55
A5R9	00344735	Res., 47kΩ 1/4W 5% comp	1	01121	CB4735
A5R10	04650751	Res., 100kΩ 1/8W 0.1% T-1 MF	1	03888	PME-55
A5R11	04620250	Res., 250Ω 1/8W 0.1% T-1 MF	1	03888	PME-55
A5R12	04630350	Res., 2kΩ 1/8W 0.1% T-1 MF	1	03888	PME-55
A5R13	04620501	Res., 500Ω 1/8W 0.1% T-1 MF	1	03888	PME-55
A5R14	02130753	Res., 2kΩ 1/8W 1% T-1 MF	1	03888	PME-55
A5R15	02138001	Res., 8kΩ 1/8W 1% T-1 MF	1	03888	PME-55
A5R16	02142002	Res., 20kΩ 1/8W 1% T-1 MF	1	03888	PME-55
A5R17	02151483	Res., 148kΩ 1/8W 1% T-1 MF	1	03888	PME-55
A5R18, A5R19	03340743	Res., 20kΩ 1/3W 0.01%	4	01686	7017HS
A5R20	02128200	Res., 820Ω 1/8W 1% T-1 MF	1	03888	PME-55
A5R21, A5R22	03340743	Res., 20kΩ 1/3W 0.01%	-	01686	7017HS
A5R23	17221630	Pot., 100Ω	-	01121	RP101M
A6	99006005	709 Plug-In Test Socket, Figure 1-2.	1	29832	
A6C1, A6C2	06040949	Cap., .01μF 100V 20% disc	2	56289	CO23B101F103M
A6C3	06030945	Cap., .005μF 100V 20% disc	1	56289	40C172
A6C4	06020898	Cap., 220pF 1kV 10% disc	1	71590	DD-221
A6R1	00331525	Res., 1.5kΩ 1/4W 5% comp	1	01121	CB1525
A7	99006008	7-pin Q Plug-In Test Socket Figure 1-2.	1	29832	
A7R1	17241560	Pot., 50kΩ	1	01121	FR503M

APPENDIX A

OPERATIONS MANUAL UPDATE INFORMATION

At Teledyne Philbrick Nexus we endeavor to provide you with the latest most up to date improvements and information as it becomes available. Due to printing and shipping requirements it is not always possible to incorporate these developments as they occur. They will, however, be forwarded to you as they become available. We strongly recommend that you make the necessary changes in your manual as they are received so that it will be current with the latest developments.

