

INSTRUCTION MANUAL

Serial Number B020198

26A2

**DIFFERENTIAL
AMPLIFIER**

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TABLE OF CONTENTS

SECTION 1 26A2 SPECIFICATION	Page	SECTION 4 MAINTENANCE	Page
Introduction	1-1	Introduction	4-1
Amplifier Characteristics		Cleaning	4-1
Electrical	1-1	Recalibration	4-1
Environmental	1-3	Troubleshooting	4-1
Accessories	1-4	Troubleshooting Aids	4-1
		General	4-1
		Corrective Maintenance	4-3
		Obtaining Replacement Parts	4-3
		Soldering Techniques	4-3
		Component Replacement	4-4
		General	4-4
		Circuit Board Removal	4-4
		Pushbuttons	4-4
		Semiconductor Replacement	4-5
		Lamp Replacement	4-5
		Instrument Repackaging	4-6
SECTION 2 OPERATING INSTRUCTIONS			
Introduction	2-1		
Controls	2-1		
Inputs	2-1		
Outputs	2-2		
General Operating Instructions	2-2		
Common-Mode Rejection	2-2		
Common-Mode Signal	2-2		
Common-Mode Rejection Ratio	2-2		
Common-Mode Signal Maximum	2-2		
Amplitude and Common-Mode Rejection	2-2		
Factors which Affect CMRR	2-2		
Differential Amplifier Application	2-3		
Guarded Input Differential Amplifier	2-4		
Signal Input Connections	2-6		
		SECTION 5 PERFORMANCE CHECK/ADJUSTMENT	
		Introduction	5-1
		Test Equipment Required	5-1
		General	5-1
		Test Equipment	5-1
		Short Form Performance Check and Index	5-2
		Performance Check Procedure	5-2
		General	5-2
		Performance Check	5-3
		Short Form Adjustment Procedure and Index	5-7
		Adjustment Procedure	5-7
SECTION 3 CIRCUIT DESCRIPTION			
Introduction	3-1		
Block Diagram Description	3-1		
Preamp	3-1		
LF -3 dB POINT Selector	3-1		
Gain Switched Amplifier	3-1		
HF -3 dB POINT Selector	3-1		
VARIABLE Gain Stage	3-1		
Output Amplifier Stage	3-1		
Overrange Detector	3-1		
DC Supply Regulators	3-1		
Detailed Circuit Description	3-1		
Input Coupling	3-1		
Input Overdrive Protection	3-2		
Gate Current Compensation	3-2		
Preamp	3-2		
LF -3 dB POINT Selector	3-4		
Gain Switching Amplifier	3-4		
HF -3 dB POINT Selector	3-4		
Variable Gain Stage	3-4		
Output Amplifier	3-4		
Overrange Indicator	3-5		
Low Voltage Power Supply	3-5		
		SECTION 6 ELECTRICAL PARTS LIST	
		Parts List Abbreviations	
		Parts Ordering Information	
		Special Notes and Symbols	
		Complete Parts List	
		SECTION 7 DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS	
		Special Symbols	
		Schematics	
		Index of Mechanical Parts Illustrations	
		SECTION 8 MECHANICAL AND REPACKAGING ILLUSTRATIONS	
		Mechanical Parts List	
		Exploded Views	
		Repackaging Information	

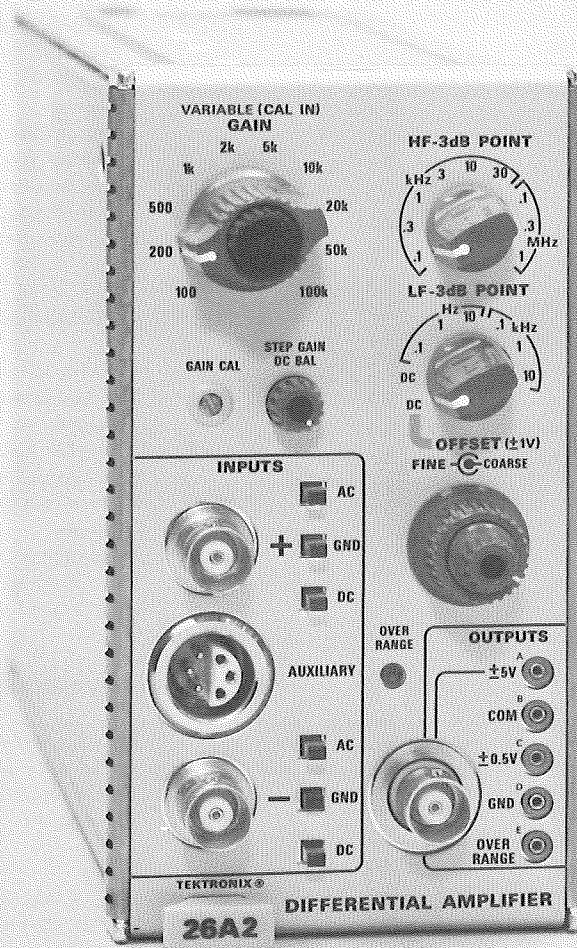


Fig. 1-1. 26A2 Differential Amplifier.

SECTION 1

26A2 SPECIFICATION

Change information, if any, affecting this section will be found at the rear of this manual.

Introduction

The 26A2 is a DC coupled differential amplifier with excellent common-mode rejection capabilities and high gain for low level applications.

The DC OFFSET capability permits nulling up to one volt DC, so that low level, low frequency signals impressed on DC can be amplified without the degradation often introduced by input AC coupling.

High and low frequency -3 dB points can be selected at the front panel to suit the application.

A guard signal is derived from the common-mode signal within the amplifier, and is available at the front panel Auxiliary Input Connector for driving cable shields. Plus and minus 15 volts are also provided via this connector to

permit use of special active probes, transducer adapter, etc. The input shunt RC network for both the + and - inputs can be disconnected from ground and tied to the GUARD signal for low frequency applications requiring high common-mode input impedance.

Signal outputs are available at the rear connector as well as at the front panel.

A front-panel lamp indicates most over-range conditions of excessive input signal (either differential or common mode), excessive gain, or excessive offset. A logic signal output is provided coincident with lamp indication.

The 26A2 is designed for use in 2600-Series mainframes and can be adapted to use in 7000-Series mainframes with adapter 013-0115-00

Amplifier Characteristics

ELECTRICAL

Characteristic	Performance Requirement	Supplemental Information
Gain	100 to 100,000 in a 1-2-5 sequence	
Accuracy	Within 2%	Adjustable to zero on any one range
Frequency Response		
Direct Coupled	DC to 1 MHz within +25%, -15% at -3 dB point	
AC Coupled	2 Hz or less, at low frequency -3 dB point to 1 MHz +25%, -15%	
Output (maximum rated)		
Terminal A		
Voltage Swing	± 5 V	Short proof to ground and ± 15 volts
Current	± 20 mA	
R_o		5Ω or less
Minimum Load Impedance		250Ω

ELECTRICAL (cont)

Characteristic	Performance Requirement	Supplemental Information
Terminal C		
Voltage Swing	± 0.5 V	
R_o		50 Ω , within 2%
Bandwidth		
HF -3 dB point	100 Hz to 1 MHz (9 steps in a 1-3 sequence)	
Accuracy		Within +25%, -15%
LF -3 dB point	0.1 Hz to 10 kHz (6 steps in a 1-10 sequence)	
Accuracy		Within 20%
Common Mode		
Range	± 5 V	
Rejection Ratio	50,000:1, DC to 50 kHz	Direct coupled with inputs shorted together. See Fig. 1-2. At least 10,000:1 at 60 Hz, with 5 k Ω source resistance imbalance, and input shunt RC network connected to Guard.
Differential Signal		
Range (Except in DC OFFSET)		-50 μ V to +50 μ V at 100,000 Gain, increasing to -50 mV to +50 mV at 100 Gain.
DC Offset Range		At least + and -1 volt
Over Range		
Terminal E Gate		
Amplitude		+3 V, within 20% in "over-range" state. 0 V, within 100 mV in normal state.
R_o		Approximately 80 Ω in "overrange" state.

ELECTRICAL (cont)

Characteristic	Performance Requirement	Supplemental Information
Maximum Safe Input Voltage		
Direct Coupled		15 V (DC + Peak AC) to 5 MHz.
AC Coupled		500 V DC blocking, 15 V AC to 5 MHz.
Maximum Input Gate Current (each input)		50 pA at 25°C 250 pA at +50°C
Noise (Tangentially Measured)	25 μ V or less	With 25 Ω or less source resistance, from 5 Hz to 1 MHz.
Voltage Drift with Time		
Short Term		10 μ V (Peak-to-Peak) per minute
Long Term		20 μ V (Peak-to-Peak) per hour
Voltage Drift with Temperature		100 μ V per °C
Power Out		
At Auxiliary Input Connector (–15 and +15 V)		–15 volts and +15 volts at 100 mA each, short circuit protected to ground and to each other.

ENVIRONMENTAL

Characteristic	Performance Requirement	Supplemental Information
Temperature		
Operating	0°C to +50°C	
Storage		–40°C to +75°C

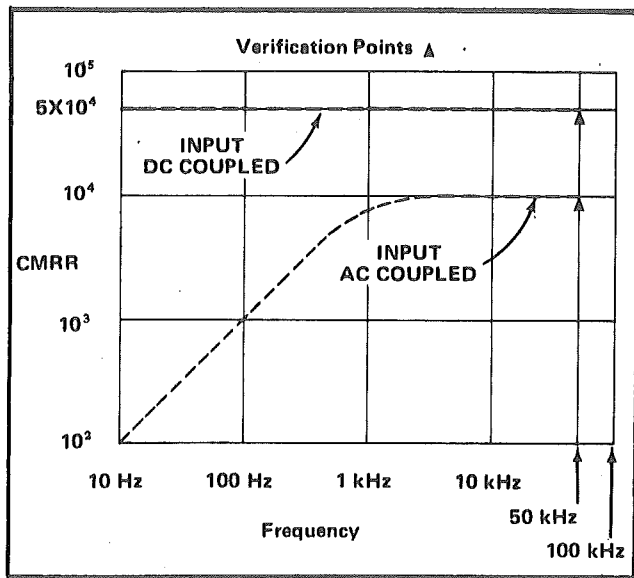


Fig. 1-2. Minimum Common-Mode Rejection Ratio.

Accessories

An illustrated list of Standard Accessories and a list of Optional Accessories for the 26A2 will be found at the end of the Mechanical Parts List pullout pages.

NOTE

The pins, jacks and cables supplied to interconnect 2600-System modules are based upon a standard 40-mil (0.040 inch or ≈ 1 mm) pin diameter. These items are manufactured by Cambion [®] (Cambridge Thermionic Corp.) and others. Allied Radio Shack catalogs the basic elements of this 40-mil system.

SECTION 2

OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of this manual.

Introduction

The 26A2 Differential Amplifier unit is one of a series of plug-in modules in the 2600 System. The 26A2 and other units in the series may be plugged into 2600-System main-frames or into 7000-Series Oscilloscopes by using an adapter.

This section describes the functions and features of the controls, connectors, and indicator lights.

CAUTION

During turn-on and turn-off of the 26A2, several milliamperes can momentarily flow from the 26A2. To avoid damage to biological specimens, disconnect the electrodes for a few seconds during this period. This can be accomplished by pushing the GND buttons on both 26A2 INPUT coupling switches.

CONTROLS

GAIN—Selects amplifier gain in ten calibrated steps from 100 to 100,000 in a 1-2-5 sequence.

VARIABLE (CAL IN)—Provides 2.5X variable gain on any GAIN step selected. Clockwise rotation increases gain. Variable gain is not recommended below 100X gain. Use an external attenuator to reduce signal amplitude.

GAIN CAL—Front-panel screwdriver adjustment provides precise adjustment of gain on any one setting of the GAIN switch.

STEP GAIN DC BAL—Control for DC-balancing the Pre-amp stage. With the inputs grounded (GND buttons pushed), the control is adjusted for no Output DC shift as the GAIN switch is rotated throughout its range.

HF -3 dB POINT—Nine-position switch to select the approximate high frequency -3 dB point. The approximate frequencies are: .1 kHz, .3 kHz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, .1 MHz, .3 MHz, and 1 MHz.

LF -3 dB POINT—Eight-position switch to select DC Coupling, or the approximate low frequency -3 dB points. The switch positions and approximate frequencies are: DC OFFSET, DC, .1 Hz, 1 Hz, 10 Hz, .1 kHz, 1 kHz, and 10 kHz.

DC OFFSET (DC OFFSET mode only)—Coarse and fine controls provide internal offset bias while maintaining differential capability. Range of offset is at least + and -1 volt.

Inputs

+ Input—Signal input connector. Positive-going input signal at the connector produces positive-going output signal.

+ AC-GND-DC Selector—A miniature illuminated push-button type switch. The buttons are mechanically interlocked so that only one button may be depressed at one time.

When the AC button is pressed, the input signal is coupled through C10 to the Input Amplifier, and only the varying component of the signal is amplified.

When the DC button is pressed, the input signal is coupled directly to the Input Amplifier and the entire signal (both AC and DC components) is amplified.

When the GND button (or none of the buttons) is pressed, the input signal is coupled through C10 and R10 to ground and the Amplifier input is grounded.

- Input—Signal input connector. Positive-going input signal produces a negative-going output signal.

- AC-GND-DC Selector—Same function as the + AC-GND-DC switch, but applied to the - Input.

AUXILIARY Input (see Fig. 2-1)—Provides access to the + and - amplifier inputs, guard output, reference ground, and the +15-volt and -15-volt supplies. Guard voltage is permanently connected to the guard terminal to provide guard signal to input cable shields, if used.

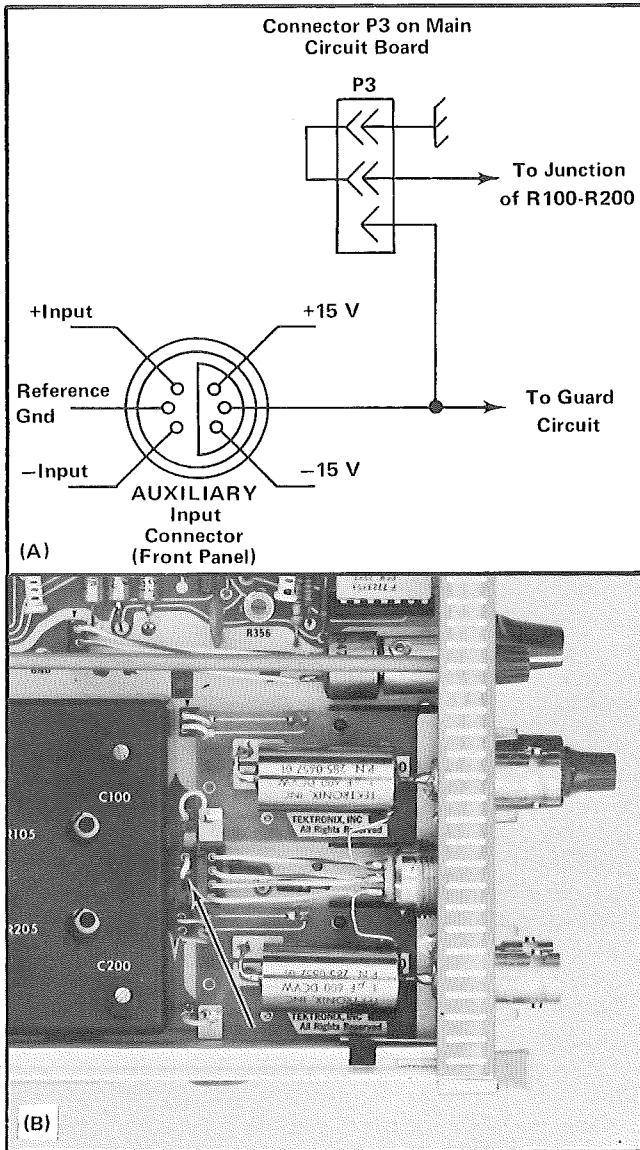


Fig. 2-1. (A) AUXILIARY Input Connector and Input Guarding connector. (B) Location of Input Guarding connector.

Internal Link, P3 (see Fig. 2-1)—Provides a means to connect the input shunt R and C to reference ground or to the guard circuitry.

Outputs (appear also at Rear Connector)

±5 V—Amplifier Output voltage swing which appears at both the BNC and pin jack (A) connectors.

$$R_o = 5 \Omega \text{ or less.}$$

±0.5 V—Amplifier Output voltage swing which appears at pin jack (C).

$$R_o = 50 \Omega$$

COM—Reference Ground for ±5 V and ±0.5 V outputs. Appears at both the BNC and pin jack (B) connectors.

OVERRANGE Indicator—Lamp indicates most overrange conditions.

OVERRANGE Output (D). Provides a logic signal coincident with the lamp indication.

GND (E). Signal reference ground.

GENERAL OPERATING INFORMATION

Common-Mode Rejection

The definition of the term “differential amplifier” implies that equal amplitude signals applied coincidentally to the two inputs are rejected. However, the degree of rejection depends primarily on the symmetry of the amplifier inputs. The amount of difference signal from a particular amplifier can be shown as a mathematical relationship called common-mode rejection ratio (CMRR). This ratio and associated terms are defined as follows:

Common-Mode Signal. The instantaneous algebraic average of two signals applied to both inputs in the same phase and amplitude.

Common-Mode Rejection Ratio. The ratio of the amplitude of the common-mode signal to the amplitude of an equivalent differential signal that would produce the same output from the amplifier. Example: If a differential amplifier is driven by a 5.0-volt common-mode signal and produces an output that corresponds to the output from a 0.005-volt differential input, the amplifier has a CMRR of 5/0.005 or 1000:1.

Common-Mode Signal Maximum. The largest common-mode signal at which the specified common-mode rejection ratio is valid.

Amplitude and Common-Mode Rejection

In the following text, the term maximum common-mode input voltage means the maximum voltage that will not overdrive the amplifier. This should not be confused with the maximum nondestructive limits of the amplifier components.

Factors Which Affect CMRR

Frequency. Since the common-mode output voltage is a function of phase difference as well as gain between

channels, the frequency of the input common-mode signal has a definite bearing on the CMRR. Generally, as the frequency of the input signal increases, the CMRR is more difficult to maintain.

Source Impedance. The specified CMRR assumes that the points being measured have identical source impedance. The source impedance and the amplifier input impedance form an RC divider which determines the portion of the signal that appears across the amplifier input, and the apparent effect on CMRR. See Fig. 2-2.

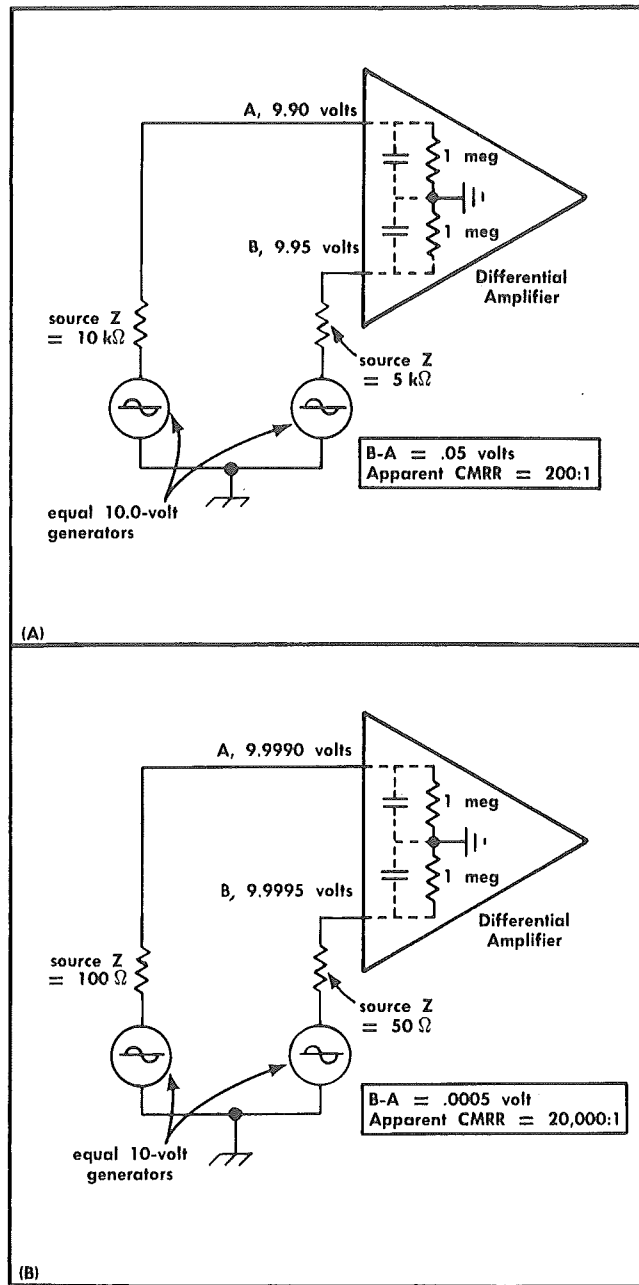


Fig. 2-2. Relationship of test point source impedance to the amplifier input impedance and the apparent CMRR caused by (A) large difference between test-point impedances and (B) low impedance test points.

Signal Transporting Leads. A principal requirement for maximum CMRR is that the signals must arrive at the two inputs in precisely the same phase and amplitude. Slight differences in attenuation factors or phase shift between two attenuators can significantly reduce the CMRR. Attenuator probes extend the usable voltage range of a differential amplifier by reducing the input signal level below the maximum common-mode input voltage. However, the probes may cause a reduction in the CMRR due to component value differences within the probes. For example, Fig. 2-3 illustrates the change in CMRR (apparent) due to 10X probes that are within 1%, 2%, and 3% of their attenuation values.

In measurements that involve high voltage levels in which attenuator probes must be used, and a high CMRR must be maintained, the Tektronix P6055 Probe is recommended. The P6055 is a 10X, low capacitance probe with a variable attenuator to compensate for differences in the input resistance of the amplifier.

Ground Connections. Avoid shield-grounding arrangements which produce ground-loop currents in the shields.

Differential Amplifier Applications

In differential measurements, each input of the amplifier acts as a reference for the other. Chassis ground connections are valuable primarily for safety reasons.

In applications with DC coupling in which a signal is superimposed on some DC level, an offset voltage may be

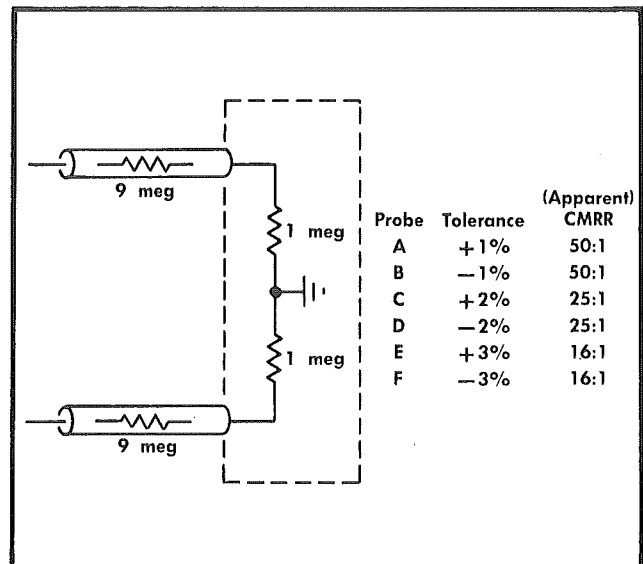


Fig. 2-3. Simplified input circuit and table showing the change in apparent CMRR due to 10X probes that are within 1, 2, and 3% of their attenuation values (with matched 1 MΩ resistors).

Operating Instructions—26A2

applied to the other input of the differential amplifier to slide the output signal back. For example; if a differential amplifier is set for a gain of 100 (or greater) and a DC level of 1 volt is applied to the + Input, the amplifier will be overdriven differentially. If a level of +1 volt is applied to the - Input, the 1 volt is common-mode and the amplifier will function as a differential amplifier for any differential signal superimposed on the 1-volt common-mode level. The 26A2 provides this offset voltage internally, offsetting DC levels up to 1 volt, either + or -, with the LF -3 dB POINT switch set in the DC OFFSET position.

When measuring the potential of any source having a resistance greater than approximately 20 k Ω , measure differentially, rather than single ended.

Guarded Input Differential Amplifier¹

Common-mode rejection can be enhanced if the apparent shunt resistances to ground (Z₃ and Z₄ in Fig. 2-4) are made to appear larger than actual. The greater the input impedance, the less effect source impedance imbalances have on CMRR. This is described as follows:

¹ Tektronix concept book "Biophysical Measurements", Chapter 19, is a recommended treatise on differential amplifier measurements and input guarding. The Tektronix Part Number is 062-1247-00.

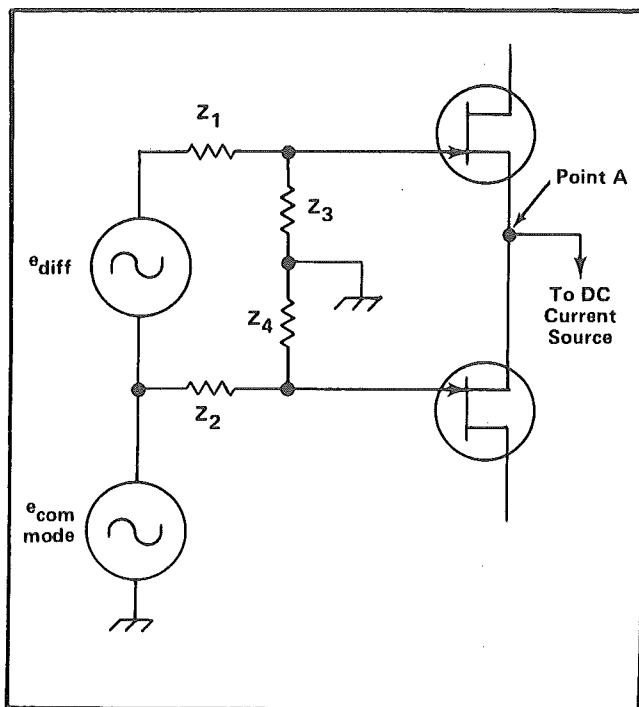


Fig. 2-4. Differential amplifier input showing source (Z₁ - Z₂) and input shunt (Z₃ - Z₄) impedances.

