

# INSTRUCTION MANUAL

Serial Number \_\_\_\_\_

## **5A21N**

### **DIFFERENTIAL AMPLIFIER**



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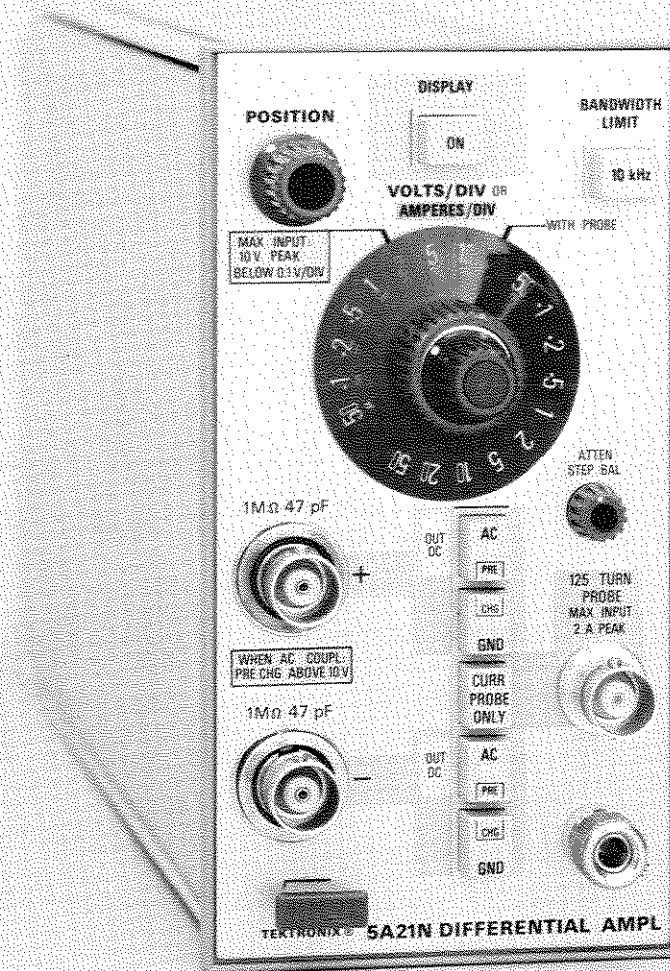


Fig. 1-1. 5A21N Differential Amplifier.

# SECTION 1

## 5A21N SPECIFICATION

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

### Introduction

The 5A21N Differential Amplifier is a high-gain differential amplifier plug-in unit for use with Tektronix 5100-series oscilloscopes, and permits the measurement of current signals as well as voltage signals. The unit features high sensitivity with direct-coupled inputs (50  $\mu$ V/DIV or 0.5 mA/DIV), and has a high common-mode rejection ratio. An illuminated knob skirt provides deflection factor read-out. The unit has a bandwidth capability of DC to one megahertz, and a front-panel pushbutton switch allows

reduction of the upper bandwidth limit, thus increasing the signal-to-noise ratio for low-frequency applications.

This instrument will meet the performance requirements listed in Table 1-1 following complete calibration as given in Section 4. The following electrical characteristics apply over an ambient temperature range of 0°C to +50°C.

In this manual the word Volts/Div or division refers to major graticule division.

TABLE 1-1  
ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Deflection Factor		
VOLTS/DIV		
Calibrated Range	50 microvolts/division to 5 volts/division.	16 steps in a 1-2-5 sequence.
Accuracy	Within 2%.	
AMPERES/DIV		
Calibrated Range	0.5 milliampere/division to 0.5 ampere/division.	10 steps in a 1-2-5 sequence.
Accuracy	Within 3%.	
Step Attenuator Balance		Adjustable for one division or less trace movement as VOLTS/DIV is rotated throughout its range.
Uncalibrated (Var) Range		At least 2.5:1.
Frequency Response		
Bandwidth (8 Div Reference)		
DC (Direct) Coupled		
1 MHz	DC to at least 1 megahertz.	
10 kHz	DC to $\approx$ 10 kilohertz.	Within 20%.
AC (Capacitive) Coupled		
1 MHz	2 hertz or less to at least 1 megahertz.	
10 kHz	2 hertz or less to $\approx$ 10 kilohertz.	Within 20%.

TABLE 1-1 (cont.)

Characteristic	Performance Requirement	Supplemental Information
AMPERES Mode		
1 MHz	15 hertz or less to at least 1 megahertz.	
10 kHz	15 hertz or less to 10 kilohertz.	Within 20%.
Step Response (Displayed) Aberrations	±2% or less of pulse amplitude.	
Inputs		
Voltage Mode		
Resistance	1 megohm, within 0.1%.	Time constant normalized for 47 microseconds, within 3% between channels.
Capacitance	≈ 47 picofarads.	
Maximum Safe Input Voltages		
DC (Direct) Coupled		
50 $\mu$ V/Div to 50 mV/Div	10 volts (DC + Peak AC)	
100 mV/Div to 5 V/Div	350 volts (DC + Peak AC)	
AC (Capacitive) Coupled		
50 $\mu$ V/Div to 50 mV/Div	350 volts DC (Coupling capacitor pre-charged), 10 volts peak AC.	
100 mV/Div to 5 V/Div	350 volts (DC + Peak AC)	
DC Rejection, AC (Capacitive) Coupled	At least 100,000:1 after 20 minute warmup.	
Input Gate Current	100 picoamperes or less (equivalent to 100 microvolts or less, depending on external loading) at 25°C.	
Current Mode Maximum Equivalent Input	4 amperes peak to peak (at probe tip) with 125-turn current probe.	
POSITION Range		At least + and - 10 divisions from graticule center.
Common Mode Rejection		
DC (Direct) Coupled	At least 100 dB, DC to 30 kilohertz at 50 $\mu$ V/div and .1 mV/div with up to 20-volt peak to peak sine wave, decreasing by less than 20 dB/decade on lower sensitivity ranges up to 50 mV/div. From 100 mV/div to 5 V/Div, CMRR is at least 50 dB with up to 100-volt peak-to-peak sine wave. CMRR with two P6060 probes is at least 50 dB at any deflection factor.	
AC (Capacitive) Coupled		
50 $\mu$ V/div to 0.5 mV/div	At least 80 dB at 5 kilohertz and above, decreasing to 50 dB at 10 hertz.	

TABLE 1-2  
ENVIRONMENTAL CHARACTERISTICS

Characteristic	Performance Requirement
Temperature	
Operating Range	0°C to +50°C.
Non-operating Range	-55°C to +70°C
Altitude	
Operating Range	To 15,000 feet.
Non-operating Range	To 15,000 feet.
Vibration Range	To 0.015 inch peak-to-peak displacement at 50 cycles per second.
Shock Range	To 30 g's, 1/2 sine, 11 milliseconds duration.





# SECTION 2

## OPERATING INSTRUCTIONS

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

### Introduction

The 5A21N Differential Amplifier Plug-In operates with a Tektronix 5100N-series oscilloscope system. An understanding of the 5A21N operation and capabilities is essential for obtaining best results. This section of the manual gives a brief functional description of the front-panel controls and connectors, a familiarization procedure and general operating information.

### PLUG-IN INSERTION AND REMOVAL

The 5A21N is calibrated and ready for use as it is received. It can be installed in any compartment of the 5100N-series Power Supply/Amplifier module, but it is intended for primary use in vertical compartments (the center and left compartments). For X-Y operation, the 5A21N may also be installed in the horizontal (right) compartment (refer to the Oscilloscope System instruction manual for information on X-Y operation).

#### NOTE

*The Power Supply/Amplifier module is designed so that in the absence of DISPLAY ON logic levels from the vertical plug-ins, it will display the output of the unit in the left compartment.*

To install, align the upper and lower rails of the 5A21N with the plug-in compartment tracks and fully insert it (the plug-in panel must be flush with the oscilloscope panel). To remove, pull the release latch to disengage the 5A21N from the oscilloscope.

### CONTROLS AND CONNECTORS

This is a brief description of the function or operation of the front-panel controls and connectors. More detailed information is given under General Operating Information.

#### DISPLAY ON

Applies and removes logic levels to the oscilloscope system to enable or disable plug-in operation. Switch is functional only when plug-in is operated in one of the vertical plug-in compartments.

#### POSITION

Positions display.

#### BANDWIDTH LIMIT

Allows reduction of the upper bandwidth limit to increase the signal-to-noise ratio for low-frequency applications. Selects upper bandwidth limit at either 1 MHz (button out) or 10 kHz (button in).

#### VOLTS/DIV- AMPERES/DIV

Volts or amperes per major graticule division. Selects calibrated deflection factor in a 1-2-5 sequence, from 50  $\mu$ V/Div to 5 V/Div in 16 steps, or from 0.5 mA/Div to 0.5 A/Div in 10 steps (deflection factor uncalibrated from 1 A/Div to 50 A/Div because of attenuator). Knob skirt is illuminated to indicate deflection factor, and X10 scaling of readout is provided automatically when a 10X coded probe is used.

#### Variable (Volts/Div or Amperes/Div)

Provides uncalibrated, continuously variable deflection factor between calibrated steps; extends range to 12.5 V/Div or 1.25 A/Div.

#### STEP ATTEN BAL

Balances the input amplifier for minimum trace shift throughout the deflection factor gain-switching range.

#### CURR PROBE ONLY

Button pushed in selects AMPERES/DIV function of the deflection factor switch. Enables 125 TURN PROBE input and disables differential voltage input.

Button out selects VOLTS/DIV function of the deflection factor switch. Enables differential voltage input and disables current input.

#### Input Coupling Pushbuttons

AC-DC: Button pushed in selects capacitive coupling of signal applied to associated input connector; button out selects direct coupling of input signal.

## Operating Instructions—5A21N

Input Coupling (cont) Pushbuttons	GND: Disconnects the input signal and provides ground reference to the amplifier input stage.  PRE CHG: Both AC-DC and GND buttons pushed in permits pre-charging of the coupling capacitor to the input signal DC level. Release GND button for measurement.
+ and — Input Connectors	BNC connectors for application of external voltage signals. Connector labeled + indicates that a positive-going signal will cause upward deflection; connector labeled — indicates that a positive-going signal will cause downward deflection. Connectors include coded-probe input rings for activation of X10 readout.
125 TURN PROBE Connector	Provides connection for current probe (limited to current probe transformers with 125-turn secondary windings). Recommended probe is the Tektronix P6051.

## FIRST TIME OPERATION

### Preparation

The first few steps of the following procedure are intended to help place the trace on the screen quickly and prepare the instrument for immediate use. The remainder of the steps demonstrate some of the basic functions of the 5A21N. Operation of other instruments in the system is described in the instruction manuals for those units.

1. Insert the unit all the way into the oscilloscope system plug-in compartment.

2. Turn the oscilloscope Intensity control fully counterclockwise and turn the oscilloscope system Power On. Pre-set the time-base and triggering controls for a 2-millisecond/division sweep rate and automatic triggering.

3. Set the 5A20N front-panel controls as follows:

DISPLAY	ON (readout illuminates)
POSITION	Midrange
BANDWIDTH LIMIT	1 MHz (button out)
CURR PROBE ONLY	VOLTS (button out)
VOLTS/DIV	.1 V
STEP ATTEN BAL	Midrange
+ Input Coupling	DC, GND
— Input Coupling	DC, GND

### NOTE

*About five minutes is sufficient time for warmup when using the 5A21N for short-term DC measurements. For long-term DC measurements using the lower deflection factors, allow at least 15 minutes.*

4. Adjust the Intensity control for normal viewing of the trace. The trace should appear near the graticule center.

5. Move the trace two divisions below the graticule centerline with the POSITION control.

### CAUTION

*If the maximum input voltage rating at the gates of the input FET's is exceeded, the gates are diode-clamped at about + or — 12.5 volts. If the signal source can supply more than 1/16 A, the input protective fuse(s) will open.*

6. Apply a 400-millivolt peak-to-peak signal (available at the oscilloscope Calibrator loop) through a test lead or 1X probe to the + input connector.

7. For DC-coupled, single-ended operation, release the GND button associated with the + Input Coupling switch. The display should be a square wave four divisions in amplitude, with the bottom of the display at the reference established in step 5. Rotate the Variable Volts/Div control counterclockwise out of its detent position, observing reduction of the display. Return the Variable control to the detent (CAL) position.

8. For AC-coupled, single-ended operation, re-position the display with the POSITION control to place the bottom of the display at the graticule centerline.

9. Push in the AC button and note that the display shifts downward about two divisions to its average level.

10. Disconnect the coaxial cable from the + input connector. Connect a dual input cable to the + and — input connectors, then connect the coaxial cable from the Calibrator to the dual input cable.

11. For AC-coupled differential operation, set the — Input Coupling to AC (AC button in, GND button out). The calibrator signal is now coupled to both inputs as a common-mode signal. A straight line display should be observed, since the common-mode signal is being rejected.

### Step Attenuator Balance Adjustment

If this control is not properly adjusted, the CRT zero reference point (trace or spot) will shift vertically due to differential DC imbalance in the amplifier as the VOLTS/DIV switch is rotated throughout its range. The shift is more noticeable on the most sensitive positions.

a. With the instrument operating, ground both the + and – inputs (GND buttons pushed in), set the VOLTS/DIV switch to 5 V, and move the trace to graticule center with the POSITION control.

b. Adjust the STEP ATTEN BAL control for minimum trace shift as the VOLTS/DIV switch is rotated throughout its range.

### Gain Check

Whenever the 5A21N is inserted into a plug-in compartment other than the one in which it was calibrated, the amplifier gain may be checked and, if necessary, adjusted. See the Calibration Procedure in this manual for complete instructions.

## GENERAL OPERATING INFORMATION

### Applying Signals

When measuring DC voltages, use the largest deflection factor (5 V/Div) when first connecting the 5A21N to an unknown voltage source. If the deflection is too small to make the measurement, switch to a lower deflection factor. If the input stage is overdriven, a large amount of current might flow into the input and open the protective fuse. See CAUTION after item 5 of the First Time Operation.

**Pre-charging.** When only the AC component of a signal having both AC and DC components is to be measured, use the Input Coupling switches (AC and GND pushbuttons) to take advantage of the pre-charging circuit incorporated in the unit. The pre-charging circuit permits charging the coupling capacitor to the DC source voltage when the AC and GND buttons are pressed in. The procedure for using this circuit is as follows:

a. Before connecting the 5A21N to a signal containing a DC component, push in the AC and GND buttons. Then connect the input to the circuit under test.

b. Wait about one second for the coupling capacitor to charge.

c. Remove the ground from the coupling capacitor (GND button out). The display will remain on-screen, and the AC component can be measured in the usual manner.

The above procedure should be followed whenever a signal having a different DC level is connected.

### CAUTION

*If the 5A21N input is connected to a large DC voltage source without using the pre-charge provision, the peak charging current (into a 0.1  $\mu$ F capacitor) will be limited only by the internal resistance of the signal source, and this source may be damaged.*

### Signal Input Connectors

When connecting signals to the + and – input connectors on the 5A21N, consider the method of coupling that will be used. Sometimes unshielded test leads can be used to connect the 5A21N to a signal source, particularly when a high level, low-frequency signal is monitored at a low impedance point. However, when any of these factors is missing, it becomes increasingly important to use shielded signal cables. In all cases, the signal-transporting leads should be kept as short as practical.

When making single-ended input measurements (conventional amplifier operation), be sure to establish a common ground connection between the device under test and the 5A21N. The shield of a coaxial cable is normally used for this purpose.

In some cases, differential measurements require no common ground connection,<sup>1</sup> and therefore are less susceptible to interference by ground-loop currents. Some problems with stray magnetic coupling into the signal-transporting leads can also be minimized by using a differential rather than a single-ended measurement. These considerations are discussed later in this section under Differential Operation.

