INSTRUCTION MANUAL

Serial Number _____

5A22N

DIFFERENTIAL AMPLIFIER

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070-1230-00

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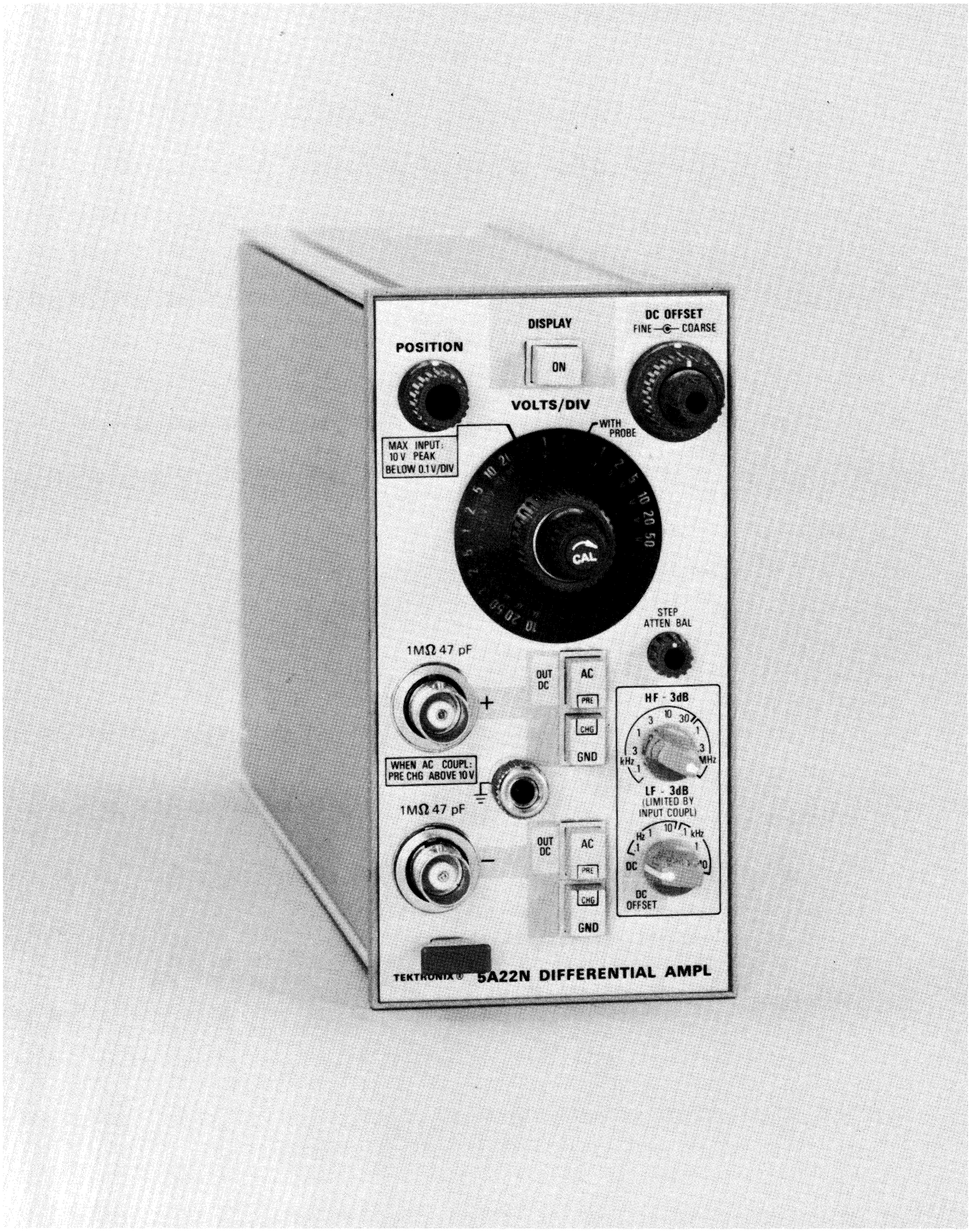


5A22N Differential Amplifier

SECTION 1
OPERATING INSTRUCTIONS

Instrument Description

The 5A22N Differential Amplifier is a high-gain differential amplifier plug-in unit for use with Tektronix 5100-Series Oscilloscopes. The unit features high sensitivity with direct-coupled inputs, high common-mode rejection, and variable DC offset. An illuminated knob skirt provides deflection factor readout. The unit has a maximum bandwidth capability of DC to one megahertz with selectable high and low-frequency limits for increasing the signal-to-noise ratio at low frequencies.

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 Information.

DISPLAY — 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.

HF –3 dB — Allows reduction of the upper bandwidth frequency limit to increase the signal-to-noise ratio for low-frequency applications.

LF –3 dB — Allows lower bandwidth frequency to be increased, thus reducing bandwidth and increasing the signal-to-noise ratio. Also, low-frequency drift can be reduced by restricting frequency response. When AC coupled, the lower bandwidth frequency is limited to 2 hertz by the coupling capacitor. This control also provides DC offset operation when in the DC OFFSET position.

VOLTS/DIV — Volts per major graticule division. Selects calibrated deflection factor in a 1-2-5 sequence, from 10 μV/Div to 5 V/Div in 18 steps. 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) — Provides uncalibrated, continuously variable deflection factor between calibrated steps; extends range to 12.5 V/Div.

DC OFFSET — COARSE and FINE controls provide on-screen display of small signal variations on relatively large DC levels. LF –3 dB switch must be in the DC OFFSET position.

STEP ATTEN DC BAL — Balances the input amplifier for minimum trace shift throughout the deflection factor gain-switching range.

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

Input Coupling (cont) Pushbutton — 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 precharging 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.

BASIC OPERATION

Preparation

The 5A22N 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 5A22N 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 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 5A22N 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 5A22N from the oscilloscope.

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 5A22N. 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. Preset the time-base and triggering controls for a 2-millisecond/division sweep rate and automatic triggering.

3. Set the 5A22N front-panel controls as follows:

DISPLAY

DISPLAY	ON (readout illuminates)
POSITION	Midrange
LF and HF —3 dB	Full bandwidth
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 5A22N 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 — 12.0 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 + input GND button. The display should be a four division square wave 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 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 5A22N 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 INFORMATION

Applying Signals

CAUTION

If the 5A22N input is connected to a large DC voltage source without using the pre-charge provision, the peak charging current (into a 0.1 μF capacitor) will be limited only by the internal resistance of the signal source, and this source may be damaged.

When measuring DC voltages, use the largest deflection factor (5 V/Div) when first connecting the 5A22N 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 Basic 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 5A22N 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.

Signal Input Connectors

When connecting signals to the + and – input connectors on the 5A22N, consider the method of coupling that will be used. Sometimes unshielded test leads can be used to connect the 5A22N 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 5A22N. The shield of a coaxial cable is normally used for this purpose.

In some cases, differential measurements require no common ground connection,[1] 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 5A22N. The circuit at the input connectors can normally be represented by a 1 megohm resistance to ground paralleled by the 47 pF. A few feet of shielded 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 5A22N 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 5A22N 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 an FET Probe or the high impedance input provision of the 5A22N.

High Impedance Input

In the 50 mV through 10 μV 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. 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 10 μV/div, and DC coupling must be used.

[1] **The DC plus AC voltages on the test points (with respect to the chassis potential of the 5A22N) should be limited to the levels listed in Electrical Characteristics under Common-Mode Rejection. Higher levels will degrade the common-mode rejection ratio and exceed the input voltage rating of the unit.**

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.

Gate Current Compensation

The leakage current associated with the gates of the input FETs may be as high as 100 picoamperes. This leakage current will produce an offset voltage which, at the higher input sensitivities, is not acceptable. For example, 100 picoamperes through a one-megohm input resistance to ground produces an offset voltage of 100 microvolts which could drive a display off-screen at 10 microvolts per division. To compensate this effect, the gates of the input FETs may be adjusted to zero volts by returning R120 and R126 through potentiometers R121 and R127 to a slightly negative supply voltage.

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 at higher frequencies and drift at lower frequencies and obtain a more usable display when the VOLTS/DIV switch is set to the more sensitive positions, reduce bandwidth with LF and HF −3 dB switches.

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 5A22N, 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 accomodate large ratios. In doing so, regard the numbers which designate the switch positions as ratio factors rather than voltages.

Differential Operation

Single-ended measurements often yield unsatisfactory results because of interference resulting from ground-loop currents between the 5A22N 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 5A22N 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 Electrical Characteristics.

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. 1-1.

The ability of the 5A22N 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 lower deflection factors (10 μV/DIV and 20 μV/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 measurements) 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 (swapping probes may improve the rejection ratio).

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.