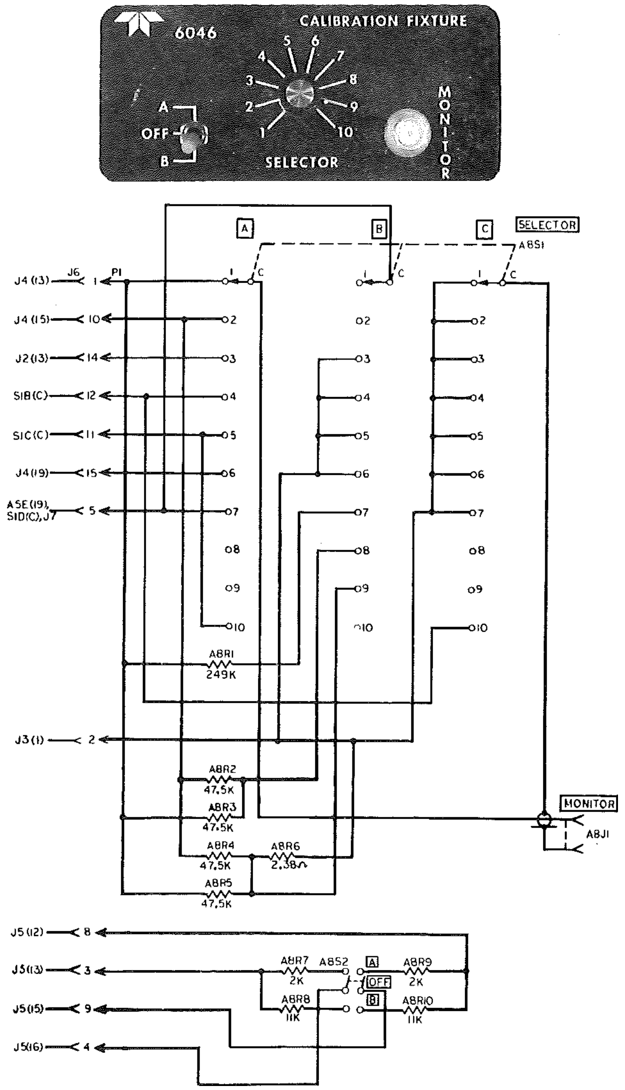


Figure 1-3. Calibration Fixture

SECTION 1-3. ACCESSORIES

A plug-in Calibration Fixture, the Model 6046, is supplied to provide the capability with which to verify and calibrate the Model 5102 Operational Amplifier Tester. With this unit, both verification of specifications and calibration of the instrument will be reduced to a simple routine. The A/ OFF/ B toggle switch (S2) is used in calibrating the programmable plus and minus supplies while the ten position rotary SELECTOR (S1) selects the proper calibration configurations. The MONITOR jack (J1) provides access to the various test points within the instrument. The following is a list of SELECTOR positions and corresponding calibration modes.

SELECTOR position	Calibration Modes
1	Programmable plus supply
2	Programmable minus supply
3	Absolute Value Circuit (A2A2)
4	-Ibias Circuit (A3A1)
5	+Ibias Circuit (A3A3)
6	-Ibias Circuit (A3A2)
7	Meter Movement
8	Log Scale (low end)
9	Log Scale (high end)
10	CMRR bridge

The layout and circuit configuration is shown in Figure 1-3. Refer to Section 5-2 for the operation of this unit.

SECTION 5-2.

Paragraph 5-2. as presently written is to be used in calibrating instruments with serial numbers of 110 or less. Instruments with a serial number greater than 110 are adapted for use with the Calibration Fixture, Model 6046. When one of these is used substitute the following:

5-2. CALIBRATION

The Model 5102 Operational Amplifier Tester is designed for ease of calibration within its own enclosure using a minimum of peripheral test equipment. Refer to Table 5-1 for the Recommended List of Required Test Equipment. A step-by-step calibration procedure, necessary to verify the operating specifications of the instrument, is performed as follows:

1. Remove the back cover from the unit by loosening the six (6) twist lock screws.

2. Ensure that the Program Card Assembly (A4) is removed from connector J5.

3. Loosen the four (4) retaining screws that hold the Relay & Amplifier Assembly (A3) into

place and carefully orient it to provide an access to the Logic Assembly (A2) adjustments.

4. Provide a ground return for the Relay & Amplifier Assembly (A3) by clipping a lead from the outer ground strip to an unpainted surface on the case.

5. Insert the Calibration Fixture plug-in Model 6046, into the front panel connector (J6).

6. Set the following controls as indicated:

METER SENSITIVITY 1000
DC TEST. . . . . ±Icc
TEST SELECT . . . . DC TEST
INPUT/ POLARITY
SELECTOR. . . . . +
LOAD Ω . . . . EXT

7. Plug the power cable into a 115Vac, 50 to 60 Hz line source.

8. Depress to illuminate the POWER pushbutton and allow a 30-minute warmup period for the circuits of the instrument to stabilize.

NOTE
Depress to extinguish the IC PWR pushbutton, if illuminated.

9. Connect a suitable cable from the voltmeter to the MONITOR jack (J1).

10. Depress to illuminate the IC PWR pushbutton.

11. Perform the positive power supply calibration adjustments as follows:

a. Set the SELECTOR (S1) to position "1" and the A/ OFF/ B switch (S2) to the "A" position.

b. Adjust potentiometer R8 for a voltmeter indication of +6V ±100mV. See Figure 5-1. for the location of this adjustment.

c. Set the A/ OFF/ B switch to the "B" position.

d. Adjust potentiometer R10 for a voltmeter indication of +15V ±100mV. See Figure 5-1. for the location of this adjustment.

e. Alternately repeat Step 11b. with the A/ OFF/ B switch in the "A" position and Step 11d. with the A/ OFF/ B switch in the "B" position until both specifications are achieved.