It is always important to consider the signal source loading (and resulting change in the source operating characteristics) due to the signal-transporting leads and the input circuit of the 5A21N. The circuit at the input connectors can normally be represented by a 1 megohm resistance to ground paralleled by about 47 pF. A few feet of shielded

<sup>1</sup> The DC plus AC voltages on the test points (with respect to the chassis potential of the 5A21N) should be limited to the levels listed in Section 1 under Maximum Common-Mode Input Voltage characteristics. Higher levels will degrade the common-mode rejection ratio and exceed the input voltage rating of the unit.

cable (20 to 40 pF per foot) may increase the parallel capacitance to 100 pF or more. In many cases, the effects of these resistive and capacitive loads may be too great and it may be desirable to minimize them through the use of an attenuator probe.

Attenuator probes not only decrease the resistive capacitive loading of a signal source, but also extend the measurement range of the 5A21N to include substantially higher voltages. Passive attenuator probes having attenuation factors of 10X, 100X, and 1000X, as well as other special-purpose types, are available through your Tektronix Field Engineer or Field Office.

Some measurement situations require a high resistance input to the 5A21N with very little source loading or signal attenuation. In such situations, a passive attenuator probe cannot be used. However, this problem may be solved by using a FET Probe or the high impedance input provision of the 5A21N.

### High Impedance Input

In the 50 mV through 50  $\mu$ V positions of the VOLTS/DIV switch, where the input attenuator is not used, the internal gate return resistors alone establish the 1 megohm input resistance. The removal of the strap from the circuit board disconnects these resistors from ground and permits the input FET gates to float, providing a very high input impedance (see Fig. 4-1 in the Calibration section for location of the strap). The signal source must then provide a DC path for the FET gate current.

The input signal must be kept to relatively low amplitudes, since the deflection factor is restricted to 50 mV/div through 50  $\mu$ V/div, and DC coupling must be used.

#### NOTE

*In the 0.1 V to 5 V range of the VOLTS/DIV switch, the input impedance is paralleled by the resistors in the attenuator. When the link is removed, the attenuation ratio is affected, causing the deflection factors in this range to be incorrect. To determine the deflection factor, check the deflection with an input signal of known amplitude.*

The signal source impedance is an important factor, since gate current will produce a DC offset. For example, a 100 picoampere gate current through 10 megohms produces a one-millivolt offset, which may result in significant error where small voltages are of concern.

The high frequency response will also depend upon the signal source impedance, since various shunt capacitances

between the source and the input gate must charge and discharge through that impedance.

### Display Polarity

Single-ended signals applied to the + input connector produce a display in phase with the input signal. Signals applied to the - input connector will be inverted.

A similar polarity relationship exists for differentially applied signals, but it pertains to the direction of voltage change at one input with respect to the other, rather than with respect to chassis potential.

### Deflection Factor

The amount of trace deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of the probe, the setting of the VOLTS/DIV switch, and the setting of the Variable control. The calibrated deflection factors are indicated by the VOLTS/DIV switch only when the Variable control is rotated fully clockwise into the detent position.

The range of the Variable control is at least 2.5:1. It provides uncalibrated deflection factors covering the full range between the fixed settings of the VOLTS/DIV switch. The control can be set to extend the deflection factor to at least 12.5 volts/division.

To reduce noise and obtain a more usable display when the VOLTS/DIV switch is set to the more sensitive positions, set the BANDWIDTH LIMIT switch to 10 kHz if this limit does not appreciably distort the desired features of the signal under observation. Fig. 2-1 shows the improvement in a displayed one-kilohertz signal when the BANDWIDTH LIMIT switch is used.

### Voltage Comparison Measurements

Some applications require deflection factors other than the fixed values provided by the VOLTS/DIV switch. One such application is comparison of signal amplitudes by ratio rather than by absolute voltage. To accomplish this, apply a reference signal to either input of the 5A21N, and set the VOLTS/DIV switch and Variable control so that the reference display covers the desired number of graticule divisions. Do not change this setting of the Variable control throughout the subsequent comparisons. The settings of the VOLTS/DIV switch can be changed, however, to accommodate large ratios. In doing so, regard the numbers which designate the switch positions as ratio factors rather than voltages.

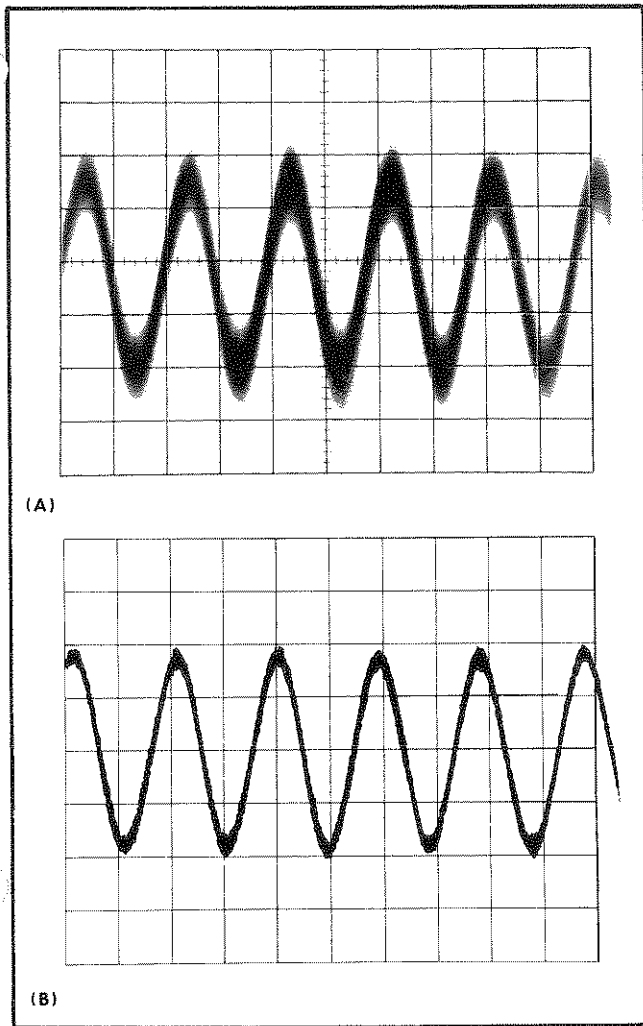


Fig. 2-1. Improving signal-to-noise ratio by setting bandwidth; (A) signal applied with the BANDWIDTH LIMIT switch set to 1 MHz, (B) same signal with the BANDWIDTH LIMIT switch set to 10 kHz.

## Differential Operation

Single-ended measurements often yield unsatisfactory results because of interference resulting from ground-loop currents between the 5A21N and the device under test. In other cases, it may be desirable to eliminate a DC voltage by means other than the use of a DC-blocking capacitor, which could limit the low-frequency response.

These limitations of single-ended measurements are effectively eliminated using differential measurements. Differential measurements are made by connecting each input (+ input and - input) to selected points in the test circuit. Since the chassis of the 5A21N need not be connected in any way to the test circuit, there are few limitations to the selection of these test points. In any case, do

not exceed the maximum safe input voltages listed in Section 1.

Both Input Coupling switches should be set to the same position, AC or DC, depending on the method of signal coupling required.

Only the voltage difference between two signals is amplified and displayed in differential measurements, while the common-mode signals (common in amplitude, frequency, and phase) are rejected. See Fig. 2-2.

The ability of the 5A21N to reject common-mode signals is indicated by the common-mode rejection ratio (CMRR). CMRR is at least 100,000:1 at the input connectors for the over deflection factors (50  $\mu\text{V}/\text{DIV}$  and 100  $\mu\text{V}/\text{DIV}$ ) when signals between DC and 30 kHz are DC coupled to the inputs. To illustrate this characteristic, assume that a single-ended input signal consists of an unwanted 60 Hz signal at 1 volt peak to peak, plus a desired signal at 1 mV peak to peak. If an attempt is made to display the described signal (single-ended measurement) at .2 mV/DIV, the 60 Hz signal will produce a deflection equivalent to 5000 divisions and the 1 mV signal will be lost.

If the same 1 mV signal is measured differentially with the 60 Hz signal common to both inputs, no more than one part in 100,000 of the common-mode signal will appear in the display. The desired signal will produce a display of 5 divisions, with not more than 0.1 division of display produced by the common-mode signal (CMRR not specified when residual display is 0.1 division or less).

There are a number of factors which can degrade common-mode rejection. The principal requirement for maximum rejection is for the common-mode signal to arrive at the input FET gates in precisely the same form. A difference of only 0.01% in the attenuation factors of the input attenuators may reduce the rejection ratio to 10,000:1. Likewise, any difference in source impedance at the two points in the source under test will degrade the rejection ratio. Attenuator probes which do not have adjustable R and C may reduce the rejection ratio to 100:1 or less.

Outside influences such as magnetic fields can also degrade the performance, particularly when low level signals are involved. Magnetic interference may be minimized by using identical signal-transporting leads to the two inputs and twisting the two leads together over as much of their length as possible.

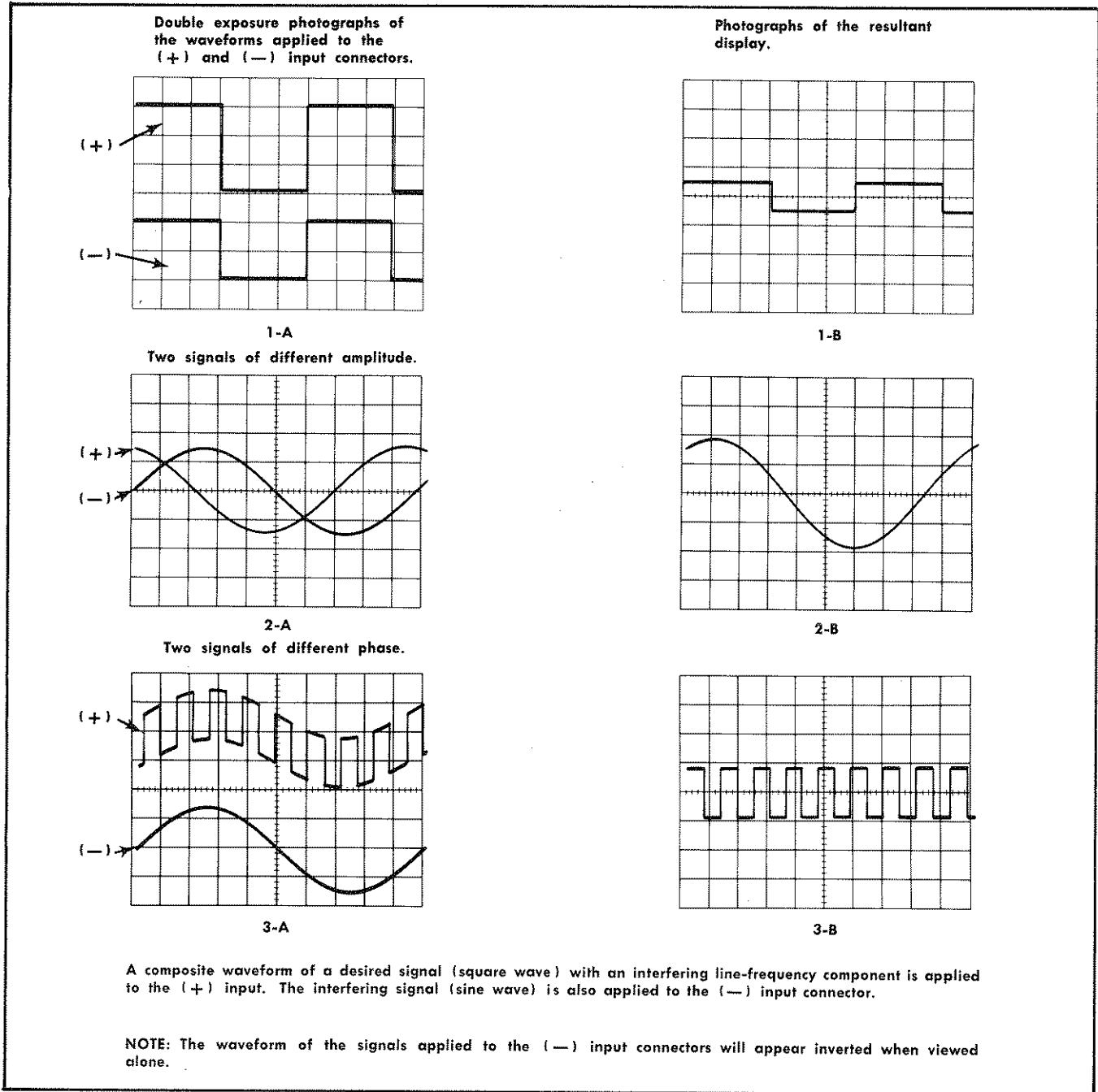


Fig. 2-2. Three examples of differential applications.

### Voltage Probes

In general, probes offer the most convenient means of connecting a signal to the input of the 5A21N. Tektronix probes are shielded to prevent pickup of electrostatic interference. A 10X attenuator probe offers a high input impedance and allows the circuit under test to perform very close to normal operating conditions. See your Tektronix, Inc., catalog for characteristics and compatibility of probes for use with this system.

**Differential Measurement.** The following adjustment procedure is recommended when preparing to use two Tektronix P6023 probes for differential measurement. (This probe type does not have the coding feature to be discussed later.)

- a. Connect one probe for DC-coupled single-ended input. Obtain a triggered display of an appropriate square wave, such as that from a calibrator or square-wave generator.

Adjust the probe DC Atten Calibration control for correct deflection sensitivity, then compensate the probe square-wave response using the AC Fine Comp adjust and the AC Coarse Comp adjust if necessary.

b. Connect a second probe for DC-coupled operation. Apply the square wave to both probes at 100 volts peak to peak. Free run the sweep and adjust the DC Atten Calibration of the second probe for maximum low frequency cancellation (minimum signal amplitude, or elimination of the two-trace appearance).

c. Adjust the AC Fine Comp and AC Coarse Comp, if necessary, of the second probe to minimize the amplitude of the differential pulses on the displayed trace.

d. The above procedure matches the probes for use at any sensitivity which employs the particular 5A21N input attenuator (1X or 100X) used in steps b and c. When it is necessary to use the other input attenuator, steps b and c should be repeated for that attenuator.

e. When examining a small differential signal in the presence of relatively large common-mode components, fine adjustment of probe CMRR may be made by temporarily connecting both probes to either of the two signal sources.

f. Movement of the probes should be kept to a minimum after the adjustment.

**Coded Probes.** The 5A21N is designed for compatibility with coded probes, such as the Tektronix P6060 or P6052 1X/10X Passive Probe. The + and — input connectors have an outer ring to which the coding ring on the probe connector makes contact. This type of probe allows the vertical deflection factor indicated by the readout to correspond with the actual voltage at the probe tip, eliminating the need to consider the attenuation factor when measuring the signal amplitude on the graticule scale.

Attenuation on the P6052 probe is selected by a sliding collar on the probe barrel. When the collar is pulled back (away from the probe tip), 1X attenuation is selected; when the collar is pushed forward (nearest the probe tip), 10X attenuation is selected. Input resistance for 1X attenuation is 1 megohm; for 10X, 10 megohms. Probe compensation is obtained in the usual manner (see probe manual for details).

### Current Probes

The current probe input is limited to current probe transformers with 125-turn secondary windings. No special preparation of the 5A21N is required. Connect the probe to the 125 TURN PROBE connector and select the CURR PROBE ONLY mode of instrument operation. Refer to the current probe manual for probe details.