Voltage Probes

In general, probes offer the most convenient means of connecting a signal to the input of the 5A22N. 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

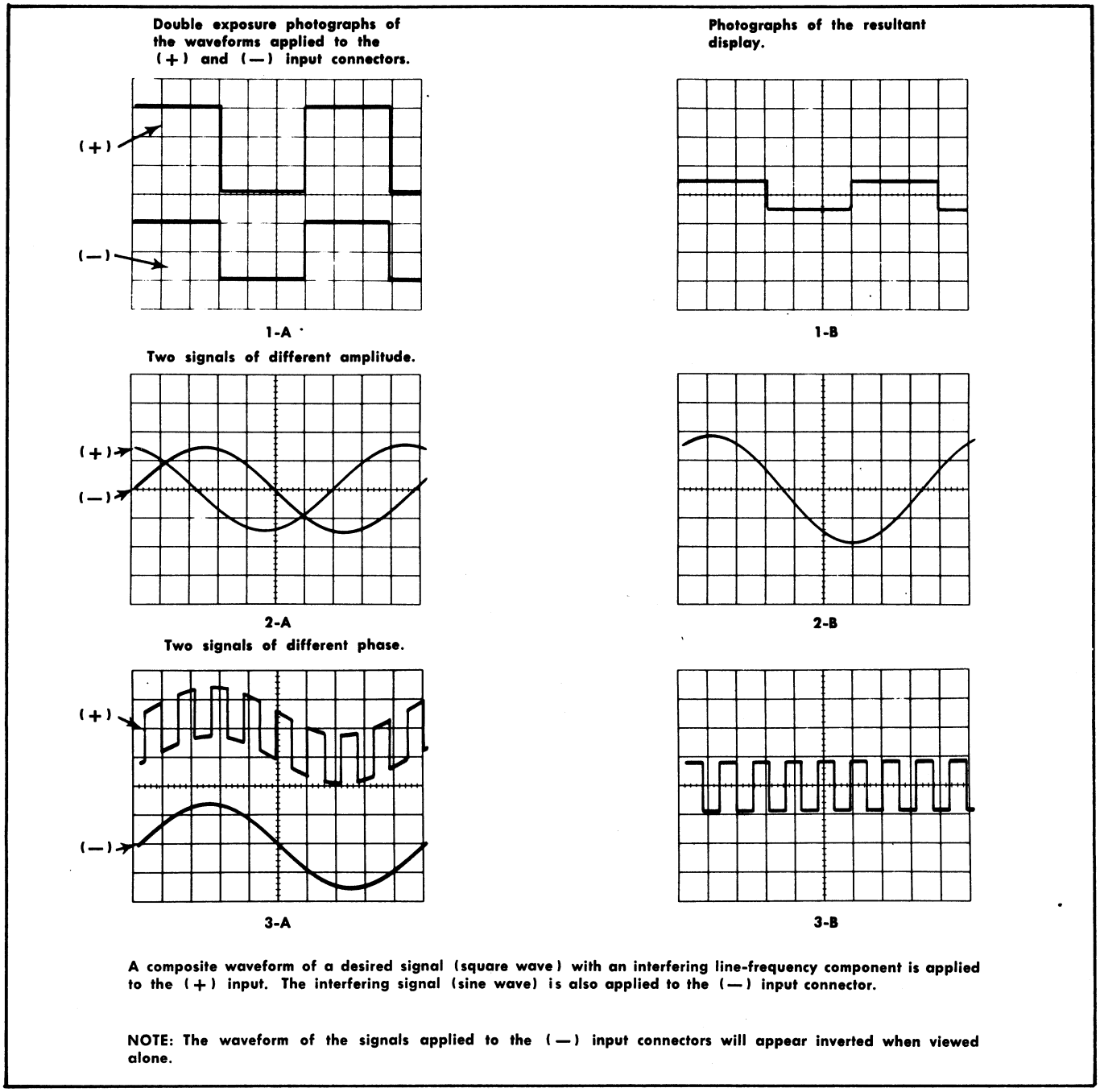


Fig. 1-1. Three examples of differential applications.

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 5A22N 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 5A22N 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).

ELECTRICAL CHARACTERISTICS

Performance Conditions

The following characteristics apply when the 5A22N is operating within the environment described in the 5100-Series Oscilloscope System manual. In addition, the 5A22N must have been calibrated at an ambient temperature between +20°C and +30°C.

Bandwidth (−3 dB)

DC (DIRECT) COUPLED: DC to at least 1 MHz independent of deflection factor. Selectable high- and low-frequency limits.

AC (CAPACITIVE) COUPLED: 2 Hz to at least 1 MHz.

High and Low −3 dB Frequencies

HF −3 dB: Selectable from 0.1 kHz to 1 MHz in a 7 step, 1-3-10 sequence.

LF −3 dB: Selectable from DC to 10 kHz in a 7 step, 1-10-100 sequence. Limited to 2 Hz when AC-coupled.

Deflection Factor

10 μV/div to 5 V/div within 2% in an 18 step, 1-2-5 sequence.

Uncalibrated, continuously variable between steps and to 12.5 V/div.

Common-Mode Rejection

DC (DIRECT) COUPLED: At least 100 dB, DC to 30 kHz at 10 μV/div to 0.1 mV/div with up to 20 V P-P sine wave, decreasing by 20 dB/decade or less on lower deflection factors up to 50 mV/div. At least 50 dB, 0.1 V/div to 5 V/div with up to 100 V P-P sine wave. At least 50 dB at any deflection factor with two P6060 probes.

AC (CAPACITIVE) COUPLED: At least 80 dB at 5 kHz and above, decreasing to 50 dB at 10 Hz.

DC Offset Range

At least + and −0.5 V from 10 μV/div to 50 mV/div. At least + and −50 V from 100 mV/div to 5 V/div.

Input RC

1 MΩ within 0.1% paralleled by ≈ 47 pF.

Overdrive Recovery

Unit recovers to within 0.5% of the quiescent level, in 5 μs after overdriving signal has been applied for 1 s.

Maximum Input Gate Current

100 pA (100 μV depending on external loading) at 25°C.

Maximum Safe Input Voltages

DC (DIRECT) COUPLED: 10 V (DC + peak AC) from 10 μV/div to 50,mV/div. 350 V (DC + peak AC) from 100 mV/div to 5 V/div.

AC (CAPACITIVE) COUPLED: 350 VDC + 10 V peak AC from 10 μV/div to 50 mV/div with coupling capacitor precharged. 350 V (DC + peak AC) from 100 mV/div to 5 V/div.

DC Stability

DRIFT WITH TEMP: 100 μV/°C.

Displayed Noise

20 μV or less measured tangentially at full bandwidth (DC to 1 MHz) with 25 Ω source resistance.

SECTION 2
THEORY OF OPERATION

Introduction

This section of the manual contains an electrical description of the circuits in the 5A22N 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 button is pressed, a logic level is applied to the oscilloscope to enable 5A22N 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.

The input attenuators are frequency-compensated voltage dividers. 1X attenuation is provided for positions 10 μV 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 ATTEN DC CMR 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 output of the preamplifier stage is a push-pull signal, opposite in polarity to that applied to the input. The signal is then passed through a switchable low-frequency limiting circuit.

The gain switching stage consists of two identical operational amplifiers operating in a differential mode. The VOLTS/DIV switch changes the value of the common source/emitter resistor between the two sides, thus changing the gain for the various deflection factors.

The offset generator compensates for DC levels up to + or – 0.5 volt. 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 5A22N. 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 button, S108, 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, S110A and S110B for the + input and S140A and S140B 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, C110 is placed in the circuit to couple signals to about two hertz (–3 dB point) and 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.

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 R132, ATTEN DC CMR. 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 F118, F148 and diodes CR136, CR137, CR138, and CR139. If the signal should reach a level sufficient to forward bias one of the protection 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 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.

Gate Current Compensation

The leakage current associated with the gates of the input FET's may be as high as 100 pA. This 100 pA of leakage current (through 1 megohm to ground, R120 or R126) will produce an offset of 100 μV, which at high input sensitivities is not acceptable. To compensate this effect, the gates of the input FET's may be adjusted to zero volts by returning R120, R126 through variable controls R121 and R127 to a slightly negative supply voltage.

Leakage current associated with the gates of the input FET's and the overdrive protection diodes increases rapidly with temperature, approximately doubling for every 10°C. To compensate this increase, a temperature sensitive input current balancing network is included, using thermistors as the sensing elements.

As the voltage across R120 and R126 increases due to increasing FET gate current at increased temperatures, an equal voltage change is produced in the thermistor compensating circuit, maintaining the FET gate level at zero volts.

The gate current compensation becomes inoperative if the straps are removed for high input impedance operation.

Preamplifier Stage

The preamplifier consists of two identical operational amplifiers, connected in a differential configuration. Fig. 2-1 shows a simplified block diagram of the Preamp.

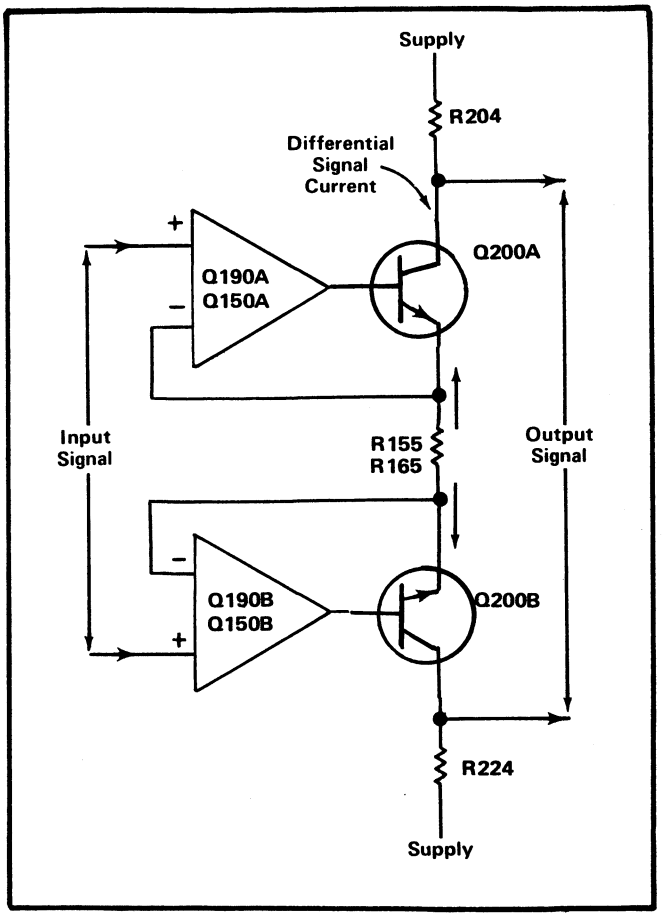


Fig. 2-1. Input Preamp detailed block diagram showing signal current paths.