When a pure differential signal is applied to the input, there is no common voltage variation at the FET sources (point A in Fig. 2-4) with respect to ground. However, any common-mode signal applied to the inputs is reproduced to some extent at point A. With proper design of the current source and other parts of the input stage, low frequency common-mode signals will appear at point A with less than 0.05% loss in amplitude.

Consider the addition of Q₁ and its related components as illustrated in Fig. 2-5, disregarding any effect Q₁ may have on normal operation at point A. Assume that 99.9% of a 60 Hz input common-mode signal is transferred to point B via Q₁. Thus, a one volt common-mode signal applied to the inputs will produce an in-phase signal at point B of 999 mV. Since there is only one mV of change across R₃-R₄, the effect as seen from the input is an apparent multiplication of the values of R₃ and R₄, as shown by:

$$R_{in} = \frac{\Delta E_{in}}{\Delta I_{in}} \quad \text{and} \quad \Delta I_{in} = \frac{\Delta E_{in} - \Delta E_{\text{point B}}}{R_3}$$

When $\Delta E_{in} = 1$ volt,

$$I_{in} = \frac{1 \text{ volt} - 999 \text{ mV}}{R_3} = \frac{1 \text{ mV}}{R_3} \quad \text{and}$$

$$R_{in} = \frac{\Delta E_{in}}{\Delta I_{in}} = \frac{1 \text{ volt}}{1 \text{ mV}} = \frac{1 \text{ volt} \times R_3}{10^{-3} \text{ volt}} = R_3 \times 10^3.$$

If R₃ and R₄ are 1 M Ω resistors, the apparent input resistance from each side is 1000 M Ω .

By the same reasoning, the capacitive common-mode current can be reduced by a factor of 1000 if the input cable shield is returned to the guard voltage (AUXILIARY Input connector on the 26A2). From Q = CE, it follows that if the E across the input capacitance can be reduced by a factor of 1000, the capacitive current will be reduced by the same factor. Since the input signal amplitude remains the same but the capacitive current is reduced, the effect is that of reducing the input capacitance.

For any measurement in which the source impedance is high, or where there may be considerable source impedance imbalance, input guarding can be achieved when using the BNC input connectors by reversing connector P3 (connector arrows not aligned).

To apply guard voltage to the cable shield(s) to reduce the apparent input capacitance, use the AUXILIARY Input connector. See Fig. 2-6.

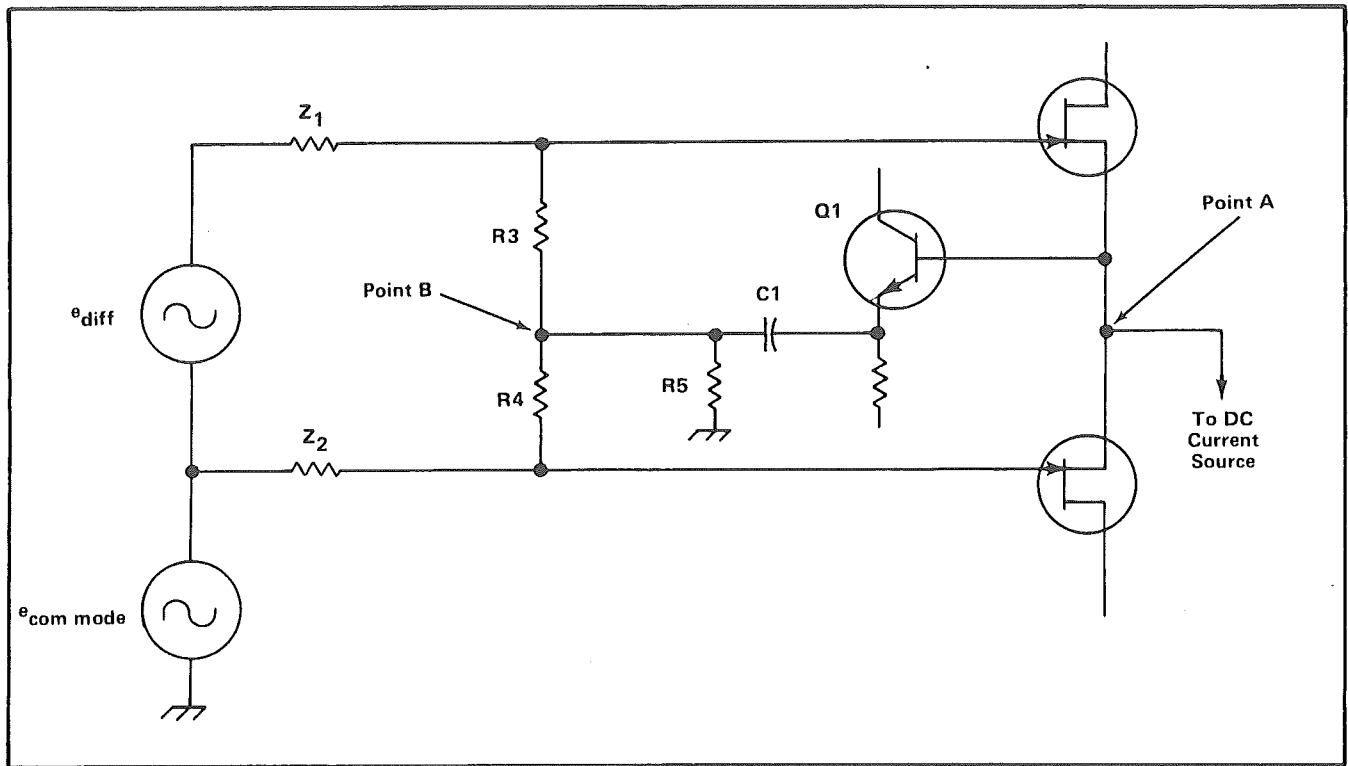


Fig. 2-5. Differential amplifier showing guard voltage fed to Point B.

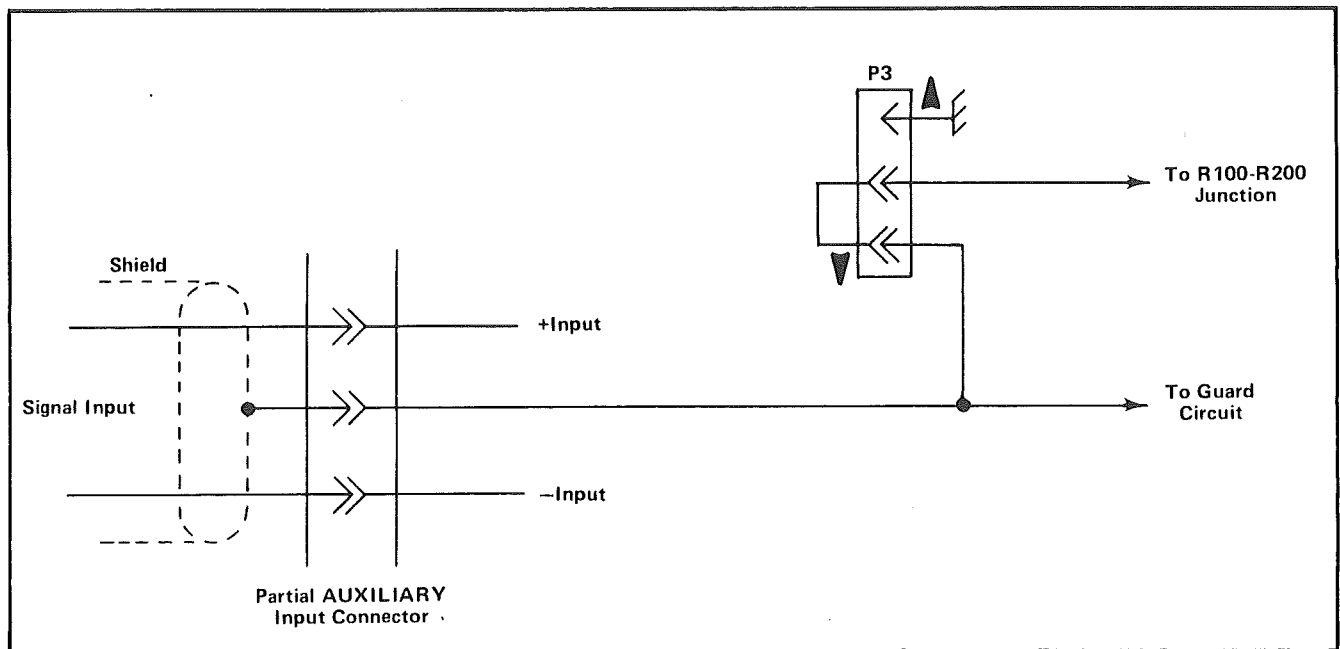


Fig. 2-6. Guarding the Input (including shield(s)).

Operating Instructions—26A2

The differential input resistance and capacitance of the amplifier are not affected by the guard circuit.

Signal Input Connections

When making single-ended measurements (conventional amplifier operation), establish a common ground connection between the device under test and the 26A2 through the probe shield or the shield of a coaxial cable. For low frequency, low gain measurements, a BNC to Dual Binding Post adapter can be used.

Differential measurements require no common ground connection; however, voltages on the test point with respect to the chassis potentials on the 26A2 should be limited to the common-mode range listed in Section 1, under common-mode characteristics. Higher signal levels degrade the common-mode rejection. The maximum DC plus peak AC input voltage rating (15 volts) of the unit should not be exceeded.

Interference from outside influences such as electromagnetic fields can be minimized by using the same type

and length of signal transporting lead for each input. If possible, when making low frequency measurements, use shielded cable and connect the shields at the signal source end. Where an interfering magnetic field can not be avoided or a shield can not be used because of shunt capacitance, the two leads should be equally exposed to the magnetic field by taping or twisting them together throughout their length. Low frequency measurements can be similarly protected by using a shielded cable which contains a twisted pair of conductors (AUXILIARY Input connector only in the 26A2).

Consider the change in the source operating characteristics due to the 26A2 input circuit loading and signal cables. The circuit at the input connectors can be represented by approximately $1\text{ M}\Omega$ to ground paralleled by approximately 20 pF . A few feet of shielded cable may increase the parallel capacitance to 60 pF or more, which could be excessive in many situations. To minimize these effects, it may be advisable to use an attenuator probe.

Attenuator probes not only decrease the resistance and capacitance loading of the signal source; they also extend the measurement range of the 26A2 to higher voltages.

SECTION 3

CIRCUIT DESCRIPTION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section describes the function of each block of the Block Diagram preceding the Schematic Diagrams, followed by a description of the circuits within each block.

Simplified drawings are provided to illustrate some descriptions.

Complete schematic diagrams are included in the Diagrams section.

BLOCK DIAGRAM DESCRIPTION

Preamp

The preamp is a differential amplifier having a gain of approximately 42.

Contained in, or associated with, this block are Input coupling, a floating power supply to improve common-mode rejection; Input Overdrive protection, a Gate Current Leakage compensation circuit, a DC Offset circuit to supply a variable internal voltage to offset any differential input DC level up to 1 volt, and a Step Gain DC Bal control to balance the preamp out.

LF -3 dB POINT Selector

Selects the desired mode: DC OFFSET, DC, or one of six low frequency -3 dB Points.

Gain Switched Amplifier

A differential amplifier having a front-panel switch-selected gain range of 0.48 to 480 in ten steps. Provides a signal to the overrange detector circuit when gain is set too high.

HF -3 dB POINT Selector

Selects one of nine high frequency -3 dB Points.

VARIABLE Gain Stage

Provides, through the front-panel VARIABLE (CAL IN) control, a gain ratio of 2.5 from minimum to maximum positions.

Furnishes a signal to the overrange detector circuit if the output swing of this stage is excessive.

This stage also provides the control which sets the Output Amplifier DC level to zero volts, and converts from differential to single-ended output.

Output Amplifier Stage

The Output Amplifier is a single-ended transimpedance amplifier which supplies two low impedance outputs, ± 5.0 volts and ± 0.5 volt.

Overrange Detector

This circuit detects overrange signals from either the preamp, the Gain Switched Amplifier, or the Variable Gain stage to give a front-panel indication of almost any overrange condition occurring in the amplifier (except output overload).

DC Supply Regulators

Provide additional regulation of the pre-regulated voltages supplied by the 2600-Series Mainframe.

DETAILED CIRCUIT DESCRIPTION

Input Coupling

Signals may be coupled to the amplifier via the BNC connectors or the AUXILIARY Input connector. The AUXILIARY input connector is a six terminal device providing regulated +15 and -15 volts, reference ground, a guard voltage derived from the common-mode signal component, and two (+ and -) signal input terminals.

The coupling switches, S10 and S20, provide AC or DC coupling to the input amplifier, plus a GND position which grounds the gates of Q121 A and B, the Input amplifiers. The GND position also precharges the coupling capacitor, C10 (C20), to the DC signal level through R10 (R20).

Modification Point, P3 (on the main circuit board) connects either the reference ground or guard voltage to the junction of R100 and R200. Guard voltage and reference

Circuit Description—26A2

ground are permanently connected to the AUXILIARY Input connector.

Input Overdrive Protection

F100 and the diode clamps, CR108-CR109, provide input overdrive protection for Q121A. F200 and CR208-CR209 provide overdrive protection for the -Input (Q121B).

Should the input signal exceed the level set by VR438 or VR448, CR108 (CR208) or CR109 (CR209) conduct and the voltage swings at the gates of Q121 are limited to approximately ± 15 volts. If the signal amplitude equals or exceeds about 16.5 volts (depending on the duration of the rise) one of the Input fuses (F100 or F200) opens.

CAUTION

Since the input protection circuit clamps the input to a fixed voltage when too large an input signal is applied, there is a possibility of damage to the signal source. Large current surges can flow before the fuse(s) open.

Gate Current Compensation

Leakage current, associated with the gates of the Input FETs, through the input resistors, R100 and R200, develop an offset voltage at the input gates. At high gain settings, this offset drives the output into overrange. This leakage can be as high as 100 pA (at 25°C), although usually it is much less. 100 pA through 1 M Ω to ground will produce a DC offset of 100 μ V. To compensate for this leakage current, the FET gates are returned to an adjustable, slightly negative voltage source through R106, R107, and variable R105.

Leakage current, associated with the input FET gates and the overdrive protection diodes, increases quite rapidly with temperature increase, approximately doubling every 10°C. To compensate for this temperature-dependent leakage, a temperature sensitive current balancing network is included using thermistors (RT104-RT203) as the sensing elements.

Preamp

The preamp circuit in the 26A2 is made up of two identical feedback amplifiers connected in a differential configuration.

The overall gain of the preamp is approximately 42 to the output of Q152A and B.

The supply voltages for the preamp are obtained from a common power supply which is bootstrapped to the input to improve common-mode rejection.

Current Sources-Floating Power Supplies: The positive current source, Q410 A and B and Q416 and its associated circuitry, is one end of a divider string (see Fig. 3-1) which provides the correct operating potentials for the stages in the preamp. The current sink at the bottom of the divider string is Q443.

The current branches through parallel paths at the top of the string, and is summed back into the string via Q445. The difference in current magnitudes at the top and bottom of the string is absorbed by Q451.

Q422 A and B and Q426 and associated circuitry make up the negative current source for the input FETs.

Since the current sources are very high impedances, both the negative and positive supplies 'float' with the common-mode signal swing of ± 5 volts. The common-mode signal is introduced into the supplies via Q451 in the positive supply and via the common sources of the Input FETs in the negative supply.

DC Offset. Q141 A and B, Q145 A and B, and OFFSET COARSE and FINE controls, R30 and R31, provide means to offset any differential DC component of the input signal. This allows observation of AC components while maintaining good differential capability.

R461, Coarse Step Gain DC Bal adjustment (on the switching diagram) provides current balance in the two sides of the amplifier on all positions of the LF -3 dB POINT switch, except DC OFFSET.

Input Cross Neutralization. Stray capacitive coupling exists between components of the + and - Input amplifiers of the Preamp. If a signal is applied to the + Input, capacitive coupling produces undesirable currents in the - Amplifier input. If there is any impedance between the - Input and ground, the capacitive current produces a voltage across that impedance. This voltage across the - input impedance subtracts from the + Input signal, producing an erroneous output.

C222, connected in the -Input amplifier can be adjusted to divert the undesirable capacitive current away from the input line, minimizing the unbalance. C122 performs the same function for signal applied to the + Input.

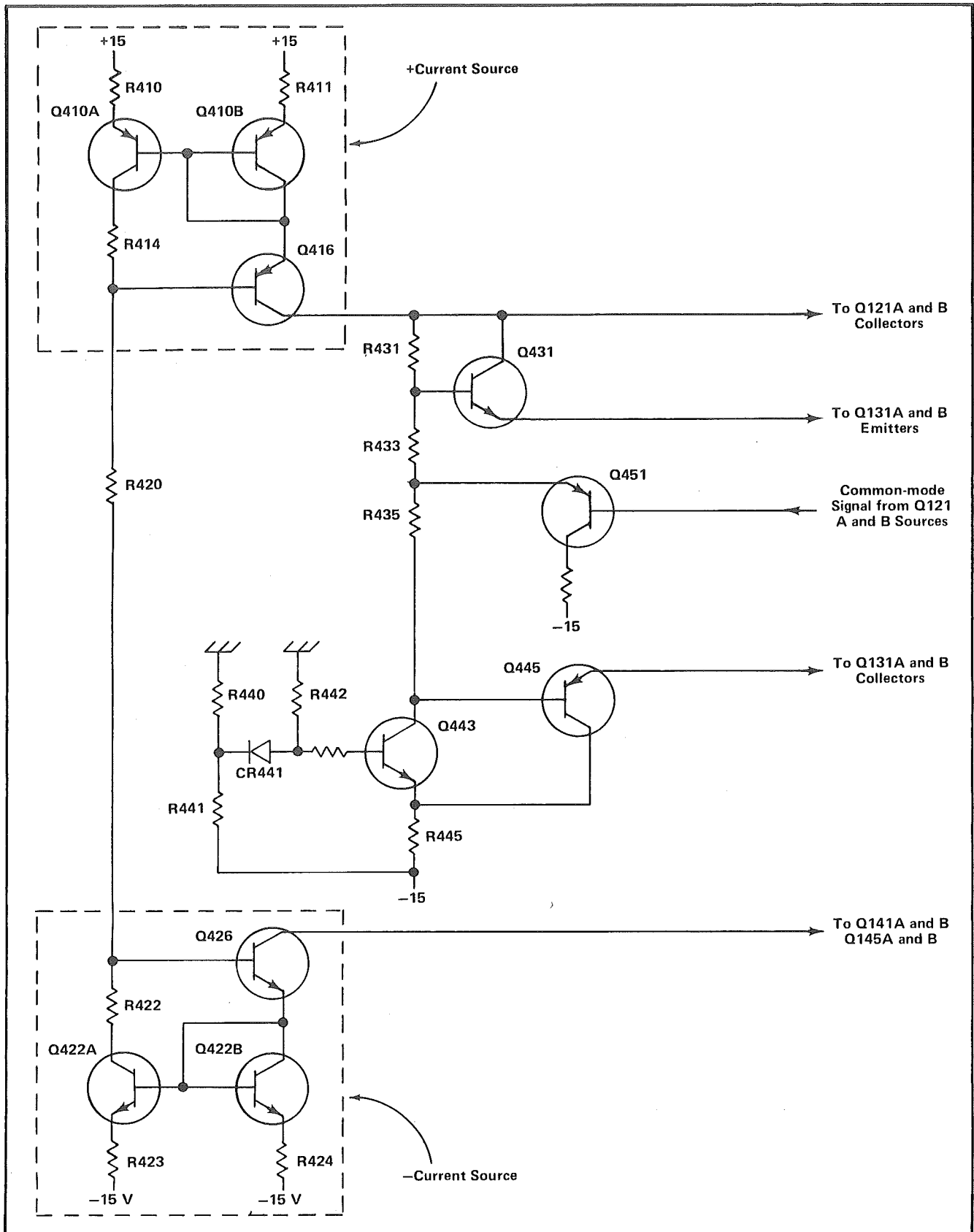


Fig. 3-1. + and - Current sources and divider.

High Frequency Common-Mode Balance. At higher frequencies, stray capacitances to ground at various points in the preamp begin to inject a significant differential current (as a result of common-mode signals) into the amplifier, producing a signal at the amplifier output. C150, connected from a common-mode signal point (the floating power supply) can be adjusted to minimize this output current to extend the range of frequencies over which useful common-mode rejection can be obtained.

Preamp Output Stage. The final stage (Q152 A and B) of the preamp contributes a small amount of gain. Its primary function is to reduce the common-mode DC level to zero volts. This stage also includes a front-panel screwdriver gain control, R38, for overall amplifier Gain calibration.

CR150 and CR250 rectify the input signal to drive the overrange detector circuitry. The diodes are normally conducting very slightly. When the input signal exceeds about 5 volts common-mode, the diodes turn on hard and drive the emitter of Q251 in the Overrange Detector circuit to light the OVERRANGE Indicator.

Step Gain DC Bal, R35, provides a balance which prevents output DC level shift when the GAIN switch is rotated through its gain setting positions.

LF —3 dB POINT Selector

The LF —3 dB POINT selector switch selects the low frequency —3 dB point of the amplifier by switching series RC networks between the output of Q152 and the input of Q162. The selector has a range of 0.1 Hz through 10 kHz in decade steps.

Gain Switching Amplifier

The Gain Switching Amplifier is a differential feedback amplifier having a gain range of 0.48 to 480. The gain is changed by switching values of resistance between Q162 A and B sources. This amplifier configuration has high open loop gain in the differential mode while offering very low common-mode gain.

R161, Step Gain AC Bal, balances the bias voltages of Q164 A and Q164 B.

Q167 and Q267 serve two functions. The base-emitter junctions of these transistors serve as reverse bias protection for Q168 and Q268. When the stage gain is excessive, the output signal at Q167-Q267 drives the overrange indicator circuitry to indicate a differential overrange condition.

HF —3 dB POINT Selector

The HF —3 dB POINT Selector switch selects the high frequency point by switching shunt capacitance across the output of the Gain Switching stage. The selector has a range of 100 Hz through 1 MHz in a 1-3 sequence.

Variable Gain Stage

The Variable Gain stage is a feedback amplifier having a gain of approximately ten in the calibrated variable position (switch S40 closed) and a gain of approximately four with R40 set at maximum resistance (S40 open).

R269 corrects for current imbalance introduced by the previous stage (bias balancing Q164 A and B). With Q171A and Q171B source voltages identical, rotating the front-panel VARIABLE control causes no shift of the DC output level.

CR181 and CR281 act as peak detectors, providing a signal to the overrange detector circuit (Q501 emitter). A swing greater than +6 volts on either Q181 or Q281 collector will give an overrange indication.

The common-mode level is detected at the junction of R178-R278 and is compared to ground in the comparator Q195-Q196. The comparator output is fed back to Q171A and B via Q269 to maintain the R178-R278 junction at zero volts.

The single ended output of the Variable Gain stage is fed to the unity gain transimpedance Output Amplifier.

Output Amplifier

The Output Amplifier provides a ± 5 -volt differential swing with a zero-volt DC level. The output R_O is approximately 2Ω .

The output signal voltage is divided down by R575-R576 to provide an output swing of ± 0.5 volt, with an R_O of 50Ω .

The Output Amplifier is short circuit-protected to ground and to the power supply. If the current in R571 causes the voltage at Q571 B collector to fall far enough below the level of Q555 emitter, CR555 conducts, stealing current from Q555 (the current source for Q561 A), reducing the drive to Q571 B, limiting the output current.

Overrange Indicator

When any of the three input transistors, Q501, Q511, or Q521, is turned on by an overrange signal from the amplifier, a turn-on current is supplied to Q532 base.

Q532 and Q541 comprise a monostable multivibrator which has a minimum on time of approximately 200 ms; thus, the indicator lamp is held on for a minimum of 200 ms, regardless of the duration of the overrange signal.

An overrange gate signal (output of Q543) is provided at the front panel (pin jack E) and to the rear connector for use with other instrumentation to indicate incorrect output signal.

Low Voltage Power Supply

General. The regulated DC is supplied in two stages, (1) pre-regulation of the power transformer primary in the mainframe, and (2) regulation in the 26A2 of the three individual voltages supplied by the mainframe (transformer secondary).

Each of the three mainframe supplies (−17 V, +7 V, and +17 V) is rectified and filtered in the mainframe and supplied to the 26A2 via the rear connector.

If the 26A2 is used in a 7000-Series oscilloscope, which provides the necessary regulated voltages, the −15-volt and

+15-volt regulators are disabled via the disable lines. The 7000-Series oscilloscope supplies regulated voltage to the input and output of each regulator and to each disable line.

The heart of each regulator is a $\mu A723C$ integrated precision voltage regulator, containing a feedback amplifier, reference voltage, current limiter, and output emitter follower. Fig. 3-2 shows the equivalent circuit of the $\mu A723C$.

The −15-volt supply provides the reference voltage for the +15-volt supply, and the regulated +15-volts is the reference for the +5-volt supply.

+15-Volt Supply

Error voltage from the junction of R315-R316 is compared to ground in U310 to set the base drive to Q321, the external series pass transistor.

R314, with a transistor in U310 (pins 2 and 3), limits the base drive to Q321, allowing Q323 to limit the overload current.