# SECTION 3

## CIRCUIT DESCRIPTION

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

### Introduction

This section of the manual contains an electrical description of the circuits in the 5A21N Differential Amplifier unit. Complete schematic diagrams and an overall block diagram of the unit are given on pullout pages at the back of this manual.

### BLOCK DIAGRAM DESCRIPTION

When the DISPLAY ON button is pressed, a logic level is applied to the oscilloscope to enable 5A21N operation (switch function is limited to operation in a vertical compartment), and the front-panel readout lamp illuminates to indicate the ON mode.

Voltage signals applied to the + and - input connectors can be passed directly to the attenuators (DC coupled) or they can be capacitively (AC) coupled to block the DC component of the signal. The GND switch disconnects DC-coupled signals and applies a reference ground to the preamplifier input; for AC-coupled signals, the coupling capacitor is allowed to pre-charge to the DC level of the signal, preventing a damaging current surge when the ground is removed.

A current signal applied via a 125-turn probe is AC-coupled to the preamplifier + input when the CURR PROBE ONLY button is pressed. The signal is also applied to a feedback amplifier which compensates the probe characteristics. The compensated signal is then AC-coupled to the preamplifier - input.

The input attenuators are frequency-compensated voltage dividers. 1X attenuation is provided for positions 50  $\mu$ V to 50 mV of the VOLTS/DIV switch, and 100X attenuation is provided for positions 0.1 V to 5 V. Balance to a low-frequency common-mode signal between the attenuators of the two inputs is set by adjustment of the LF CMRR potentiometer.

From the input attenuators, the signal is passed directly to the preamplifier. The inputs to the preamplifier are fuse- and diode-protected. The preamplifier consists of two identical operational amplifiers connected in a differential

configuration. Common-mode signals between ground and the two inputs are rejected, due to a bootstrapped floating power supply that moves with the common-mode signal to maintain constant operating characteristics of the active devices. The difference between the two inputs is amplified. The VOLTS/DIV switch changes the value of the common source/emitter resistor between the two sides, thus changing the gain for various deflection factors. The output of the preamplifier stage is a push-pull signal, opposite in polarity to that applied to the input.

The BANDWIDTH LIMIT 10 kHz switch places a capacitor across the two output lines to reduce the bandwidth, and thus limit the noise referred to the input. The signal is then passed through an emitter-follower isolation stage to the output amplifier.

The output differential amplifier is operated push-pull, presenting a signal to the output terminals of the same polarity as that applied to the preamplifier input. Emitter degeneration produced by the Variable Volts/Div and Gain controls provides a means of varying the gain of the 5A21N. A positioning-current driver is connected to the output lines to alter the quiescent CRT beam position.

A triggering signal is tapped from the emitter-follower isolation stage, amplified and made available to an associated time-base plug-in unit. Triggering signal amplitude is about 0.25 volt per displayed division.

### DETAILED CIRCUIT DESCRIPTION

#### Plug-In Logic

When the DISPLAY ON button, S180, is pressed, a logic level is applied to the electronic switching circuit in the oscilloscope to enable plug-in operation. Power is applied to illuminate the front-panel knob-skirt readout lamp, indicating the ON mode.

#### Input Coupling

Signals applied to the front-panel + and - input connectors may be capacitive coupled (AC), direct coupled (DC), or internally disconnected (GND). Input coupling is selected by means of two pushbutton switches at each input, S1A and S1B for the + input and S1D and S1E for the - input.

Assuming that a signal is applied to the + input, the applied signal is passed directly to the attenuators when both buttons are out. When the AC button is pressed, C4 is placed in the circuit to couple signals of about two hertz (-3 dB point) higher to the attenuator. This capacitor blocks any DC component of the signal. When the GND button is pressed, a ground reference is provided to the input of the amplifier without the need to remove the applied signal from the input connector.

**NOTE**

*When DC levels (above 10 volts) are to be blocked by AC coupling, both the AC and GND buttons should be pressed in (PRE CHG) while input connections are made or broken, or when voltage levels are changed. This will allow the coupling capacitor to charge without blowing the input fuses or overdriving the amplifier.*

**Current Probe Amplifier**

The current probe amplifier, made up of Q20, Q30 and their associated passive circuitry, is an operational amplifier which compensates for the probe characteristics. When the CURR PROBE ONLY button is pressed, S1C disconnects the + and - voltage inputs and connects the current probe signal to the input attenuators. Probe signal is applied from J21 to the base of Q20A, and at the same time, it is applied via C37 to the positive side of the preamplifier input. The compensated signal is developed at the collector of Q30 and applied via C36 to the negative side of the preamplifier input.

**Input Attenuators**

The input attenuators are frequency-compensated voltage dividers which provide 100X attenuation in positions 0.1 to 5 of the VOLTS/DIV switch. At DC and for low-frequency signals, the dividers are essentially resistive (attenuation ratio determined by the resistance ratio). Balance to a low-frequency common-mode signal between the attenuators of the two inputs is set by adjustment of R109, LF CMRR. At higher frequencies, the capacitive reactance becomes effective and the attenuation ratio is determined by the impedance ratio.

In addition to providing constant 100X attenuation at all frequencies within the bandwidth capabilities of the instrument, the input attenuators maintain a constant input RC characteristic (one megohm paralleled by about 47 pF) for settings 0.1 to 5 of the VOLTS/DIV switch.

**Input Protection**

Input protection consists of fuses F20, F206 and diodes CR111, CR112, CR113, and CR114. If the signal should reach a level sufficient to forward bias one of the protec-

tion diodes (a potential greater than about 12.5 volts), current will be conducted through that diode, protecting the input FET's. If that current should exceed the I<sup>2</sup>T rating of the fuse, the protective fuse(s) will open. If the signal source is not able to supply enough current to open the fuse, damage to the signal source may result.

**Preamplifier Stage**

The preamplifier consists of two identical operational amplifiers, connected in a differential configuration. Fig. 3-1 shows a simplified block diagram of the Preamp.

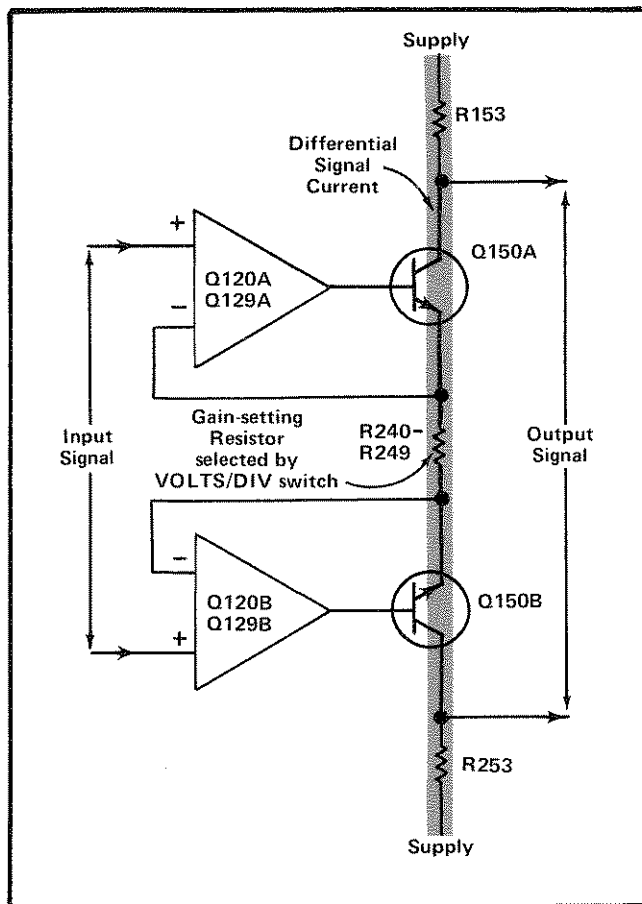


Fig. 3-1. Input Preamp detailed block diagram showing signal current paths.

The operational amplifiers are composed of Q120A, Q129A and Q150A on one side, and Q120B, Q129B and Q150B on the other side. Q120A and Q120B provide a voltage follower input to output transistors Q150A and Q150B. Total gain of the stage is determined by the resistance between the two sides of the amplifier, and R153 and R253 (the signal current path in Fig. 3-1).

Quiescently, the two sides of the amplifier are balanced so that there is no current through R240. When a differ-

ential signal is applied to the gates of Q120A and Q120B, the signal current is developed through the parallel combination of the gain-setting resistor R240-R249 and R140-R141. Conduction of Q150A and Q150B is changed by the amount of this current, developing the output voltage across R153 and R253. The output is a push-pull signal, opposite in polarity to the signal applied to the inputs. The value of R240-R249 is selected by the VOLTS/DIV switch, S240, to determine the gain.

To minimize trace shift as different vertical deflection factors are selected, the outputs at Q150A and Q150B collectors are DC balanced at equal potentials so that the voltage across the gain-setting resistors is zero at all settings of the VOLTS/DIV switch. This DC balancing is achieved by adjusting R227, Coarse Bal, and R127, STEP ATTEN BAL, with the gates of Q120A and Q120B effectively tied together and the VOLTS/DIV switch set to 1 mV.

R159, Var Bal, located in the emitter circuit of constant-current source transistors Q158A and Q158B, is adjusted with a zero input signal to set the voltage across the Variable control (R169) in the output amplifier stage to zero volts. With both sides of the amplifier so balanced, trace deflection is prevented as the Variable control is rotated throughout its range.

Normally, the frequency response of the preamplifier is from DC to at least one megahertz; however, for low-frequency applications where high input sensitivities are used, the overall frequency response can be limited to about ten kilohertz to reduce noise referred to the input. This is achieved by pushing the BANDWIDTH LIMIT 10 kHz switch, S259, which connects C259 across the output of the preamplifier stage.

### Common-Mode Rejection

One of the primary functions of the preamplifier is to reject any common-mode component of the input signal and amplify only the difference. Assume that the inputs are tied together and a voltage is applied to the common input. The amplifier differential output is ideally zero, and would actually be zero provided that the characteristics of all corresponding elements on the two sides of the amplifier were matched (e.g., Q120A and Q120B transconductance and  $\mu$ , Q129A and Q129B beta, current sources, etc.). In practice, any mismatch will cause a differential output.

**Floating Power Supply.** A floating power supply made up of Q130, Q140, Q146 and Zener diodes VR148 and VR149 minimize inherent common-mode difficulties and therefore improves the common-mode rejection ratio (refer to Fig. 3-2). Q146 is a constant-current high-impedance source for Q140, and Q130 is the current return for the preamplifier stage.

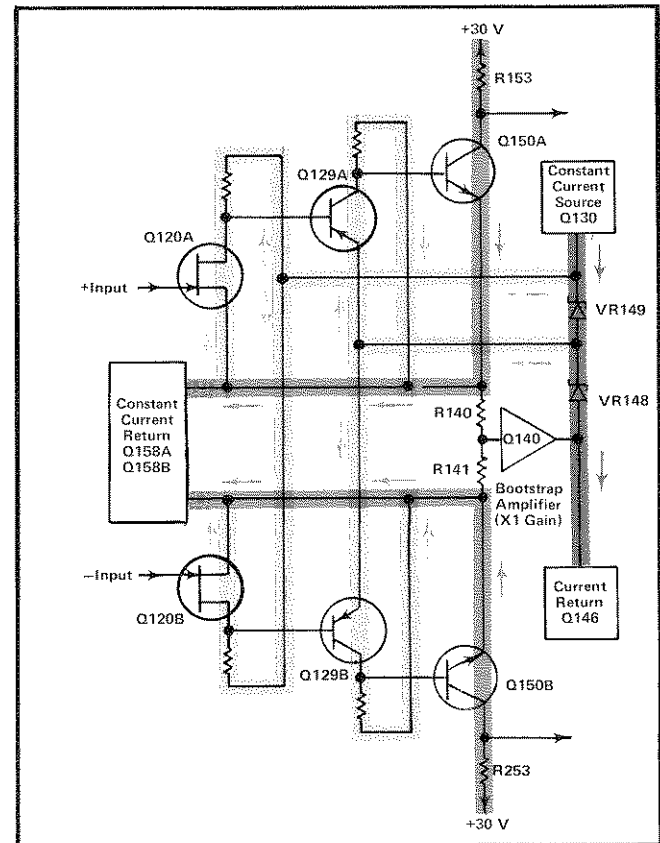


Fig. 3-2. Floating Power Supply detailed block diagram showing standing current paths through the Preamp.

The input to the bootstrap (X1 gain) amplifier is connected to the junction of R140 and R141. The bootstrap amplifier portion of the supply consists of emitter-follower Q140 and DC level-shifting Zener diodes VR148 and VR149. The collector impedance of Q146 presents minimum loading to the Q140 output and maintains the gain of the amplifier (bootstrap efficiency) very close to one.

The entire power supply and amplifier voltages move an amount equal to the common-mode voltage, maintaining a constant operating characteristic of the elements in the preamplifier stage. Since no signal current is developed, the output at the collectors of Q150A and Q150B remains unchanged; that is, the common-mode signal is rejected.

C221 (CMRR 1) and C250 (CMRR 2) are adjusted on high-frequency common-mode signals to normalize the effective capacitance of the active devices on one side of the amplifier to the other.

### Isolation Stage

The differential signal developed at the collectors of Q150A and Q150B is passed through emitter followers Q160 and Q260 to the output amplifier. Q160 and Q260

## Circuit Description—5A21N

isolate the preamplifier from the loading of the output amplifier and trigger signal amplifier.

### Output Amplifier

The output amplifier consists of push-pull amplifier Q163-Q263. With a signal applied, potentiometer R268, Gain, provides emitter degeneration, the gain being determined by the total emitter resistance. This allows the overall gain of the 5A21N to be adjusted to match the main-frame requirements. Also, the Variable Volts/Div control, R169, allows gain to be adjustable over a 2.5 to 1 ratio.

Q170 and Q270 are positioning-current drivers. R179, POSITION, provides an adjustable change in the conduction of the transistors, which provide a current to either add to or subtract from the Q163-Q263 currents to alter the quiescent vertical position of the display.

### Trigger Signal Amplifier

Differential amplifier Q280-Q286 receives the triggering signal from the emitters of Q160 and Q260 in the isolation stage. The triggering signal is amplified and passed through emitter-follower Q288, where it is made available to an associated time-base unit via output terminal A4. The triggering signal is of the same polarity as that applied to the gate of Q120A, and has an amplitude of about 0.25 volt per displayed division.

### Vertical Switching and Readout

The VOLTS/DIV switch, S240, is made up of a series of cam lobes, which engage and disengage various contacts at different positions of the switch. Cams 1 through 4 control switching of the input attenuators and cams 5 through 13 control switching of the gain-setting resistor R240-R249 in the preamplifier stage. Those contacts that are engaged at any given position of the switch are shown by black dots on the switch logic diagram.

Either of two lamp bulbs located behind the knob skirt of the VOLTS/DIV switch illuminates the selected deflection factor to provide a direct readout. Normally, DS182, which is physically located behind the upper left portion of the knob skirt, is lit. Connection of a readout-coded 10X probe to either the + or - input automatically changes the readout by a factor of 10 (i.e., extinguishes DS182 and illuminates DS187) to reflect the correction of probe attenuation, eliminating possible error by the operator of the instrument. J1 and J11, the + and - input connectors, have probe rings, allowing the 10X probe to apply a ground connection to the base of Q182. Q182 turns off, allowing Q187 to turn on, switching current from DS182 to DS187. When the instrument is operated in the CURR PROBE ONLY mode, DS187 is illuminated to indicate the vertical deflection factor in units of amperes per division.

# SECTION 4

## CALIBRATION

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

### Introduction

Before complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section of the Oscilloscope System manual.