The operational amplifiers are composed of Q150A, Q190A, and Q200A on one side, and Q150B, Q190B and Q200B on the other side. Q150A and Q150B provide a voltage follower input to output transistors Q200A and Q200B. Total gain of the stage is determined by the resistance between the two sides of the amplifier, and R204 and R224.

DC Offset

To amplify varying signals having other than a ground reference, and still maintain the amplifier differential capabilities, the Offset Generator is designed to cancel out small DC components of the input signal. See Fig. 2-2. This is achieved by producing a current to offset the current developed by the DC voltage. The result is that the Q150A/B drain currents remain balanced and unchanged; thus, no output is produced. In this manner, the DC component of the signal may be offset up to 0.5 volt. Due to the wide range of the Offset Generator (100,000 div at 10 μV per div), stable components are used, and circuit techniques which minimize drift and noise are employed.

The Offset Generator is essentially a voltage comparator composed of Q240 and Q246A on one side; Q244 and Q246B on the other. Q258 serves as a constant current return. When the LF −3 dB switch, S210, is in the DC OFFSET position, the DC OFFSET COARSE and FINE potentiometers, R260 and R268, tap an adjustable portion of the voltage across Zener diode VR251 and apply it to the emitter of Q246B. Divider R250/R251/R254 supplies a reference voltage for the emitter of Q246A. Any difference in the applied voltage is reproduced across resistors R246 and R248, producing an offset current which is conducted through Q240 and Q244 to the Preamp.

When the offset is not in use, the emitter of Q146B is switched to a fixed divider, R252/R253, by the LF −3 dB switch. The Q246A emitter voltage is adjustable over a small range with respect to the Q246B emitter of R250 (COARSE DC BAL) which adjusts out any initial DC unbalance in the Preamp, and brings its output to zero when the input FET gates are grounded.

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

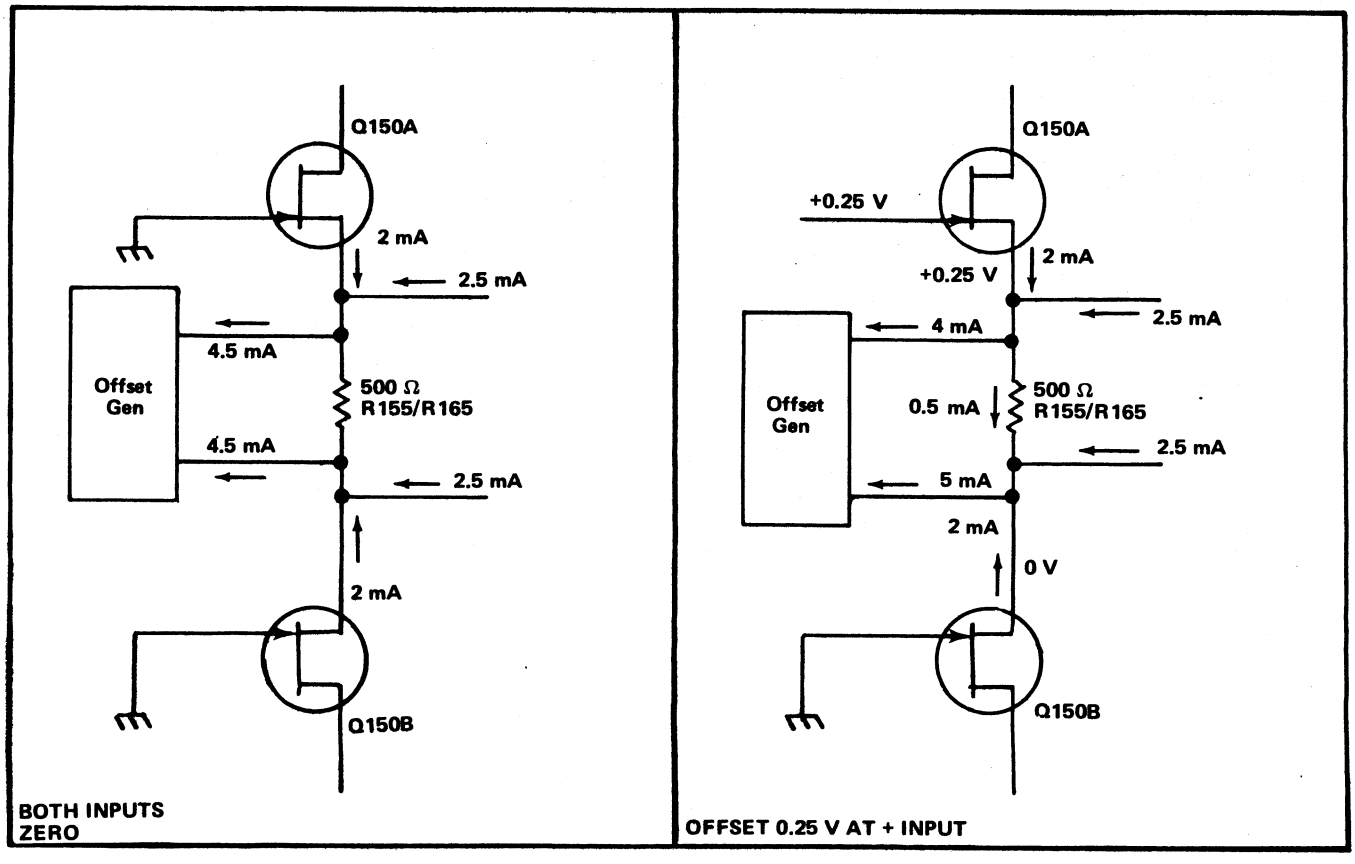


Fig. 2-2. DC Offset block diagram showing current flow with and without an offset voltage at the + input.

were matched (e.g., Q150A/B transconductance and μ, Q190A/B beta, current sources, etc.). In practice, any mismatch will cause a differential output.

Floating Power Supply

A floating power supply made up of Q170, Q176, Q180 and Zener diodes VR173, VR175 and VR176 minimizes inherent common-mode difficulties, and therefore improves the common-mode rejection ratio (refer to Fig. 2-3). Q170 and Q176 are constant current sources that drive current through Zener string VR173, VR175, and VR176 which establish the voltages for the Preamp.

The input to the bootstrap (X1 gain) amplifier is connected to the junction of R155 and R165. The bootstrap amplifier portion of the supply consists of emitter-follower Q180 and DC level-shifting Zener diodes VR173, VR175 and VR176. The collector impedance of Q176 presents minimum loading to the Q180 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 pre-amplifier stage. Since no signal current is developed, the output at the collectors of Q200A/B remains unchanged; that is, the common-mode signal is rejected.

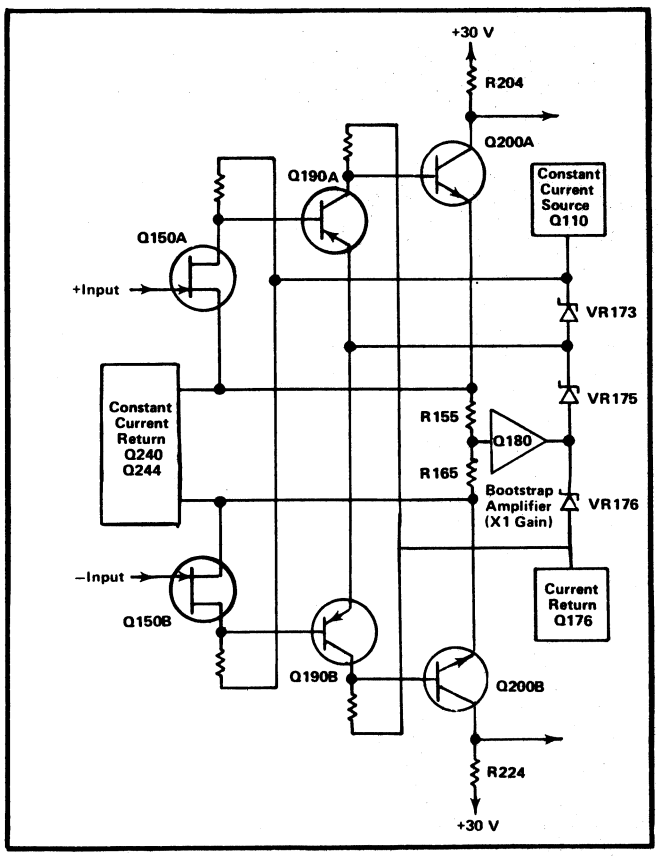


Fig. 2-3. Floating Power Supply block diagram showing standing current paths through the Preamp.

C220 (CMR 1) and C160 (CMR 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. C210 (CMR 3) is adjusted so that rejection is maintained in any position of the LF –3 dB switch.