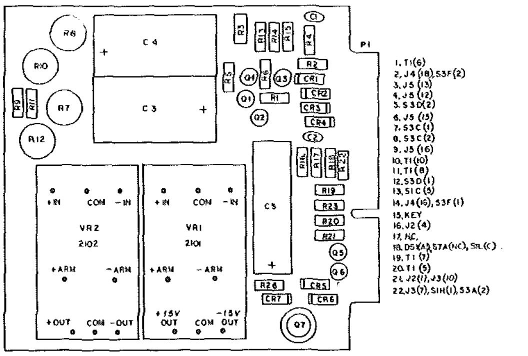


Figure 5-1. Power Supply Assembly (A1) Adjustments

12. Perform the negative power supply calibration adjustments as follows:

a. Set the SELECTOR to position "2" and the A/ OFF/ B switch to the "A" position.

b. Adjust potentiometer R7 for a voltmeter indication of -6V ±100mV. See Figure 5-1. for the location of this adjustment.

c. Set the A/ OFF/ B switch to the "B" position.

d. Adjust potentiometer R12 for a voltmeter indication of -15V ±100mV. See Figure 5-1. for the location of this adjustment.

e. Alternately repeat Step 12b. with the A/ OFF/ B switch in the "A" position and Step 12d. with the A/ OFF/ B switch in the "B" position until both specifications are achieved.

13. Depress to extinguish the IC PWR pushbutton.

14. Verify the programmed operation of the positive and negative power supplies as follows:

a. Set the A/ OFF/ B switch to the "OFF" position.

NOTE
The A/ OFF/ B switch must always be in the "OFF" position whenever a Program Card Assembly (A4) is used in the operation of this instrument.

b. Insert the Program Card Assembly (A4) into connector J5.

c. Depress to illuminate the IC PWR pushbutton.

d. Set the SELECTOR to position "1".

e. Verify that the voltmeter indication meets the positive quiescent voltage specification (+Vcc) for the particular Program Card Assembly (A4) being used. Refer to Table 5-2. for the associated Program Card Assembly (A4) specifications.

f. Set the SELECTOR to position "2".

g. Verify that the voltmeter indication meets the negative quiescent voltage specification (-Vcc) for the particular Program Card Assembly (A4) being used. Refer to Table 5-2. for the associated Program Card Assembly (A4) specifications.

Model	+Vcc	-Vcc
6007	+15V ±100mV	-15V ±100mV
6016	+ 6V ±100mV	- 6V ±100mV
6017	+12V ±100mV	-12V ±100mV
6018	+18V ±100mV	-18V ±100mV
6019	+12V ±100mV	- 6V ±100mV
6020	+24V ±100mV	-24V ±100mV
6022	+ 9V ±100mV	- 9V ±100mV

Table 5-2. Program Card Assembly (A4) Specifications

15. Perform the clock frequency calibration adjustment as follows:

a. Set the TEST SELECT switch to the "±Eout" position.

b. Connect a suitable cable from the vertical input of the oscilloscope to the AMP OUT connector (J7), located at the rear of the instrument.

c. Monitor the square-wave presentation and adjust potentiometer R18 for a 200 ±20 millisecond period. See Figure 5-2. for the location of this adjustment.

16. Remove the cable from the AMP OUT connector.

17. Perform the absolute-value circuit calibration adjustment as follows:

a. Set the TEST SELECT switch to the "±PSRR" position and the SELECTOR to position "3".

NOTE

The meter may indicate full-scale since there is no signal present at the input of the demodulator circuit.

b. Adjust potentiometer R72 for a voltmeter indication of 0V ±300μV. See Figure 5-2. for the location of this adjustment.

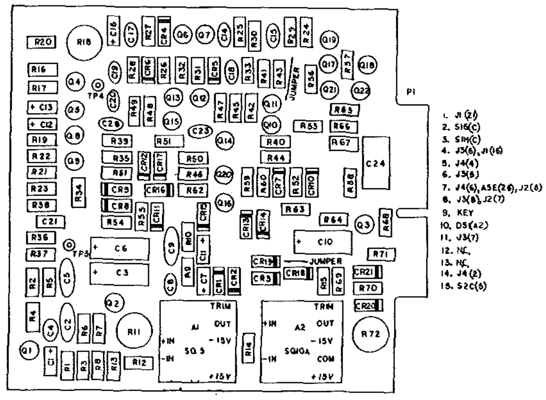


Figure 5-2. Logic Assembly (A2) Adjustments

18. Perform the oscillation detection circuit calibration adjustment as follows:

a. Set the TEST SELECT switch to the "DC TEST" position, the DC TEST selector to the "OSC DET" position and the SELECTOR to position "2".