### Services Available

Tektronix, Inc. provides complete instrument repair and recalibration at local Field Service Centers and at the Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

### Using This Procedure

**General.** This section provides several features to facilitate checking or adjusting the 5A21N. These are:

**Index.** To aid in locating a step in the Performance Check or Adjustment procedure, an index is given preceding Part I – Performance Check and Part II – Adjustment procedure.

**Performance Check.** The performance of this instrument can be checked without removing the covers or making internal adjustments by performing only Part I – Performance Check. This procedure checks the instrument against the tolerances listed in the Performance Requirement column of Section 1. Also, a reference is made to the step in Part II – Adjustment which will return the instrument to the correct calibration. In most cases, the adjustment step can be performed without changing control settings or equipment connections.

**Adjustment Procedure.** To return this instrument to correct calibration with the minimum number of steps, perform only Part II – Adjustment. The Adjustment procedure gives the recommended calibration procedure for all circuits in this instrument. Procedures are not given for checks which can be made without removing the covers; see Part I – Performance Check for the correct procedure for making these checks.

**Complete Performance Check/Adjustment.** To completely check and adjust all parts of this instrument, perform both Parts I and II. Start the complete procedure by

removing instrument covers as outlined in the Preliminary Procedure of Part II – Adjustment. Then follow the Performance Check, referring to the Adjustment procedure as directed to make the actual adjustments. This method will ensure that the instrument is both correctly adjusted and performing within all given specifications.

### TEST EQUIPMENT REQUIRED

#### General

The following test equipment and accessories, or its equivalent, is required for complete calibration of the 5A21N. Specifications given for the test equipment are the minimum necessary for accurate calibration. Therefore, some of the specifications listed here may be somewhat less rigorous than the actual performance capabilities of the test equipment. All test equipment is assumed to be correctly calibrated and operating within the listed specifications.

The Performance Check and Adjustment procedures are based on this recommended equipment. If other equipment is substituted, control settings or calibration setup may need to be altered to meet the requirements of the equipment used. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is needed.

#### Special Calibration Fixtures

Special Tektronix calibration fixtures are used in this procedure only where they facilitate instrument calibration. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

#### Calibration Equipment Alternatives

All of the test equipment is required to completely check and adjust this instrument. However, some of the items used only for the Performance Check can be deleted without compromising the measurement capabilities of the instrument.

#### Test Equipment

1. 5100N-series oscilloscope. For this procedure, a 5103N/D10 with a 5B10N time-base is used.

## Calibration—5A21N

2. Standard amplitude calibrator. Output signal, one-kilohertz square-wave; output amplitude, .2 millivolt to 100 volts; amplitude accuracy, within 0.25%; must have a 5-milliampere current loop. Tektronix calibration fixture 067-0502-01 recommended.

3. Constant-amplitude sine-wave generator. Frequency, 2 hertz to 2 megahertz; output amplitude, from about 0.5 volt to 40 volts peak to peak. For example, General Radio 1310-A Oscillator (use a General Radio Type 274 QBJ Adapter to provide BNC output).

### Accessories

4. Plug-in extension for the 5100N-series oscilloscope (for adjustment procedure only).

5. Coaxial cable. Impedance, 50 ohms; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-01.

6. Dual-input cable. Provides matched signal paths to the + and - inputs; BNC connectors. Tektronix Calibration Fixture 067-0525-00 recommended.

7. Input RC Normalizer. RC time constant 47  $\mu$ s (1 M $\Omega$  X 47 pF); connectors, BNC. Tektronix Calibration Fixture 067-0541-00.

8. In-line termination. Impedance, 50 ohms; accuracy,  $\pm$ 2%; connectors, BNC. Tektronix Part No. 011-0049-01.

9. 1000:1 divider. Tektronix Calibration Fixture 067-0529-00.

10. 10X attenuator (2 needed). Impedance, 50 ohms; accuracy,  $\pm$ 2%; connectors, BNC. Tektronix Part No. 011-0059-01.

11. Variable attenuator. A variable attenuator that has the end terminals of a 100-ohm potentiometer connected from input to ground, and the potentiometer divider arm connects to the attenuator output. Tektronix Calibration Fixture 067-0511-00 recommended.

12. Adapter, GR to BNC female. Tektronix Part No. 017-0063-00.

13. Adapter, GR to BNC male. Tektronix Part No. 017-0064-00.

14. High-frequency current test fixture. Tektronix Calibration Fixture 067-0559-00.

15. 125-turn current-measuring probe. Tektronix P6051 AC Current Probe recommended.

### Preliminary Control Settings

Set the 5A21N and Oscilloscope System controls as follows (for both Performance Check and Adjustment procedure):

#### 5A21N

DISPLAY	ON (readout illuminates when power is on)
POSITION	Midrange
BANDWIDTH LIMIT	1 MHz (button out)
CURR PROBE ONLY	VOLTS (button out)
VOLTS/DIV	50 m
Variable Volts/Div	CAL detent (fully clockwise)
STEP ATTEN BAL	Midrange
+ Input Coupling	DC, GND
- Input Coupling	DC, GND

#### Oscilloscope

##### Mainframe (5103N/DM10)

Intensity	Normal display brightness
Focus	Adjust for best focus of trace

##### Time Base (5B10N)

Display	Alt (button out)
Position	Sweep starts at left edge of graticule
Seconds/Div	1 m
Variable Seconds/Div	Cal detent
Swp Mag	Off (button out)
Triggering Mode	Auto Trig, AC Coupling, + Slope
Triggering Source	Left
Triggering Level	Midrange

# PART I—PERFORMANCE CHECK

## Introduction

The following procedure checks the performance of the 5A21N without removing the covers or making internal adjustments. All tolerances given in this procedure are based on Section 1.

## Index to Part I — Performance Check

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1. Check Variable Balance	4-3
2. Check DC Balance	4-3
3. Check Amplifier Gain and VOLTS/DIV Switch Accuracy	4-3
4. Check Input Compensation	4-4
5. Check Attenuator Low Frequency CMRR	4-4
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7. Check Amplifier Bandwidth	4-5
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9. Check Amplifier Noise Level	4-6
10. Check Current Probe Amplifier Gain	4-6
11. Check Current Probe Amplifier Frequency Response	4-6

## Preliminary Procedure for Performance Check

### NOTE

*The performance of this instrument can be checked at any temperature within the 0°C to +50°C range unless stated otherwise.*

1. Insert the 5A21N into the left plug-in compartment of the 5103N Oscilloscope System mainframe. Insert a 5B10N time-base unit into the right compartment.

2. Connect the oscilloscope to the power source for which it is wired and turn on the power.

3. Set the controls as given under Preliminary Control Settings.

## 1. Check Variable Balance

a. Move the trace to the graticule center horizontal line with the POSITION control.

b. Rotate the Variable Volts/Div control counterclockwise.

c. CHECK—Trace should not shift more than one division as the Variable control is rotated throughout its range.

d. CALIBRATION—If shift is excessive, perform step 1 of the Adjustment procedure.

e. Return the Variable control to the CAL detent position.

## 2. Check DC Balance

a. Turn the VOLTS/DIV switch throughout its range.

b. CHECK—Trace should not shift more than one division. Adjust the front-panel STEP ATTEN BAL control for minimum trace shift as the VOLTS/DIV switch is rotated throughout its range. Readjust the POSITION control, if necessary, to return the trace to graticule center after minimum shift has been attained.

c. CALIBRATION—If balance cannot be achieved, center the STEP ATTEN BAL control and perform step 2 of the Adjustment procedure.

## 3. Check Amplifier Gain and VOLTS/DIV Switch Accuracy

### AMPLIFIER GAIN

a. Connect the standard amplitude calibrator output connector to the + input connector through a coaxial cable. Set the standard amplitude calibrator for a 5-millivolt square-wave output.

b. Set the VOLTS/DIV switch to 1 mV and release the + Input Coupling GND (button out).

c. CHECK—Display amplitude is five divisions,  $\pm 0.1$  division. Adjust positioning as required.

d. CALIBRATION—If amplitude is out of the specified tolerance, perform step 3 of the Adjustment procedure.

VOLTS/DIV ACCURACY

e. CHECK—Using the VOLTS/DIV switch and standard amplitude calibrator switch settings given in Table 4-1, check the VOLTS/DIV switch accuracy. Set the BANDWIDTH LIMIT switch to 10 kHz for the more sensitive positions.

TABLE 4-1

VOLTS/DIV Switch Setting	Standard Amplitude Calibrator Output	CRT Display (Vertical Deflection)
5 V	20 volts	4 div, ±0.08 div
2 V	10 volts	5 div, ±0.1 div
1 V	5 volts	5 div, ±0.1 div
.5 V	2 volts	4 div, ±0.08 div
.2 V	1 volt	5 div, ±0.1 div
.1 V	.5 volt	5 div, ±0.1 div
50 mV	.2 volt	4 div, ±0.08 div
20 mV	.1 volt	5 div, ±0.1 div
10 mV	50 mV	5 div, ±0.1 div

Connect a 1000:1 divider between the calibrator output and the + input connector to check higher sensitivity ranges.

5 mV	20 V	4 div, ±0.08 div
2 mV	10 V	5 div, ±0.1 div
1 mV	5 V	5 div, ±0.1 div
.5 mV	2 V	4 div, ±0.08 div
.2 mV	1 V	5 div, ±0.1 div
.1 mV	.5 V	5 div, ±0.1 div
50 μV	.2 V	4 div, ±0.08 div

f. Remove the 1000:1 divider.

4. Check Input Compensation

a. Insert a 47 pF input RC normalizer between the signal cable and the + input connector. Set the VOLTS/DIV switch to .1 V and the BANDWIDTH LIMIT to 1 MHz (button out).

b. Set the standard amplitude calibrator for a 1-volt square wave output (five divisions displayed).

c. CHECK—Optimum square leading corner of the square-wave display. Aberrations are not to exceed + or – 2%, or 3% overall on any of the checks. If roll-off or overshoot is objectionable, perform step 4 of the Adjustment procedure.

d. Set the standard amplitude calibrator for a .5-volt square-wave output and change the VOLTS/DIV switch to 50 mV.

e. CHECK—Optimum square leading corner of the square-wave display. If roll-off or overshoot is objectionable, perform step 4 of the Adjustment procedure.

f. Move the RC normalizer and calibrator signal from the + input to the – input.

g. Set the + Input Coupling to GND and the – Input Coupling to DC. Position the display to the center of the graticule area.

h. Set the VOLTS/DIV switch to .1 V and set the standard amplitude calibrator for a 1-volt square-wave output.

i. CHECK—Optimum square leading corner of the square-wave display. If roll-off or overshoot is objectionable, perform step 4 of the Adjustment procedure.

j. Set the standard amplitude calibrator for a .5-volt square-wave output and change the VOLTS/DIV switch to 50 mV.

k. CHECK—Optimum square leading corner of the square-wave display. If roll-off or overshoot is objectionable, perform step 4 of the Adjustment procedure.

l. Disconnect the RC normalizer and standard amplitude calibrator.

5. Check Attenuator Low-Frequency CMRR

a. Set the controls as follows:

VOLTS/DIV                    5 V  
 + and – Input Coupling    GND  
 Seconds/Div (time-base)   5 ms

b. Connect a dual input cable to the + and – input connectors. Connect a sine-wave generator output to the dual-input cable through a coaxial cable.

c. Set the sine-wave generator for a 100-hertz, 40-volt peak to peak reference signal (set the + Input Coupling to DC and obtain exactly eight divisions of vertical deflection).



d. Set the — Input Coupling to DC (both the + and — Input Coupling switches should be set to DC) and the VOLTS/DIV switch to .2 V.

e. CHECK—Vertical deflection is 0.2 division or less. Displayed signal of 40 millivolts (0.2 division), or less, of a 40-volt signal, indicates that CMRR is at least 1000:1 (60 dB). If vertical deflection is greater than 0.2 division, perform step 5 of the Adjustment procedure.

f. Change the sine-wave generator frequency to one kilohertz.

g. CHECK—Vertical deflection is 0.2 division or less.

## 6. Check High Frequency CMRR

a. Set the sine-wave generator for a 20-volt, 30-kilohertz output (set the VOLTS/DIV switch to 5 V, — Input Coupling to GND and obtain exactly four vertical divisions of display).

b. Set the — Input Coupling to DC and the VOLTS/DIV switch to 50 mV.

c. CHECK—Vertical deflection for all VOLTS/DIV switch ranges from 50 mV to .1 mV is two divisions or less; for 50  $\mu$ V, four divisions or less.

d. CALIBRATION—If more than two divisions of vertical display are present at these ranges, perform step 6 of the Adjustment procedure.

## 7. Check Amplifier Bandwidth

a. Set the sine-wave generator for minimum output amplitude.

b. Change the controls as follows:

VOLTS/DIV	.1 V
+ Input Coupling	AC
— Input Coupling	GND
Seconds/Div (time base)	.5 ms

c. Adjust the sine-wave generator for eight vertical divisions of one-kilohertz display as a reference. Then slowly increase the frequency until the display amplitude is 5.66 divisions. This is the upper —3 dB point.

d. CHECK—Frequency at the upper —3 dB point must be at least one megahertz.

e. Set the BANDWIDTH LIMIT to 10 kHz (button in) and adjust the sine-wave generator for eight vertical divisions of 2-kilohertz reference display. Then slowly increase the frequency until the display amplitude is 5.66 divisions.

f. CHECK—Frequency at the upper —3 dB point (bandwidth limited) is between 8 kHz and 12 kHz.

g. Release the BANDWIDTH LIMIT switch (button out) and adjust the sine-wave generator for eight vertical divisions of 2-kilohertz reference display. Then slowly decrease the frequency until the display amplitude is 5.66 divisions. This is the lower —3 dB point when AC coupling is used (determined by the coupling capacitor). Set the time-base Seconds/Div as necessary to view the signal.

h. CHECK—Frequency at the lower —3 dB point is two hertz or less.

i. Disconnect the sine-wave generator.

## 8. Check Input Gate Current

a. Position the trace to the graticule center, then change the following control settings:

VOLTS/DIV	50 $\mu$ V
+ Input Coupling	AC, GND
— Input Coupling	AC, GND
Seconds/Div (time base)	1 ms

b. Connect a 50-ohm termination to the + input connector and using the STEP ATTEN BAL control, position the trace to the graticule centerline.

c. Release the GND button of the + Input Coupling switch (input AC-coupled).

d. CHECK—Trace shift is less than  $\pm 2$  divisions. This indicates an FET gate current of 100 picoamperes or less.

e. Ground the + Input Coupling (GND button in) and move the 50-ohm termination to the — input connector.

f. Release the GND button of the — Input Coupling switch.

## Performance Check—5A21N

- g. CHECK—Trace shift is less than  $\pm 2$  divisions.
- h. Remove the 50-ohm termination.

### 9. Check Overall Noise Level Tangentially

a. Connect the standard amplitude calibrator output to the + input connector through a BNC-to-GR adapter, a variable attenuator (arrow pointing away from the calibrator output), a GR-to-BNC female adapter, a coaxial cable, two 10X attenuators, and a 50-ohm termination.

b. Set the standard amplitude calibrator for a .2-volt square-wave output and turn the variable attenuator control fully clockwise.

c. Change the following control settings:

+ Input Coupling	DC
– Input Coupling	GND
Seconds/Div (time base)	50 $\mu$ s
Triggering Level (time base)	Clockwise

d. Turn the variable attenuator control slowly counter-clockwise and observe two noise bands displayed on the CRT (noise and free-running square wave). Continue to turn the variable attenuator control until the two noise bands merge (just to the point at which the dark band between the two noise bands disappears).

e. Remove the two 10X attenuators and connect the coaxial cable to the 50-ohm termination.

f. Switch the VOLTS/DIV switch to any position that will give a convenient display (two traces).

g. CHECK—The vertical amplitude of the display. Calculate the tangentially measured noise by dividing the measured display by 100. For example, two divisions of display at .5 mV per division is equal to one millivolt. One millivolt divided by 100 is equal to 10 microvolts of tangentially measured noise. Maximum noise, 30  $\mu$ V.

h. Disconnect all test equipment.