Cross Neutralization

The use of a common bootstrap power supply results in an undesirable capacitive coupling between the two inputs. Consider the effect of applying +1 volt to the +input while keeping the –input at 0 volts (see Fig. 2-4).

The results are (a) an output current of 2 mA, as shown, and (b) a shift of all supply voltages and several other voltage levels by +0.5 V due to the divider action of R155/R165 operating into the bootstrapped power supply system. Specifically, the drain of Q150 also rises +0.5 V and injects a current i_{1b} through the drain to gate capacitance of Q150B and into the –input. If there is any impedance between the –input and ground, i_{1b} will develop a voltage across it which, being applied to the –input, subtracts from the original +input and causes an erroneous output.

Note that the output current flowing through R163 causes its output end (Q200B emitter) to go to –0.4 V. A capacitor, C162, connected from this point to the –input will divert i_{1b} away from the input line (i_{1b}) and so neutralize the effect of C_{dg} and reduce the –input current to zero. R152 and C152 perform a similar function for the +input.

LF –3 dB Selector

The LF –3 dB switch, S210, permits the lower half-power point of the amplifier bandwidth to be selected from a range of 0.1 hertz to 10 kilohertz. Selection is accomplished by switching the resistor and capacitor of a pair of AC couplings, one on each side of the amplifier, between the Preamp and Gain Switching Amplifier. For ranges 100 Hz to 10 kHz, coupling capacitors C208 and C228 are used in conjunction with the resistors on the switch to set the half-power point. For ranges 0.1 Hz to 10 Hz, C208 and C212 are connected in parallel for one side; C228 and C216 are connected in parallel for the other side. For the DC and DC OFFSET positions of the switch, the capacitors are shorted out to provide DC coupling.

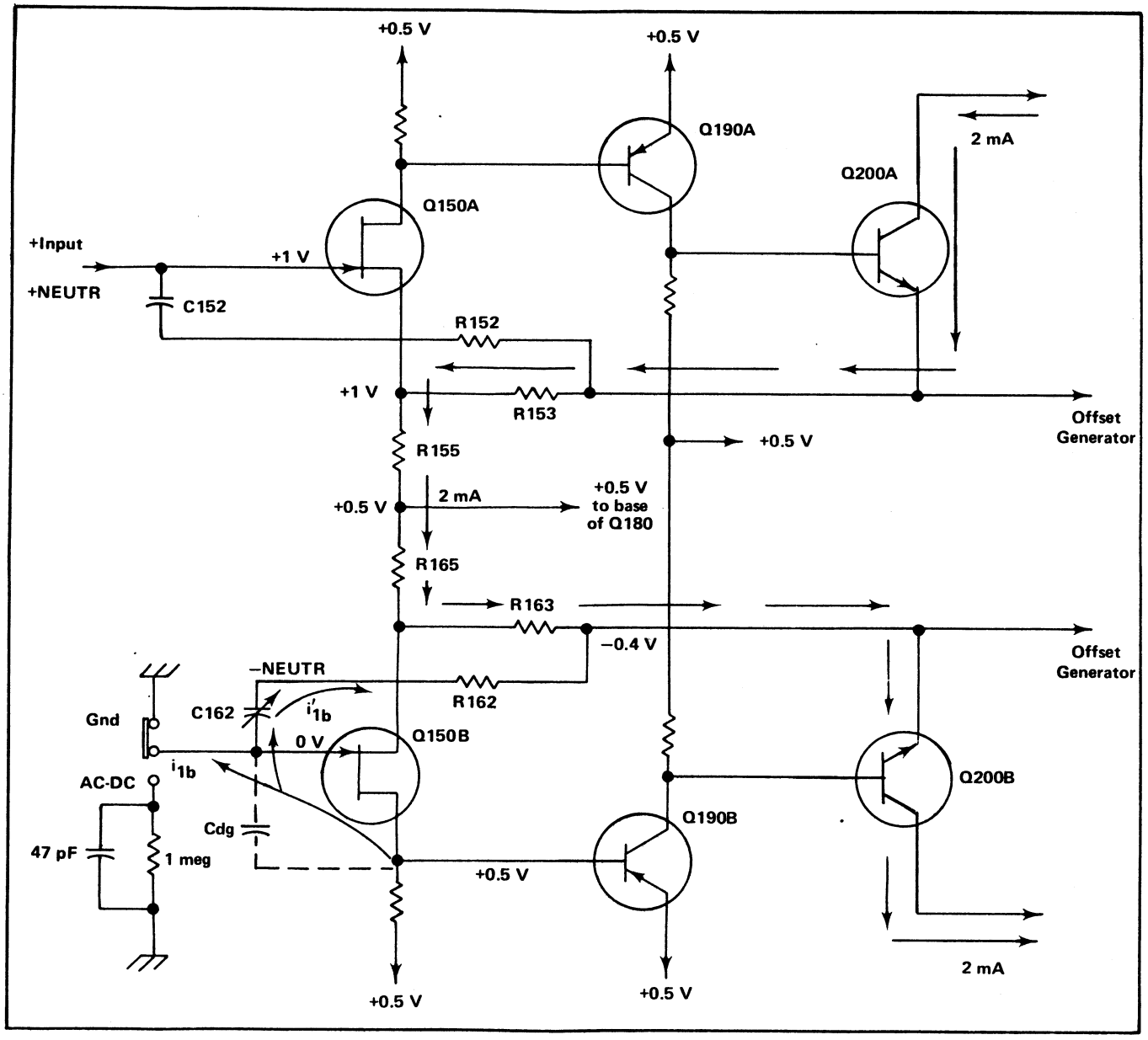


Fig. 2-4. Input cross neutralization.

Gain Switching Stage

The Gain Switching Stage consists of two identical operational amplifiers connected in a differential configuration. As in the Preamp Stage, gain is determined by the ratio of the common collector to the emitter/source resistances, i.e. R316, R318, R326 and the resistors in S280 (VOLTS/DIV). R318 (VAR BAL) divides the collector resistors so that there is no voltage difference at the output when no signal is applied to the input. R292 (AC STEP ATTEN BAL) adjusts out any unbalance between the two operational amplifiers. S330 (HF −3 dB) switches a capacitor across the output of the gain switching amplifier. The collector resistors, R316/R326 and selectable capacitors form an integrator.

Isolation Stage

The differential signal developed at the collectors of Q320A/B is passed through emitter followers Q340 and Q342 to the output amplifier. The emitter followers isolate the preamplifier from the loading of the output amplifier and trigger signal amplifier.

Output Amplifier

The output amplifier consists of push-pull amplifier Q348/Q352. With a signal applied, potentiometer R351 (GAIN) provides emitter degeneration, the gain being determined by the total emitter resistance. This allows the overall gain of the 5A22N to be adjusted to match the

main-frame requirements. Also, the Variable VOLTS/DIV control, R350, allows gain to be adjustable over a 2.5 to 1 ratio.

Q360 and Q362 are positioning-current drivers. R360, POSITION, provides an adjustable change in the conduction of the transistors, which provide a current to either add to or subtract from the Q348/Q352 currents to alter the quiescent vertical position of the display.

Trigger Signal Amplifier

Differential amplifier Q370/Q376 receives the triggering signal from the emitters of Q340/Q342 in the isolation stage. The triggering signal is amplified and passed through emitter-follower Q380, 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 Q150A, and has an amplitude of about 0.25 volt per displayed division.

Vertical Switching and Readout

The VOLTS/DIV switch, S280, is made up of a series of cam lobes, which engage and disengage various contacts at different positions of the switch. Those contacts that are engated 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, DS105, 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 DS105 and illuminates DS103) to reflect the correction of probe attenuation, eliminating possible error by the operator of the instrument. J110 and J140, the + and — input connectors, have probe rings, allowing the 10X probe to apply a ground connection to the base of Q103. Q103 turns off, allowing Q105 to turn on, switching current from DS105 to DS103.

SECTION 3
CALIBRATION

Introduction

This section of the manual contains a procedure to return the circuits of the 5A22N within their designed operating capabilities. Calibration is generally required after a repair has been made, or after long time intervals in which normal aging of components may affect instrument accuracy. For initial inspection, verify instrument operation by performing the procedures described under General Information in Section 1.

Instrument Maintenance

Before complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section of the Oscilloscope System manual. Also, the System manual contains information for general maintenance of this instrument, including preventive maintenance, component identification and replacement, etc.

Service Available

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

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories, or the equivalent is required for complete calibration of the 5A22N. Specifications given for the test equipment are the minimum necessary for accurate calibration. Therefore, some of the specifications listed may be 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.

Calibration Equipment Alternatives

If other test equipment is substituted, control settings or setup may need altering 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 fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Test Instruments

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

2. Constant amplitude sine-wave generator. Frequency, 2 Hz to 1 MHz; output amplitude, about 0.5 V to at least 40 V P-P. For example, General Radio 1310-B Oscillator (use GR Type 274 QBJ Adapter to provide BNC output).

3. Standard amplitude calibrator. Output signal, 1 kHz square wave; output amplitude, 5 mV to at least 50 V; accuracy, within 0.25%. Tektronix Calibration Fixture 067-0502-01 recommended.

Accessories

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

2. Dual-input cable. Provides matched signal paths to the inputs. Connectors are BNC. Tektronix Calibration Fixture 067-0525-00 recommended.