b. Connect a suitable cable from the output of the signal generator to the AMP OUT connector.

c. Adjust the signal generator to provide a 20mV peak-peak sine wave, centered about zero, at a frequency of 10kHz.

d. Adjust potentiometer R11 until the OSC DET lamp is extinguished. See Figure 5-2. for the location of this adjustment.

e. Readjust potentiometer R11 until the OSC DET lamp just illuminates.

19. Remove the cable from the AMP OUT connector.

20. Depress to extinguish both the IC PWR and POWER pushbuttons.

21. Remove the power cable from the 115Vac line source.

22. Fasten the Relay & Amplifier Assembly (A3) into place ensuring that the four (4) retaining screws are tightened securely.

NOTE
The ground return clip-lead may be removed at this time.

23. Plug the power cable into the 115Vac line source.

24. Depress to illuminate both the POWER and IC PWR pushbuttons.

25. Perform the input offset current and input bias current circuit calibration adjustments as follows:

a. With the TEST SELECT switch set to "DC TEST", set the DC TEST selector to the "±Ibias" position and the SELECTOR to position "4".

b. Adjust potentiometer R14 for a voltmeter indication of 0V ±300μV. See Figure 5-3. for the location of this adjustment.

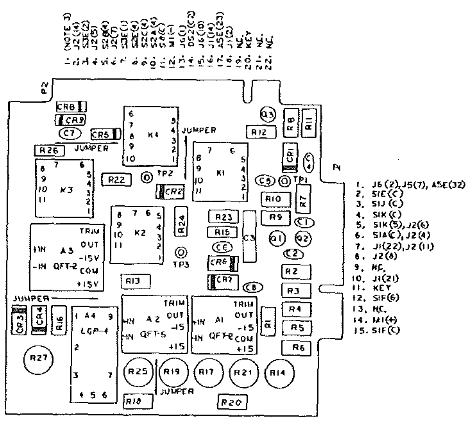


Figure 5-3. Relay & Amplifier Assembly (A3) Adjustments.

c. Set the SELECTOR to position "5".

d. Adjust potentiometer R25 for a voltmeter indication of 0V ±300μV. See Figure 5-3. for the location of this adjustment.

e. Set the SELECTOR to position "6".

f. Adjust potentiometer R21 for a voltmeter indication of 0V ±300μV. See Figure 5-3. for the location of this adjustment.

26. Perform the meter movement calibration adjustment as follows:

NOTE
6007 program card must be used.

a. Set the following controls as indicated:
TEST SELECT. . . . . . DC TEST
DC TEST. . . . . Eos
METER SENSITIVITY. . 10 (mV)
SELECTOR 7

b. Adjust potentiometer R27 for a voltmeter indication of 100mV ±1mV. See Figure 5-3. for the location of this adjustment.

27. Perform the log circuit calibration adjustments as follows:

a. Set the TEST SELECT switch to the "±PSRR" position and the SELECTOR to position "8".

b. Adjust potentiometer R17 for a front panel meter indication of 60dB ±0.5dB. See Figure 5-3. for the location of this adjustment.

c. Set the SELECTOR to position "9".

d. Adjust potentiometer R19 for a front panel meter indication of 114dB ±0.5dB. Allow sufficient time for the meter indication to settle. See Figure 5-3. for the location of this adjustment.

e. Alternately repeat Step 27b. with the SELECTOR in position "8" and Step 27d. with the SELECTOR in position "9" until both specifications are achieved.

28. Perform the common mode rejection ratio bridge calibration adjustment as follows:

NOTE
The voltmeter must have a true differential input; therefore, both input terminals must be above ground reference.

a. Set the TEST SELECT switch to the "CMRR" position, the Calibration Switch

(S7), located inside the instrument, to "CAL", and the SELECTOR to position "10".