### 10. Check Current Probe Amplifier Gain

a. Change the control settings as follows:

Volts-Amps Mode	CURR PROBE ONLY (button in)
AMPERES/DIV	1 mA
Seconds/Div (time base)	1 ms

b. Connect a 125-turn current probe (P6021) to the 125 TURN PROBE input connector and connect the probe tip to the 5-milliampere current loop of the standard amplitude calibrator. Adjust the Triggering Level control for a stable display.

c. CHECK—Five divisions,  $\pm 3\%$ , of vertical display.

### 11. Check Current Probe Amplifier Frequency Response

a. Connect a BNC to GR male adapter to the sine-wave generator output. Connect a high-frequency current test fixture to the adapter. Connect the 125-turn current probe to the test fixture.

b. Change the time-base Seconds/Div switch to .5 ms.

c. Adjust the sine-wave generator for eight vertical divisions of one-kilohertz display as a reference. Then slowly increase the frequency until the display amplitude is 5.66 divisions. This is the upper  $-3$  dB point.

d. CHECK—Frequency is at least one megahertz.

e. Set the BANDWIDTH LIMIT to 10 kHz (button in) and adjust the sine-wave generator for eight vertical divisions of 2-kilohertz reference display. Then slowly increase the frequency until the display amplitude is 5.66 divisions.

f. CHECK—Frequency at the upper  $-3$  dB point (bandwidth limited) is between 8 kHz and 12 kHz.

g. Release the BANDWIDTH LIMIT switch (button out) and adjust the sine-wave generator for eight vertical divisions of 2-kilohertz reference display. Then slowly decrease the frequency until the display amplitude is 5.66 divisions. This is the lower  $-3$  dB point. Set the time-base Seconds/Div switch as necessary to view the signal.

h. CHECK—Frequency is 15 hertz or less.

i. Disconnect all test equipment.

This completes the Performance Check portion of the Calibration procedure.

## PART II—ADJUSTMENT

### Introduction

The following procedure returns the 5A21N to correct calibration. All limits and tolerances given in this procedure are calibration guides and should not be interpreted as instrument specifications except as given in Section 1 of this manual. The actual performance of the instrument may exceed the given limits or tolerances if the instrument meets the Performance Requirements as checked in Part I — Performance Check of this section. Location of internal adjustments is shown in Fig. 4-1.

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4. Adjust Input Compensation (C1, C2, C3, C11, C12, C13)	4-8

5. Adjust Attenuator Low Frequency CMRR (R109)	4-9
6. Adjust High Frequency CMRR (C221 and C250)	4-9

### Preliminary Procedure For Adjustment

#### NOTE

*This instrument should be adjusted at an ambient temperature of  $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$  for best overall accuracy.*

1. Remove the dust cover from the left side of the 5A21N and remove the cabinet panel from the left side of the 5103N Oscilloscope mainframe.
2. Place the 5A21N on a plug-in extender and insert the extender into the left plug-in compartment of the 5103N Oscilloscope mainframe. Insert a 5B10N time-base unit into the right compartment.

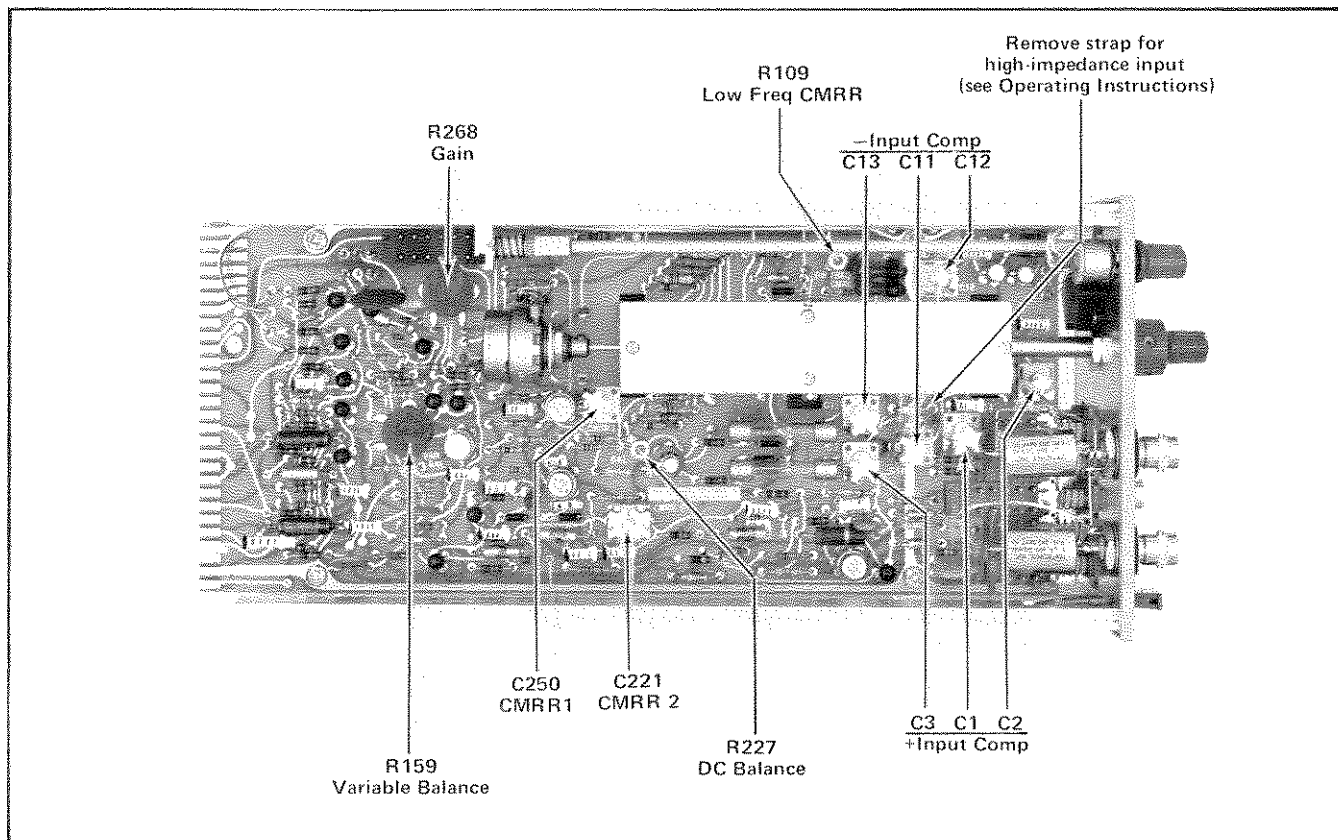


Fig. 4-1. Location of internal controls in the 5A21N.

## Adjustment—5A21N

3. Connect the oscilloscope to the power source for which it is wired and turn on the power.

4. Set the controls as given under Preliminary Control Settings.

### 1. Adjust Variable Balance (R159)

a. Move the trace to the graticule center horizontal line with the POSITION control.

b. Rotate the Variable Volts/Div control counterclockwise.

c. ADJUST—R159, Var Bal, for minimum trace shift as the Variable Volts/Div control is rotated throughout its range. Re-adjustment of the POSITION control may be necessary to return the trace to graticule center after the minimum shift has been attained.

d. Return the Variable control to the CAL detent position.

### 2. Adjust DC Balance (R227)

a. With the STEP ATTEN BAL control centered, turn the VOLTS/DIV switch throughout its range.

b. ADJUST—If the trace goes off-screen, start at the position of the VOLTS/DIV switch at which an on-screen display is obtained and adjust R227, Coarse DC Bal, working down to the 50  $\mu$ V position so the trace remains on-screen at 50  $\mu$ V. Make the fine adjustment to bring the trace to screen center with the front-panel STEP ATTEN BAL control. Maximum allowable shift of trace is one division as the VOLTS/DIV switch is rotated.

### 3. Adjust Amplifier Gain (R268)

a. Connect the standard amplitude calibrator output connector to the + input connector through a coaxial cable. Set the standard amplitude calibrator for a 5-millivolt square-wave output.

b. Set the VOLTS/DIV switch to 1 mV and release the + Input Coupling GND (button out).

c. ADJUST—R268, Gain, for a display amplitude of exactly five divisions.

### 4. Adjust Input Compensation (C1, C2, C3, C11, C12, C13)

a. Set the VOLTS/DIV switch to .1 V.

b. Insert a 47 pF input RC normalizer between the signal cable and the + input connector.

c. Set the standard amplitude calibrator for a 1-volt square-wave output (five divisions displayed).

d. ADJUST—C1 and C2 for minimum roll-off or overshoot of leading corner of square-wave display.

e. Set the standard amplitude calibrator for a .5-volt square-wave output, and change the VOLTS/DIV switch to 50 mV.

f. ADJUST—C3 for minimum roll-off or overshoot of leading corner of square-wave display.

g. Move the RC normalizer and calibrator signal from the + input to the - input.

h. Set the + Input Coupling to GND and the - Input Coupling to DC. Position the display to the center of the graticule area.

i. Set the VOLTS/DIV switch to .1 V and set the standard amplitude calibrator for a 1-volt square-wave output.

j. ADJUST—C11 and C12 for minimum roll-off or overshoot of leading corner of square-wave display.

k. Set the standard amplitude calibrator for a .5-volt square-wave output and change the VOLTS/DIV switch to 50 mV.

l. ADJUST—C13 for minimum roll-off or overshoot of leading corner of square-wave display.

m. Disconnect the RC normalizer and standard amplitude calibrator.

5. Adjust Attenuator Low-Frequency CMRR (R109)

a. Set the controls as follows:

VOLTS/DIV	5 V
+ and - Input Coupling	GND
Seconds/Div (time base)	5 ms

b. Connect a dual input cable to the + and - input connectors. Connect the sine-wave generator output connector to the dual input cable through a coaxial cable.

c. Set the sine-wave generator for a 100-hertz, 40-volt peak to peak reference signal (set the + Input Coupling to DC and obtain exactly eight divisions of vertical deflection).

d. Set the - Input Coupling to DC (both the + and - Input Coupling switches should now be set to DC) and the VOLTS/DIV switch to .2 V.

e. ADJUST-R109, LF CMRR, for minimum deflection. Set the sine-wave generator frequency to one kilohertz and check for 0.2 division or less of vertical deflection. Readjust R109, if necessary, for best compromise at 100 hertz and one kilohertz.

6. Adjust High Frequency CMRR (C221 and C250)

a. Change the following control settings:

VOLTS/DIV	5 V
- Input Coupling	GND

b. Set the sine-wave generator for exactly four divisions of 30-kilohertz display.

c. Set the - Input Coupling to DC and the VOLTS/DIV switch to 0.1 mV.

d. ADJUST-C250 (CMRR 2) for one division of vertical deflection. Then adjust C221 (CMRR 1) for minimum display amplitude when switching the VOLTS/DIV from 1 mV to 50 mV.

e. CHECK-Vertical deflection for all VOLTS/DIV switch ranges from .1 mV to 50 mV is two divisions or less. Adjust C221 and C250 for best compromise if necessary.

f. Disconnect all test equipment.

This completes the Adjustment portion of the Calibration procedure.

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# ELECTRICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

## ABBREVIATIONS AND REFERENCE DESIGNATORS

A	Assembly, separable or repairable	FL	Filter	PTM	paper or plastic, tubular molded
AT	Attenuator, fixed or variable	H	Heat dissipating device (heat sink, etc.)	R	Resistor, fixed or variable
B	Motor	HR	Heater	RT	Thermistor
BT	Battery	J	Connector, stationary portion	S	Switch
C	Capacitor, fixed or variable	K	Relay	T	Transformer
Cer	Ceramic	L	Inductor, fixed or variable	TP	Test point
CR	Diode, signal or rectifier	LR	Inductor/resistor combination	U	Assembly, inseparable or non-repairable
CRT	cathode-ray tube	M	Meter	V	Electron tube
DL	Delay line	Q	Transistor or silicon-controlled rectifier	Var	Variable
DS	Indicating device (lamp)	P	Connector, movable portion	VR	Voltage regulator (zener diode, etc.)
Elect.	Electrolytic	PMC	Paper, metal cased	WW	wire-wound
EMC	electrolytic, metal cased	PT	paper, tubular	Y	Crystal
EMT	electrolytic, metal tubular				
F	Fuse				

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CHASSIS				
CAPACITORS				
C4	295-0142-00			0.1UF (MATCHED PAIR)
C14				
BULBS				
DS182	150-0111-00			NEON,AIC
DS187	150-0111-00			NEON,AIC
CONNECTORS				
J1	131-0679-00	B010100	B041688	BNC, RECEPTACLE, ELECTRICAL
J1	131-0679-02	B041689		BNC, RECEPTACLE, ELECTRICAL
J11	131-0679-00	B010100	B041688	BNC, RECEPTACLE, ELECTRICAL
J11	131-0679-02	B041689		BNC, RECEPTACLE, ELECTRICAL
J21	131-0955-00			BNC, RECEPTACLE, ELECTRICAL
RESISTORS				
R179	311-0310-01	B010100	B039999	5K OHM,VAR
R179	311-1368-00	B040000		5K OHM,VAR
MAIN CIRCUIT BOARD ASSEMBLY				
	670-1344-00	B010100	B039999	COMPLETE BOARD
	670-1344-01	B040000		COMPLETE BOARD
CAPACITORS				
C1	281-0081-00			1.8-13PF,VAR,AIR
C2	281-0078-00			1.4-7.3PF,VAR,AIR
C3	281-0081-00			1.8-13PF,VAR,AIR
C11	281-0081-00			1.8-13PF,VAR,AIR
C12	281-0078-00			1.4-7.3PF,VAR,AIR