3. 1000:1 divider. Extends output range of Standard Amplitude Calibrator. Accuracy, within 0.2%. Tektronix Calibration Fixture 067-0529-00 recommended.

4. Input RC normalizer. RC time constant, 47 μs (1 MΩ X 47 pF); connectors, BNC. Tektronix Calibration Fixture 067-0541-00 recommended.

5. In-line termination. Impedance, 50 Ω; accuracy, within 2%; connectors, BNC. Tektronix Part No. 011-0049-01 recommended.

6. Plug-in extension for the 5100-series oscilloscope system. Tektronix Calibration Fixture 067-0645-00 (not mandatory for this procedure).

PROCEDURE

Preparation

1. Remove the protective cover from the left side of the 5A22N and also the left side-panel from the 5100-series oscilloscope. (If desired, the plug-in extender, Tektronix Calibration Fixture 067-0645-00 can be used to gain access to the internal adjustments rather than by removing the oscilloscope side-panel.) Insert the 5A22N in the center plug-in compartment, and the 5B10N into the right compartment.

2. Connect the oscilloscope to the power source for which it is wired. Set the controls as described under Initial Control Settings. Refer to Fig. 3-1 for location of internal adjustments and test points.

3. Allow 20 minutes for warmup before calibrating.

NOTE

This instrument should be calibrated at an ambient temperature between +20°C and +30°C (+68°F and +86°F) for best accuracy.

Initial Control Settings

NOTE

Do not preset internal controls unless they are known to be significantly out of adjustment, or unless repairs have been made in the circuit. In these instances, the internal controls can be set to midrange.

	5A22N
DISPLAY	ON
POSITION	Midrange
LF –3 dB	1 Hz
HF –3 dB	1 MHz
VOLTS/DIV	50 m
Variable (CAL)	Fully cw (detent)
DC STEP ATTEN BAL	Midrange
+ and – Input Coupling	GND

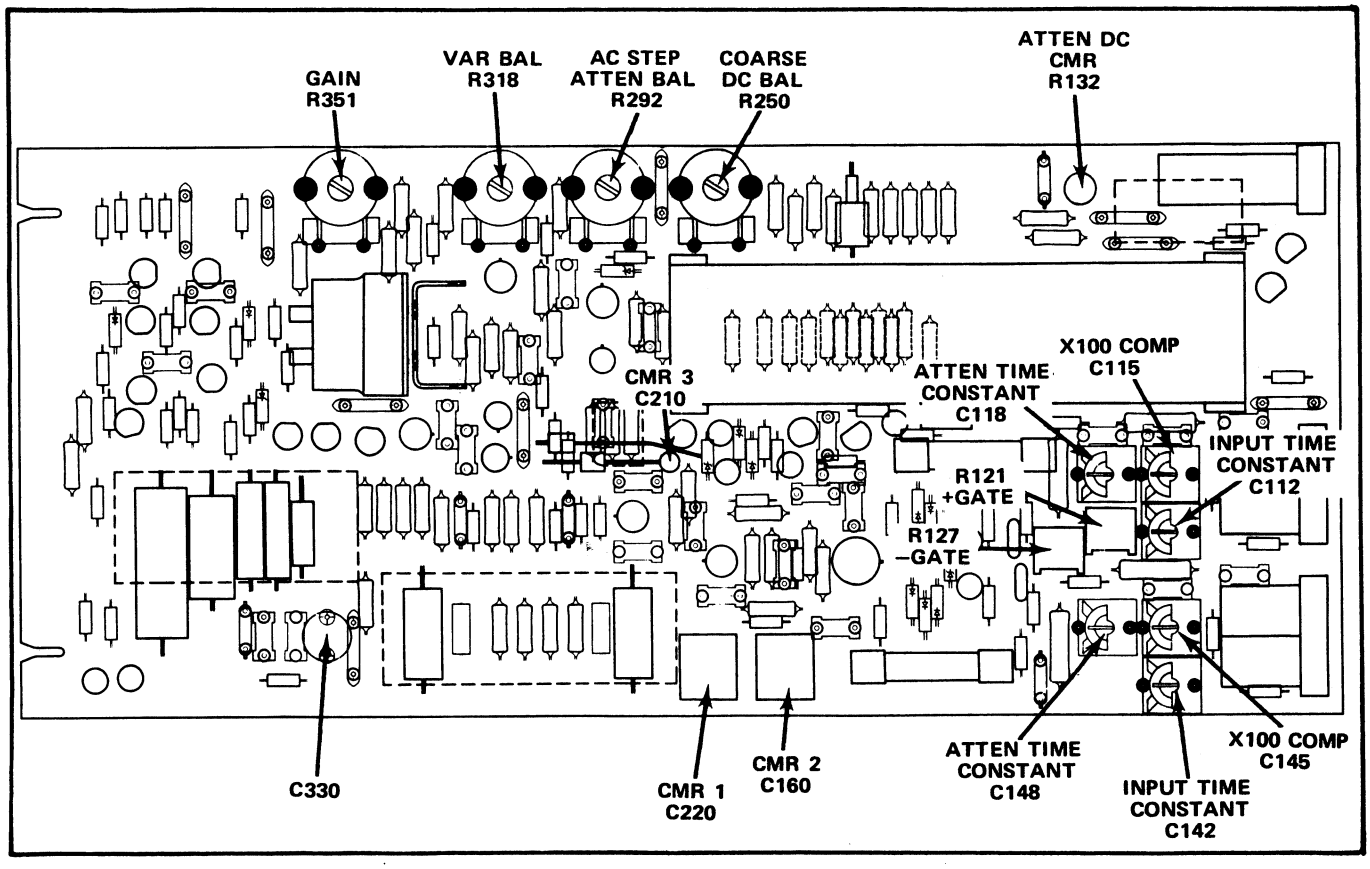


Fig. 3-1. Internal adjustment locations.

Time Base (5B10N)

Position	Sweep starts at left edge of graticule
Seconds/Div	1 m
Triggering Mode	Auto Trig, + Slope, AC Couple
Triggering Source	Composite
Triggering Level	Midrange
All other pushbuttons	Out

1. Step Attenuator Balance

a. Adjust R292 (AC STEP ATTEN BAL) for minimum trace shift while switching the VOLTS/DIV from 50 m to .1 and back.

b. Adjust R318 (VAR BAL) for minimum trace shift while turning the Variable VOLTS/DIV (CAL) from fully cw to fully ccw.

c. Set LF −3 dB to DC and adjust R250 (COARSE DC BAL) for minimum trace shift while switching the VOLTS/DIV from 50 m to .1 and back.

d. Center the trace with the POSITION control. Set the VOLTS/DIV to 50 μ and the LF −3 dB to 1 Hz and reposition the trace to graticule center with R292 (AC STEP ATTEN BAL).

e. Set the LF −3 dB to DC and again position the trace to graticule center with R250 (COARSE DC BAL).

f. Set the VOLTS/DIV to 10 μ and check that the trace is on screen.

g. Set the LF −3 dB to 1 Hz and check that the trace is within the center 2 graticule divisions.

2. Gate Current

a. Connect the 50 Ω In-Line Termination to the + input. Set LF −3 dB to DC and release the + GND button. Adjust R121 (+ GATE CURRENT) for minimum trace shift while switching the + AC button in and out.

b. Connect the 50 Ω In-Line Termination to the − input. Press the + GND button and release the − GND button. Adjust R127 (− GATE CURRENT) for minimum trace shift while switching the − AC button in and out.

3. Attenuator DC Common-Mode Rejection Ratio

a. Release the + and − GND buttons and set the VOLTS/DIV to .1.

b. Apply a 50 V squarewave from the Standard Amplitude Calibrator through the Dual-Input Cable to the + and − input.

c. Adjust R132 (ATT DC CMR) for minimum display amplitude.

4. Input Compensation

a. Press the − GND button and set the VOLTS/DIV to 50 m. Apply a 0.5 V squarewave from the Standard Amplitude Calibrator through the Input RC Normalizer to the + input. Adjust Time Base Level for a stable display.

b. Adjust C118 (ATTEN TIME CONSTANT) for the best square front corner on the display.

c. Apply a 1 V squarewave from the Standard Amplitude Calibrator and set the VOLTS/DIV to .1. Adjust C115 (X100 COMP) and C112 (INPUT TIME CONSTANT) for the best square front corner on the display.

d. Repeat the preceding procedure for the − input. Adjust C148 then C145 and C142 for the best square front corner on the display.

5. Amplifier Gain

a. Set the VOLTS/DIV to 10 m and apply a 50 mV squarewave from the Standard Amplitude Calibrator to the + input.

b. Adjust R351 (GAIN) for exactly 5 divisions of display amplitude.

c. Turn Variable VOLTS/DIV (CAL) fully ccw and check that the display amplitude is less than 2 divisions. Return CAL to detent (fully cw).

6. VOLTS/DIV Accuracy

a. Set the VOLTS/DIV to 5 and apply a 20 V squarewave from the Standard Amplitude Calibrator through the 1000:1 Divider (X1 position) to the + input.

b. Switch the VOLTS/DIV down through each position while also switching the Standard Amplitude Calibrator to maintain either 4 or 5 divisions of display amplitude. Check that the display amplitude is within 2% of the VOLTS/DIV setting.

c. When at the 5 m position of the VOLTS/DIV switch, set the 1000:1 Divider to the X1000 position and adjust the Standard Amplitude Calibrator for a 20 V squarewave. Set the HF –3 dB to 10 kHz and the Time Base Triggering Source to Line. Repeat step b. Return the HF –3 dB to 1 MHz.