NOTE
IC PWR lamp will extinguish when Calibration Switch is set to "CAL".

b. Adjust potentiometer R23 for a voltmeter indication of 0V $\pm 10\mu V$. See Figure 5-4. for the location of this adjustment.

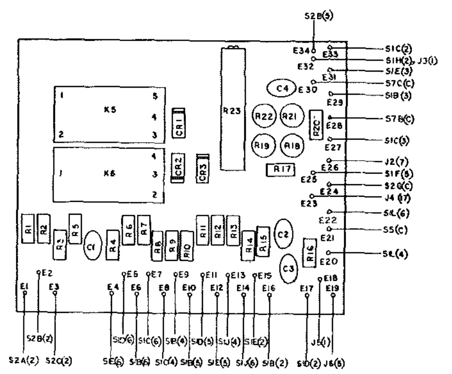


Figure 5-4. Switch Components Assembly (A5) Adjustment

29. Return the Calibration Switch to the "NORMAL" position.

FIGURE 6-2. LOGIC ASSEMBLY (A2)

Schematic Diagram

1. Delete J2(7) and J2(8) reference from connector J2(8) and J2(7), respectively.

2. Change DS1(B) reference to read DS1(A2).

3. Change A2Q17 from an NPN to PNP configuration.

4. Add a lead from the junction of A2CR21, A2R70, and A2R71 to P1(13).

5. Add J6(14) reference to connector J2(13).

Assembly Diagram

1. Delete J2(7) and J2(8) reference from connector P1(8) and P1(7), respectively.

FIGURE 6-3. RELAY & AMPLIFIER ASSEMBLY (A3)

Schematic Diagram

1. Add a lead from A3TP2 to P2(19).

2. Add J6(15) reference to connector J4(19).

Assembly Diagram

1. Add J6(15) reference to connector J4(19) in place of N. C.

2. Change NOTE 5 to read "All relays are shown de-energized (Dynamic mode of operation)."

FIGURE 6-4. PROGRAM CARD ASSEMBLY (A4)

Schematic Diagram

1. Add J6(8), J6(3), J6(9), and J6(4) references to connector J5(12), J5(13), J5(15) and J5(16), respectively.

Assembly Diagram

1. Add J6(8), J6(3), J6(9), and J6(4), references to connector J5(12), J5(13), J5(15), and J5 (16), respectively.

FIGURE 6-5. SWITCH COMPONENTS ASSEMBLY (A5)

Schematic Diagram

1. Change relay A5K6 from normally closed to normally open.

2. Interchange CR1 and CR2 reference designations.

Assembly Diagram

1. Interchange CR1 and CR2 reference designations.

FIGURE 6-6. MODEL 5102 OPERATIONAL AMPLIFIER TESTER INTERCONNECTION DIAGRAM

1. Reverse the polarity of the signs on the INPUT/ POLARITY SELECTOR from (+) to (-) and from (-) to (+).

2. Add leads from J5(12) to J6(8), J5(13) to J6(3), J5(15) to J6(9), J5(16) to J6(4), J2(13) to J6(14), and J4(19) to J6(15).

SECTION 7-3. REPLACEABLE PARTS LISTING

Reference Designation	P/N Part No.	Designation	Total Quantity	Mfgr.	Mfgr. Part No.
A8	99006046	Calibration Fixture, Figure 1-3.	1	29832	
A8J1	12591831	Connector, BNC	1	02660	UG-1094/U
A8R1	02152494	Res., 249kΩ 1/8W 1%	1	03888	PME-55
A8R2 thru A8R5	02244752	Res., 47.5kΩ 1/8W 1%	4	03888	PME-55
A8R6	03800238	Res., 2.38 Ω 1/2W 1%	1	94322	EL 1/2
A8R7	02130753	Res., 2kΩ 1/8W 1%	2	03888	PME-55
A8R8	02141102	Res., 11kΩ 1/8W 1%	2	03888	PME-55
A8R9	02130753	Res., 2kΩ 1/8W 1%	-	03888	PME-55
A8R10	02141102	Res., 11kΩ 1/8W 1%	-	03888	PME-55
A8S1	11599437	Switch, Rotary 3 pole-10 pos.	1	71590	PS-107
A8S2	11391342	Switch, Toggle DPDT	1	95146	MST-205P