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Description
CAPACITORS (CONT)				
C13	281-0081-00			1.8-13PF,VAR,AIR
C22	290-0267-00			1UF,ELCTLT,35V
C25	283-0080-00			0.022UF,CER,25V,+80-20%
C27	281-0546-00			330PF,CER,500V,10%
C32	290-0297-00			39UF,ELCTLT,10V,10%
C33	281-0579-00			21PF,CER,500V,5%
C36	290-0264-00			0.22UF,ELCTLT,35V,10%
C37	290-0264-00			0.22UF,ELCTLT,35V,10%
C38	283-0003-00	XB040000		0.01UF,CER,150V,+80-20%
C101	281-0658-00			6.2PF,CER,500V,+/-0.25PF
C104	281-0628-00	B010100	B029999	15PF,CER,600V,5%
C104	281-0657-00	B030000		13PF,CER,500V,2%
C108	283-0626-00			1800PF,MICA,500V,5%
C111	290-0267-00			1UF,ELCTLT,35V
C121	281-0604-00			2.2PF,CER,500V,+/-0.25PF
C122	281-0604-00			2.2PF,CER,500V,+/-0.25PF
C129	281-0709-00			7PF,CER,500V,+/-0.1PF
C131	281-0504-00			10PF,CER,500V,10%
C135	290-0267-00			1UF,ELCTLT,35V
C140	281-0534-00	B010100	B039999	3.3PF,CER,500V,+/-0.25PF
C140	281-0504-00	B040000		10PF,CER,500V,10%
C148	290-0297-00			39UF,ELCTLT,10V,10%
C149	290-0297-00			39UF,ELCTLT,10V,10%
C150	281-0618-00			4.7PF,CER,200V,+/-0.5PF
C158	281-0504-00			10PF,CER,500V,10%
C163	281-0540-00			51PF,CER,500V,5%
C170	283-0000-00			0.001UF,CER,500V
C181	283-0002-00			0.01UF,CER,500V
C184	283-0002-00			0.01UF,CER,500V
C204	281-0628-00	B010100	B029999	15PF,CER,600V,5%
C204	281-0657-00	B030000		13PF,CER,500V,2%
C208	283-0626-00			1800PF,MICA,500V,5%
C221	281-0114-00			1.3-5.4PF,VAR,AIR
C229	281-0709-00			7PF,CER,500V,+/-0.1PF
C250	281-0077-00			1.3-5.4PF,VAR,AIR
C256	283-0003-00			0.01UF,CER,150V
C259	283-0041-00			0.0033UF,CER,500V,5%
C263	281-0540-00			51PF,CER,500V,5%
C279	281-0586-00			25PF,CER,500V,5%
C281	281-0534-00			3.3PF,CER,500V,+/-0.25PF
C287	290-0134-00			22UF,ELCTLT,15V
SEMICONDUCTOR DEVICE,DIODES				
CR111	152-0324-00			SILICON,TEK SPEC
CR112	152-0324-00			SILICON,TEK SPEC
CR113	152-0324-00			SILICON,TEK SPEC
CR114	152-0324-00			SILICON,TEK SPEC
CR163	152-0185-00			SILICON,REPLACEABLE BY 1N4152
CR263	152-0185-00			SILICON,REPLACEABLE BY 1N4152
VR111	152-0168-00			ZENER,1N963A,400MW,12V,5%
VR114	152-0168-00			ZENER,1N963A,400MW,12V,5%
VR148	152-0280-00			ZENER,1N753A,400MW,6.2V,5%
VR149	152-0279-00			ZENER,1N751A,400MW,5.1V,5%



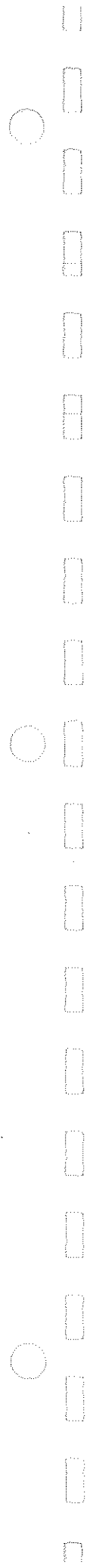
Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Description
<b>FUSES</b>				
F20	159-0024-00			1/16A, 3AG, FAST-BLO
F206	159-0024-00			1/16A, 3AG, FAST-BLO
<b>INDUCTORS</b>				
L174	108-0200-00			40UH
L274	108-0200-00			40UH
LR100	108-0565-00	XB040000		5UH (WOUND ON A 200 OHM, 0.25W, 5% RESISTOR)
LR200	108-0565-00	XB040000		5UH (WOUND ON A 200 OHM, 0.25W, 5% RESISTOR)
<b>TRANSISTORS</b>				
Q20A,B	151-0308-00			SILICON, NPN, TEK SPEC, DUAL
Q30	151-0219-00	B010100	B039999	SILICON, PNP, TO-18, REPLACEABLE BY 2N4250
Q30	151-0164-00	B040000		SILICON, PNP, TO-5, 2N5447
Q120A,B	151-1049-00			SILICON, JFET, TO-7L, TEK SPEC
Q129A,B	151-0261-00			SILICON, PNP, TO-78, TEK SPEC, DUAL
Q130	151-0220-00			SILICON, PNP, TO-18, 2N4122
Q140	151-0273-00			SILICON, NPN, TO-98, 2N5249
Q146	151-0341-00			SILICON, NPN, TO-106, 2N3565
Q150A,B	151-0232-00			SILICON, NPN, TO-78, TEK SPEC, DUAL
Q158A,B	151-0232-00			SILICON, NPN, TO-78, TEK SPEC, DUAL
Q160	151-0341-00			SILICON, NPN, TO-106, 2N3565
Q163	151-0219-00			SILICON, PNP, TO-18, REPLACEABLE BY 2N4250
Q170	151-0341-00			SILICON, NPN, TO-106, 2N3565
Q182	151-0347-00			SILICON, NPN, TO-92, 2N5551
Q187	151-0347-00			SILICON, NPN, TO-92, 2N5551
Q260	151-0341-00			SILICON, NPN, TO-106, 2N3565
Q263	151-0219-00			SILICON, PNP, TO-18, REPLACEABLE BY 2N4250
Q270	151-0341-00			SILICON, NPN, TO-106, 2N3565
Q280	151-0219-00			SILICON, PNP, TO-18, REPLACEABLE BY 2N4250
Q281	151-0341-00			SILICON, NPN, TO-106, 2N3565
Q286	151-0219-00			SILICON, PNP, TO-18, REPLACEABLE BY 2N4250
<b>RESISTORS... (resistors are fixed, composition, <math>\pm 10\%</math> unless otherwise indicated)</b>				
R4	316-0105-00			1M OHM, 0.25W
R14	316-0105-00			1M OHM, 0.25W
R21	316-0102-00			1K OHM, 0.25W
R22	316-0100-00			10 OHM, 0.25W
R23	321-0292-00			10.7K OHM, 0.125W, PREC, 1%
R24	321-0210-00	B010100	B039999	1.5K OHM, 0.125W, PREC, 1%
R24	321-0222-00	B040000		2K OHM, 0.125W, PREC, 1%
R25	315-0101-00			100 OHM, 0.25W, 5%
R27	315-0203-00			20K OHM, 0.25W, 5%
R32	321-0248-00	B010100	B039999	3.74K OHM, 0.125W, PREC, 1%
R32	321-0250-00	B040000		3.92K OHM, 0.125W, PREC, 1%
R33	321-0222-00			2K OHM, 0.125W, PREC, 1%
R35	304-0122-00			1.2K OHM, 1W
R36	321-0068-00			49.9 OHM, 0.125W, PREC, 1%
R37	321-0010-00			12.4 OHM, 0.125W, PREC, 1%
R100	315-0270-00	B010100	B039999X	27 OHM, 0.25W, 5%
R103	322-0624-07			990K OHM, 0.25W, PREC, 0.1%
R106	322-0481-07			1M OHM, 0.25W, PREC, 0.1%
R108	321-0289-03			10K OHM, 0.125W, PREC, 0.25%
R109	311-0605-00			200 OHM, VAR

Electrical Parts List—5A21N

Ckt No.	Tektronix Part No.	Serial/Model No. Eff	Discont	Description
RESISTORS (CONT)				
R111	315-0153-00			15K OHM,0.25W,5%
R114	315-0242-00			2.4K OHM,0.25W,5%
R120	315-0201-00			200 OHM,0.25W,5%
R121	321-0261-00			5.11K OHM,0.125W,PREC,1%
R125	321-0078-00			63.4 OHM,0.125W,PREC,1%
R126	321-0126-00			200 OHM,0.125W,PREC,1%
R127	311-1116-00			100 OHM,VAR
R131	315-0270-00			27 OHM,0.25W,5%
R135	315-0331-00			330 OHM,0.25W,5%
R137	315-0362-00			3.6K OHM,0.25W,5%
R140	321-0816-03			5K OHM,0.125W,PREC,0.25%
R141	321-0816-03			5K OHM,0.125W,PREC,0.25%
R144	315-0153-00			15K OHM,0.25W,5%
R145	315-0153-00			15K OHM,0.25W,5%
R146	315-0682-00			6.8K OHM,0.25W,5%
R151	321-0222-00			2K OHM,0.125W,PREC,1%
R152	321-0216-00			1.74K OHM,0.125W,PREC,1%
R153	321-0231-00			2.49K OHM,0.125W,PREC,1%
R155	321-0197-00			1.1K OHM,0.125W,PREC,1%
R158	321-0233-00			2.61K OHM,0.125W,PREC,1%
R159	311-1120-00			100 OHM,VAR
R162	315-0153-00			15K OHM,0.25W,5%
R167	321-0272-00			6.65K OHM,0.125W,PREC,1%
R168	321-0182-00	B010100	B039999	768 OHM,0.125W,PREC,1%
R168	321-0181-00	B040000		750 OHM,0.125W,PREC,1%
R169	311-1121-00			2K OHM,VAR
R170	315-0912-00			9.1K OHM,0.25W,5%
R171	315-0513-00			51K OHM,0.25W,5%
R174	316-0102-00			1K OHM,0.25W
R175	321-0184-00			806 OHM,0.125W,PREC,1%
R178	315-0103-00			10K OHM,0.25W,5%
R181	316-0154-00			150K OHM,0.25W
R182	316-0105-00			1M OHM,0.25W
R184	315-0103-00			10K OHM,0.25W,5%
R185	316-0124-00			120K OHM,0.25W
R187	316-0105-00			1M OHM,0.25W
R200	315-0270-00	B010100	B039999X	27 OHM,0.25W,5%
R203	322-0624-07			990K OHM,0.25W,PREC,0.1%
R206	322-0481-07			1M OHM,0.25W,PREC,0.1%
R208	321-0289-03			10K OHM,0.125W,PREC,0.25%
R211	321-0261-00			5.11K OHM,0.125W,PREC,1%
R220	315-0201-00			200 OHM,0.25W,5%
R227	311-0622-00			100 OHM,VAR
R240	321-0933-03			6.66K OHM,0.125W,PREC,0.25%
R241	321-0932-03			2.5K OHM,0.125W,PREC,0.25%
R242	321-0931-03			1.11K OHM,0.125W,PREC,0.25%
R243	321-0660-03			417 OHM,0.125W,PREC,0.25%
R244	321-0930-03			204 OHM,0.125W,PREC,0.25%
R245	321-1097-03			101 OHM,0.125W,PREC,0.25%
R246	321-0030-03			20 OHM,0.125W,PREC,0.25%

Ckt No.	Tektronix Part No.	Serial/Model No. Eff Dscont	Description
RESISTORS (CONT)			
R249	321-0030-03		20 OHM, 0.125W, PREC, 0.25%
R251	321-0222-00		2K OHM, 0.125W, PREC, 1%
R253	321-0231-00		2.49K OHM, 0.125W, PREC, 1%
R255	321-0197-00		1.1K OHM, 0.125W, PREC, 1%
R256	321-0306-00		15K OHM, 0.125W, PREC, 1%
R257	321-0306-00		15K OHM, 0.125W, PREC, 1%
R258	321-0233-00		2.61K OHM, 0.125W, PREC, 1%
R262	315-0153-00		15K OHM, 0.25W, 5%
R267	321-0272-00		6.65K OHM, 0.125W, PREC, 1%
R268	311-1120-00		100 OHM, VAR
R274	316-0102-00		1K OHM, 0.25W
R275	321-0184-00		806 OHM, 0.125W, PREC, 1%
R278	315-0103-00		10K OHM, 0.25W, 5%
R280	315-0331-00		330 OHM, 0.25W, 5%
R281	316-0102-00		1K OHM, 0.25W
R282	315-0331-00		330 OHM, 0.25W, 5%
R283	321-0251-00		4.02K OHM, 0.125W, PREC, 1%
R284	315-0331-00		330 OHM, 0.25W, 5%
R285	315-0331-00		330 OHM, 0.25W, 5%
R286	321-0280-00		8.06K OHM, 0.125W, PREC, 1%
R288	316-0392-00		3.9K OHM, 0.25W
R289	316-0181-00		180 OHM, 0.25W
SWITCHES			
S1A	260-1210-00		PUSH BUTTON:PRE AC
S1B			PUSH BUTTON:CHG GND
S1C			PUSH BUTTON:CURR PROBE ONLY
S1D			PUSH BUTTON:PRE AC
S1E			PUSH BUTTON:CHG GND
S180	260-1209-00		PUSH BUTTON:DISPLAY ON
S240 <sup>1</sup>	105-0293-00		CAM ACTUATOR ASSY, VOLTS/DIV OR AMPERES/DIV
S259	260-1208-00		PUSH BUTTON:BANDWIDTH LIMIT 10 KHZ

<sup>1</sup>See Mechanical Parts List for replacement parts.



# SECTION 6

## DIAGRAM AND CIRCUIT BOARD ILLUSTRATION

### Symbols and Reference Designators

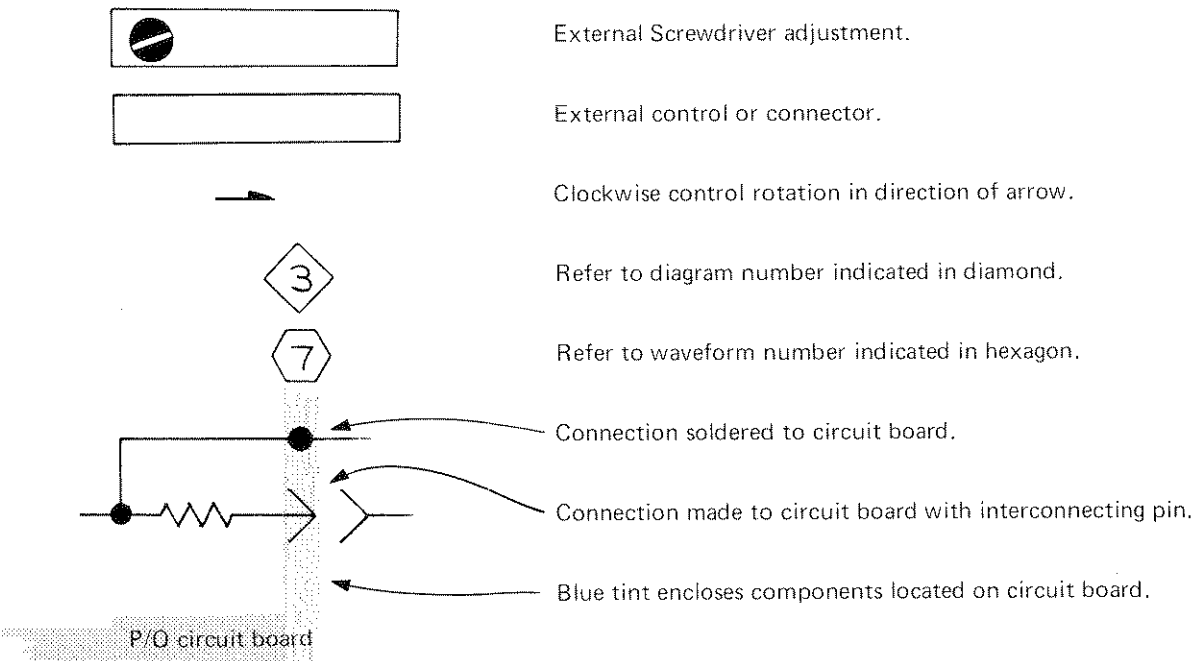
Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors =	Values one or greater are in picofarads (pF). Values less than one are in microfarads ( $\mu$ F).
Resistors =	Ohms ( $\Omega$ )

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:

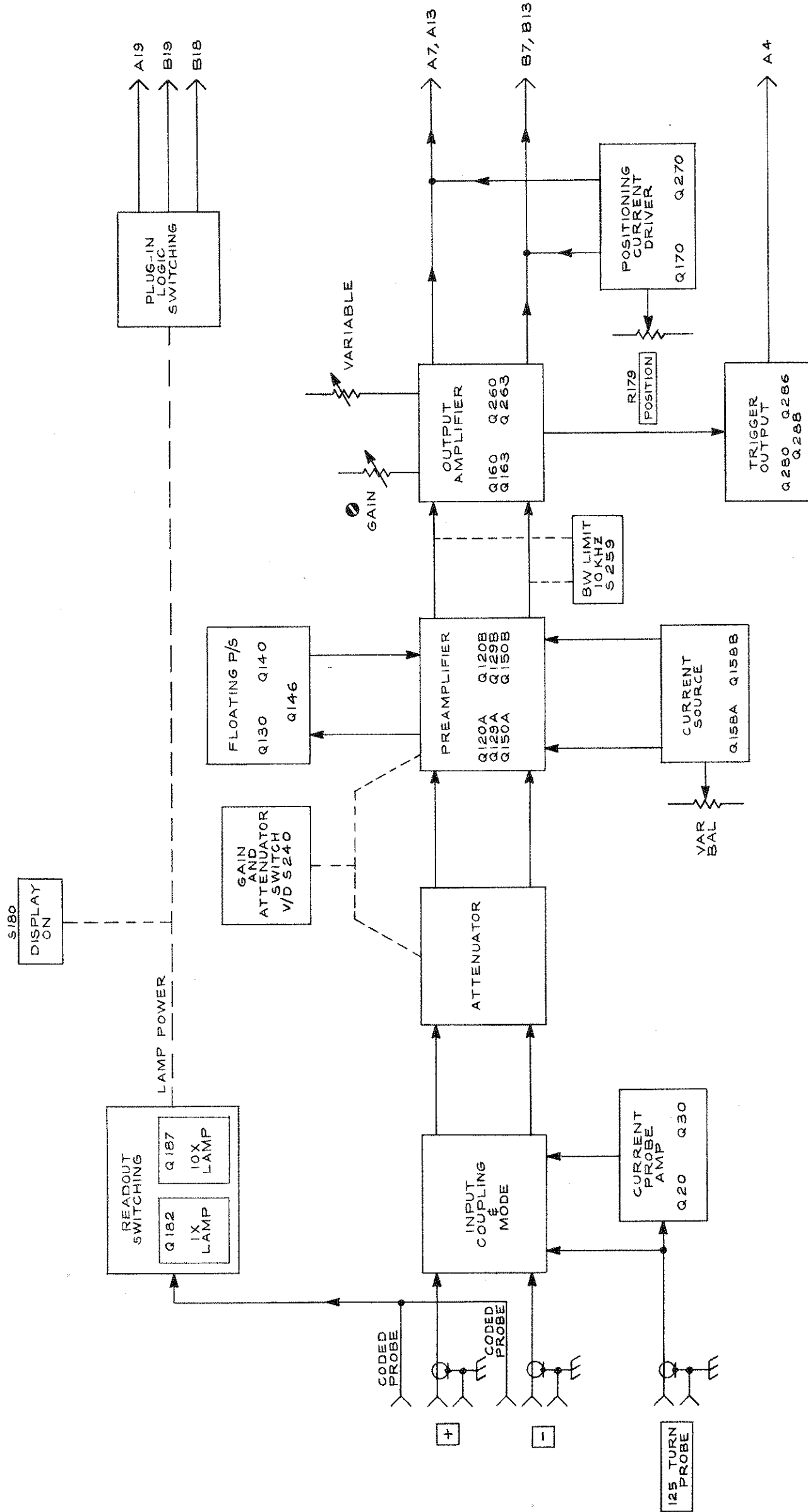


The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

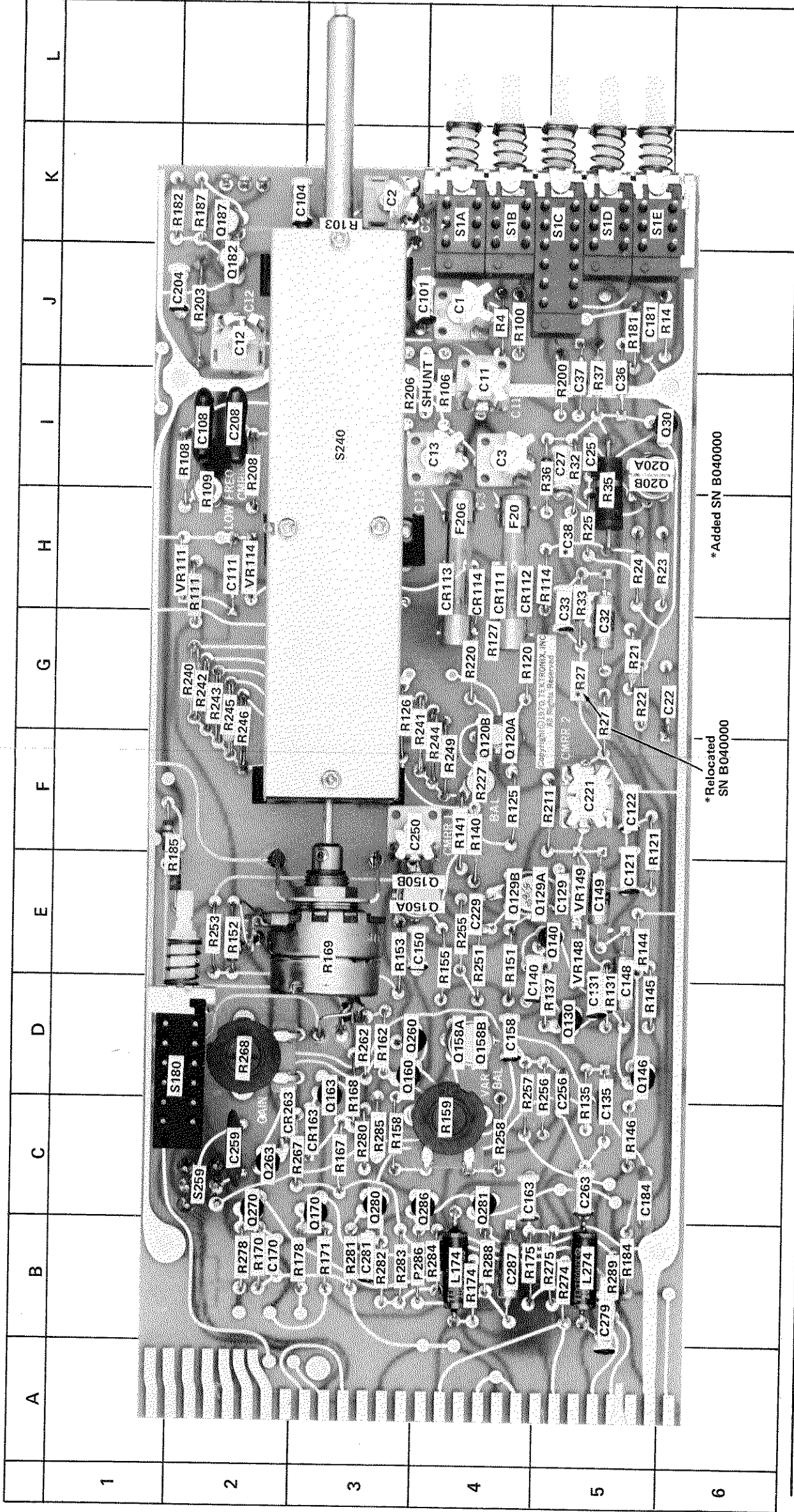
A	Assembly, separable or repairable (circuit board, etc.)	LR	Inductor/resistor combination
AT	Attenuator, fixed or variable	M	Meter
B	Motor	Q	Transistor or silicon-controlled rectifier
BT	Battery	P	Connector, movable portion
C	Capacitor, fixed or variable	R	Resistor, fixed or variable
CR	Diode, signal 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		



BLOCK DIAGRAM



5A21N PARTS LOCATION GRID



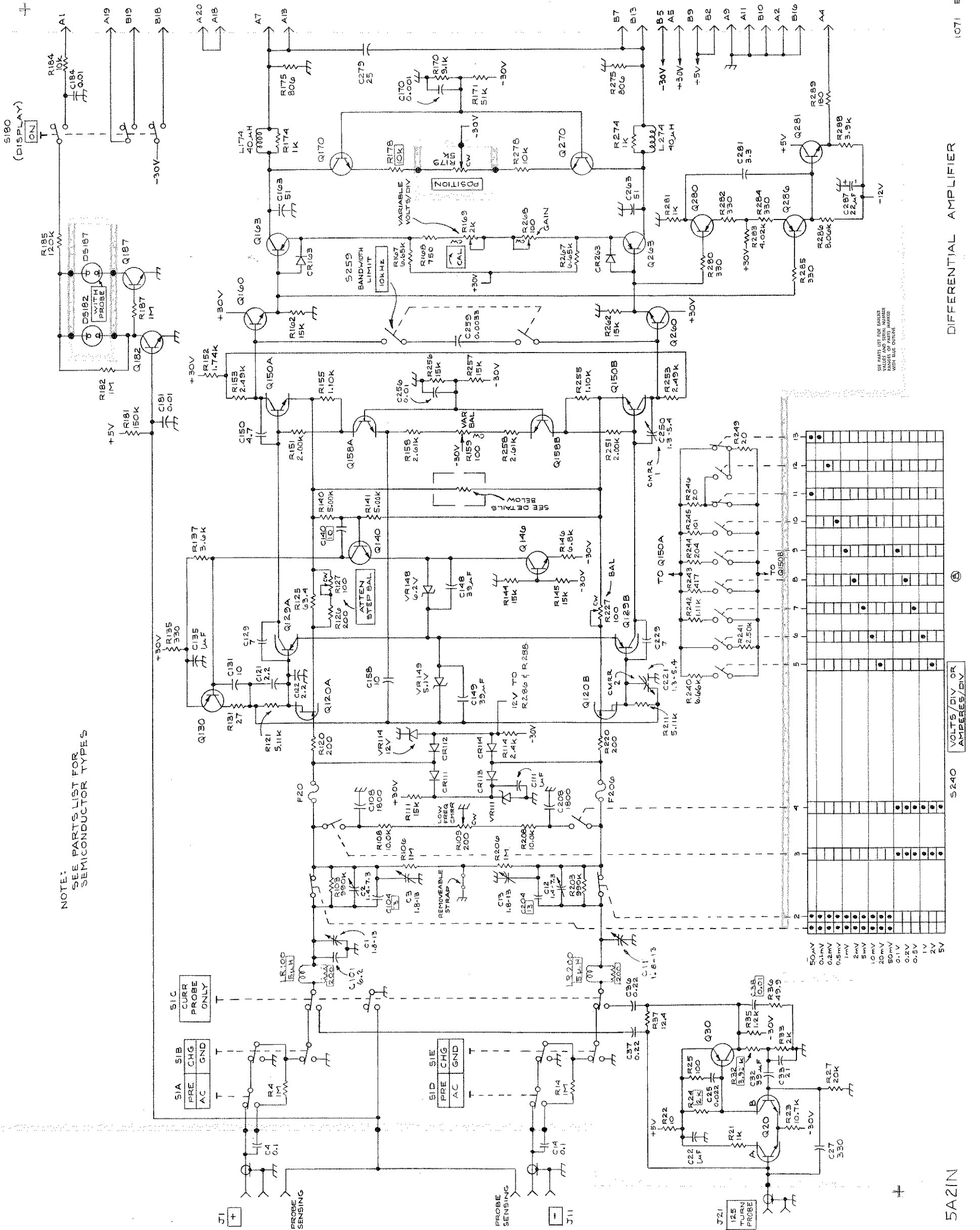
CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC	CKT NO	GRID LOC
C1	J-4	C108	I-2	C184	H-2	CR111	H-4	F20	H-4	L174	H-4	L274	H-4	Q263	C-2
C2	K-3	C111	H-2	C204	E-5	CR112	H-4	F206	H-4	L274	H-4	L274	H-4	Q270	C-2
C3	I-4	C121	E-5	C208	F-5	CR113	H-4							Q280	C-3
C11	I-4	C122	F-5	C221	F-5	CR114	H-4							Q281	C-4
C12	J-2	C129	E-5	C229	E-4	CR163	C-3							Q286	C-4
C13	I-4	C131	D-5	C250	F-3	CR263	C-2								
C22	G-6	C135	D-5	C256	D-5	VR111	H-2								
C25	I-5	C140	E-4	C259	C-2	VR114	H-2								
C27	I-5	C148	D-5	C279	C-5	VR148	E-5								
C32	G-5	C149	E-5	C281	B-3										
C36	I-5	C150	H-5	C287	B-4										
C37	I-5	C158	D-4												
C38	H-5	C163	C-4												
C101	J-3	C170	B-2												
C104	K-2	C181	J-5												

\*Relocated SN B040000

\*Added SN B040000



# DIFFERENTIAL AMPLIFIER



1071 EEB

DIFFERENTIAL AMPLIFIER

5A2IN

SEE PARTS LIST FOR BANDWIDTH BANDS OF PARTS NUMBER WITH THIS OUTLINE



# MECHANICAL PARTS LIST

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

## ABBREVIATIONS

BHB	binding head brass	h	height or high	OHB	oval head brass
BHS	binding head steel	hex.	hexagonal	OHS	oval head steel
CRT	cathode-ray tube	HHB	hex head brass	PHB	pan head brass
csk	countersunk	HHS	hex head steel	PHS	pan head steel
DE	double end	HSB	hex socket brass	RHS	round head steel
FHB	flat head brass	HSS	hex socket steel	SE	single end
FHS	flat head steel	ID	inside diameter	THB	truss head brass
Fl HB	fillister head brass	lg	length or long	THS	truss head steel
Fl HS	fillister head steel	OD	outside diameter	w	wide or width

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty						Name & Description	
		Eff	Dscont		1	2	3	4	5		
1-1	366-0494-00			1						1	KNOB, GRAY--POSITION
	213-0153-00			1						1	. SETSCREW, 5-40 X 0.125 INCH, HSS
-2	-----			--							RESISTOR, VARIABLE
											(ATTACHING PARTS)
-3	210-0583-00			1						1	NUT, HEX., 0.25-32 X 0.312 INCH
-4	210-0940-00			1						1	WASHER, FLAT, 0.375 ID X 0.50 INCH OD
											----- * -----
-5	131-0679-00	B010100	B041688	2						2	CONNECTOR, RECEPTACLE, 3 CONTACT, BNC
	131-0679-02	B041689		2						2	CONNECTOR, RECEPTACLE, 3 CONTACT, BNC
											(ATTACHING PARTS FOR EACH)
	220-0497-00	XB041689		1						1	NUT, PLAIN, HEX., 0.095 X 0.562 INCH
	210-1039-00	XB041689		1						1	WASHER, LOCK, INT, 0.521 ID X 0.625 INCH OD
											----- * -----
	129-0103-00			1						1	BINDING POST ASSEMBLY
-6	129-0077-00			1						1	. STUD
-7	200-0103-00			1						1	. CAP
											(ATTACHING PARTS)
-8	210-0583-00			1						1	NUT, HEX., 0.25-32 X 0.312 INCH
-9	210-0046-00			1						1	WASHER, LOCK, INTERNAL, 0.261 ID X 0.40 INCH OD
											----- * -----
-10	131-0955-00			1						1	CONNECTOR, RECEPTACLE, BNC, FEMALE
-11	366-1036-01			1						1	KNOB, GRAY--ATTEN STEP BAL
-12	384-1065-00			1						1	SHAFT, EXTENSION, 3.485 INCHES LONG
-13	376-0051-00	B010100	B039999	1						1	COUPLING
	376-0051-01	B040000		1						1	COUPLING
	213-0022-00	B010100	B039999	4						4	. SETSCREW, 4-40 X 0.188 INCH, HSS
	213-0178-00	B040000		4						4	. SETSCREW, 4-40 X 0.125 INCH, HSS
	354-0251-00			2						2	. RING
	376-0049-00			1						1	. COUPLING
-14	366-1286-00	B010100	B039999	1						1	KNOB, LATCH
	366-1286-03	B040000		1						1	KNOB, LATCH
	214-1840-00	XB040000		1						1	PIN, KNOB SECURING
-15	214-1513-00	B010100	B039999	1						1	LATCH, PLUG-IN
	214-1513-01	B040000		1						1	LATCH, PLUG-IN
											(ATTACHING PARTS)
-16	213-0254-00			1						1	SCREW, THREAD CUTTING, 2-56 X 0.25", 100 DEG CSK, FHS
											----- * -----
-17	366-1257-15			1						1	KNOB, GRAY--10 KHZ (BANDWIDTH LIMIT)
-18	384-1058-00			1						1	SHAFT, EXTENSION, 7.781 INCHES LONG
-19	366-1292-00			2						2	PUSH BUTTON, GRAY
-20	426-0681-00			7						7	FRAME, PUSH BUTTON
-21	366-1257-11			1						1	PUSH BUTTON, GRAY--AC (+)
-22	366-1257-12			1						1	PUSH BUTTON, GRAY--GND (+)