R321 at the emitter of Q321 senses load current and, during output overloads, turns Q323 on to divert base current from Q321. If the output voltage level starts to drop with increasingly heavy output load, CR327 will turn on, driving Q323 into heavier conduction, stealing more

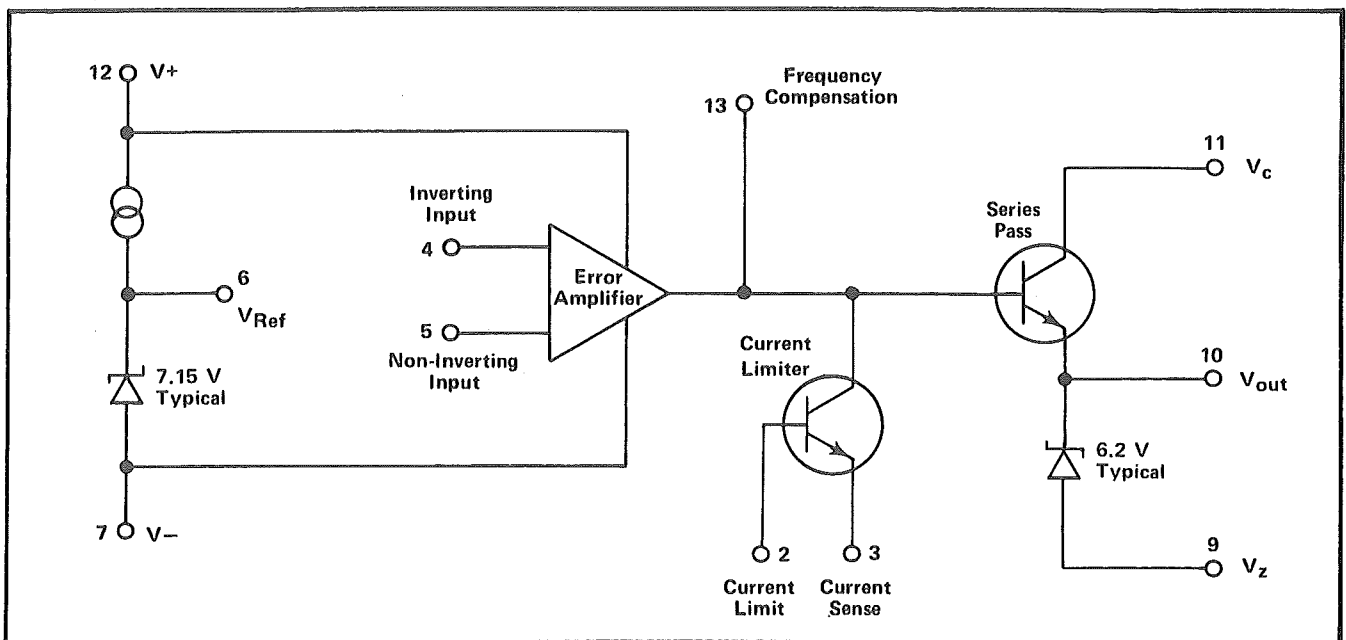


Fig. 3-2. Equivalent circuit of the $\mu A723C$.

Circuit Description—26A2

base current from Q321, causing the output load current curve to 'fold back', reducing the short circuit current to a value lower than that at lighter overloads.

C315 prevents oscillations in the regulator feedback loop.

+5-Volt Supply

The +5-volt supply voltage is set by a divider, R340-R341, between the regulated +15 volts and ground. Q345 is the pass transistor, isolated from the divider by Q343.

—15-Volt Supply

The —15-volt supply is basically the same as the +15-volt supply except the reference voltage is provided by the ref-

erence supply (R354 and a temperature compensated Zener in U350).

The output voltage is adjusted by setting the level of error fed back from the divider string, R355-R356-R357 to the error amplifier in U350 (pin 4).

R361 senses overload current which is fed back as a signal through Q363 to U350 and decreases the base drive to pass transistor Q361. CR367 provides 'foldback limiting' for short circuit protection as described for the +15-volt supply.

C357 prevents oscillations in the regulator feedback loop.

SECTION 4

MAINTENANCE

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section contains preventive and corrective maintenance information, plus troubleshooting procedures for the 26A2.

NOTE

Corrections and modifications to the circuits are described on inserts bound into the rear of the manual. Check for changes to the manual or the instrument. Verify component values by checking their descriptions in the Electrical Parts List in Section 6.

Cleaning

Clean the instrument often enough to prevent accumulation of dust or dirt on or in it.

Avoid the use of chemical cleaning agents which might damage the plastics used in the instrument. Avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents.

Recalibration

A recalibration check is recommended after each 1000 hours of operation, or every year if used infrequently. Replacement of components may necessitate recalibration of the affected circuits. Complete calibration instructions are given in the Performance Check/Adjustment section.

Circuit Board Illustrations. Each electrical component and test point is identified on the pictorial circuit board illustration on the inside fold of the corresponding circuit diagram. These illustrations, together with circuit diagrams, allow the troubleshooter to methodically trace the operation of each circuit.

Wiring Color Code. Color coded wire is used to aid circuit tracing. Power supply, DC voltage leads have either a white background for positive voltage or a violet background for negative voltage. The EIA standard color code is used to signify the approximate voltage value on the wire. The widest strip denotes the first significant figure.

Signal wires and coaxial cables use an identifying one-band or two-band color code.

TROUBLESHOOTING

The ability to recognize and locate trouble is acquired through experience and familiarity with the instrument. The following describes a few aids that may assist in locating a trouble. After the defective component has been located, refer to Corrective Maintenance procedures for removal and replacement instructions.

Troubleshooting Aids

Diagrams. Complete circuit diagrams are provided on foldout pages in the Diagrams section. The component numbers and electrical values are shown on the diagrams along with significant voltages. Each major circuit is assigned a series of numbers for the electrical components. Circuits mounted on circuit boards are outlined with a blue line.

Multiple Terminal Connector Holders. Most inter-circuit connections, between the circuit boards or between the boards and chassis mounted components, are made through pin connectors. The terminals in the connector holder are identified with numbers. Connector orientation to the circuit board is keyed with arrows, one on the holder and one on the circuit board. See Fig. 4-1. Most connectors consist of more than one section, so sections of a connector can be disconnected for troubleshooting. Wiring color code for these connectors is shown at the end of this section. The connectors are mounted with the open side facing the front or the right side (looking from the front) of the board.

Resistor Color Code. In addition to the brown composition resistors, some metal-film resistors (identifiable by their gray body color) and some wire-wound resistors are used in the 26A2. The resistance value of a wire-wound resistor is printed on the body of the component. The resistance value of a composition resistor or metal-film resistor

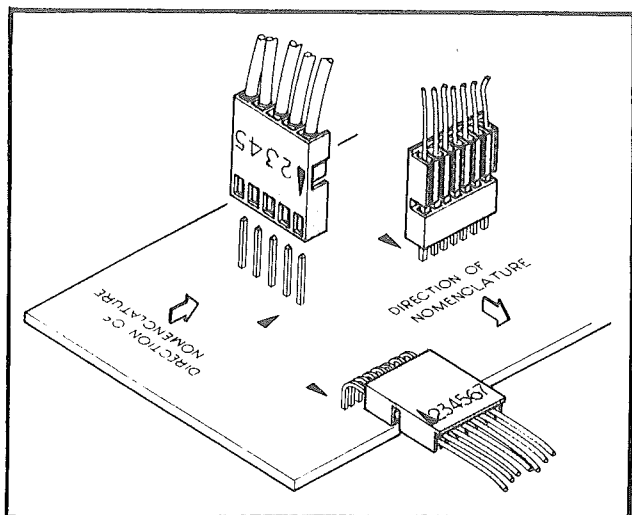


Fig. 4-1. Multipin circuit board connectors.

is color-coded on the component with EIA color-code (some metal-film resistors may have the value printed on the body).

Capacitor Marking. The capacitance value of a common disc capacitor or small electrolytic is marked in microfarads on the side of the component body. The white ceramic capacitors are color coded in picofarads.

Diode Color Code. The cathode of each glass encased diode is indicated by a stripe, a series of stripes or a dot.

General

If trouble occurs in the 26A2, the following procedure should facilitate locating the problem and expedite repairs.

1. Insure that the malfunction exists in the instrument. Check operation of the associated equipment and the operating procedure of the 26A2 (see Operating Instructions).

2. Determine and evaluate all trouble symptoms. Try to isolate the problem to a circuit or assembly. The block diagram in the Diagrams section is an aid for signal or circuit isolation.

3. Visually inspect the area or the assembly for such defects as broken or loose connections, improperly seated components, over-heated or burned components, chafed insulation or cracked insulators etc. Repair or replace all obvious defects. In the case of overheated parts, try to determine the cause of overheating and correct before applying power.

4. Check power supply voltages. Table 4-1 lists the voltage and ripple tolerances of the power supplies. If a power supply voltage and ripple are within the listed tolerance, the supply can be assumed to be working properly. If outside the tolerance, the supply may be misadjusted or operating incorrectly.

TABLE 4-1

Supply	Ripple	Voltage
-15	3 mV, p-p	-15 V, ±100 mV
+5	2 mV, p-p	+4.5 V to +5.0 V
+15	3 mV, p-p	+15 V, ±150 mV

5. Check circuit voltages. The schematic diagrams contain pertinent voltages for this purpose. Component locations and test points are shown on circuit callout illustrations.

NOTE

Voltages on the diagrams are not absolute and may vary between instruments. The first diagrams page lists the conditions set to obtain these voltages.

CAUTION

When measuring voltages and waveforms, use extreme care in placing meter leads or probes. Because of high component density, and the limited access within the instrument, an inadvertent movement of the leads or probe can cause a short circuit, producing transient voltages that may destroy many components.

6. Check calibration adjustments of the affected circuit, if applicable. Before changing any adjustment, note its position so it can be returned to the original setting if adjustment has no effect on the trouble. This will facilitate recalibration after locating and repairing the trouble.

If trouble has not been found and corrected by the foregoing procedure, a more detailed analysis must be performed. The Circuit Description section describes the operational theory of each circuit and should aid in evaluating the problem.

Semiconductor failures account for the majority of electronic equipment failures. Because most semiconductor devices (transistors and IC's) are socket-mounted, substitution is often the most practical means of checking their performance. The following guide lines should be followed when substituting these components:

1. Determine first that circuit voltages are safe for the substituted component, so the replacement will not be damaged.

2. Use only good components for substitution.

3. Turn the power off before a component is substituted.

4. Be sure the component is inserted properly in the socket.

5. Return good components to their original sockets. This will reduce calibration time and run-in period.

6. Check calibration and performance after a faulty component has been replaced.

If a substitute is not available, check the transistor or FET with a dynamic tester such as the Tektronix Type 576 Curve Tracer.

A static type tester, such as an ohmmeter, can be used to check resistance ratios across semiconductor junctions if no other method is available. Use the high resistance ranges (R X 1 k or higher) to limit the external current to less than 2 mA. If uncertain, measure the external current with an ammeter. Resistance ratios across base-to-emitter or base-to-collector junctions usually run 100:1 or higher. The ratio is measured by connecting the meter leads across the terminals, noting the reading, then reversing the leads and noting the second reading.

Diode Checks. Most diodes can be checked in the circuit by taking measurements across the diode and comparing these with the voltage listed on the diagram. Forward-to-back resistance ratios can usually be taken by referring to the schematic and pulling appropriate transistors and pin connectors to remove low resistance loops around the diode. If necessary, unsolder one end of the diode and lift it clear so the ratio can be taken. Observe suggested solder practices (using a heat sink) when soldering or unsoldering the diode.

CAUTION

Do not use an ohmmeter scale with a high external current to check the diode junction.

CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and instrument repair. Special techniques and procedures, required to replace components in this instrument, are described here.

Obtaining Replacement Parts

All electrical and mechanical parts replacements can be obtained through your local Tektronix Field Office or representative. Many of the standard electronic components, however, can be obtained locally in less time than that required to order from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Parts List for value, tolerance and rating. The Parts section contains instructions on how to order these replacement parts.

Soldering Techniques

Circuit Boards. Use ordinary 60/40 solder and a 15 watt pencil type soldering iron on the circuit boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the wiring from the base material. Most components can be replaced without removing the boards from the instrument.

The following procedure is recommended to replace a component on a circuit board.

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection.

NOTE

Some components have clinched leads which should be straightened before removal to protect the plated-through holes.

2. When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick into the hole. A vacuum-type desoldering tool can also be used for this purpose.

3. Bend the new component leads to fit the holes in the board. If the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the holes in the board so the component is firmly seated (or as positioned originally). If it does not seat properly, heat the solder and gently press the component into place.

Maintenance—26A2

4. Heat-sensitive components are protected by holding the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink. Touch the iron to the connection and apply a small amount of solder to make a firm solder joint.

5. Clip the excess leads that protrude through the board.

6. Clean the area around the solder connection with a flux-remover solvent. Be careful not to remove information printed on the board.

COMPONENT REPLACEMENT

General

The exploded-view drawings associated with the Mechanical Parts Lists pullout page (Fig. 1, EXPLODED) may be helpful when disassembling or reassembling individual components or sub-assemblies.

Circuit Board Removal

Cam Switch Board. Remove the three multi-pin connectors from the pins.

Loosen the hex set screws holding the shaft at each cam switch (HF -3 dB POINT and LF -3 dB POINT).

Remove the cam switch shafts through the front panel.

Loosen the four knurled-head machine screws which secure the Cam Switch Board to the main board.

Carefully lift the circuit board straight away from the main board and interconnecting pins.

NOTE

When replacing the Cam Switch Board, be sure that the pin connectors on the board are properly aligned with the mating pins on the main board.

With the Cam Switch Board removed, all components are accessible on both boards. However, to remove the Main Board from the frame, proceed as follows:

Remove GAIN and VARIABLE knobs.

Remove the three machine screws holding Q321, Q345, and Q361 to the top rail. Note the mica washer between each transistor and the rail.

Unsolder the heavy lead at the rear of the "GAIN-VARIABLE-CAL IN" switch assembly.

Remove the two machine screws holding the Gain Switch assembly to the top rail and remove the switch assembly.

Disconnect all multi-pin connectors and two single-pin connectors from the circuit board.

Remove the machine screw holding the ground lug to the Output connector shield assembly.

Remove the four machine screws securing the rear plastic connector-guide assembly to the rails.

Slide the circuit board to the rear, making sure that the plastic positioning clips move out with the board. Note the positions of the three plastic clips for re-assembly.

Pushbuttons

The pushbutton switches are not repairable and should be replaced as a unit. The pushbutton-illuminating lamp and one resistor are the only replaceable components on the pushbutton assembly circuit boards (see the information under Lamp Replacement).

The following procedure removes the pushbutton switches.

1. Remove the GAIN, VARIABLE, HF -3 dB POINT, LF -3 dB POINT, and OFFSET switch knobs (front panel).

2. Insert a screwdriver blade between the bottom of the front-panel casting and the indentation at the bottom center of the front panel overlay. Carefully twist the screwdriver to move the overlay away from the sub-panel. Remove the overlay.

3. Remove the two flat-head machine screws and remove the switch from the rear.

To replace the switch, reverse the above procedure.

Semiconductor Replacement

Replacement semiconductors should be of the original type or a direct replacement. Fig. 4-2 shows the lead configuration of the semiconductors used in this instrument. Some plastic cased transistors may have lead configurations which do not agree with those shown here. If a replacement transistor is made by a manufacturer other than the original, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are

wired for the standard basing as used for metal cased transistors.

Lamp Replacement (Series 70 Switches)

The following procedure describes lamp replacement in the pushbutton assembly.

1. Remove the pushbutton switch as described previously.

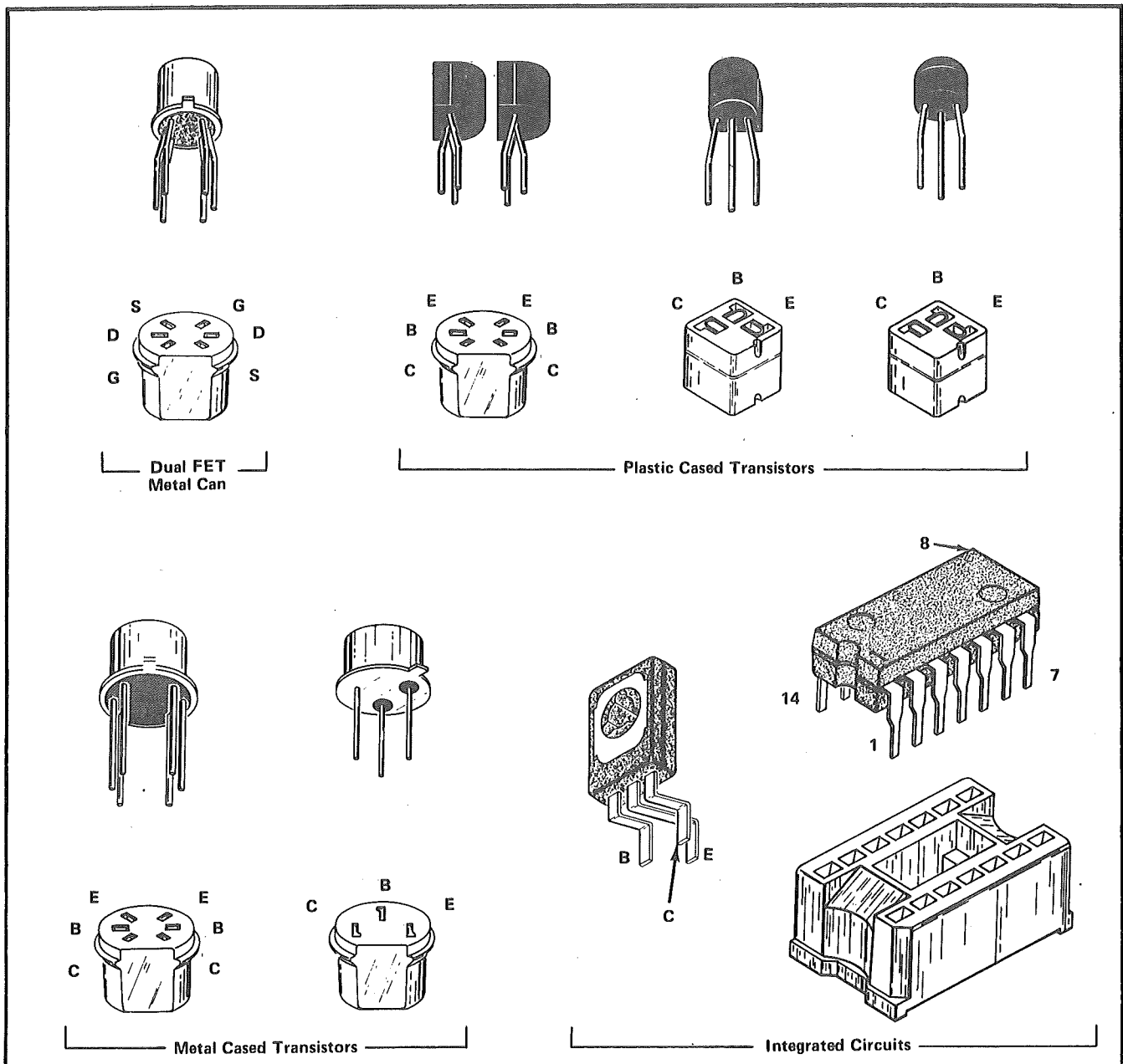


Fig. 4-2. Semiconductor lead configuration.

Maintenance—26A2

2. Note the position of the lamp on the circuit board. Unsolder the lamp leads from the circuit board.

3. Move the lamp out through the light manifold.

4. Install the new lamp in the same position as the original and solder the leads to the circuit board. Use a heat sink to protect the lamp during soldering.

INSTRUMENT REPACKAGING

If the 26A2 is to be shipped over long distances by commercial transportation, it is recommended that the instrument be repackaged in the original manner for maximum protection. Repackaging information and/or new shipping carton may be obtained from Tektronix, Inc. Contact the nearest Tektronix Field Office or Representative. See Fig. 2, Repackaging (Pullout, Mechanical Parts List, Section 7).

SECTION 5

PERFORMANCE CHECK / ADJUSTMENT

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

A performance check is recommended every 1000 hours of operation, or every year if used infrequently. Before complete calibration, the instrument should be cleaned and inspected as outlined in the Maintenance section.

The Performance Check can be used to check instrument performance without making any internal adjustments.

As an aid to checking the performance of the 26A2, a Short-Form Procedure is given preceding the complete procedure. To facilitate instrument checkout, the Short-Form Procedure lists the check and applicable tolerances. This procedure also includes the step, number, and title as listed in the complete Performance Check, and the page number on which each step begins. The Short-Form Procedure also provides spaces to record performance data or to check off steps as they are completed.

Following the Performance Check is a complete ADJUSTMENT procedure. Completion of the Adjustment Procedure insures that the instrument meets the electrical specifications given in Section 1.

NOTE

Limits, tolerances and waveforms in the ADJUSTMENT procedure are given as calibration guides and should not be interpreted as instrument specifications except as specified in Section 1. All waveforms shown in this procedure were taken with a Tektronix Oscilloscope Camera System.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories, or equivalent, are required for complete check or adjustment of the 26A2. Specifications given are the minimum necessary for accurate check or adjustment. Some of the recommended equipment may have specifications that exceed those given. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specification of the recommended equipment.

Special Tektronix calibration fixtures are used to facilitate calibration and performance checks. These special fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Test Equipment

1. Test Oscilloscope, consisting of Indicator and Vertical and Horizontal plug-ins as follows:

Differential Comparator: Comparison voltage range, 0 to + and - 15 volts; deflection factor, 1 mV/Div to 1 V/Div.

Time Base: Horizontal deflection factor, 1 μ s/Div to 1 ms/Div.

The following oscilloscopes and plug-ins are recommended:

Tektronix 7403N Oscilloscope,

7A13 Differential Comparator

7B50 Time Base

Or, Tektronix Type 561B Oscilloscope

3A7 Differential Comparator

2B67 or 3B4 Time Base Unit

2. Pulse Generator: Output pulse duration, 1 ms; output amplitude, variable from +1 V to +10 V. A Tektronix Type 114, 115, or 2101 Pulse Generator is recommended.

3. Constant Amplitude Sine Wave Generator: Frequency range, 2 Hz to 1.25 MHz; output amplitude, 0 to 10 V (peak-to-peak). The General Radio Type 1310A Oscillator is recommended.

4. 2600-Series Mainframe: Provides operating power for the 26A2.

5. Plug-in extender: Provides access to the adjustments and test points in the 26A2. Tektronix Part Number 067-0630-00.

Performance Check/Adjustment—26A2

6. Coaxial Cable Assembly (three required): Connectors, BNC; impedance, 50 Ω. Tektronix Part Number 012-0057-01.

7. BNC 'T' Connector. Tektronix Part Number 103-0030-00.

8. 1X Probe (if differential comparator is used to measure supply voltages). Tektronix Type P6011 is recommended. Tektronix Part Number is 010-0192-00.

9. Dual Input Connector: Connectors, BNC. Provides matched signal paths to both 26A2 Input connectors. Tektronix Part Number 067-0525-00.

10. 1000:1 Precision Divider: Accuracy, 0.2%. Tektronix Part Number 067-0529-00.

11. Input RC Normalizer: RC time constant, 1 MΩ and 20 pF; Connectors, BNC. Tektronix Part Number 067-0538-00.

12. Termination: Impedance, 50 Ω; connectors, BNC. Tektronix Part Number 011-0049-01.

13. Attenuator (six required): Impedance, 50 Ω; attenuation factor 10X; connectors, BNC. Tektronix Part Number 011-0059-01.

3. Check Frequency Response (AC Coupled)

–3 dB frequency is 2 Hz or less

4. Check Common-Mode Rejection Ratio

CMRR is 50,000:1 or greater

5. Check Overall Noise (Tangentially Measured)

Noise level is not greater than 25 μV

PERFORMANCE CHECK PROCEDURE

General

The following procedure is arranged to check the 26A2 with the least reconnection of equipment. The control settings throughout the procedure continue from the preceding step unless otherwise noted.

NOTE

Control titles which are printed on the front panel of the 26A2 are capitalized in this procedure (e.g., STEP GAIN DC BAL). Associated equipment controls are initial capitalized only (e.g., Output Amplitude).

The following procedure uses the equipment listed under Test Equipment Required. If other equipment is substituted, control settings or checking setup may need to be altered to meet the requirements of the equipment used. Operating instructions for the test equipment are not given in this procedure. Refer to the test equipment instruction manual if more information is required.

NOTE

The performance of this instrument may be checked at any temperature from 0°C to +50°C, provided the instrument was adjusted within an ambient range of +20°C to +30°C.

NOTE

Bandpass or transient response measurements requiring high gain settings should be made with the side covers in place.

SHORT FORM PERFORMANCE CHECK AND INDEX

26A2 Serial Number

Date

By

1. Check Gain Accuracy

Within 2%

2. Check Frequency Response (DC Coupled)

–3 dB frequency is within +25% and –15% of 1 MHz

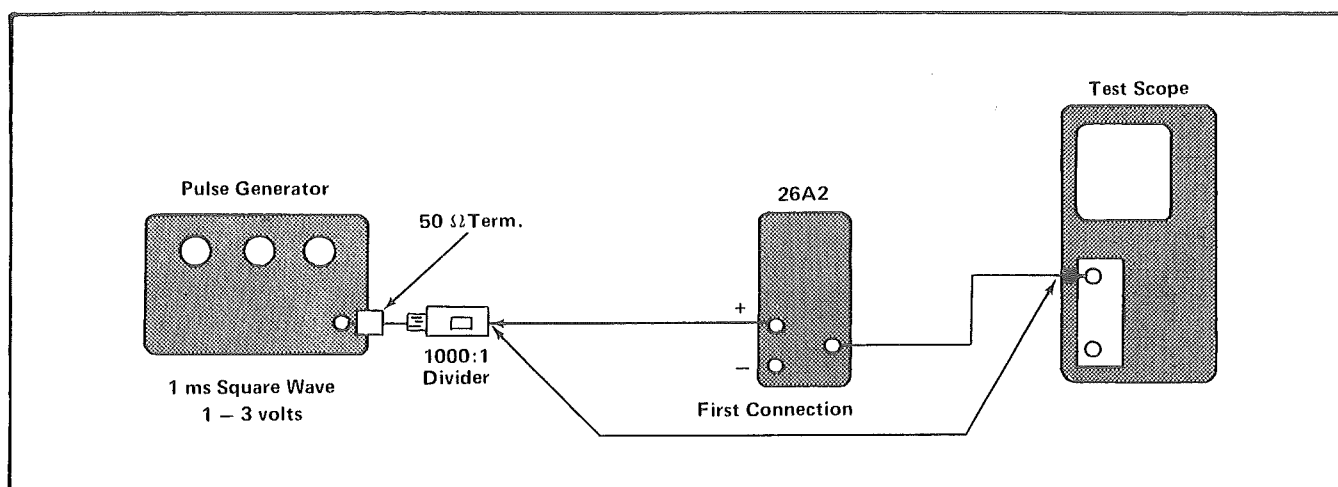


Fig. 5-1. Equipment setup for step 2.