7. Common-Mode Rejection Ratio

a. Release – GND button and set the VOLTS/DIV to 10 m. Apply a 20 V P-P, 50 kHz signal from the Constant Amplitude Sine-Wave Generator through the Dual-Input Cable to the + and – inputs.

b. Adjust C160 (CMR 2) for minimum display amplitude. Set the VOLTS/DIV to 50 μ, Time Base Seconds/Div to 10 μ, and Triggering Source to Composite. Adjust Level for a stable display.

c. Adjust C220 (CMR 1) for minimum display amplitude. Set the LF –3 dB to .1 kHz.

d. Adjust C210 (CMR 3) for minimum display amplitude. Repeat steps b. and c. until there is minimum interaction.

8. Bandwidth

a. Press the – GND button. Set the VOLTS/DIV to 1 m, LF –3 dB to DC, and Time Base Seconds/Div to 1 m.

b. Apply a 1 kHz, 8 division signal from the Constant Amplitude Sine-Wave Generator to the + input. Set Generator for a 1 MHz output.

c. Adjust C330 for a 5.6 division display amplitude.

NOTE

Some drift due to heating may occur if the 5A22N has been operating for a time with two other plug-ins. If so, recheck the Step Attenuator Balance and repeat the procedure outlined in step 1.

This completes the 5A22N calibration procedure.

SECTION 4
DIAGRAMS AND PARTS LISTS

Symbols and Reference Designators

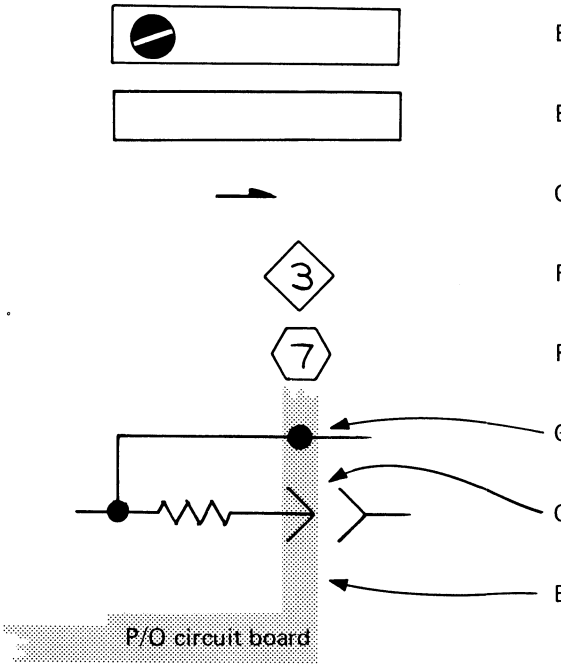
Electrical components shown on the diagrams are in the following units unless noted otherwise:

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

Symbols used on the diagrams are based on ANSI Y32.2-1970.

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:



External Screwdriver adjustment.

External control or connector.

Clockwise control rotation in direction of arrow.

Refer to diagram number indicated in diamond.

Refer to waveform number indicated in hexagon.

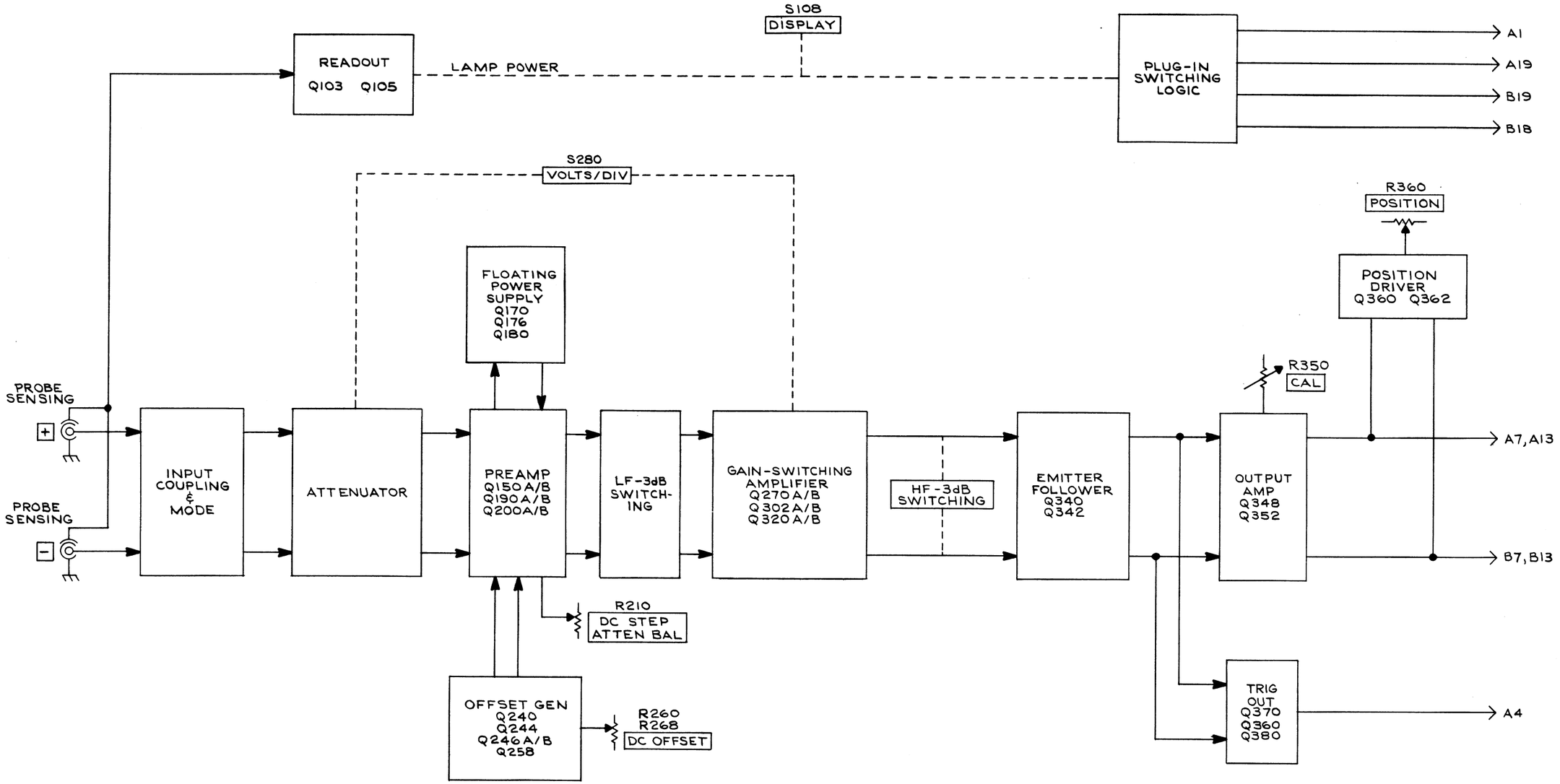
Connection soldered to circuit board.

Connection made to circuit board with interconnecting pin.

Blue tint encloses components located on circuit board.

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



5A22N

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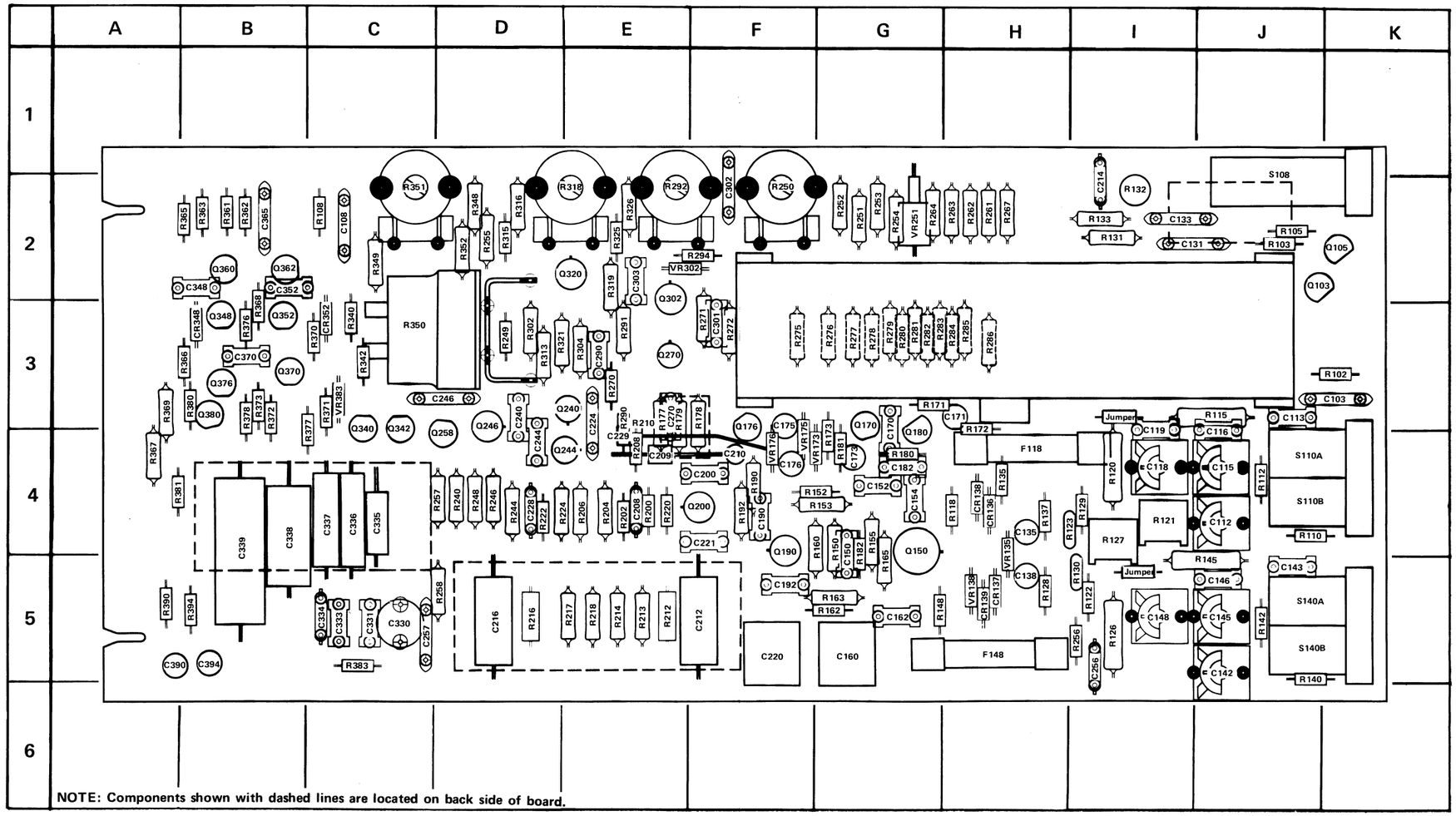
BLOCK DIAGRAM GRS 1071