FIGURE 1 EXPLODED (CONT)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty						Name & Description
		Eff	Dscont		1	2	3	4	5	
1-23	366-1257-13			1						PUSH BUTTON,GRAY--CURR PROBE ONLY
-24	366-1257-11			1						PUSH BUTTON,GRAY--AC (-)
-25	366-1257-12			1						PUSH BUTTON,GRAY--GND (-)
-26	366-1257-14			1						PUSH BUTTON,GRAY--ON (DISPLAY)
-27	384-1059-00			1						SHAFT,EXTENSION,6.581 INCHES
-28	136-0429-00			2						LIGHT,INDICATOR
-29	337-1430-00			1						SHIELD,LIGHT
-30	213-0254-00			2						SCREW,THREAD CUTTING,2-56 X 0.25",100 DEG CSK,FHS (ATTACHING PARTS) - - - * - - -
-31	366-0493-00			1						KNOB,RED--VARIABLE
	213-0153-00			1						. SETSCREW,5-40 X 0.125 INCH,HSS
-32	366-1295-00			1						KNOB,CHARCOAL-VOLTS/DIV OR AMPERES/DIV
	213-0153-00			2						. SETSCREW,5-40 X 0.125 INCH,HSS
-33	333-1388-00			1						PANEL,FRONT
-34	386-1914-00			1						SUBPANEL,FRONT
-35	337-1396-00			1						SHIELD,ELECTRICAL
-36	426-0725-00			1						FRAME SECTION, TOP (ATTACHING PARTS)
-37	213-0229-00			2						SCREW,THREAD FORMING,#6 X 0.375",100 DEG CSK,FHS - - - * - - -
-38	337-1399-00			2						SHIELD,SIDE
-39	426-0724-00			1						FRAME SECTION,BOTTOM (ATTACHING PARTS)
-40	213-0229-00			2						SCREW,THREAD FORMING,#6 X 0.375",100 DEG CSK,FHS - - - * - - -
-41	670-1344-00	B010100	B039999	1						CIRCUIT BOARD ASSEMBLY--MAIN
	670-1344-01	B040000		1						CIRCUIT BOARD ASSEMBLY--MAIN
	388-1903-00			1						. CIRCUIT BOARD
-42	131-0566-00			1						. LINK,TERMINAL CONNECTING
-43	136-0235-00			5						. SOCKET,TRANSISTOR,6 PIN
-44	214-0579-00			4						. PIN,TEST POINT
-45	260-1209-00			1						. SWITCH,PUSH--ON (DISPLAY) (ATTACHING PARTS)
-46	361-0383-00			2						. SPACER,SWITCH - - - * - - -
-47	-----			1						. RESISTOR,VARIABLE (ATTACHING PARTS)
-48	210-0583-00			1						. NUT,HEX.,0.25-32 X 0.312 INCH
-49	210-0046-00			1						. WASHER,LOCK,INTERNAL,0.261 ID X 0.40" OD
-50	387-0794-00			1						. PLATE,MOUNTING
-51	210-0940-00			1						. WASHER,FLAT,0.35 ID X 0.37 INCH OD - - - * - - -
-52	260-1208-00			1						. SWITCH,PUSH--10 KHZ (BANDWIDTH LIMIT) (ATTACHING PARTS)
-53	361-0385-00			2						. SPACER,SWITCH - - - * - - -
-54	260-1210-00			1						. SWITCH,PUSH--INPUT COU;ING/MODE (ATTACHING PARTS)
-55	361-0384-00			5						. SPACER,SWITCH - - - * - - -
-56	344-0154-00			4						. CLIP,FUSE
-57	131-0604-00			13						. CONTACT,ELECTRIAL
-58	105-0239-00			1						. ACTUATOR ASSEMBLY--VOLTS/DIV OR AMPERES/DIV
	105-0221-00			1						. . DRUM
-59	401-0056-00			1						. . BEARING,REAR
-60	220-0636-00			6						. . NUT,HEX.,4-40 X 0.188 INCH
-61	407-0653-00			1						. . BRACKET,SUPPORT
-62	401-0057-00			1						. . BEARING,FRONT
	131-1219-00	XB040000		1						. . CONTACT,ELECTRICAL GROUNDING

FIGURE 1 EXPLODED (CONT)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty						Name & Description
		Eff	Dscont		1	2	3	4	5	
1-63	354-0219-00			1	.	.				RING, RETAINER
-64	214-1127-00			1	.	.				ROLLER, DETENT
-65	214-1139-03			1	.	.				SPRING, FLAT, RED
-66	214-1139-02			1	.	.				SPRING, FLAT, GREEN
-67	200-0943-01			1	.	.				COVER
										(ATTACHING PARTS)
-68	211-0079-00			1	.	.				SCREW, 2-56 X 0.188 INCH, PHS
-69	210-0001-00			3	.	.				WASHER, LOCK, 0.092 ID X 0.175 INCH OD
-70	210-0259-00			1	.	.				LUG, SOLDER, #2
-71	220-0636-00			4	.	.				NUT, HEX., 2-56 X 0.188 INCH
										(ATTACHING PARTS)
-72	211-0116-00			6	.	.				SCREW, SEMS, 4-40 X 0.312 INCH, PHB
-73	-----			1	.	.				RESISTOR, VARIABLE
										(ATTACHING PARTS)
-74	220-0495-00			1	.	.				NUT, HEX., 0.375-32 X 0.438 INCH
-75	407-0894-00			1	.	.				BRACKET
-76	210-0012-00			1	.	.				WASHRE, LOCK, INTERNAL, 0.375 ID X 0.50" OD
-77	384-0242-00			1	.	.				ROD, EXTENSION, 7.281 INCHES
										(ATTACHING PARTS)
-78	213-0048-00			1	.	.				SETSCREW, 4-40 X 0.125 INCH, HSS
										(ATTACHING PARTS)
-79	213-0146-00			4	.	.				SCREW, THERAD FORMING, #6 X 0.313 INCH, PHS
-80	210-0590-00			1	.	.				NUT, HEX., 0.375-32 X 0.312 INCH
-81	210-0978-00			1	.	.				WASHER, FLAT, 0.375 ID X 0.50 INCH OD
-82	358-0029-00			1	.	.				BUSHING

STANDARD ACCESSORIES

070-1139-00	1	MANUAL, INSTRUCTION
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FIGURE 1 EXPLODED

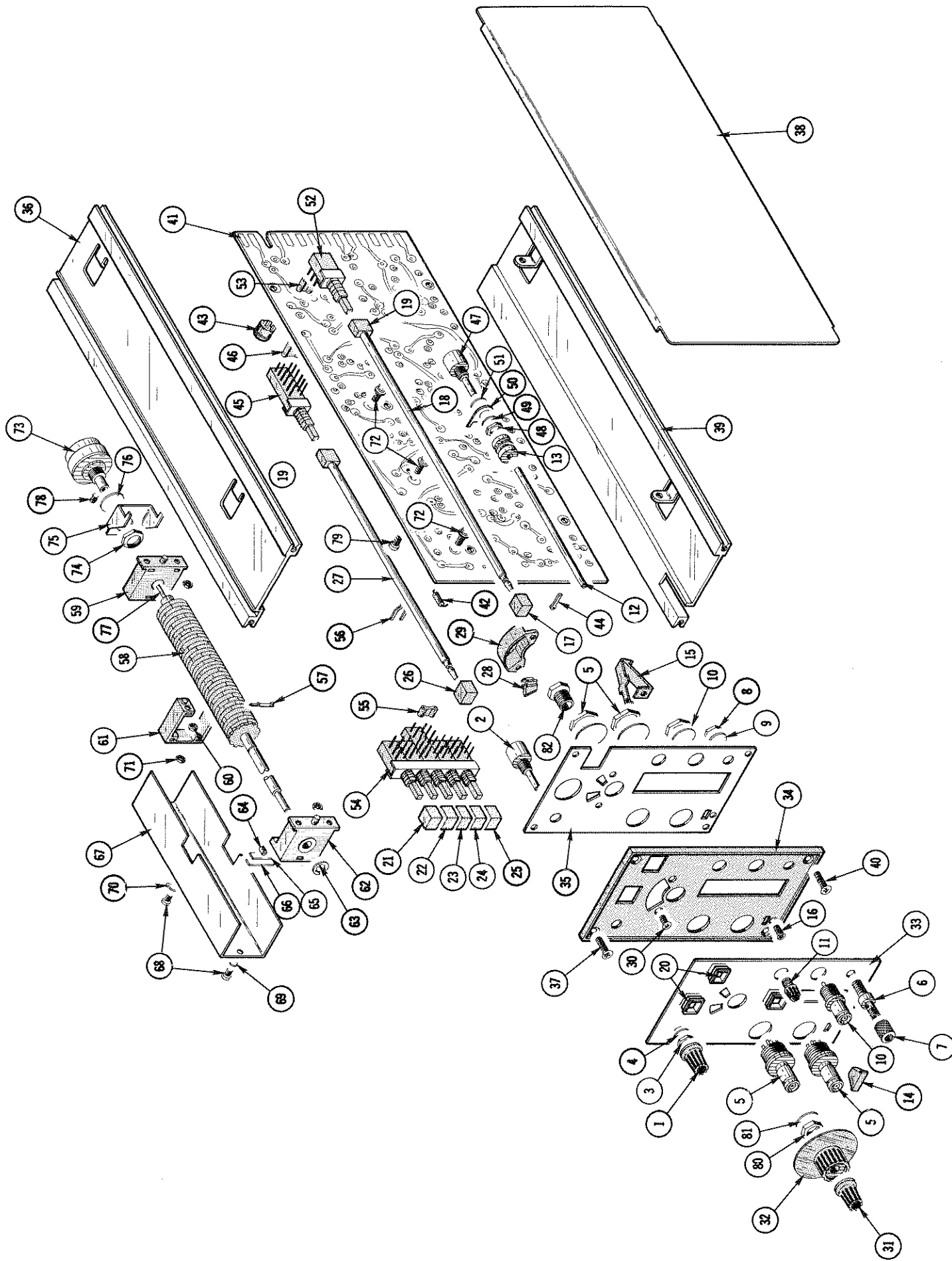


Fig. & Index No.	Tektronix Part No.	Serial/Model No.	Q					Description
			Eff	Disc	t	Y	1 2 3 4 5	
2-	070-1139-00		1					MANUAL, instruction (not shown)

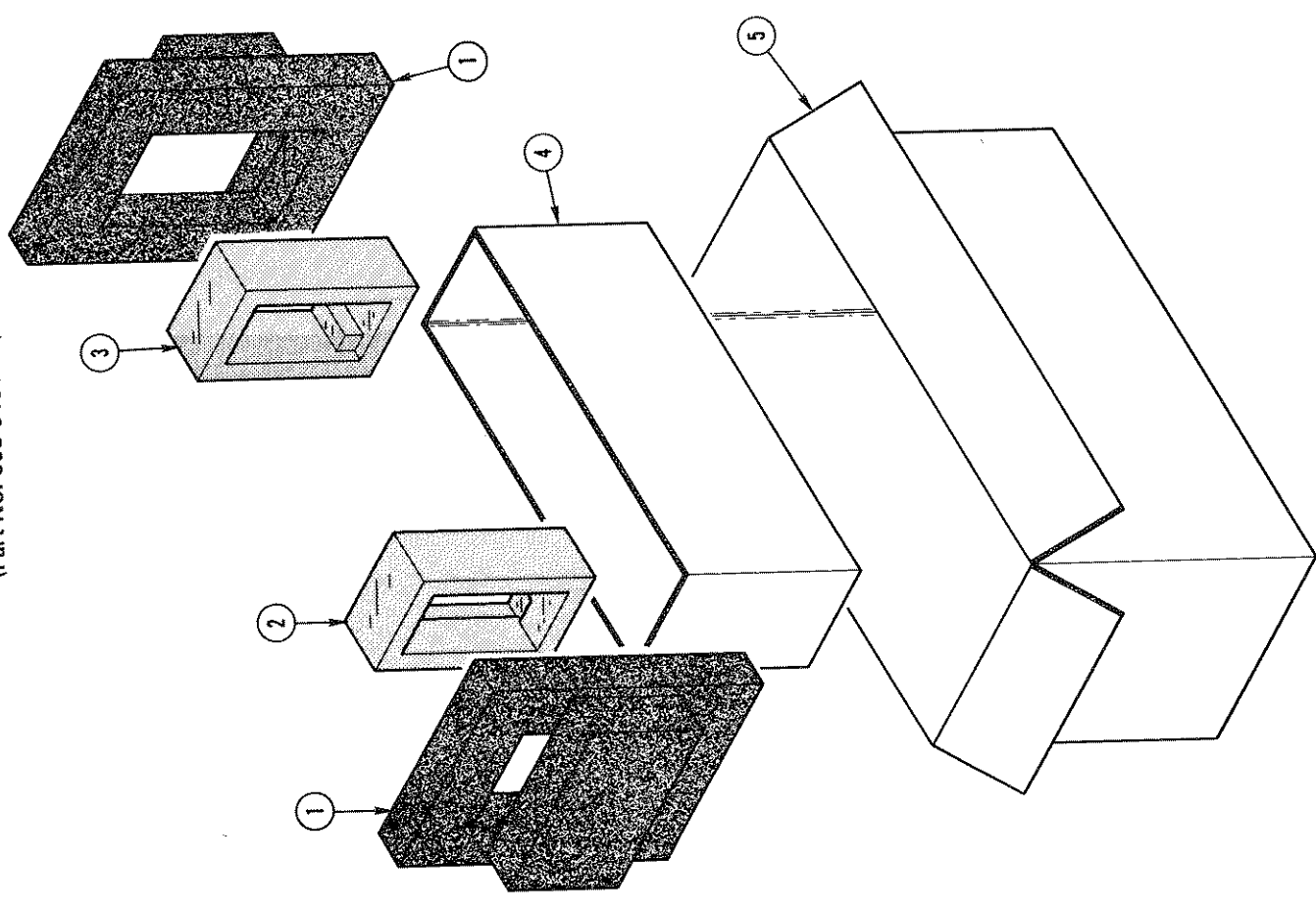


Fig. & Index No.	Tektronix Part No.	Serial/Model No.	Q					Description
			Eff	Disc	t	Y	1 2 3 4 5	
2-	065-0151-00		1					CARTON ASSEMBLY
	-----							carton assembly includes:
-1	004-0282-00		2					FRAME
-2	004-0243-00		1					END CAP, front
-3	004-0242-00		1					END CAP, rear
-4	004-1093-00		1					PAD
-5	004-0612-00		1					CARTON



## **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.

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