PERFORMANCE CHECK

1. Check Gain Accuracy

- a. Set up the test equipment as illustrated in Fig. 5-1.
- b. Set the 26A2 controls as follows:

GAIN	1 k
HF -3 dB POINT	1 MHz
LF -3 dB POINT	DC
- c. Connect the 50 Ω BNC termination and 1000:1 Divider as illustrated. Set the divider switch to 1000:1.
- d. Connect the 1000:1 divider output to the test oscilloscope differential comparator +Input.
- e. Switch the differential comparator +Input to DC, -Input to GND, and Comparison Voltage to +1.00.
- f. Vertically position the bottom of the display to graticule center. Switch -Input to V_C .
- g. Adjust the pulse generator output Amplitude to 1.00 volt as accurately as possible (set top of display to graticule center).
- h. Switch the 1000:1 divider to X1000 and connect the divider output to the 26A2 +Input.
- i. Switch the differential comparator -Input to GND and connect the 26A2 OUTPUT (± 5 V) to the differential comparator +Input. Adjust the differential comparator Vertical Position control to set the bottom of the display to graticule center.
- j. Switch the differential comparator -Input to V_C and adjust the Comparison Voltage to position the top of the display to graticule center.
- k. CHECK—The comparison voltage readout should be within 2% of 1.00 volt (0.98 V to 1.02 V). To precisely set gain, for the 1k GAIN switch position, set the differential comparator Comparison Voltage to 1.00 V and vertically position the top of the display to graticule center. Reset the comparison Voltage to 0.00 and adjust the 26A2 front-panel GAIN CAL to position the bottom of the display to graticule center.

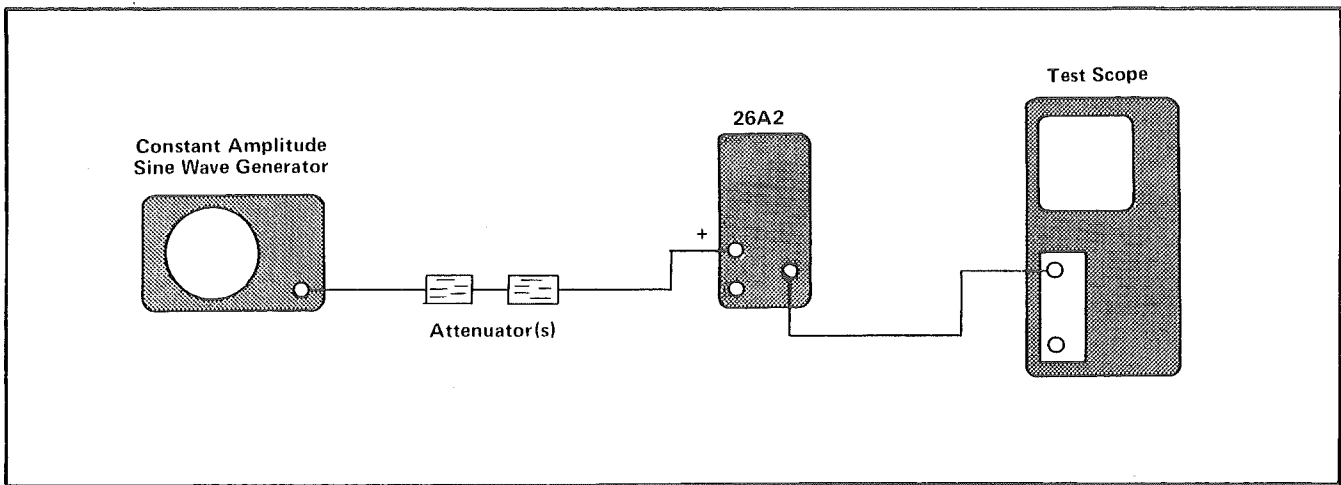


Fig. 5-2. Equipment setup for step 2.

2. Check Frequency Response (DC Coupled)

- a. Set up the test equipment as illustrated in Fig. 5-2.
- b. Set the equipment controls as follows:

	26A2
GAIN	100
HF -3 dB POINT	1 MHz
LF -3 dB POINT	DC

	Constant Amplitude Sine Wave Generator
Frequency	50 kHz
	Test Oscilloscope
Vertical deflection factor	200 mV/Div
Horizontal deflection factor	10 μ s/Div (free-running sweep)

c. Adjust the sine wave generator output level to give five divisions of display on the test scope (use attenuators as necessary to reduce generator output to a level suitable for the 26A2 input).

d. Increase the sine wave generator Frequency to the point at which the 26A2 output amplitude display drops to 3.53 divisions (70.7% of reference 5 div.) on the test scope.

e. CHECK—The sine wave generator frequency is within +25% or -15% of 1 MHz (1.25 MHz to 0.85 MHz). This is the upper frequency -3 dB point.

NOTE

If the sine wave generator does not have constant output amplitude, check its output level with a monitoring device for each frequency change.

3. Check Frequency Response (AC Coupled)

- a. Equipment setup is the same as in step 2.
- b. Set the equipment controls as follows:

	26A2
GAIN	100
HF -3 dB POINT	1 MHz
LF -3 dB POINT	DC
AC-GND-DC Switch	AC

	Constant Amplitude Sine Wave Generator
Frequency	2 kHz
	Test Oscilloscope
Vertical deflection factor	200 mV/Div
Horizontal deflection factor	.1 s/Div (free-running sweep)

c. Adjust the sine wave generator amplitude for a five division display reference on the test oscilloscope.

d. Reduce the sine wave generator Frequency to 2 Hz.

e. CHECK—The display amplitude should equal or exceed 3.53 divisions (70.7% of five divisions) or the low frequency -3 dB point.

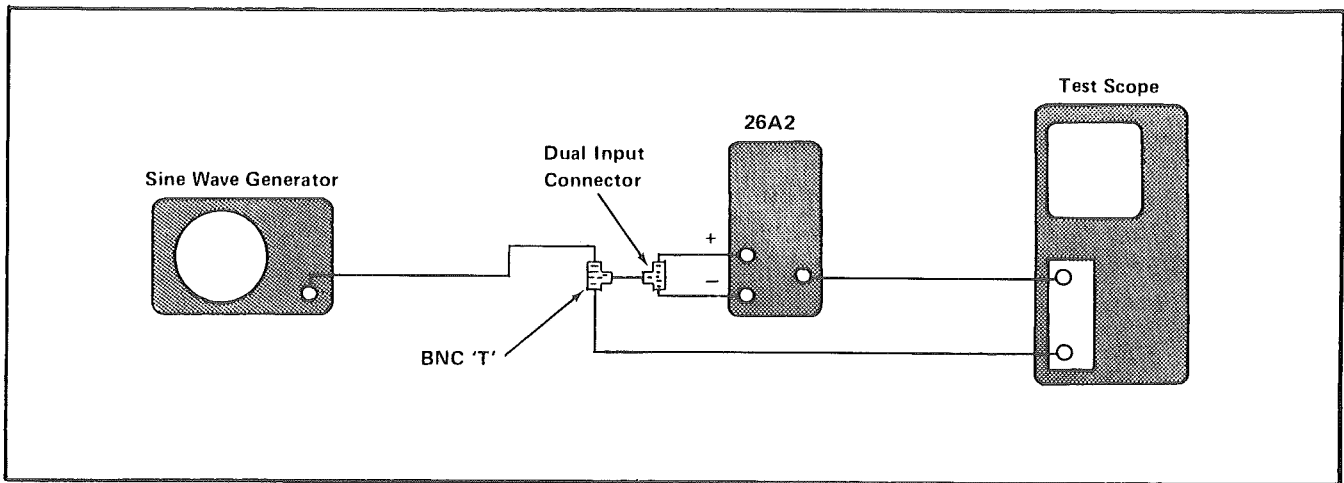


Fig. 5-3. Equipment setup for step 4.

NOTE

If the sine wave generator does not have constant output amplitude, check its output level for each frequency change.

Monitor the output amplitude with the test oscilloscope (-Input set to 2 volts/Div and +Input set to GND).

c. Switch test scope -Input to GND and +Input to DC. Set +Input deflection factor to 10 mV/Div.

4. Check Common-Mode Rejection Ratio

a. Set up the equipment as illustrated in Fig. 5-3.

d. CHECK—The output display amplitude should not exceed 20 mV (2 divisions).

b. Set the equipment controls as follows:

CMRR is the ratio of the common-mode signal (10 volts), to the differential input that produces the same output level.

26A2

GAIN	100
HF -3 dB POINT	1 MHz
LF -3 dB POINT	DC

$$\frac{\text{Equivalent differential signal in}}{\text{signal in}} = \frac{e_{\text{out}}}{\text{GAIN}}$$

and

Constant Amplitude Sine Wave Generator

Frequency	50 kHz
Amplitude	10 volts P-P

$$\begin{aligned} \text{CMRR} &= \frac{e_{\text{in common mode}} \times \text{gain}}{e_{\text{out}}} = \frac{10 \text{ V} \times 100}{20 \text{ mV (max)}} \\ &= \frac{10^3}{2 \times 10^{-2}} = 0.5 \times 10^5 = 50,000:1 \end{aligned}$$

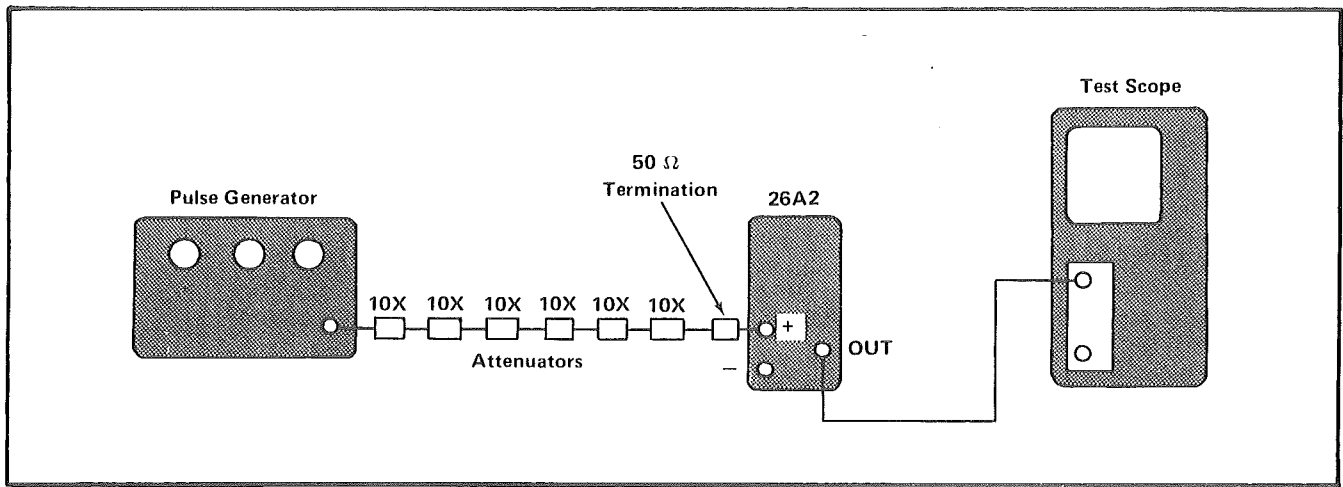


Fig. 5-4. Equipment setup for step 5.

5. Check Overall Noise (Tangentially Measured)

- a. Set up the equipment as illustrated in Fig. 5-4.
- b. Set the equipment controls as follows:

26A2	
GAIN	100 k
HF -3 dB POINT	1 MHz
LF -3 dB POINT	DC
+Input	DC
-Input	GND

Pulse Generator	
Period	1 ms
Amplitude	1 to 3 volts
Variable	clockwise

c. Apply the output of the pulse generator through six 50 Ω attenuators, through a 50 Ω termination, to the 26A2 +Input.

d. Monitor the 26A2 OUTPUT with the test oscilloscope vertical deflection factor set to .2 V/Div.

e. Adjust the pulse generator output (Variable amplitude control) and observe two noise bands as shown in Fig. 5-5A (remove one attenuator, if necessary, to produce the desired display).

f. Decrease the pulse amplitude until the noise bands merge (dark area between bands just disappears). See Fig. 5-5B.

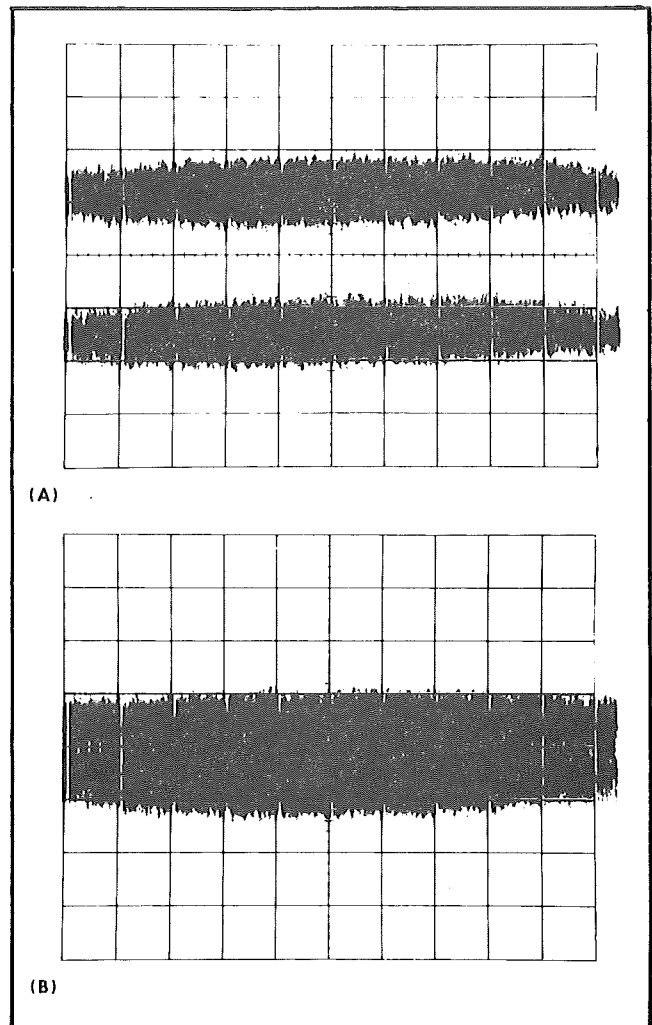


Fig. 5-5. Typical display of (A) two noise bands and (B) noise bands merged.

g. Remove three of the 10X attenuators and connect the signal through the remaining attenuators (including the 50 Ω termination) to the test scope Input and measure the pulse generator signal level.

h. CHECK—The noise level as follows:

Calculate the level from:

$$\text{Noise} = \frac{\text{Signal level (measured in step g)}}{\text{Attenuation removed}}$$

= Noise in μV .

Typical figures are:

$$\frac{12 \text{ mV}}{10^{-3}} = 12 \times 10^{-6} = 12 \mu\text{V}$$

of noise

SHORT FORM ADJUSTMENT PROCEDURE AND INDEX

1. Adjust -15-Volt Supply Page 5-7

ADJUST—R356 to -15 volts, ± 100 mV.

2. Adjust Step Gain AC Bal Page 5-9

ADJUST—R161 for no output DC level change as GAIN switch is rotated through its range.

3. Adjust Var Gain DC Bal Page 5-9

ADJUST—R269 for no output DC level shift as VARIABLE control is rotated through its range.

4. Adjust Output DC Level Page 5-9

ADJUST—R191 to set the Output voltage to zero volt.

5. Adjust Coarse Step Gain DC Bal Page 5-9

ADJUST—R461 for zero volt (within 1 volt) DC Output level.

6. Adjust +Input Gate Leakage Current Compensation Page 5-9

ADJUST—R105 for minimum trace shift when switching +Input from GND to AC.

7. Adjust -Input Gate Leakage Current Compensation Page 5-9

ADJUST—R208 for minimum trace shift when switching -Input from GND to AC.

8. Adjust Input Cross Neutralization Page 5-10

ADJUST—C222 for similar display (upper corner of the leading edge) in the DC switch position as that seen in the GND position.

ADJUST—C122 for similar display (upper corner of the leading edge) in the DC switch position as that seen in the GND position.

9. Adjust Input Capacitance Page 5-10

ADJUST—C200 for the best upper corner on the leading edge of the displayed square wave.

ADJUST—C100 for the best upper corner on the leading edge of the displayed square wave.

10. Adjust HF -3 dB POINT Page 5-11

ADJUST—C490 to set the display amplitude to 3.53 divisions.

11. Adjust High Frequency CMRR Page 5-12

ADJUST—C150 for minimum Output amplitude.

ADJUSTMENT PROCEDURE

1. Adjust -15-Volt Supply (R356)

a. Connect the test scope differential comparator, set to measure -15 volts (within 100 mV), between the -15-volt Test Point and GND. See Fig. 5-6 for location of controls and test points.

b. ADJUST—R356 to set the voltage to -15 volts, ± 100 mV.

c. Check the voltages at the +5-volt test point (+4.5 volts to 5.0 volts) and at the +15-volt test point (+15 volts, ± 150 mV).

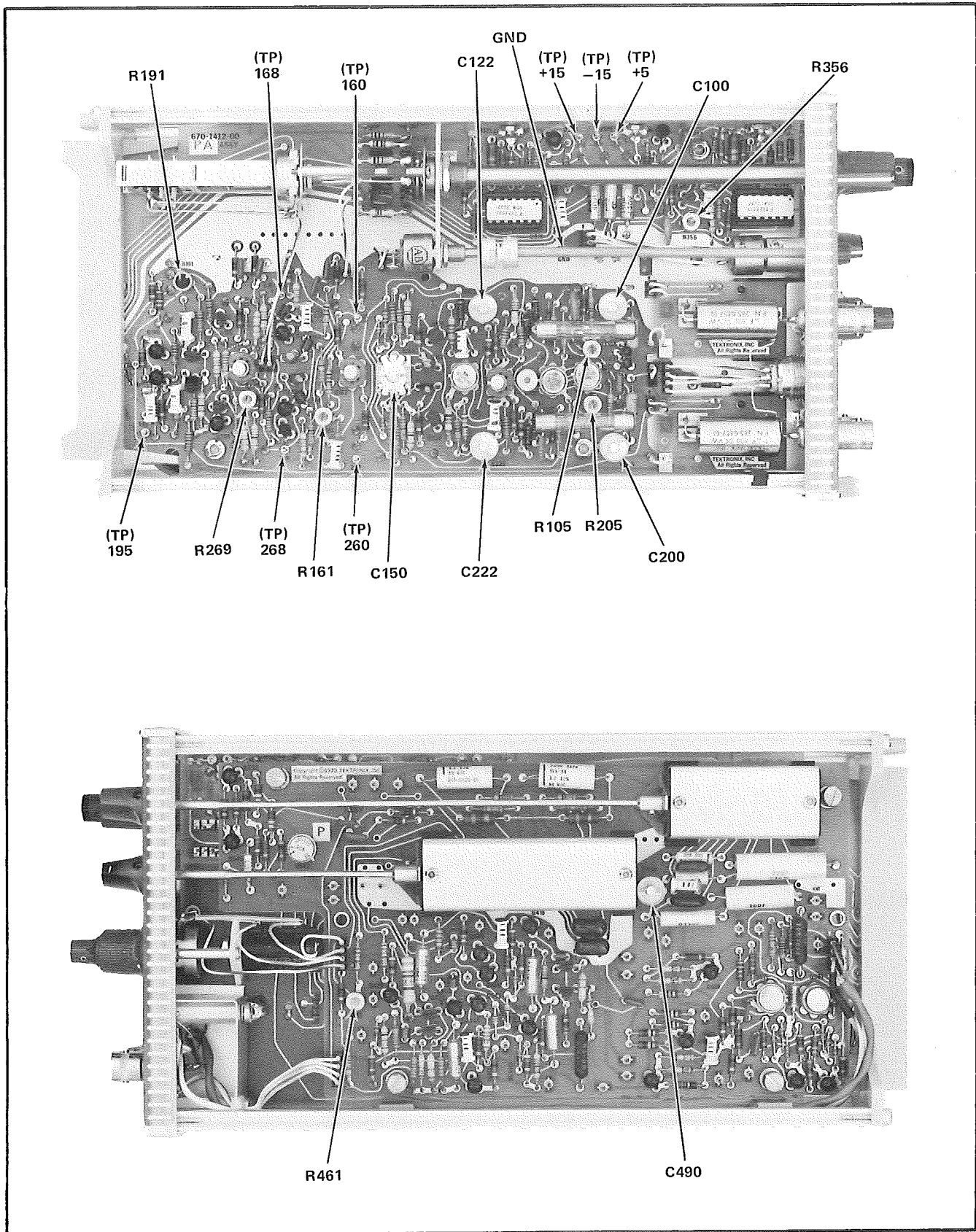


Fig. 5-6. Location of controls and Test Points.

2. Adjust Step Gain AC Bal (R161)

- a. Set the 26A2 controls as follows:

LF -3 dB POINT	10 Hz
HF -3 dB POINT	.1 kHz
GAIN	100

b. Monitor the 26A2 output DC level with the test oscilloscope.

c. ADJUST—R161 for no output DC level change as the GAIN switch is rotated through its range.

3. Adjust Var Gain DC Bal (R269)

- a. Use the same setup as in step 2.

b. Push the VARIABLE knob to release to the Un-calibrated position.

c. ADJUST—R269 for no output DC level shift as the VARIABLE control is rotated through its range.

4. Adjust Output DC Level (R191)

- a. Use the same setup as in step 2.

b. Establish a zero DC reference (GND) on the test oscilloscope with vertical deflection set at .1 V/Div.

c. ADJUST—R191 to set the output voltage to the zero reference level.

5. Adjust Coarse Step Gain DC Bal (R461)

- a. Use the same setup as in step 2.

b. Set the 26A2 controls as follows:

LF -3 dB POINT	DC
GAIN	10 k
STEP GAIN DC BAL	Midrange

c. ADJUST—R461 for a zero volt (within 1 volt) DC level at the 26A2 OUTPUT BNC connector.

6. Adjust +Input Gate Leakage Current Compensation (R105)

- a. Use the same setup as in the previous step.

b. Set the 26A2 controls as follows:

HF -3 dB POINT	.1 kHz
LF -3 dB POINT	DC
GAIN	10 k
+ and - Inputs	GND

c. Terminate the +Input BNC connector with a 50 Ω termination.

d. Observe the 26A2 output on the test oscilloscope, with the vertical deflection factor set to 100 mV/Div. Vertically position the trace to graticule center.

e. Switch the +Input AC-GND-DC switch to AC and watch for trace shift on the test scope.

f. ADJUST—R105 for minimum trace shift when switching +Input from GND to AC.

7. Adjust -Input Gate Leakage Current Compensation (R205)

- a. Use the same setup as in step 6.

b. Terminate the 26A2 -Input with a 50 Ω termination.

c. Switch the AC-GND-DC switch to AC and watch for trace shift on the test scope.

d. ADJUST—R205 for minimum trace shift when switching the -Input from GND to AC.

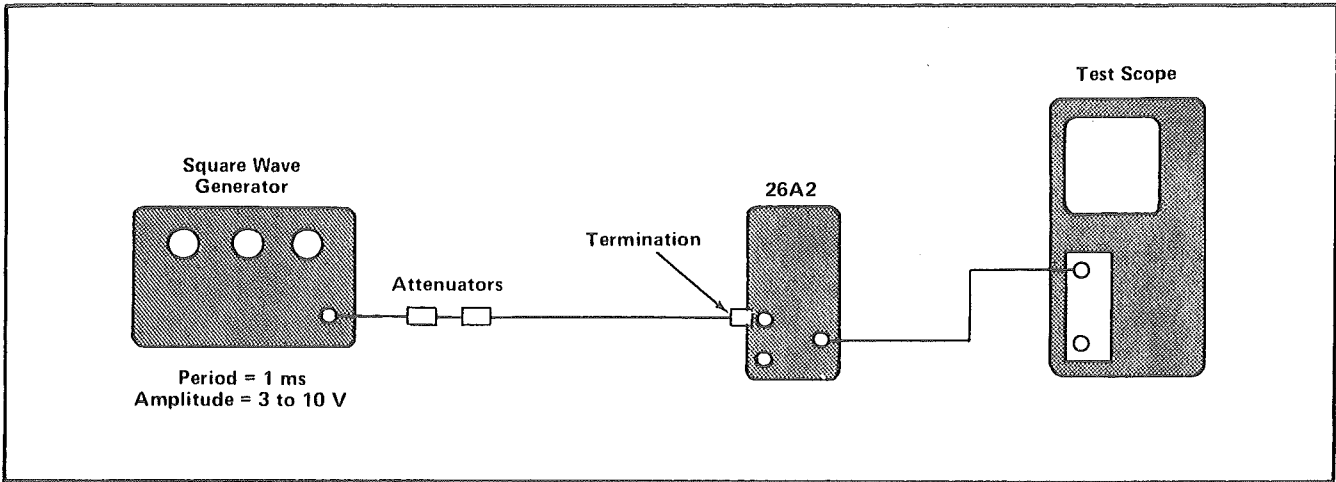


Fig. 5-7. Equipment setup for step 8.

8. Adjust Input Cross Neutralization (C122-C222)

a. Set up the test equipment as illustrated in Fig. 5-7.

b. Set the equipment controls as follows:

26A2

GAIN	100
HF -3 dB POINT	1 MHz
LF -3 dB POINT	DC

Pulse Generator

Period	1 ms (square wave)
Amplitude	3 to 10 volts
Amplitude Variable	Counterclockwise

Test Scope

Vertical deflection factor	1 V/Div
Horizontal deflection factor	1 ms/Div

c. Connect the pulse generator signal through attenuators (as necessary) and a 50 Ω Termination to the 26A2 +Input.

d. Set the pulse generator amplitude to display approximately four divisions on the test scope.

e. Switch the -Input AC-GND-DC switch between GND and DC.

f. ADJUST-C222 for similar display (upper corner of the leading edge), in the DC switch position, as that seen in the GND position.

g. Move the signal to the 26A2 -Input and switch the -Input to DC.

h. Switch the +Input AC-GND-DC switch between GND and DC.

i. ADJUST-C122 for similar display (upper corner of the leading edge) in the DC switch position as that seen in the GND position.

9. Adjust Input Capacitance (C100-C200)

a. Using the same setup as described in step 8, add a 20 pF Normalizer (067-0538-00) between the 50 Ω termination and the 26A2 -Input. Increase the signal amplitude to maintain four divisions of display.

b. ADJUST-C200 (Input Capacitance) for the best upper corner on the leading edge of the displayed square wave.

c. Move the signal source and normalizer to the +Input connector and switch the +Input to DC and -Input to GND.

d. ADJUST-C100 for best upper corner on the leading edge of the displayed square wave.