5A22N PARTS LOCATION GRID



NOTE: Components shown with dashed lines are located on back side of board.

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.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ASSEMBLY					
A1		670-1894-00			MAIN Circuit Board Assembly (part of)
CAPACITORS					
C103[1]	K3	283-0002-00			0.01 µF, Cer, 500 V
C110[1]		295-0155-00			0.1 µF, Plastic, 600 V, 10%
C112	J4	281-0081-00			1.8-13 pF, Var, Air
C113	J3	281-0503-00			8 pF, Cer, 500 V, ±0.5 pF
C115	J4	281-0078-00			1.4-7.3 pF, Var, Air
C116	J3	281-0509-00			15 pF, Cer, 500 V, 10%
C118	I4	281-0081-00			1.8-13 pF, Var, Air
C119	I3	281-0501-00			4.7 pF, Cer, 500 V, ±1 pF
C131	I2	283-0626-00			1800 pF, Mica, 5%
C133	I2	283-0626-00			1800 pF, Mica, 5%
C135	H4	290-0534-00			1 µF, Elect., 35 V, 20%
C138	H5	290-0534-00			1 uF, Elect., 35 V, 20%
C140[2]		295-0155-00			0.1 µF, Plastic, 600 V, 10%
C142	J5	281-0081-00			1.8-13 pF, Var, Air
C143	J5	281-0503-00			8 pF, Cer, 500 V, ±0.5 pF
C145	J5	281-0078-00			1.4-7.3 pF, Var, Air
C146	J5	281-0621-00			12 pF, Cer, 500 V, 1%
C148	I5	281-0081-00			1.8-13 pF, Var, Air
C150	G4	281-0604-00			2.2 pF, Cer, 500 V, ±0.25 pF
C152	G4	281-0542-00			18 pF, Cer, 500 V, 10%
C154	G4	281-0534-00			3.3 pF, Cer, ±0.25 pF

[1]Furnished as a matched pair with C140.
[2]Furnished as a matched pair with C110.

Electrical Parts List (cont)

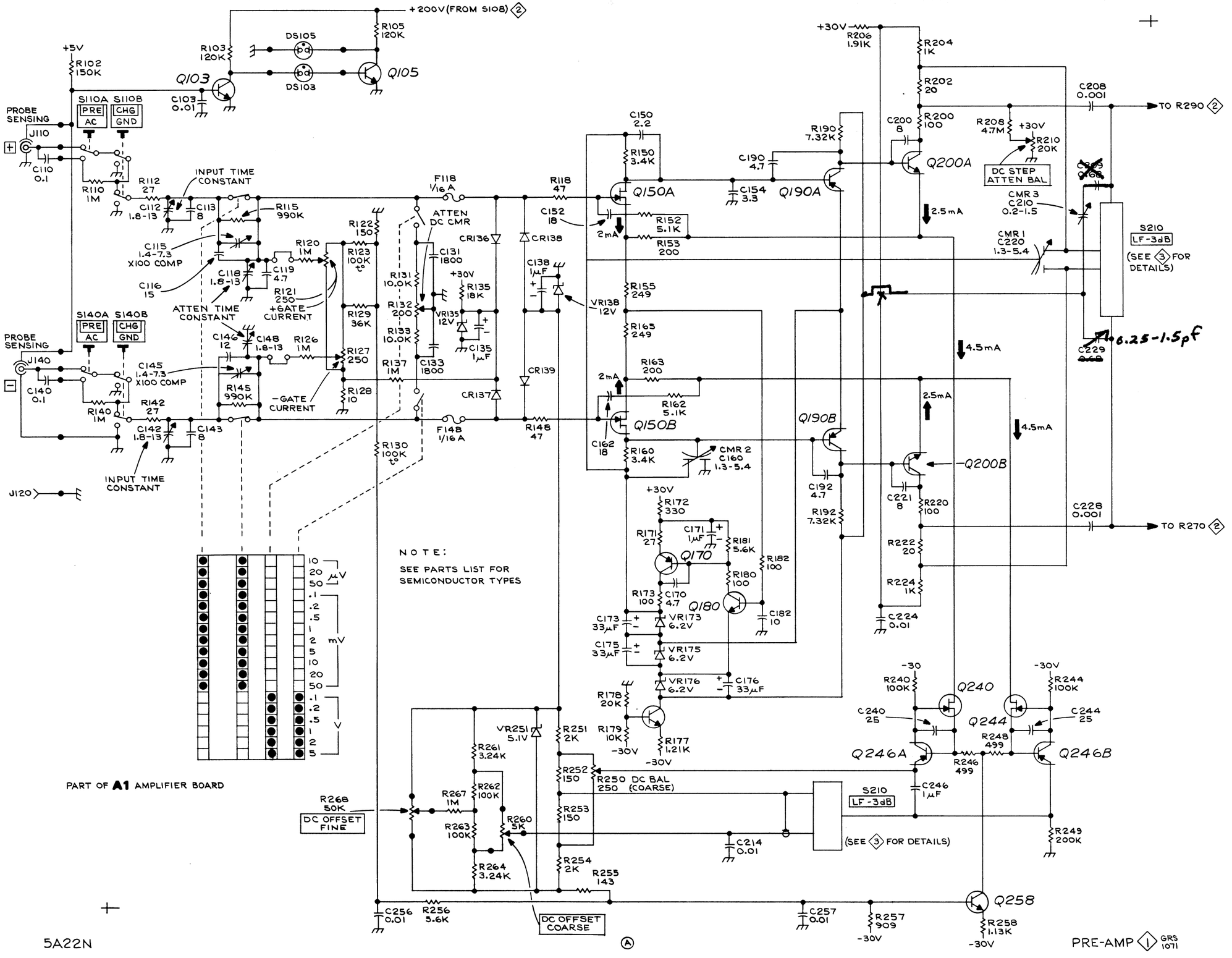
Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
CAPACITORS (cont)					
C160	G5	281-0114-00			1.3-5.4 pF, Var, Air
C162	G5	281-0542-00			18 pF, Cer, 500 V, 10%
C170	G3	281-0501-00			4.7 pF, Cer, 500 V, ±1 pF
C171	H3	290-0534-00			1 µF, Elect., 35 V, 20%
C173	G4	290-0535-00			33 µF, Elect., 10 V, 20%
C175	F3	290-0535-00			33 µF, Elect., 10 V, 20%
C176	F4	290-0535-00			33 µF, Elect., 10 V, 20%
C182	G4	281-0504-00			10 pF, Cer, 500 V, 10%
C190	F4	281-0501-00			4.7 pF, Cer, 500 V, ±1 pF
C192	F5	281-0501-00			4.7 pF, Cer, 500 V, ±1 pF
C200	F4	281-0503-00			8 pF, Cer, 500 V, ±0.5 pF
C208	E4	283-0594-00			0.001 µF, Mica, 100 V, 1%
~~C209~~	~~E4~~	~~281-0537-00~~			~~0.68 pF, Cer, 500 V, 20%~~
C210	F4	281-0064-00			0.25-1.5 pF, Plastic, 600 V
C214	I2	283-0002-00			0.01 µF, Cer, 500 V
C220	F5	281-0114-00			1.3-5.4 pF, Var, Air
C221	F4	281-0503-00			8 pF, Cer, 500 V, ±0.5 pF
C224	E3	283-0002-00			0.01 µF, Cer, 500 V
C228	D4	283-0594-00			0.001 µF, Mica, 100 V, 1%
C229	E4	281-~~0537~~-00	0064		~~0.68 µF, Cer, 500 V, 20%~~ 0.25-1.5pf
C240	D3	281-0552-00			25 pF, Cer, 500 V
C244	D4	281-0552-00			25 pF, Cer, 500 V
C246	D3	283-0059-00			1 µF, Cer, 25 V, +80%-20%
C256	I5	283-0002-00			0.01 µF, Cer, 500 V
C257	C5	283-0002-00			0.01 uF, Cer, 500 V
SCD, DIODES					
CR136	H4	152-0323-00			Silicon, replaceable by SE365
CR137	H5	152-0323-00			Silicon, replaceable by SE365
CR138	H4	152-0323-00			Silicon, replaceable by SE365
CR139	H5	152-0323-00			Silicon, replaceable by SE365
VR135	H4	152-0520-00			Zener, replaceable by UZ8712 or HW12B, 1 W, 12 V, 5%
VR138	H5	152-0520-00			Zener, replaceable by UZ8712 or HW12B, 1 W, 12 V, 5%
VR173	G4	152-0166-00			Zener, selected from 1N753A, 0.4 W, 6.2 V, 5%
VR175	F4	152-0166-00			Zener, selected from 1N753A, 0.4 W, 6.2 V, 5%
VR176	F4	152-0166-00			Zener, selected from 1N753A, 0.4 W, 6.2 V, 5%
VR251	G2	152-~~0481~~-00 0226			Zener, replaceable by 1N3826A, 1 W, 5.1 V, 5%
BULBS					
DS103		150-0111-00			Neon AIC, 1.2 mA
DS105		150-0111-00			Neon AIC, 1.2 mA
FUSES					
F118	H4	159-0024-00			0.6 A, 3 AG, fast-blo
F148	H5	159-0024-00			0.6 A, 3 AG, fast-blo
CONNECTORS					
J110		131-0679-00			Receptacle, electrical, BNC
J140		131-0679-00			Receptacle, electrical, BNC