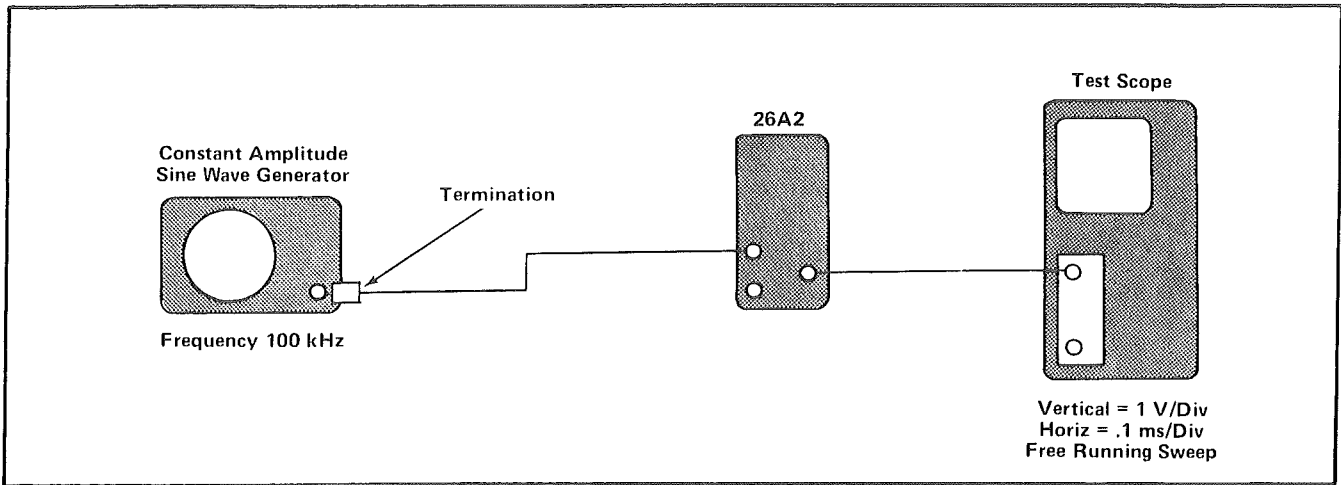


Fig. 5-8. Equipment setup for step 10.

10. Adjust HF -3 dB POINT (C490)

- a. Set up the equipment as illustrated in Fig. 5-8.
- b. Set the equipment controls as follows:

	26A2
GAIN	100
HF -3 dB POINT	1 MHz
LF -3 dB POINT	DC

Constant Amplitude Sine Wave Generator

Frequency	100 kHz
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Test Oscilloscope

Vertical deflection factor	1 V/Div
Horizontal deflection factor	.1 ms/Div free running sweep mode

c. Adjust the sine wave generator amplitude for a display that is an accurate 5 volts peak-to-peak (five divisions on Test Scope).

d. Change the sine wave generator frequency to 1.1 MHz.

e. ADJUST—C490 to set the display amplitude to 3.53 divisions (70.7% of 5 divisions).

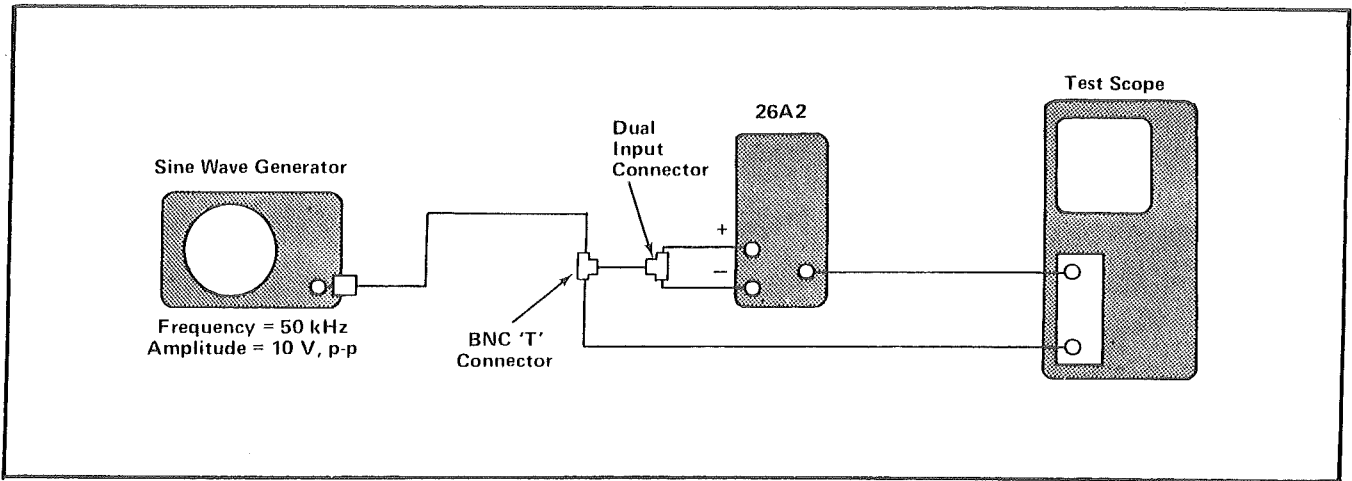


Fig. 5-9. Equipment setup for step 11.

11. Adjust High Frequency CMRR (C150)

a. Set up the equipment as illustrated in Fig. 5-9.

b. Set the equipment controls as follows:

26A2	
GAIN	100
HF -3 dB POINT	1 MHz
LF -3 dB POINT	DC
+Input	DC
-Input	DC

Sine Wave Generator

Frequency	50 kHz
Amplitude	10 volts P-P

c. Connect the sine wave generator output through a dual input connector to the 26A2 + and - Inputs.

d. Observe the 26A2 output with the test oscilloscope, with the test scope vertical deflection factor set to 20 mV/Div, and horizontal sweep rate of 20 μ s/Div.

e. ADJUST—C150 for minimum amplitude displayed on the test scope.

PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	P/O	part of
DE	double end	PHB	pan head brass
dia	diameter	PHS	pan head steel
div	division	plstc	plastic
elect.	electrolytic	PMC	paper, metal cased
EMC	electrolytic, metal cased	poly	polystyrene
EMT	electrolytic, metal tubular	prec	precision
ext	external	PT	paper, tubular
F & I	focus and intensity	PTM	paper or plastic, tubular, molded
FHB	flat head brass	RHB	round head brass
FHS	flat head steel	RHS	round head steel
Fil HB	fillister head brass	SE	single end
Fil HS	fillister head steel	SN or S/N	serial number
h	height or high	S or SW	switch
hex.	hexagonal	TC	temperature compensated
HHB	hex head brass	THB	truss head brass
HHS	hex head steel	thk	thick
HSB	hex socket brass	THS	truss head steel
HSS	hex socket steel	tub.	tubular
ID	inside diameter	var	variable
inc	incandescent	w	wide or width
		WW	wire-wound

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

- | | |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------|
| ×000 | Part first added at this serial number |
| 00× | Part removed after this serial number |
| *000-0000-00 | Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components. |
| Use 000-0000-00 | Part number indicated is direct replacement. |

INDEX OF ELECTRICAL PARTS LIST

Title	Page No.
CHASSIS	6-1
A1 MAIN Circuit Board Assembly	6-2
A2 CAM SWITCH Circuit Board Assembly	6-7
A3 AC-GND-DC SWITCH Circuit Board Assembly	6-11



SECTION 6

ELECTRICAL PARTS LIST

CHASSIS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
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Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

C10 } C20 }	*295-0117-00		0.1 μ F	MT Matched pair
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Bulb

DS50	150-0048-01			Incandescent #683, selected
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Connectors

J1	131-1066-00			Receptacle, electrical, 6 contact
J10	131-0955-00			Receptacle, electrical, BNC, female
J20	131-0955-00			Receptacle, electrical, BNC, female
J50	131-0274-00			BNC, chassis mounted
J51	136-0387-00			Jack, tip
J52	136-0387-00			Jack, tip
J53	136-0387-00			Jack, tip
J54	136-0387-00			Jack, tip
J55	136-0387-00			Jack, tip

Transistors

Q321	151-0324-00	Silicon	PNP	MOT case 77	MJE371
Q345	151-0323-00	Silicon	NPN	MOT case 77	MJE521
Q361	151-0323-00	Silicon	NPN	MOT case 77	MJE521

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R30	311-0889-00		5 k Ω , Var	
R31	311-0887-00		50 k Ω , Var	
R35	311-0467-00		100 k Ω , Var	
R38	311-0169-00		100 Ω , Var	
R40 ¹	311-1158-00		2 k Ω , Var	

¹Furnished as a unit with S40.

CHASSIS (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R55	308-0499-00		0.5 Ω	2.5 W	WW	
R480	321-0289-03		10 kΩ	1/8 W	Prec	1/4%
R481	321-0816-07		5 kΩ	1/8 W	Prec	1/10%
R482	321-0222-03		2 kΩ	1/8 W	Prec	1/4%
R483	321-0193-03		1 kΩ	1/8 W	Prec	1/4%
R484	321-0612-03		500 Ω	1/8 W	Prec	1/4%
R485	321-0126-03		200 Ω	1/8 W	Prec	1/4%
R486	321-0097-03		100 Ω	1/8 W	Prec	1/4%
R487	321-0771-03		50 Ω	1/8 W	Prec	1/4%
R488	321-0030-02		20 Ω	1/8 W	Prec	1/2%
R489	321-0001-01		10 Ω	1/8 W	Prec	1/2%

Switch

Wired or Unwired

S40 ¹					CAL IN
S480	260-1234-00		Rotary		GAIN

A1 MAIN Circuit Board Assembly

*670-1412-00

Complete Board

Capacitors

Tolerance ±20% unless otherwise indicated.

C100	281-0093-00	5.5-18 pF, Var	Cer		
C107	283-0003-02	0.01 μF	Cer	150 V	
C122	281-0093-00	5.5-18 pF, Var	Cer		
C131	281-0544-00	5.6 pF	Cer	500 V	10%
C146	283-0177-01	1 μF	Cer	25 V	+80%—20%
C150	281-0114-00	1.3-5.4 pF, Var	Air		
C164	281-0523-00	100 pF	Cer	350 V	
C176	281-0501-00	4.7 pF	Cer	500 V	±1 pF
C195	281-0518-00	47 pF	Cer	500 V	
C200	281-0093-00	5.5-18 pF, Var			
C207	283-0003-02	0.01 μF	Cer	150 V	
C210	283-0111-01	0.1 μF	Cer	50 V	
C222	281-0093-00	5.5-18 pF, Var	Cer		
C231	281-0544-00	5.6 pF	Cer	500 V	10%
C264	281-0523-00	100 pF	Cer	350 V	

¹Furnished as a unit with R40.

A1 MAIN Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Capacitors (cont)				
C276	281-0501-00		4.7 pF	Cer 500 V ±1 pF
C315	281-0523-00		100 pF	Cer 350 V
C330	290-0135-00		15 μ F	Elect. 20 V
C333	283-0111-01		0.1 μ F	Cer 50 V
C335	283-0111-01		0.1 μ F	Cer 50 V

C341	283-0111-01		0.1 μ F	Cer 50 V
C354	290-0135-00		15 μ F	Elect. 20 V
C355	283-0003-02		0.01 μ F	Cer 150 V
C357	281-0523-00		100 pF	Cer 350 V
C361	290-0135-00		15 μ F	Elect. 20 V
C373	283-0111-01		0.1 μ F	Cer 50 V
C375	283-0111-01		0.1 μ F	Cer 50 V

Semiconductor Device, Diodes

CR108	*152-0323-00		Silicon	Tek Spec
CR131	*152-0185-00		Silicon	Replaceable by 1N4152
CR109	*152-0323-00		Silicon	Tek Spec
CR150	*152-0185-00		Silicon	Replaceable by 1N4152
CR181	*152-0185-00		Silicon	Replaceable by 1N4152
CR208	*152-0323-00		Silicon	Tek Spec
CR209	*152-0323-00		Silicon	Tek Spec
CR231	*152-0185-00		Silicon	Replaceable by 1N4152
CR250	*152-0185-00		Silicon	Replaceable by 1N4152
CR281	*152-0185-00		Silicon	Replaceable by 1N4152
CR310	*152-0185-00		Silicon	Replaceable by 1N4152
CR321	*152-0107-00		Silicon	Replaceable by 1N647
CR327	*152-0185-00		Silicon	Replaceable by 1N4152
CR367	*152-0185-00		Silicon	Replaceable by 1N4152
CR370	*152-0107-00		Silicon	Replaceable by 1N647
VR252	152-0168-00		Zener	1N963A 400 mW, 12 V, 5%
VR310	152-0168-00		Zener	1N963A 400 mW, 12 V, 5%
VR361	152-0243-00		Zener	1N965B 400 mW, 15 V, 5%

Fuses

F100	159-0024-00		1/16A	3AG Fast-Blo
F200	159-0024-00		1/16A	3AG Fast-Blo

A1 MAIN Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
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Inductors

L101	*108-0409-00		17.5 μ H	
L164	*108-0409-00		17.5 μ H	
L201	*108-0409-00		17.5 μ H	
L264	*108-0409-00		17.5 μ H	

Transistors

Q121A,B	*151-1027-00	Silicon	FET	TO-18	Tek Spec, dual
Q131A,B	*151-0261-00	Silicon	PNP	TO-78	Tek Spec, dual
Q136	151-1025-00	Silicon	FET	TO-18	N channel, junction type
Q141A,B	*151-0309-00	Silicon	NPN		Tek Spec, dual
Q145A,B	*151-0261-00	Silicon	PNP	TO-78	Tek Spec, dual
Q152A,B	*153-0586-00	Silicon	NPN	TO-92	2N3904, matched pair
Q162A,B	151-1036-00	Silicon	JFET	TO-71	N channel, dual
Q164A,B	*153-0586-00	Silicon	NPN	TO-92	2N3904, matched pair
Q167	151-0190-00	Silicon	NPN	TO-92	2N3904
Q168	151-0220-00	Silicon	PNP	TO-18	2N4122
Q171A,B	151-1029-00	Silicon	FET	TO-18	N channel, dual
Q181	151-0188-00	Silicon	PNP	TO-92	2N3906
Q185	151-0190-00	Silicon	NPN	TO-92	2N3904
Q195	151-0220-00	Silicon	PNP	TO-18	2N4122
Q196	151-0220-00	Silicon	PNP	TO-18	2N4122
Q236	151-1025-00	Silicon	FET	TO-18	N channel, junction type
Q267	151-0190-00	Silicon	NPN	TO-92	2N3904
Q268	151-0220-00	Silicon	PNP	TO-18	2N4122
Q269	151-0220-00	Silicon	PNP	TO-18	2N4122
Q281	151-0188-00	Silicon	PNP	TO-92	2N3906
Q285	151-0190-00	Silicon	NPN	TO-92	2N3904
Q323	151-0220-00	Silicon	PNP	TO-18	2N4122
Q343	151-0190-00	Silicon	NPN	TO-92	2N3904
Q363	151-0190-00	Silicon	NPN	TO-92	2N3904

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R100	322-0687-07	1.005 M Ω	1/4 W	Prec	1/10%
R103	315-0822-00	8.2 k Ω	1/4 W		5%
RT104	307-0181-00	100 k Ω	Thermal		
R105	311-0607-00	10 k Ω , Var			
R106	317-0107-00	100 M Ω	1/8 W		5%

A1 MAIN Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R107	317-0107-00		100 M Ω	$\frac{1}{8}$ W		5%
R120	316-0470-00		47 Ω	$\frac{1}{4}$ W		
R121	321-0222-09		2 k Ω	$\frac{1}{8}$ W	Prec	1%
R122	315-0512-00		5.1 k Ω	$\frac{1}{4}$ W		5%
R125	321-0114-00		150 Ω	$\frac{1}{8}$ W	Prec	1%
R126	321-0927-07		125 Ω	$\frac{1}{8}$ W	Prec	1/10%
R131	321-0251-00		4.02 k Ω	$\frac{1}{8}$ W	Prec	1%
R136	321-0199-06		1.15 k Ω	$\frac{1}{8}$ W	Prec	$\frac{1}{4}$ %
R137	316-0101-00		100 Ω	$\frac{1}{4}$ W		
R141	321-0813-07		495 Ω	$\frac{1}{8}$ W	Prec	1/10%
R145	321-0353-00		46.4 k Ω	$\frac{1}{8}$ W	Prec	1%
R146	321-0272-00		6.65 k Ω	$\frac{1}{8}$ W	Prec	1%
R152	321-0222-09		2 k Ω	$\frac{1}{8}$ W	Prec	1%
R154	321-0225-06		2.15 k Ω	$\frac{1}{8}$ W	Prec	$\frac{1}{4}$ %
R155	321-0154-00		392 Ω	$\frac{1}{8}$ W	Prec	1%
R157	316-0564-00		560 k Ω	$\frac{1}{4}$ W		
R160	315-0102-00		1 k Ω	$\frac{1}{4}$ W		5%
R161	311-0634-00		500 Ω , Var			
R162	321-0240-00		3.09 k Ω	$\frac{1}{8}$ W	Prec	1%
R164	321-0309-00		16.2 k Ω	$\frac{1}{8}$ W	Prec	1%
R166	321-0143-00		301 Ω	$\frac{1}{8}$ W	Prec	1%
R168	321-0224-00		2.1 k Ω	$\frac{1}{8}$ W	Prec	1%
R170	315-0102-00		1 k Ω	$\frac{1}{4}$ W		5%
R171	321-0277-00		7.5 k Ω	$\frac{1}{8}$ W	Prec	1%
R174	321-1267-03		5.97 k Ω	$\frac{1}{8}$ W	Prec	$\frac{1}{4}$ %
R175	321-0147-00		332 Ω	$\frac{1}{8}$ W	Prec	1%
R176	321-0239-07		3.01 k Ω	$\frac{1}{8}$ W	Prec	1/10%
R178	321-0289-07		10 k Ω	$\frac{1}{8}$ W	Prec	1/10%
R181	321-0187-00		866 Ω	$\frac{1}{8}$ W	Prec	1%
R184	321-0297-00		12.1 k Ω	$\frac{1}{8}$ W	Prec	1%
R185	321-0236-00		2.8 k Ω	$\frac{1}{8}$ W	Prec	1%
R191	311-0613-00		100 k Ω , Var			
R193	316-0474-00		470 k Ω	$\frac{1}{4}$ W		
R195	315-0512-00		5.1 k Ω	$\frac{1}{4}$ W		5%
R196	315-0682-00		6.8 k Ω	$\frac{1}{4}$ W		5%
R198	316-0472-00		4.7 k Ω	$\frac{1}{4}$ W		
R200	322-0687-07		1.005 M Ω	$\frac{1}{4}$ W	Prec	1/10%
RT203	307-0181-00		100 k Ω	Thermal		
R205	311-0607-00		10 k Ω , Var			
R206	317-0107-00		100 M Ω	$\frac{1}{8}$ W		5%

A1 MAIN Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R207	317-0107-00		100 M Ω	$\frac{1}{8}$ W		5%
R210	316-0276-00		27 M Ω	$\frac{1}{4}$ W		
R220	316-0470-00		47 Ω	$\frac{1}{4}$ W		
R221	321-0222-09		2 k Ω	$\frac{1}{8}$ W	Prec	1%
R222	315-0512-00		5.1 k Ω	$\frac{1}{4}$ W		5%
R225	321-0114-00		150 Ω	$\frac{1}{8}$ W	Prec	1%
R226	321-0927-07		125 Ω	$\frac{1}{8}$ W	Prec	1/10%
R231	321-0251-00		4.02 k Ω	$\frac{1}{8}$ W	Prec	1%
R236	321-0199-06		1.15 k Ω	$\frac{1}{8}$ W	Prec	$\frac{1}{4}$ %
R237	316-0101-00		100 Ω	$\frac{1}{4}$ W		
R241	321-0813-07		495 Ω	$\frac{1}{8}$ W	Prec	1/10%
R245	321-0353-00		46.4 k Ω	$\frac{1}{8}$ W	Prec	1%
R246	321-0272-00		6.65 k Ω	$\frac{1}{8}$ W	Prec	1%
R252	321-0222-09		2 k Ω	$\frac{1}{8}$ W	Prec	1%
R254	321-0225-06		2.15 k Ω	$\frac{1}{8}$ W	Prec	$\frac{1}{4}$ %
R255	321-0154-00		392 Ω	$\frac{1}{8}$ W	Prec	1%
R260	315-0102-00		1 k Ω	$\frac{1}{4}$ W		5%
R261	321-0239-07		3.01 k Ω	$\frac{1}{8}$ W	Prec	1/10%
R262	321-0240-00		3.09 k Ω	$\frac{1}{8}$ W	Prec	1%
R264	321-0309-00		16.2 k Ω	$\frac{1}{8}$ W	Prec	1%
R266	321-0143-00		301 Ω	$\frac{1}{8}$ W	Prec	1%
R268	321-0224-00		2.1 k Ω	$\frac{1}{8}$ W	Prec	1%
R269	311-0634-00		500 Ω , Var			
R270	315-0102-00		1 k Ω	$\frac{1}{4}$ W		5%
R271	321-0277-00		7.5 k Ω	$\frac{1}{8}$ W	Prec	1%
R274	321-1267-03		5.97 k Ω	$\frac{1}{8}$ W	Prec	$\frac{1}{4}$ %
R275	321-0147-00		332 Ω	$\frac{1}{8}$ W	Prec	1%
R276	321-0239-07		3.01 k Ω	$\frac{1}{8}$ W	Prec	1/10%
R278	321-0289-07		10 k Ω	$\frac{1}{8}$ W	Prec	1/10%
R284	321-0314-00		18.2 k Ω	$\frac{1}{8}$ W	Prec	1%
R285	321-0236-00		2.8 k Ω	$\frac{1}{8}$ W	Prec	1%
R310	316-0103-00		10 k Ω	$\frac{1}{4}$ W		
R314	316-0470-00		47 Ω	$\frac{1}{4}$ W		
R315	321-0603-07		15 k Ω	$\frac{1}{8}$ W	Prec	1/10%
R316	321-0603-07		15 k Ω	$\frac{1}{8}$ W	Prec	1/10%
R321	307-0093-00		1.2 Ω	$\frac{1}{2}$ W		5%
R323	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R325	315-0152-00		1.5 k Ω	$\frac{1}{4}$ W		5%
R326	315-0752-00		7.5 k Ω	$\frac{1}{4}$ W		5%
R327	315-0242-00		2.4 k Ω	$\frac{1}{4}$ W		5%

A1 MAIN Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R333	316-0100-00		10 Ω	1/4 W		
R335	316-0100-00		10 Ω	1/4 W		
R340	315-0912-00		9.1 k Ω	1/4 W		5%
R341	315-0622-00		6.2 k Ω	1/4 W		5%
R343	315-0102-00		1 k Ω	1/4 W		5%
R345	307-0106-00		4.7 Ω	1/4 W		5%
R350	316-0103-00		10 k Ω	1/4 W		
R354	315-0152-00		1.5 k Ω	1/4 W		5%
R355	321-0243-00		3.32 k Ω	1/8 W	Prec	1%
R356	311-0634-00		500 Ω , Var			
R357	321-0239-07		3.01 k Ω	1/8 W	Prec	1/10%
R361	307-0093-00		1.2 Ω	1/2 W		5%
R362	316-0181-00		180 Ω	1/4 W		
R363	315-0101-00		100 Ω	1/4 W		5%
R365	315-0752-00		7.5 k Ω	1/4 W		5%
R366	315-0152-00		1.5 k Ω	1/4 W		5%
R367	315-0242-00		2.4 k Ω	1/4 W		5%
R373	316-0100-00		10 Ω	1/4 W		
R375	316-0100-00		10 Ω	1/4 W		

Integrated Circuits

U310	156-0071-00		Volt reg, Replaceable by Fairchild μ A723C			
U350	156-0071-00		Volt reg, Replaceable by Fairchild μ A723C			

A2 CAM SWITCH Circuit Board Assembly

*670-1413-00

Complete Board

Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

C431	290-0135-00		15 μ F	Elect.	20 V	
C433	290-0135-00		15 μ F	Elect.	20 V	
C435	290-0135-00		15 μ F	Elect.	20 V	
C443	290-0135-00		15 μ F	Elect.	20 V	
C450	281-0504-00		10 pF	Cer	500 V	10%
C455	281-0504-00		10 pF	Cer	500 V	10%
C470	283-0594-00		0.001 μ F	Mica	100 V	1%
C471	283-0594-00		0.001 μ F	Mica	100 V	1%
C472	285-0809-00		1 μ F	Plastic	50 V	10%
C473	285-0809-00		1 μ F	Plastic	50 V	10%

A2 CAM SWITCH Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Capacitors (cont)						
C490	281-0093-00		5.5-18 pF, Var	Cer		
C491	281-0528-00		82 pF	Cer	500 V	10%
C493	283-0604-00		304 pF	Mica	300 V	2%
C494	283-0594-00		0.001 μ F	Mica	100 V	1%
C495	285-0627-00		0.0033 μ F	PTM	100 V	5%
C496	285-0598-00		0.01 μ F	PTM	100 V	5%
C497	285-0702-00		0.033 μ F	PTM	100 V	5%
C498	285-0703-00		0.1 μ F	PTM	100 V	5%
C499	285-0633-00		0.22 μ F	PTM	100 V	10%
C530	283-0111-01		0.1 μ F	Cer	50 V	
C536	290-0267-00		1 μ F	Elect.	35 V	
C552	281-0511-00		22 pF	Cer	500 V	10%
C560	283-0111-01		0.1 μ F	Cer	50 V	
C561	290-0267-00		1 μ F	Elect.	35 V	
C570	283-0111-01		0.1 μ F	Cer	50 V	
C571	290-0267-00		1 μ F	Elect.	35 V	
C591	283-0111-01		0.1 μ F	Cer	50 V	
C592	283-0111-01		0.1 μ F	Cer	50 V	

Semiconductor Device, Diodes

CR438	*152-0185-00	Silicon	Replaceable by 1N4152
CR441	*152-0185-00	Silicon	Replaceable by 1N4152
CR448	*152-0185-00	Silicon	Replaceable by 1N4152
CR531	*152-0185-00	Silicon	Replaceable by 1N4152
CR546	*152-0185-00	Silicon	Replaceable by 1N4152
CR555	*152-0185-00	Silicon	Replaceable by 1N4152
CR558	*152-0185-00	Silicon	Replaceable by 1N4152
CR561A,B	*153-0029-00	Silicon	1N4152 matched pair
CR571A,B	*153-0029-00	Silicon	1N4152 matched pair
VR438	152-0405-00	Zener	15 V, 1 W
VR448	152-0405-00	Zener	15 V, 1 W

Inductors

L416	276-0507-00	Core, ferramic suppressor
L426	276-0507-00	Core, ferramic suppressor
L445	276-0507-00	Core, ferramic suppressor
L458	276-0507-00	Core, ferramic suppressor

A2 CAM SWITCH Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Transistors				
Q410A,B	*153-0586-00		Silicon	PNP TO-92 2N3906, matched pair
Q416	151-0220-00		Silicon	PNP TO-18 2N4122
Q422A,B	*153-0587-00		Silicon	NPN TO-92 2N3904, matched pair
Q426	151-0190-00		Silicon	NPN TO-92 2N3904
Q431	151-0190-00		Silicon	NPN TO-92 2N3904
Q443	151-0190-00		Silicon	NPN TO-92 2N3904
Q445	151-0220-00		Silicon	PNP TO-18 2N4122
Q451	151-0220-00		Silicon	PNP TO-18 2N4122
Q456	151-0190-00		Silicon	NPN TO-92 2N3904
Q458	151-0220-00		Silicon	PNP TO-18 2N4122
Q501	151-0220-00		Silicon	PNP TO-18 2N4122
Q511	151-0220-00		Silicon	PNP TO-18 2N4122
Q521	151-0220-00		Silicon	PNP TO-18 2N4122
Q532	151-0190-00		Silicon	NPN TO-92 2N3904
Q541	151-0220-00		Silicon	PNP TO-18 2N4122
Q543	151-0260-00		Silicon	NPN TO-39 2N5189
Q555	151-0220-00		Silicon	PNP TO-18 2N4122
Q558	151-0190-00		Silicon	NPN TO-92 2N3904
Q561A,B	*151-0307-00		Silicon	PNP Tek Spec, dual
Q571A,B	*151-0309-00		Silicon	NPN Tek Spec, dual

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R410	321-0068-00	49.9 Ω	$\frac{1}{8}$ W	Prec	1%
R411	321-0068-00	49.9 Ω	$\frac{1}{8}$ W	Prec	1%
R414	315-0680-00	68 Ω	$\frac{1}{4}$ W		5%
R420	308-0498-00	2.94 k Ω	2.5 W	WW	1%
R421	323-0274-00	6.98 k Ω	$\frac{1}{2}$ W	Prec	1%
R422	315-0470-00	47 Ω	$\frac{1}{4}$ W		5%
R423	321-0068-00	49.9 Ω	$\frac{1}{8}$ W	Prec	1%
R424	321-0068-00	49.9 Ω	$\frac{1}{8}$ W	Prec	1%
R431	321-0182-00	768 Ω	$\frac{1}{8}$ W	Prec	1%
R433	321-0179-00	715 Ω	$\frac{1}{8}$ W	Prec	1%
R435	321-0233-00	2.61 k Ω	$\frac{1}{8}$ W	Prec	1%
R436	316-0472-00	4.7 k Ω	$\frac{1}{4}$ W		
R438	316-0222-00	2.2 k Ω	$\frac{1}{4}$ W		
R440	321-0268-00	6.04 k Ω	$\frac{1}{8}$ W	Prec	1%
R441	321-0247-00	3.65 k Ω	$\frac{1}{8}$ W	Prec	1%
R442	321-0400-00	143 k Ω	$\frac{1}{8}$ W	Prec	1%
R443	316-0471-00	470 Ω	$\frac{1}{4}$ W		
R445	321-0218-00	1.82 k Ω	$\frac{1}{8}$ W	Prec	1%
R446	316-0472-00	4.7 k Ω	$\frac{1}{4}$ W		
R448	316-0222-00	2.2 k Ω	$\frac{1}{4}$ W		

A2 CAM SWITCH Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R450	316-0222-00		2.2 kΩ	1/4 W		
R451	316-0101-00		100 Ω	1/4 W		
R455	316-0222-00		2.2 kΩ	1/4 W		
R456	316-0103-00		10 kΩ	1/4 W		
R458	316-0333-00		33 kΩ	1/4 W		
R460	321-0229-00		2.37 kΩ	1/8 W	Prec	1%
R461	311-0605-00		200 Ω, Var			
R462	321-0229-00		2.37 kΩ	1/8 W	Prec	1%
R464	321-0204-00		1.3 kΩ	1/8 W	Prec	1%
R466	316-0105-00		1 MΩ	1/4 W		
R470	301-0165-00		1.6 MΩ	1/2 W		5%
R471	301-0165-00		1.6 MΩ	1/2 W		5%
R474	321-0408-00		174 kΩ	1/8 W	Prec	1%
R475	321-0408-00		174 kΩ	1/8 W	Prec	1%
R478	321-0303-00		14 kΩ	1/8 W	Prec	1%
R479	321-0303-00		14 kΩ	1/8 W	Prec	1%
R501	316-0225-00		2.2 MΩ	1/4 W		
R503	321-0452-00		499 kΩ	1/8 W	Prec	1%
R504	321-0423-00		2.49 kΩ	1/8 W	Prec	1%
R507	316-0473-00		47 kΩ	1/4 W		
R510	316-0104-00		100 kΩ	1/4 W		
R511	316-0104-00		100 kΩ	1/4 W		
R513	316-0104-00		100 kΩ	1/4 W		
R521	316-0276-00		27 MΩ	1/4 W		
R523	321-0423-00		249 kΩ	1/8 W	Prec	1%
R524	321-0452-00		499 kΩ	1/8 W	Prec	1%
R527	316-0104-00		100 kΩ	1/4 W		
R531	316-0224-00		220 kΩ	1/4 W		
R532	316-0103-00		10 kΩ	1/4 W		
R533	316-0103-00		10 kΩ	1/4 W		
R536	316-0104-00		100 kΩ	1/4 W		
R541	316-0681-00		680 Ω	1/4 W		
R542	316-0103-00		10 kΩ	1/4 W		
R546	315-0111-00		110 Ω	1/4 W		5%
R547	315-0301-00		300 Ω	1/4 W		5%
R550	315-0682-00		6.8 kΩ	1/4 W		5%
R551	315-0153-00		15 kΩ	1/4 W		5%
R552	316-0102-00		1 kΩ	1/4 W		
R553	315-0682-00		6.8 kΩ	1/4 W		5%
R555	315-0302-00		3 kΩ	1/4 W		5%
R558	315-0302-00		3 kΩ	1/4 W		5%
R559	315-0202-00		2 kΩ	1/4 W		5%
R560	316-0101-00		100 Ω	1/4 W		

A2 CAM SWITCH Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R561	315-0181-00		180 Ω	1/4 W		5%
R562	307-0104-00		3.3 Ω	1/4 W		5%
R570	316-0101-00		100 Ω	1/4 W		
R571	315-0181-00		180 Ω	1/4 W		5%
R572	307-0104-00		3.3 Ω	1/4 W		5%
R575	321-0612-03		500 Ω	1/8 W	Prec	1/4 %
R576	321-0750-06		55.5 Ω	1/8 W	Prec	1/4 %
R579	308-0499-00		0.5 Ω	2.5 W	WW	
R591	316-0100-00		10 Ω	1/4 W		
R592	316-0100-00		10 Ω	1/4 W		

Switches

Wired or Unwired

S10A ¹	*670-1413-00	Cam	LF-3 dB point
S20A ¹	*670-1413-00	Cam	HF-3 dB point

A3 AC-GND-DC SWITCH Circuit Board Assembly (2)

*670-1414-00

Complete Board

Bulbs

DS10	*150-0048-01	Incandescent #683, selected
DS20	*150-0048-01	Incandescent #683, selected

ResistorsResistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R10	315-0105-00	1 M Ω	1/4 W	5%
R20	315-0105-00	1 M Ω	1/4 W	5%

Switches

Wired or Unwired

S470 ¹	*670-1414-00	Pushbutton	AC-GND-DC
S490 ¹	*670-1414-00	Pushbutton	AC-GND-DC

¹See Mechanical Parts List for replacement parts.



SECTION 7

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

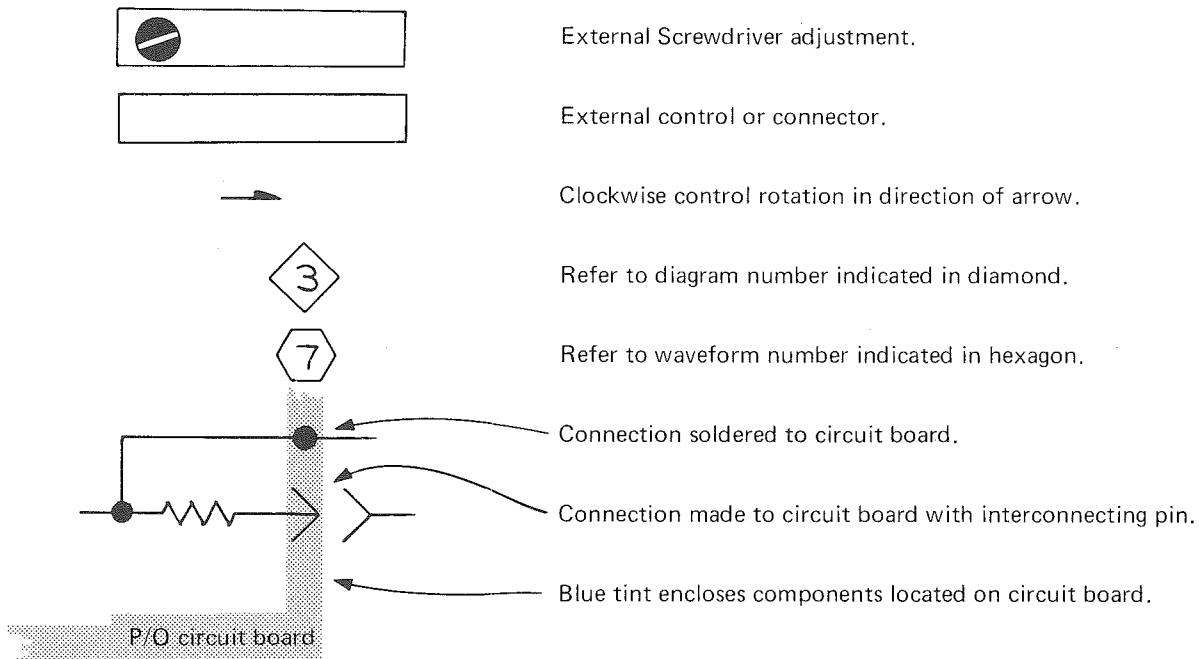
Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors =	Values one or greater are in picofarads (pF).
	Values less than one are in microfarads (μ F).
Resistors =	Ohms (Ω)

Symbols used on the diagrams are based on USA Standard Y32.2-1967.

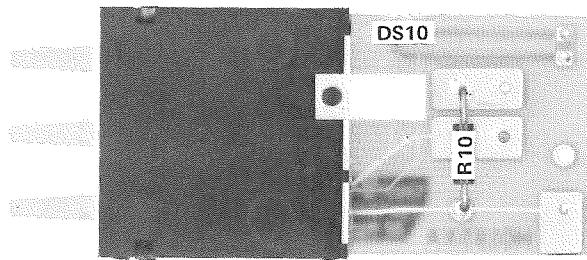
Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following special symbols are used on the diagrams:

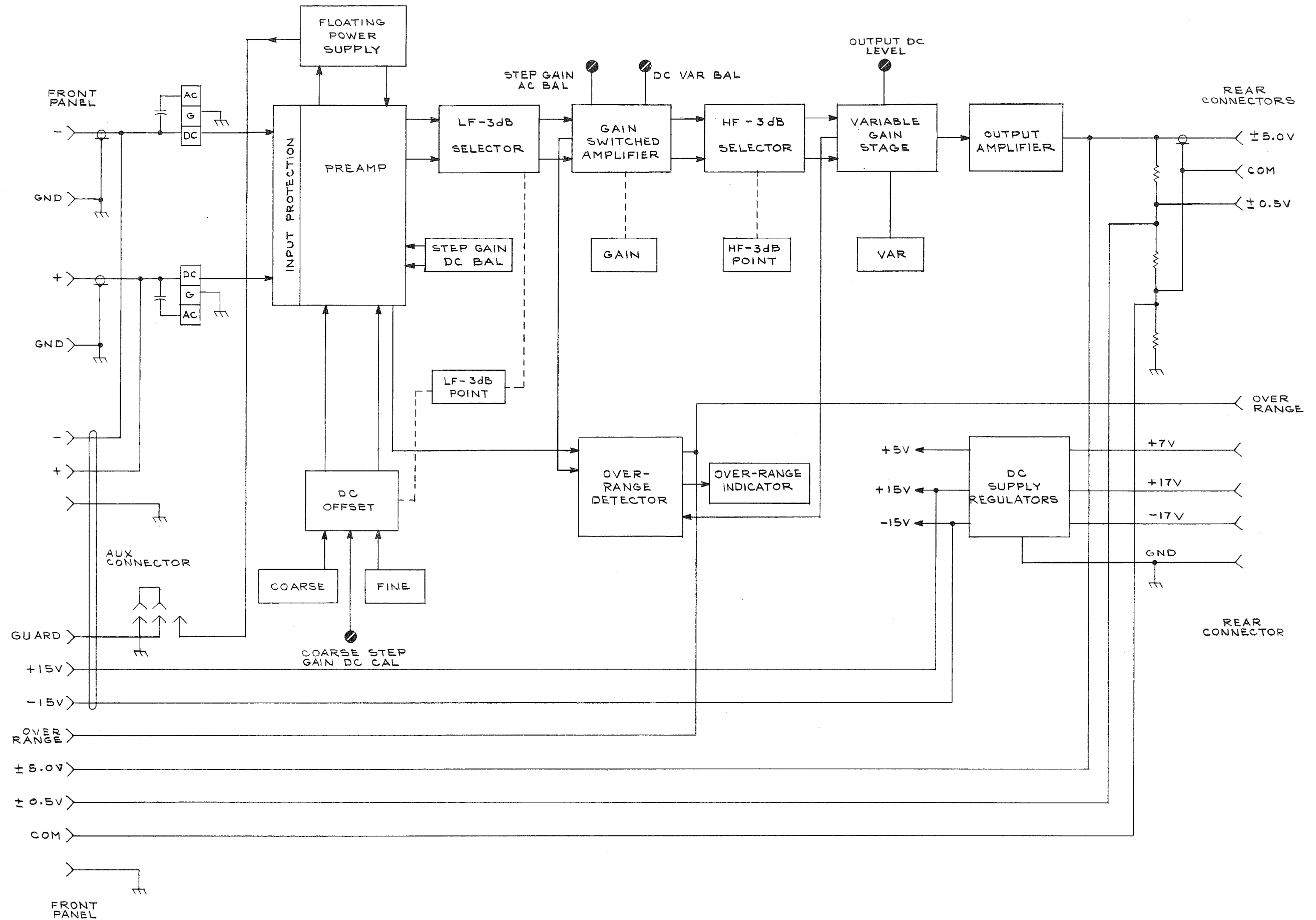


The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

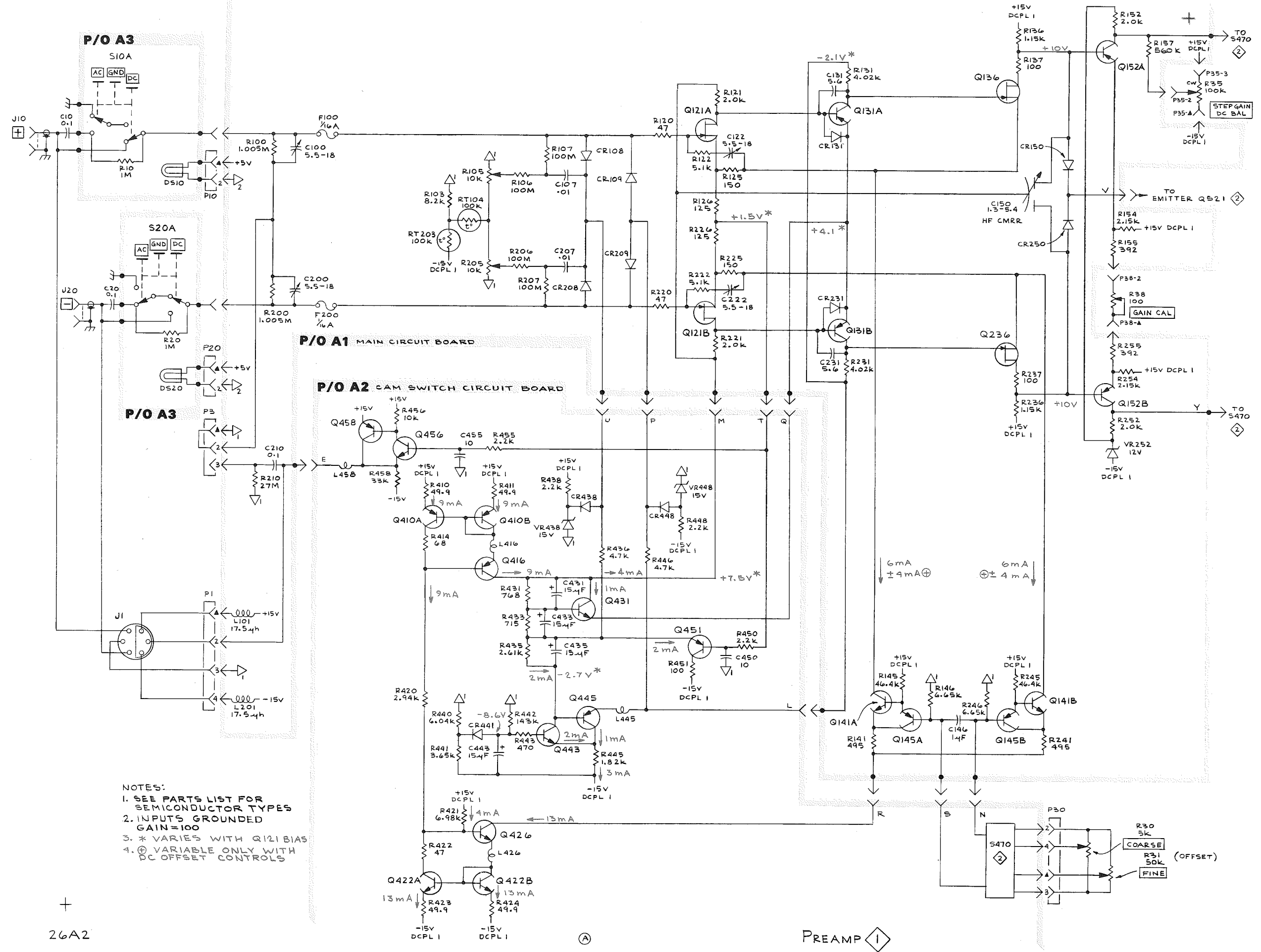
A	Assembly, separable or repairable (circuit board, etc.)	LR	Inductor/resistor combination
AT	Attenuator, fixed or variable	M	Meter
B	Motor	Q	Transistor or silicon-controlled rectifier
BT	Battery	P	Connector, movable portion
C	Capacitor, fixed or variable	R	Resistor, fixed or variable
CR	Diode, signal or rectifier	RT	Thermistor
DL	Delay line	S	Switch
DS	Indicating device (lamp)	T	Transformer
F	Fuse	TP	Test point
FL	Filter	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
H	Heat dissipating device (heat sink, heat radiator, etc.)	V	Electron tube
HR	Heater	VR	Voltage regulator (zener diode, etc.)
J	Connector, stationary portion	Y	Crystal
K	Relay		
L	Inductor, fixed or variable		



A3. Input Coupling



BLOCK DIAGRAM



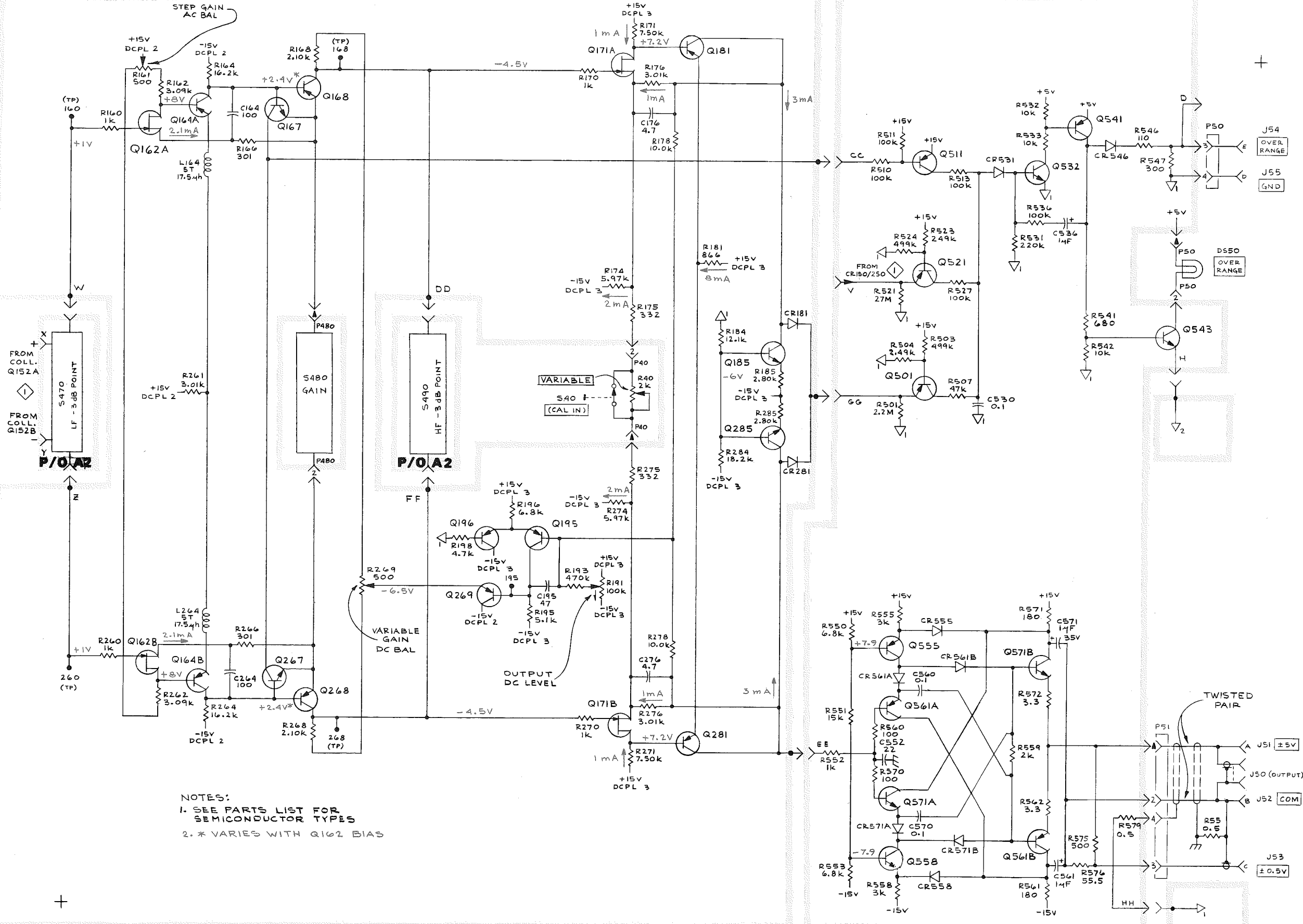
- NOTES:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
 2. INPUTS GROUNDED GAIN = 100
 3. * VARIES WITH Q121 BIAS
 4. ⊕ VARIABLE ONLY WITH DC OFFSET CONTROLS

26A2

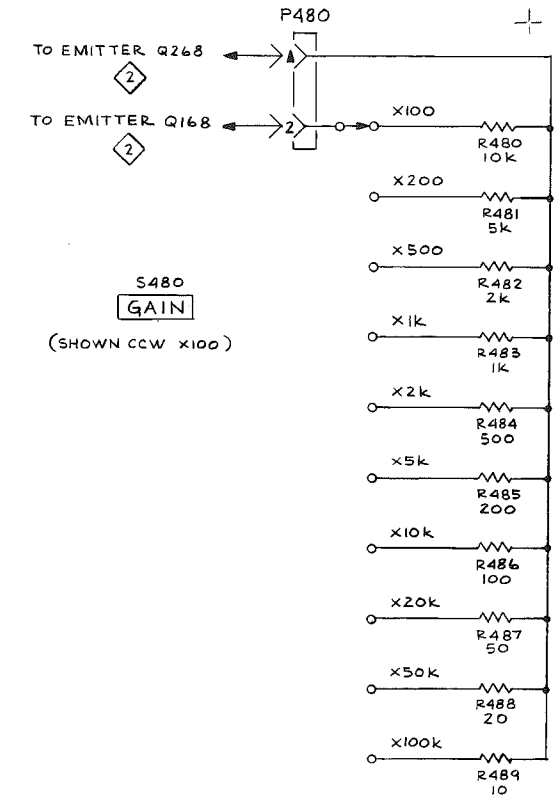
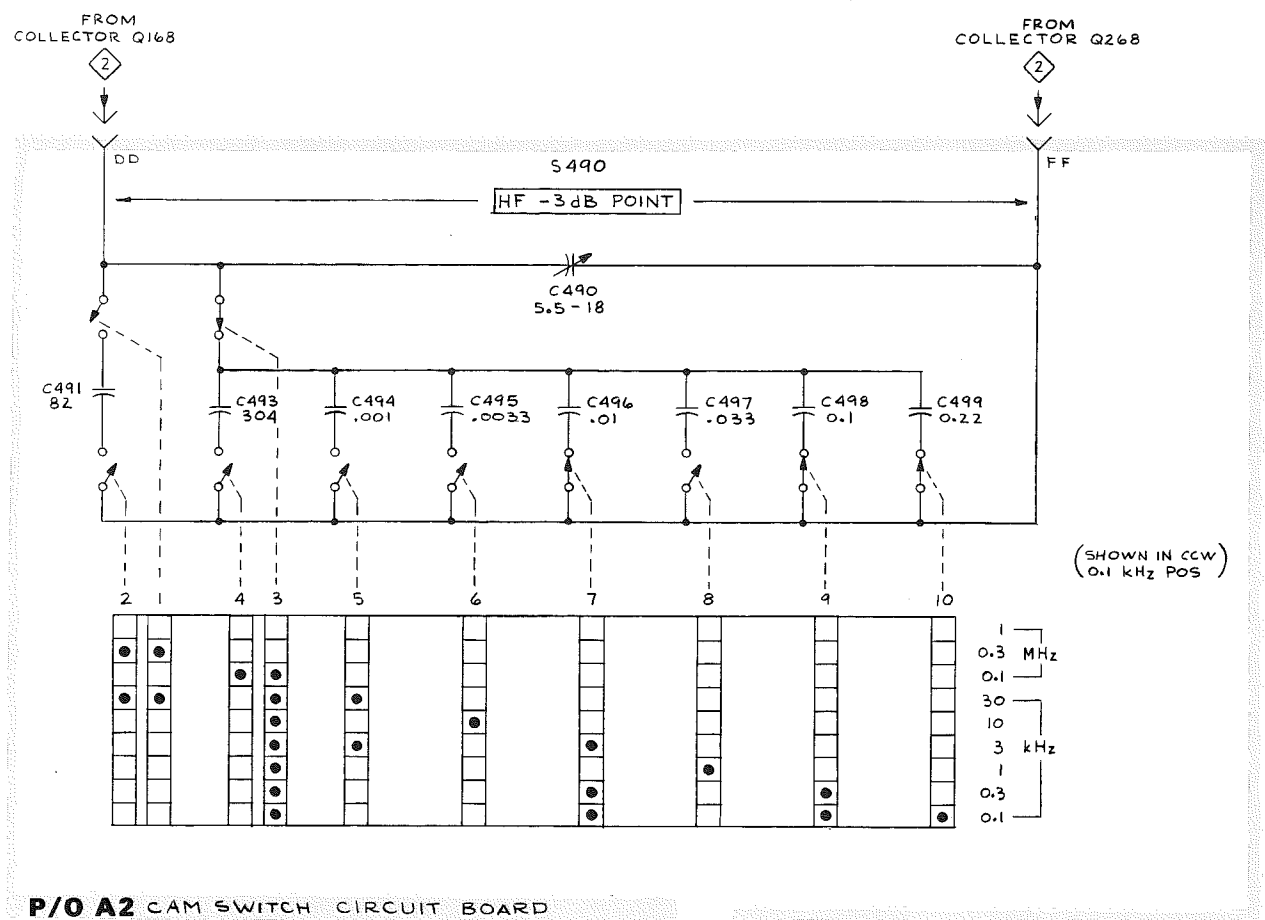
PREAMP 1

P/O A1 MAIN CIRCUIT BOARD

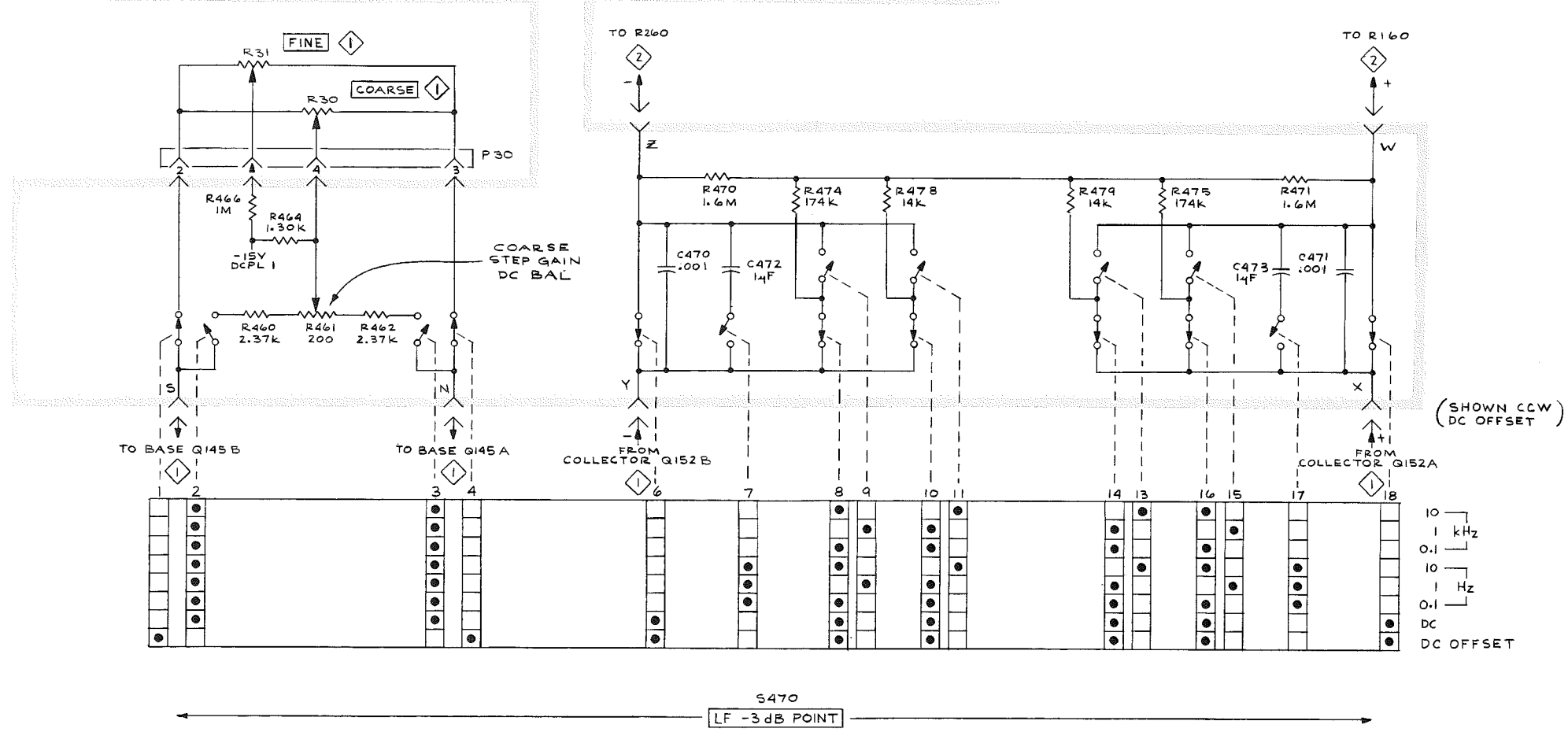
P/O A2 CAM SWITCH CIRCUIT BOARD

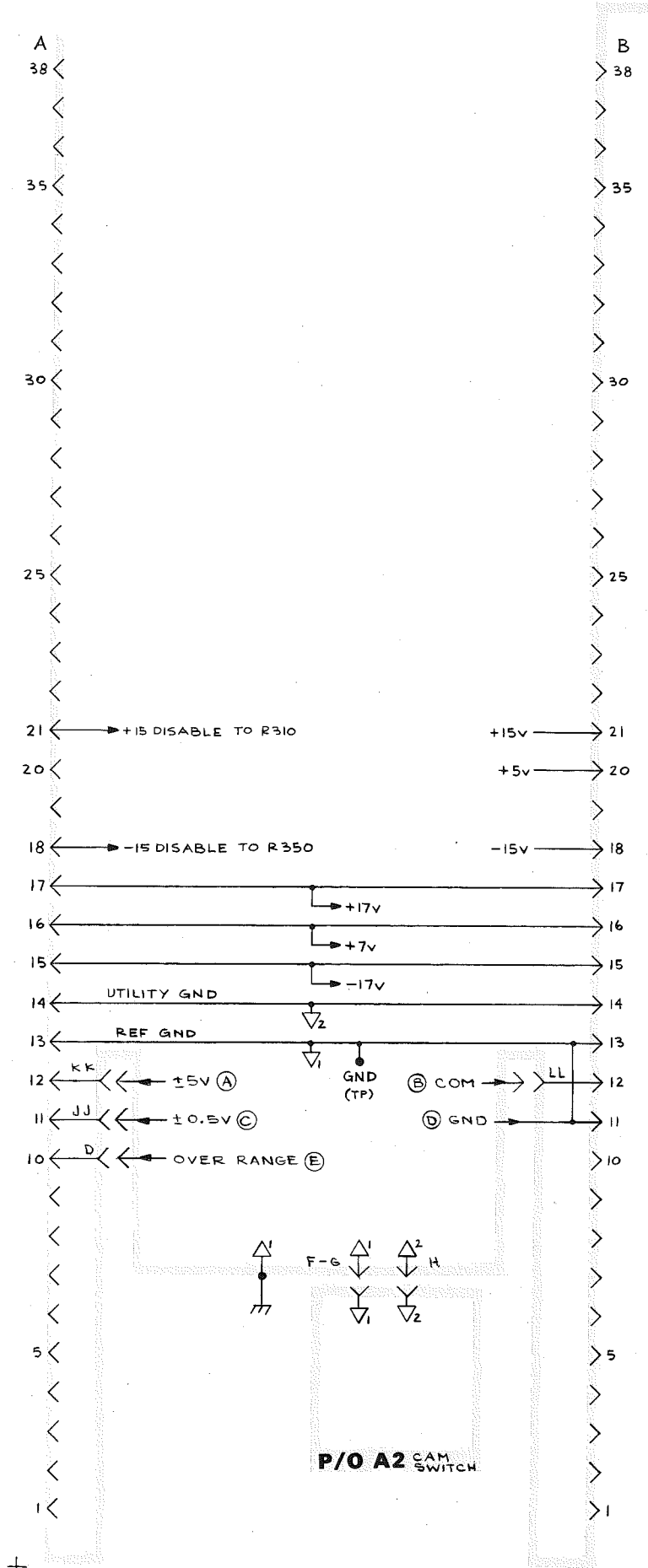


NOTES:
 1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
 2. * VARIES WITH Q162 BIAS

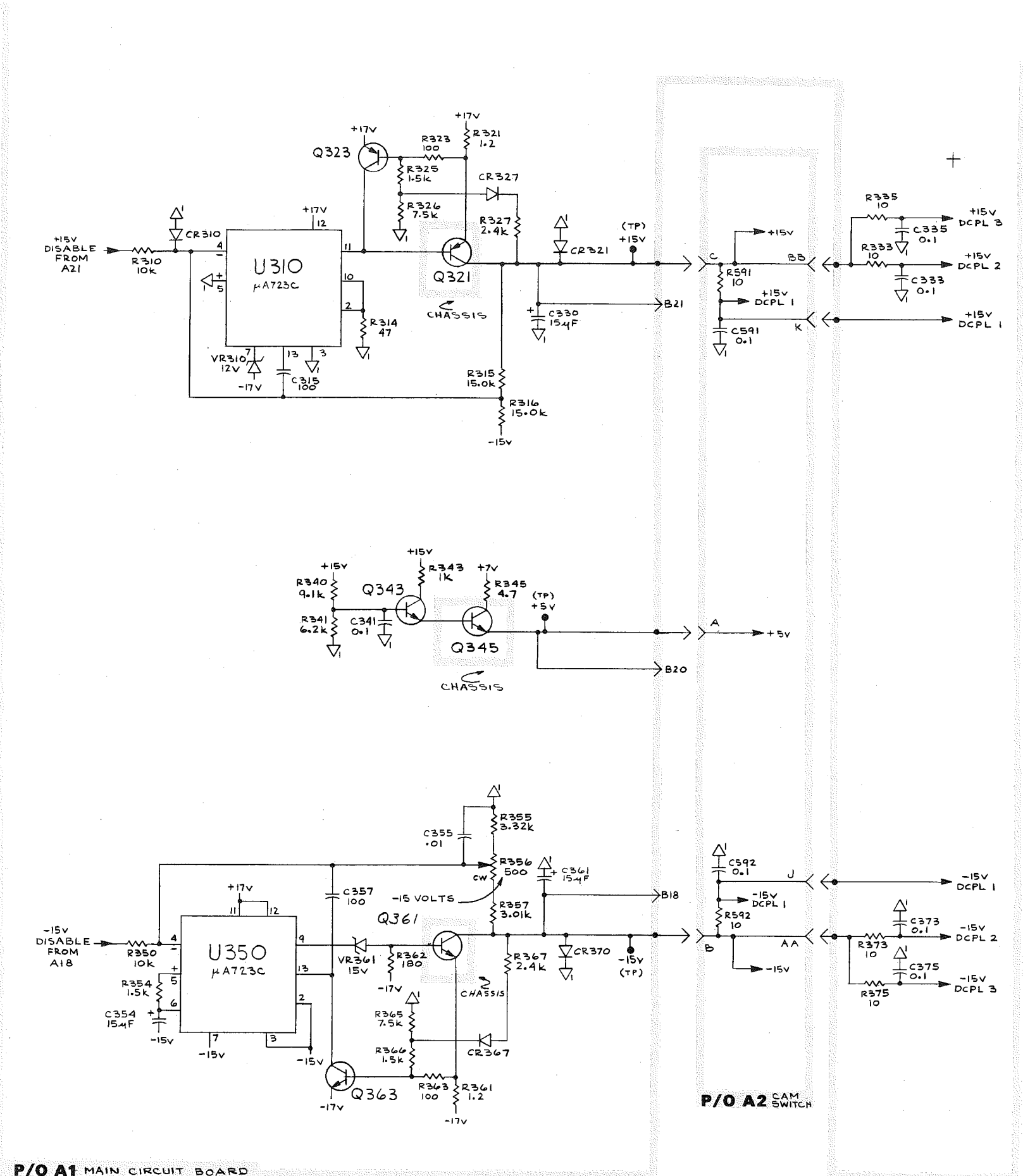


P/O A2 CAM SWITCH CIRCUIT BOARD





26A2



P/O A1 MAIN CIRCUIT BOARD

P/O A2 CAM SWITCH

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PLUG-IN CONNECTORS & POWER SUPPLY 4

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
Detail Part of Assembly and/or Component
mounting hardware for Detail Part
Parts of Detail Part
mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

INDEX OF MECHANICAL PARTS LIST & ILLUSTRATIONS

Title	Page Nos. of Parts List
FIGURE 1 EXPLODED & STANDARD ACCESSORIES	8-1 thru 8-5
FIGURE 2 REPACKAGING.....	<i>(parts list combined with illustration)</i>

SECTION 8

MECHANICAL PARTS LIST

FIGURE 1 EXPLODED & STANDARD ACCESSORIES

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q						Description
				y	1	2	3	4	5	
1-1	366-1168-00			1						KNOB, red—VARIABLE (CAL IN)
	- - - - -			-						knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-2	366-1057-00			1						KNOB, gray—GAIN
	- - - - -			-						knob includes:
	213-0153-00			2						SETSCREW, 5-40 x 0.125 inch, HSS
-3	366-1036-01			1						KNOB, gray—STEP GAIN DC BAL
-4	366-0379-00			2						KNOB, gray—POINT (HF & LF)
	- - - - -			-						each knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-5	366-1101-00			1						KNOB, gray—OFFSET (FINE)
	- - - - -			-						knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-6	366-1084-00			1						KNOB, gray—OFFSET (COARSE)
	- - - - -			-						knob includes:
	213-0140-00			1						SETSCREW, 2-56 x 0.093 inch, HSS
-7	358-0378-00			3						BUSHING, sleeve, front panel trim
-8	366-1058-27			1						KNOB, latch
	- - - - -			-						mounting hardware: (not included w/knob)
-9	214-1095-00			1						PIN, spring, split
-10	105-0076-00			1						RELEASE BAR, latch
-11	214-1280-00			1						SPRING, helical compression
-12	214-1054-00			1						SPRING, flat, latch detent
-13	105-0075-00			1						BOLT, latch, plastic
-14	348-0235-00			2						SHIELDING GASKET, electrical
-15	333-1415-00			1						PANEL, front
-16	358-0216-00			1						BUSHING, plastic, 0.25 inch diameter
-17	131-0955-00			2						CONNECTOR, receptacle, BNC, w/hardware
	- - - - -			-						mounting hardware for each: (not included w/connector)
-18	210-0255-00			1						LUG, solder, 0.375 inch diameter, SE
-19	131-0274-00			1						CONNECTOR, BNC, insulated, w/hardware
-20	131-1066-00			1						CONNECTOR, receptacle, 6 contact, w/hardware
-21	136-0387-00			5						JACK, tip, gray
-22	200-0935-00			1						CAP, lamp holder
-23	378-0602-01			1						LENS, indicator light
-24	352-0157-00			1						HOLDER, lamp
-25	386-1447-52			1						SUBPANEL, front
	- - - - -			-						mounting hardware: (not included w/subpanel)
-26	213-0192-00			4						SCREW, thread forming, 6-32 x 0.50 inch, Fil SS

FIGURE 1 EXPLODED & STANDARD ACCESSORIES (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q	Description
1-27	337-1426-00			1	SHIELD, electrical output
	- - - - -			-	mounting hardware: <i>(not included w/shield)</i>
-28	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-29	210-0202-00			1	LUG, solder, SE #6
-30	385-0122-00			1	ROD, hex., 6-32 tap both ends
	- - - - -			-	mounting hardware: <i>(not included w/rod)</i>
-31	211-0538-00			1	SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-32	210-0202-00			1	LUG, solder, SE #6
-33	385-0122-00			1	ROD, hex., 6-32 tap both ends
	- - - - -			-	mounting hardware: <i>(not included w/rod)</i>
-34	211-0538-00			1	SCREW, 6-32 x 0.312 inch, 100° csk, FHS
-35	210-0006-00			2	WASHER, lock, internal, 0.146 ID x 0.283 inch OD
-36	- - - - -			1	RESISTOR, variable, w/hardware
	- - - - -			-	mounting hardware: <i>(not included w/resistor)</i>
-37	211-0111-00			2	SCREW, 2-56 x 1 inch, PHS
-38	210-0001-00			2	WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-39	426-0474-00			2	MOUNT, plastic
-40	- - - - -			2	SPACER, sleeve, 0.095 ID x 0.125 OD x 0.25 inch long
-41	105-0296-00			1	BRAKE, shaft
-42	- - - - -			2	SPACER, shaft, 0.438 inch long
-43	386-1095-00			1	PLATE, mounting
-44	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: <i>(not included w/resistor)</i>
-45	210-0583-00			2	NUT, hex., 0.25-32 x 0.312 inch
-46	210-0940-00			1	WASHER, flat, 0.25 ID x 0.375 inch OD
-47	210-0046-00			2	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-48	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: <i>(not included w/resistor)</i>
	213-0020-00			1	SETSCREW, 6-32 x 0.125 inch, HSS
-49	- - - - -			2	RESISTOR, variable
	- - - - -			-	mounting hardware for each: <i>(not included w/resistor)</i>
-50	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-51	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD
-52	260-1234-00			1	SWITCH, rotary—GAIN, unwired
	- - - - -			-	mounting hardware: <i>(not included w/switch)</i>
-53	210-0413-00			1	NUT, hex., 0.375-32 x 0.50 inch
-54	210-0012-00			1	WASHER, lock, internal, 0.375 ID x 0.50 inch OD

FIGURE 1 EXPLODED & STANDARD ACCESSORIES (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q						Description
				†	Y	1	2	3	4	
1-55	407-0913-00			1						BRACKET, component mounting
	- - - - -			-						mounting hardware: <i>(not included w/bracket)</i>
-56	211-0101-00			2						SCREW, 4-40 x 0.25 inch, 100° csk, FHS
	-57	200-1211-00		1						COVER, circuit board
	- - - - -			-						mounting hardware: <i>(not included w/cover)</i>
-58	211-0116-00			1						SCREW, sems, 4-40 x 0.312 inch, PHB
	-59	- - - - -		3						TRANSISTOR
	- - - - -			-						mounting hardware for each: <i>(not included w/transistor)</i>
-60	211-0038-00			1						SCREW, 4-40 x 0.312 inch, 100° csk, FHS
-61	210-0921-00			1						WASHER, mica, 0.125 ID x 0.50 inch OD
-62	210-1122-00			1						WASHER, lock, dished, 0.12 ID x 0.375 inch OD
-63	210-0406-00			1						NUT, hex., 4-40 x 0.188 inch
	-64	337-1316-00		2						SHIELD, electrical, side
	-65	384-0324-00		1						ROD, extension, 3.757 inches long
	- - - - -			-						mounting hardware: <i>(not included w/rod)</i>
		213-0075-00		1						SETSCREW, 4-40 x 0.094 inch, HSS
	-66	384-0131-00		1						ROD, extension, 6.688 inches long
	- - - - -			-						mounting hardware: <i>(not included w/rod)</i>
		213-0075-00		1						SETSCREW, 4-40 x 0.094 inch, HSS
	-67	384-1072-00		1						SHAFT, extension, 4.175 inches long
	-68	376-0051-00		1						COUPLING, flexible
	- - - - -			-						coupling includes:
		213-0048-00		4						SETSCREW, 4-40 x 0.125 inch, HSS
		354-0251-00		2						RING, coupling
		376-0049-00		1						COUPLING, plastic
	-69	384-1071-00		1						SHAFT, extension, 8.10 inches long
	-70	670-1414-00		2						CIRCUIT BOARD ASSEMBLY, switch—AC GND DC (+ & -)
	- - - - -			-						mounting hardware for each: <i>(not included w/circuit board assembly)</i>
	-71	211-0156-00		2						SCREW, 1-72 x 0.25 inch, 82° csk, FHS
	-72	426-0628-00		1						FRAME SECTION, bottom
	-73	426-0747-00		1						FRAME SECTION, top
	-74	214-1061-00		1						SPRING, flat, sliding ground
	-75	386-1402-00		1						PANEL, rear
	- - - - -			-						mounting hardware: <i>(not included w/panel)</i>
	-76	213-0192-00		4						SCREW, thread forming, 6-32 x 0.50 inch, Fil HS

FIGURE 1 EXPLODED & STANDARD ACCESSORIES (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q	t	y	1	2	3	4	5	Description
1-77	670-1412-00			1								CIRCUIT BOARD ASSEMBLY—MAIN A1
	- - - - -			-								circuit board assembly includes:
	388-1967-00			1								CIRCUIT BOARD
-78	131-0590-00			35								TERMINAL, pin, 0.710 inch long
-79	131-0608-00			22								TERMINAL, pin, 0.365 inch long
	136-0252-04			42								SOCKET, pin connector
-80	136-0235-00			9								SOCKET, transistor, 6 pin
-81	136-0269-00			2								SOCKET, integrated circuit, 14 pin
-82	214-0579-00			10								PIN, test point
-83	344-0154-00			4								CLIP, electrical, fuse
-84	214-1140-00			4								SPRING, helical compression
-85	351-0188-00			4								GUIDE-POST, lock, 0.65 inch long
-86	385-0107-00			1								ROD, plastic
	- - - - -			-								mounting hardware: <i>(not included w/rod)</i>
-87	211-0116-00			1								SCREW, sems, 4-40 x 0.312 inch, PHB
	- - - - -			-								mounting hardware: <i>(not included w/circuit board assembly)</i>
-88	344-0210-00			1								CLIP, spring tension, top
-89	344-0211-00			2								CLIP, spring tension, bottom
-90	670-1413-00			1								CIRCUIT BOARD ASSEMBLY—CAM SWITCH A2
	- - - - -			-								circuit board assembly includes:
	388-1968-00			1								CIRCUIT BOARD
-91	131-0604-00			26								CONTACT, electrical
-92	131-0608-00			12								TERMINAL, pin, 0.365 inch long
	214-0579-00			1								PIN, test point
	136-0252-04			48								SOCKET, pin connector
-93	136-0235-00			4								SOCKET, transistor, 6 pin
-94	136-0263-03			35								SOCKET, pin terminal
-95	211-0155-00			4								SCREW, relieved shank, 4-40 x 0.375 inch
-96	361-0238-00			4								SPACER, sleeve, 0.345 inch long
	105-0260-00			1								ACTUATOR ASSEMBLY, cam switch—LF
	- - - - -			-								actuator assembly includes:
-97	200-1219-00			1								COVER, cam switch
	- - - - -			-								mounting hardware: <i>(not included w/cover)</i>
-98	211-0079-00			2								SCREW, 2-56 x 0.188 inch, PHS
-99	210-0001-00			2								WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-100	210-0405-00			2								NUT, hex., 2-56 x 0.188 inch
-101	354-0219-00			1								RING, retaining
-102	401-0058-00			1								BEARING, front
	- - - - -			-								mounting hardware: <i>(not included w/bearing)</i>
-103	210-0591-00			2								NUT, hex., 4-40 x 0.188 inch
-104	407-0714-00			1								BRACKET, grounding
-105	214-1127-00			1								ROLLER, detent
-106	214-1139-00 ¹			-								SPRING, flat, gold
	214-1139-02 ¹			-								SPRING, flat, green
	214-1139-03 ¹			-								SPRING, flat, red
-107	401-0061-00			1								BEARING, rear
	- - - - -			-								mounting hardware: <i>(not included w/bearing)</i>
	210-0591-00			2								NUT, hex., 4-40 x 0.188 inch

¹Replace only with part bearing the same color code as the original part in your instrument.

FIGURE 1 EXPLODED & STANDARD ACCESSORIES (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-108	105-0246-00			1	DRUM, cam switch
	- - - - -			-	mounting hardware: <i>(not included w/actuator assembly)</i>
-109	211-0116-00			4	SCREW, sems, 4-40 x 0.312 inch, PHB
-110	131-0840-00			2	CONTACT, electrical, grounding
	105-0261-00			1	ACTUATOR ASSEMBLY, cam switch—HF
	- - - - -			-	actuator assembly includes:
-111	200-0995-00			1	COVER, cam switch
	- - - - -			-	mounting hardware: <i>(not included w/cover)</i>
-112	211-0079-00			2	SCREW, 2-56 x 0.188 inch, PHS
-113	210-0001-00			2	WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-114	210-0405-00			2	NUT, hex., 2-56 x 0.188 inch
-115	354-0219-00			1	RING, retaining
-116	401-0058-00			1	BEARING, front
	- - - - -			-	mounting hardware: <i>(not included w/bearing)</i>
-117	210-0591-00			2	NUT, hex., 4-40 x 0.188 inch
-118	407-0714-00			1	BRACKET, grounding
-119	214-1127-00			1	ROLLER, detent
-120	214-1139-00 ¹			-	SPRING, flat, gold
	214-1139-02 ¹			-	SPRING, flat, green
	214-1139-03 ¹			-	SPRING, flat, red
-121	401-0061-00			1	BEARING, rear
	- - - - -			-	mounting hardware: <i>(not included w/bearing)</i>
	210-0591-00			2	NUT, hex., 4-40 x 0.188 inch
-122	105-0109-00			1	DRUM, cam switch
	- - - - -			-	mounting hardware: <i>(not included w/actuator assembly)</i>
-123	211-0116-00			4	SCREW, sems, 4-40 x 0.312 inch, PHB
-124	175-0827-00			ft	WIRE, electrical, 4 wire ribbon, 4.375 inches long
-125	131-0707-00			32	CONNECTOR, terminal
	131-0708-00			1	CONNECTOR, terminal
-126	352-0169-00			3	HOLDER, terminal connector, 2 wire <i>(black)</i>
-127	352-0161-00			2	HOLDER, terminal connector, 3 wire <i>(black)</i>
-128	352-0162-00			4	HOLDER, terminal connector, 4 wire <i>(black)</i>

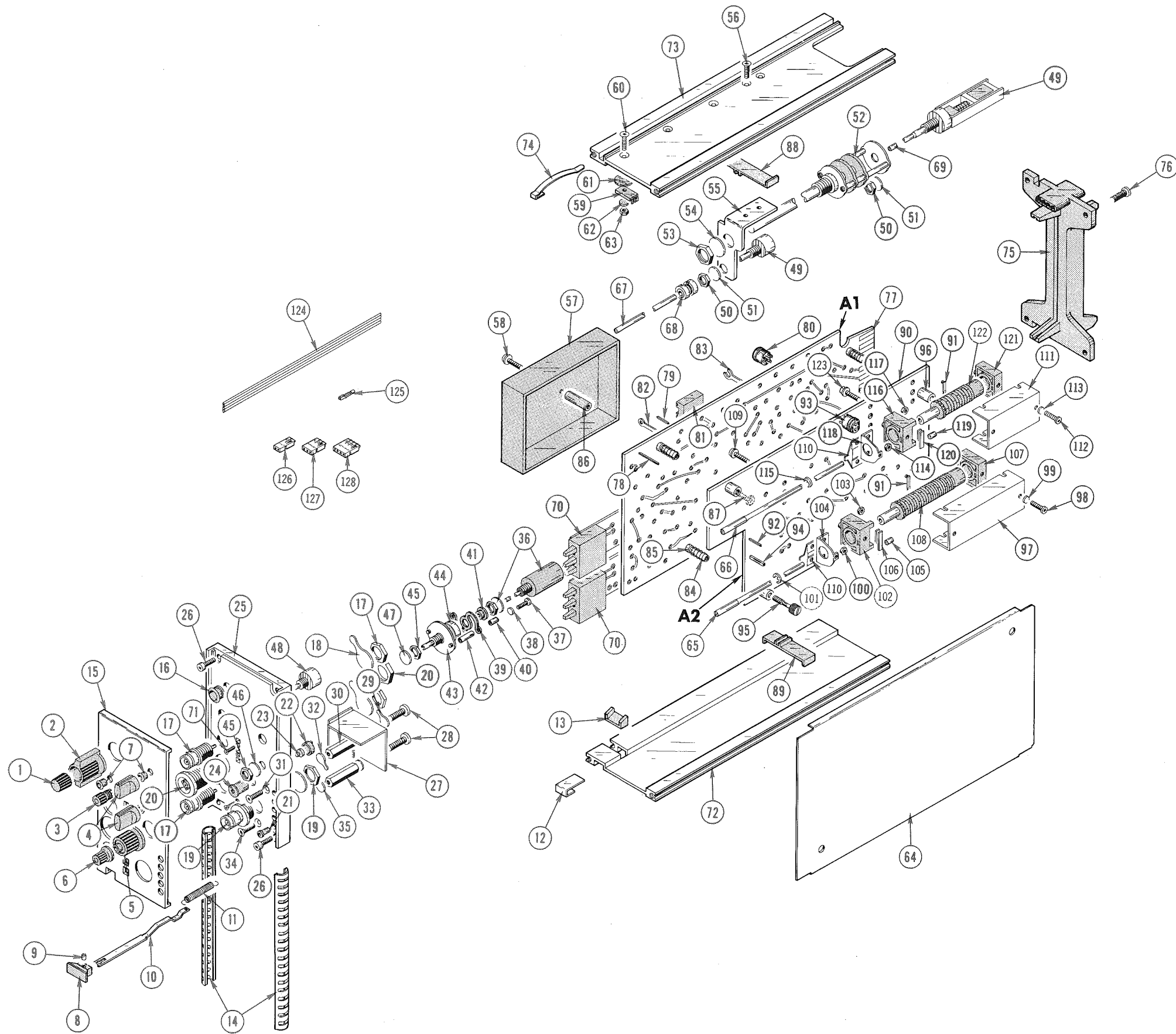
STANDARD ACCESSORIES

070-1119-00	1	MANUAL, instruction <i>(not shown)</i>
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¹Replace only with part bearing the same color code as the original part in your instrument.



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26A2 DIFFERENTIAL AMPLIFIER

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CARTON ASSEMBLY
(Part No. 065-0138-00)

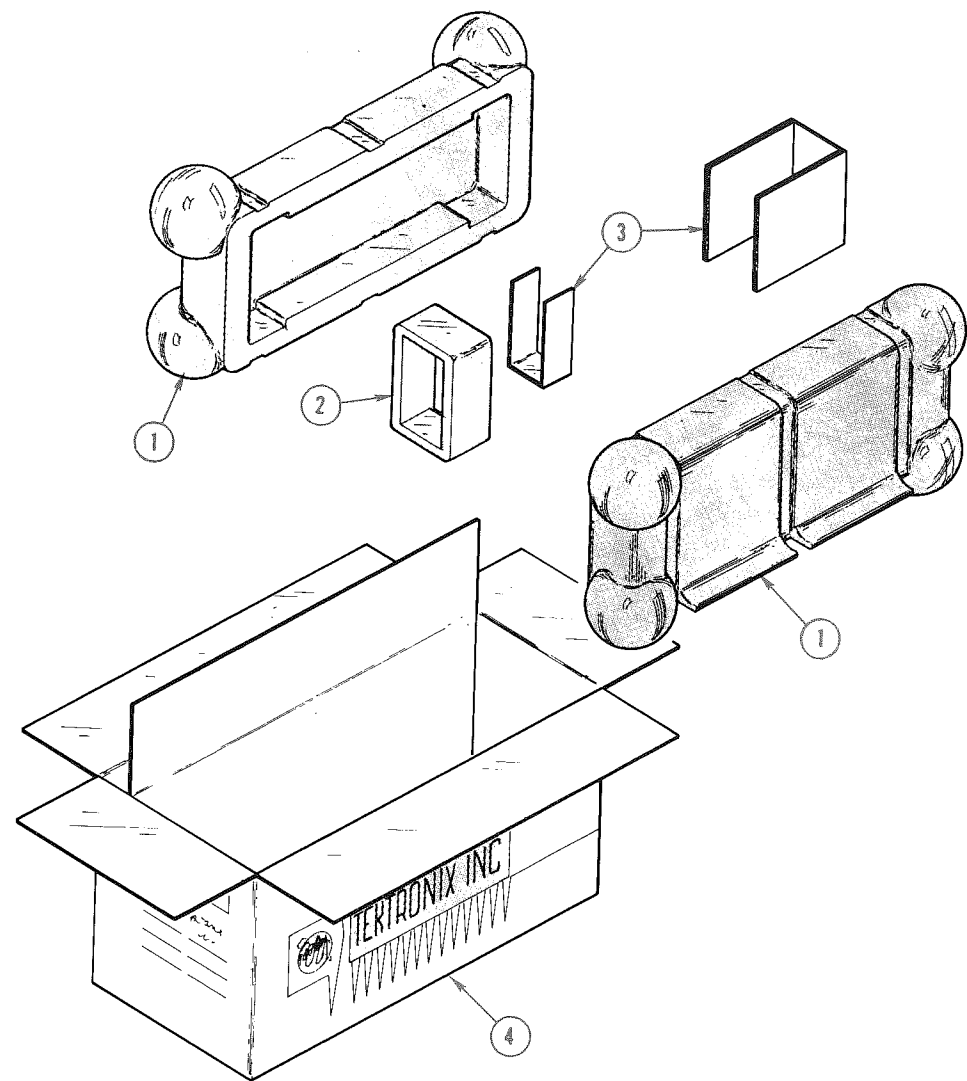


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q t y						Description
					1	2	3	4	5	
2-	065-0138-00			1						CARTON ASSEMBLY
-	-			-						carton assembly includes:
-1	004-0241-00			2						CASE HALF
-2	004-0243-00			1						END CAP, front
-3	004-1079-00			1						PAD SET, 2 piece
-4	004-0748-00			1						CARTON

26A2 DIFFERENTIAL AMPLIFIER

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MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

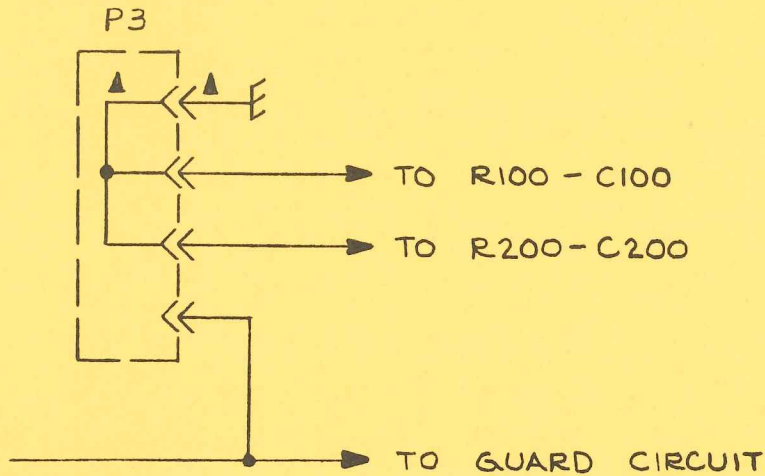
A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

TEXT CORRECTION

Section 2 Operating Instructions

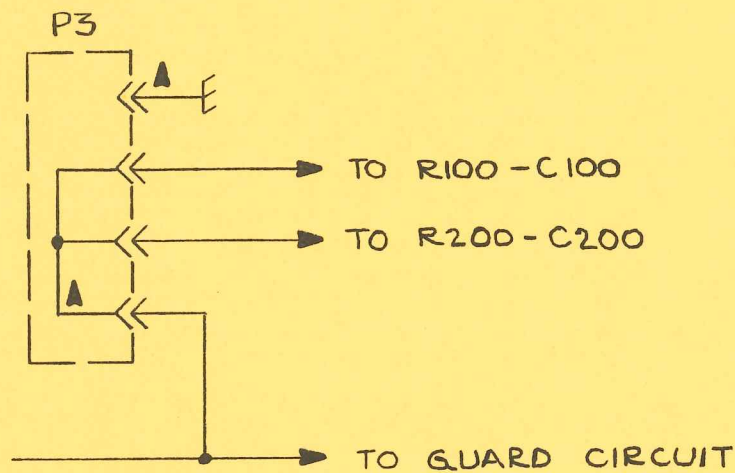
Page 2-2 Figure 2-1A

CHANGE: P3 Diagram:



Page 2-5 Figure 2-6

CHANGE: P3 Diagram:



Page 2-4

ADD: Following last paragraph:

For any application requiring high differential input resistance the input RC network R100-C100, R200-C200 may be disconnected from the circuit by removing the multi-pin connector, P3. The input resistances with the connector removed are: 200 MΩ per side and 100 MΩ common mode.

Section 3 Circuit Description

Page 3-1

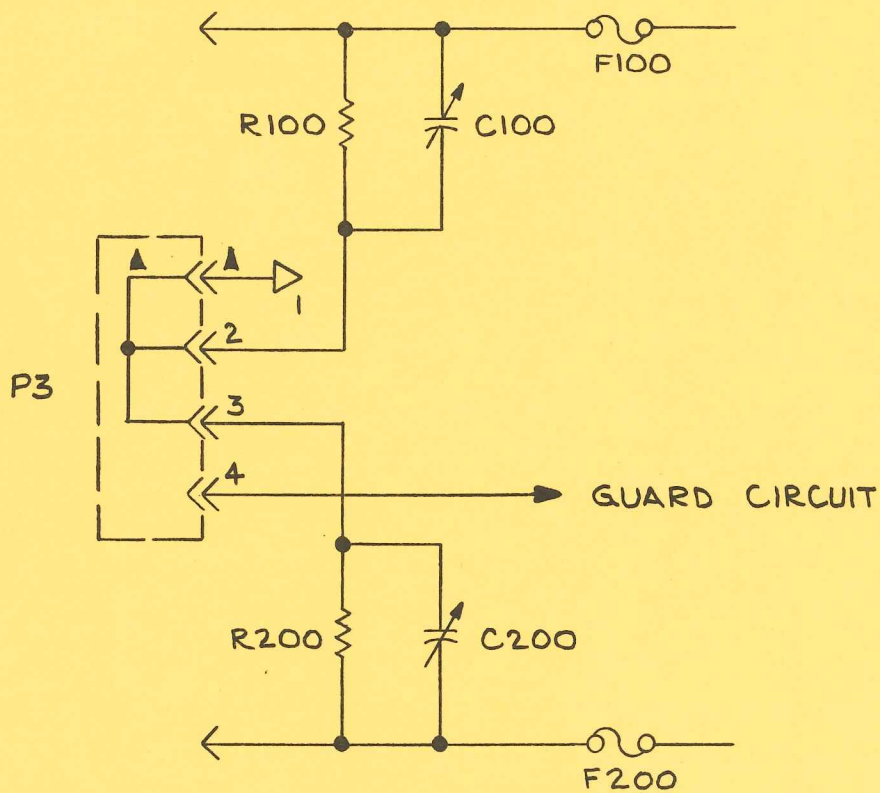
CHANGE: Last paragraph to read:

Modification Point, P3 (on the main circuit board) connects either reference ground or guard voltage to the junction of R100-R200, or disconnects the RC networks, R100-C100, R200-C200 from the input circuit.

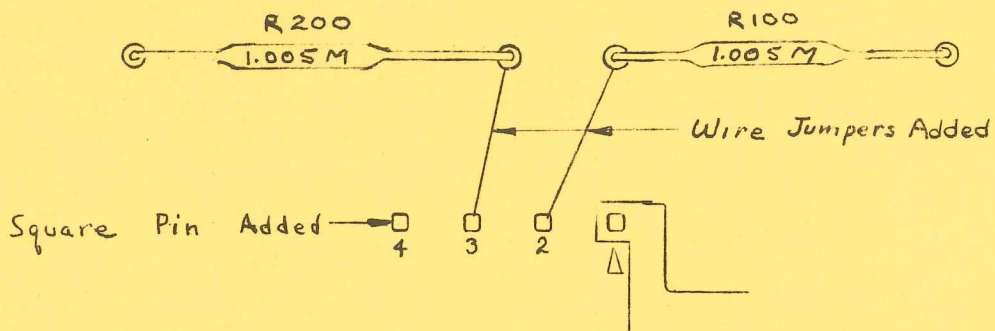
SCHEMATIC CORRECTION

Diagram 1 PREAMP
For SN B020170 and up

PARTIAL - PREAMP 1

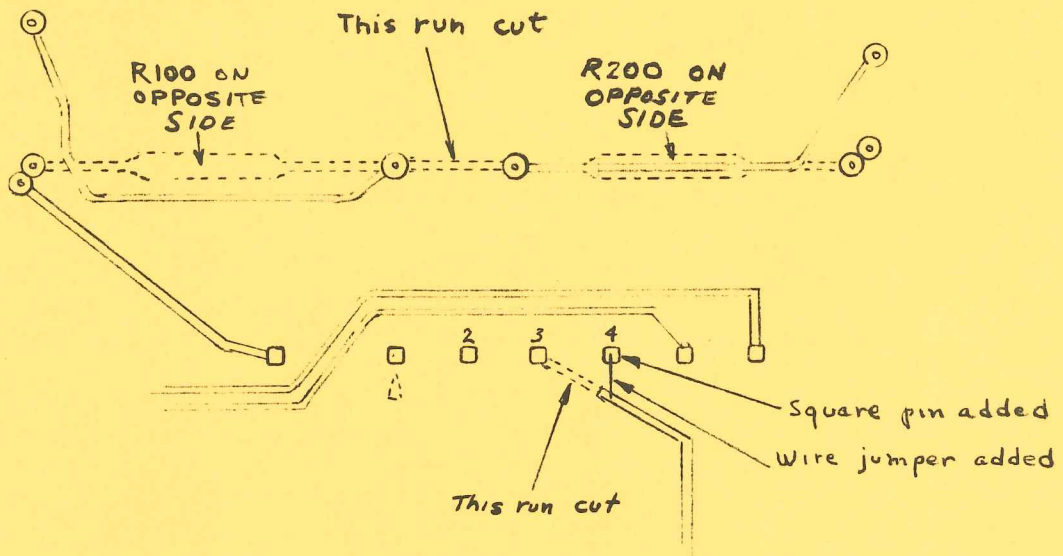


PARTIAL MAIN CIRCUIT BOARD



COMPONENT SIDE

FRONT OF INSTRUMENT
↓



BACK SIDE

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHASSIS

CHANGE TO:

R38 311-0702-00 100 Ω , Var.

A1 MAIN

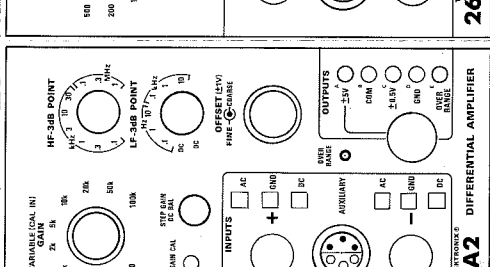
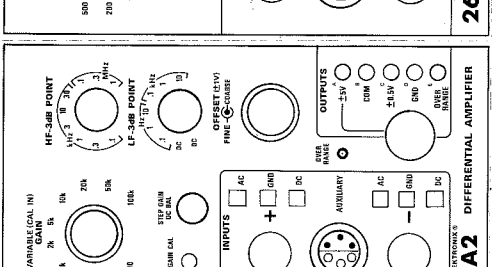
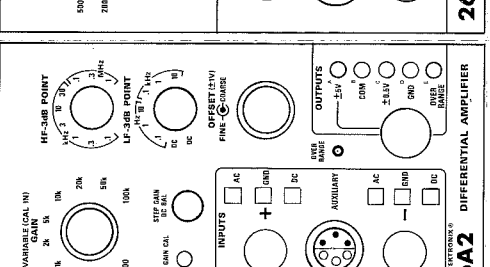
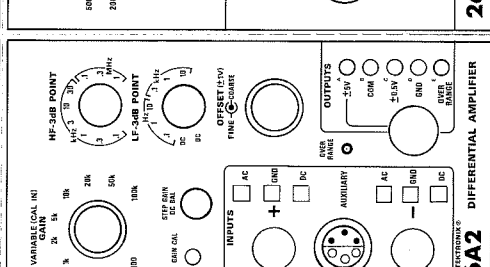
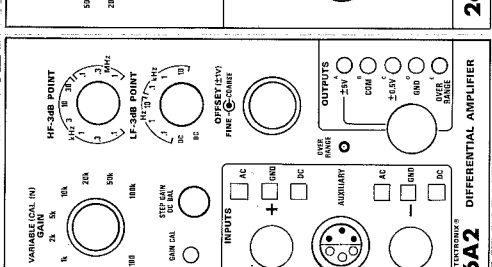
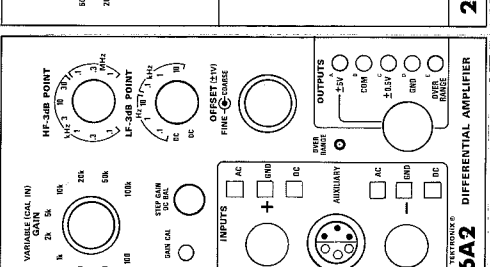
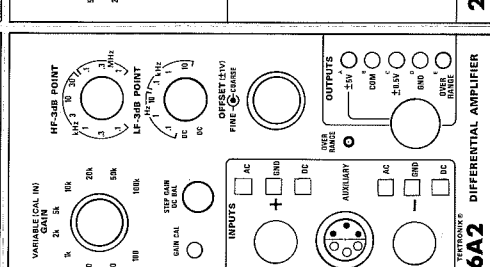
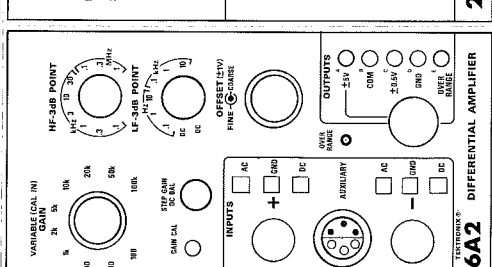
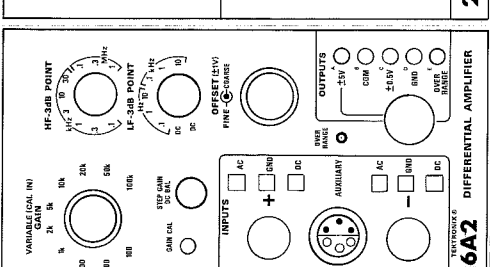
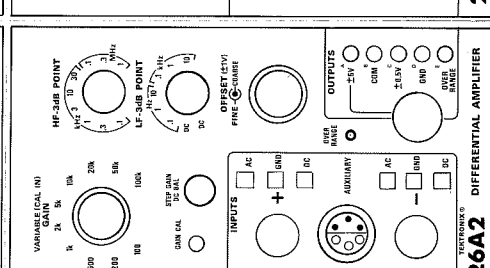
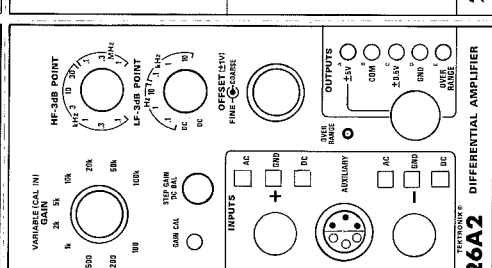
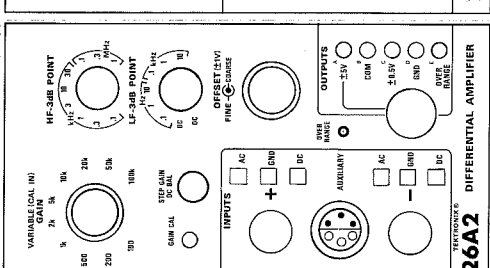
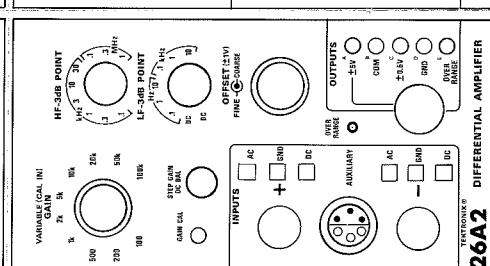
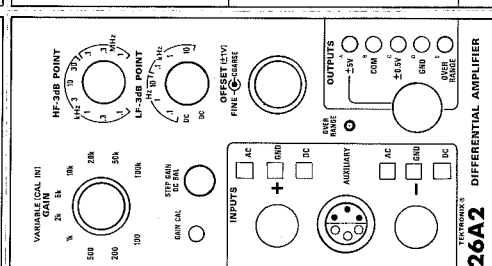
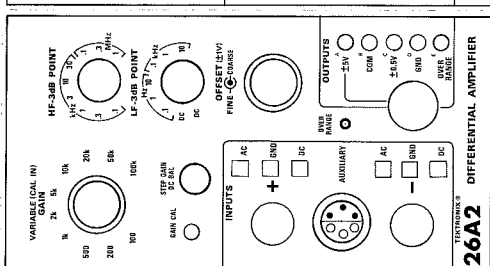
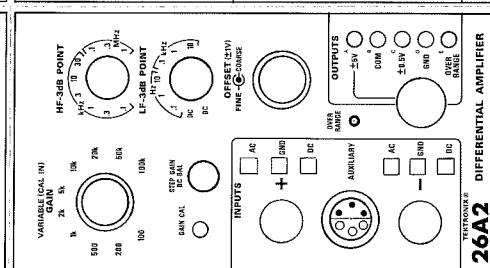
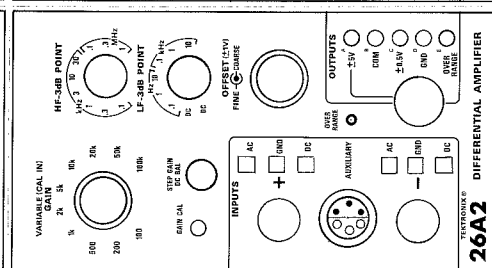
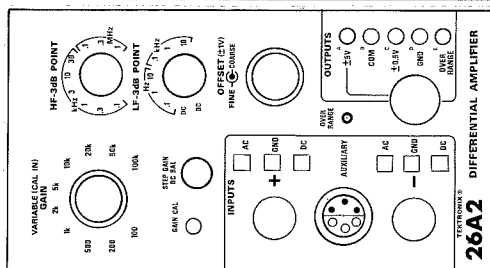
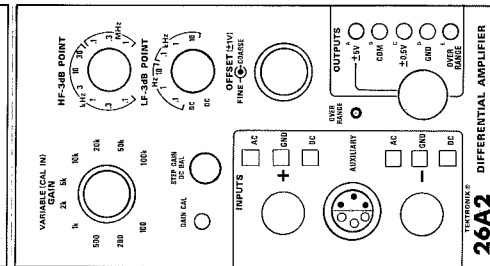
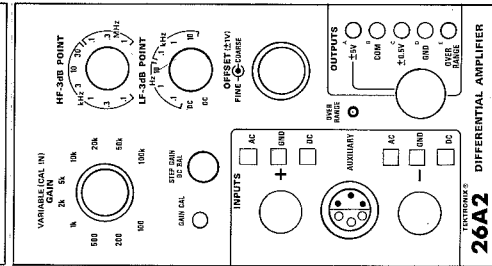
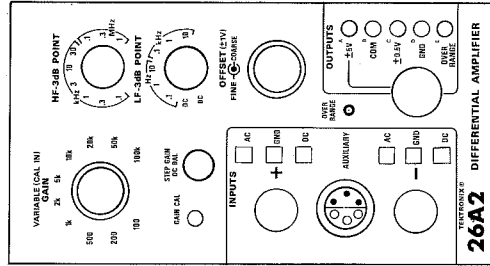
Circuit Board Assembly

CHANGE TO:

R155	321-0152-00	374 Ω	1/8 W	Prec	1%
R255	321-0152-00	374 Ω	1/8 W	Prec	1%



THESE PICTURES CAN BE INDIVIDUALLY ATTACHED TO OTHER DOCUMENTS TO PROVIDE A GRAPHIC METHOD OF RECORDING CONTROL SETTINGS OR OTHER DATA. MARK AS REQUIRED WITH A BALL-POINT OR NYLON-TIPPED PEN.



TEKTRONIX FORM NUMBER 062-1374-00 (Package of 10 sheets - Order 062-1374-01)