Electrical Parts List (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSISTORS					
Q103	J2	151-0347-00			Silicon, NPN, replaceable by 2N5551
Q105	K2	151-0347-00			Silicon, NPN, replaceable by 2N5551
Q150A,B	G4	151-1027-00			Silicon, FET, replaceable by D/2N4394 or FD1392, dual
Q170	G3	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q176	F3	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q180	F3	151-0292-00			Silicon, NPN, replaceable by A5T5058
Q190A,B	F4	151-0354-00			Silicon, PNP, replaceable by QD400, dual
Q200A,B	F4	151-0353-00			Silicon, NPN, replaceable by QD100, dual
Q240 Q244	E3 E4	151-1042-00			Silicon, FET, selected from 2N5245, matched pair
Q246A,B	D3	151-0354-00			Silicon, PNP, replaceable by QD400, dual
Q258	D4	151-0341-00			Silicon, NPN, replaceable by 2N3565
RESISTORS					
R102	K3	316-0154-00			150 kΩ, 1/4 W, 10%
R103	J2	316-0124-00			120 kΩ, 1/4 W, 10%
R105	J2	316-0124-00			120 kΩ, 1/4 W, 10%
R110	J4	316-0105-00			1 MΩ, 1/4 W, 10%
R112	J4	316-0270-00			27 Ω, 1/4 W, 10%
R115	J3	322-0624-07			990 kΩ, 1/4 W, 1/10%
R118	H4	316-0470-00			47 Ω, 1/4 W, 10%
R120	I4	322-0481-07			1 MΩ, 1/4 W, 1/10%
R121	I4	311-1223-00			250 Ω, Var
R122	I5	315-0151-00			150 Ω, 1/4 W, 5%
R123	I4	307-0181-00			100 kΩ, Thermal
R126	I5	322-0481-07			1 MΩ, 1/4 W, 1/10%
R127	I4	311-1223-00			250 Ω, Var
R128	H5	316-0100-00			10 Ω, 1/4 W, 10%
R129	I4	315-0363-00			36 kΩ, 1/4 W, 5%
R130	I5	307-0181-00			100 kΩ, Thermal
R131	I2	321-0289-03			10 kΩ, 1/8 W, 1/4%
R132	I2	311-0605-00			200 Ω, Var
R133	I2	321-0289-03			10 kΩ, 1/8 W, 1/4%
R135	H4	315-0183-00			18 kΩ, 1/4 W, 5%
R137	H4	316-0105-00			1 MΩ, 1/4 W, 10%
R140	J5	316-0105-00			1 MΩ, 1/4 W, 10%
R142	J5	316-0270-00			27 Ω, 1/4 W, 10%
R145	J5	322-0624-07			990 kΩ, 1/4 W, 1/10%
R148	G5	316-0470-00			47 Ω, 1/4 W, 10%
R150	G4	321-0244-00			3.4 kΩ, 1/8 W, 1%
R152	G4	315-0512-00			5.1 kΩ, 1/4 W, 5%
R153	G4	321-0126-00			200 Ω, 1/8 W, 1%
R155	G4	321-0135-00			249 Ω, 1/8 W, 1%
R160	G4	321-0244-00			3.4 kΩ, 1/8 W, 1%
R162	G5	315-0512-00			5.1 kΩ, 1/4 W, 5%
R163	G5	321-0126-00			200 Ω, 1/8 W, 1%
R165	G5	321-0135-00			249 Ω, 1/8 W, 1%
R171	G3	316-0270-00			27 Ω, 1/4 W, 10%
R172	H3	315-0331-00			330 Ω, 1/4 W, 5%
R173	G4	315-0101-00			100 Ω, 1/4 W, 5%
R177	E3	321-0201-00			1.21 kΩ, 1/8 W, 1%
R178	F3	321-0318-00			20 kΩ, 1/8 W, 1%
R179	E3	321-0289-00			10 kΩ, 1/8 W, 1%
R180	G4	315-0101-00			100 Ω, 1/4 W, 5%

Electrical Parts List (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS	(cont)				
R181	G4	315-0562-00			5.6 kΩ, 1/4 W, 5%
R182	G4	315-0202-00			2 kΩ, 1/4 W, 5%
R190	F4	321-0276-00			7.32 kΩ, 1/8 W, 1%
R192	F4	321-0276-00			7.32 kΩ, 1/8 W, 1%
R200	E4	315-0101-00			100 Ω, 1/4 W, 5%
R202	E4	315-0200-00			20 Ω, 1/4 W, 5%
R204	E4	321-0193-00			1 kΩ, 1/8 W, 1%
R206	E4	321-0220-00			1.91 kΩ, 1/8 W, 1%
R208	E4	316-0475-00			4.7 MΩ, 1/4 W, 10%
R210	E3	311-0881-00			20 kΩ, Var
R220	E4	315-0101-00			100 Ω, 1/4 W, 5%
R222	D4	315-0200-00			20 Ω, 1/4 W, 5%
R224	E4	321-0193-00			1 kΩ, 1/8 W, 1%
R240	D4	321-0385-00			100 kΩ, 1/8 W, 1%
R244	D4	321-0385-00			100 kΩ, 1/8 W, 1%
R246	D4	321-0164-00			499 Ω, 1/8 W, 1%
R248	D4	321-0164-00			499 Ω, 1/8 W, 1%
R249	D3	315-0204-00			200 kΩ, 1/4 W, 5%
R250	F2	311-1124-00			250 Ω, Var
R251	C2	321-0222-00			2 kΩ, 1/8 W, 1%
R252	G2	321-0114-00			150 Ω, 1/8 W, 1%
R253	G2	321-0114-00			150 Ω, 1/8 W, 1%
R254	G2	321-0222-00			2 kΩ, 1/8 W, 1%
R255	D2	321-0112-00			143 Ω, 1/8 W, 1%
R256	I5	315-0562-00			5.6 kΩ, 1/4 W, 5%
R257	D4	321-0189-00			909 Ω, 1/8 W, 1%
R258	D5	321-0198-00			1.13 kΩ, 1/8 W, 1%
R260		311-0889-00			5 kΩ, Var
R261	H2	321-0242-00			3.24 kΩ, 1/8 W, 1%
R262	H2	321-0385-00			100 kΩ, 1/8 W, 1%
R263	H2	321-0385-00			100 kΩ, 1/8 W, 1%
R264	G2	321-0242-00			3.24 kΩ, 1/8 W, 1%
R267	H2	321-0481-00			1 MΩ, 1/8 W, 1%
R268		311-0887-00			50 kΩ, Var
SWITCHES					
S110A, S110B	J4, J4	260-1207-00			Push, +AC/GND
S140A, S140B	J5, J5	260-1207-00			Push, -AC/GND


+200V(FROM S108) 2
R105 120K
R103 120K
DS105
DS103
Q103
Q105
C103 0.01
+5V
R102 150K
S110A PRE AC
S110B CHG GND
PROBE SENSING
J110
C110 0.1
R110 1M
R112 27
C112 1.8-13
C113 8
INPUT TIME CONSTANT
R115 990K
C115 1.4-7.3 X100 COMP
C116 15
C118 1.8-13
C119 4.7
R120 1M
R121 250
+GATE CURRENT
R122 150
R123 100K
R129 36K
R127 250
R128 10
-GATE CURRENT
ATTEN TIME CONSTANT
S140A PRE AC
S140B CHG GND
PROBE SENSING
J140
C140 0.1
R140 1M
R142 27
C142 1.8-13
C143 8
C145 1.4-7.3 X100 COMP
C146 12
C148 1.8-13
R126 1M
R145 990K
INPUT TIME CONSTANT
J120
F118 1/16A
ATTEN DC CMR
R131 10.0K
R132 200
R133 10.0K
R137 1M
C131 1800
C133 1800
+30V
R135 18K
VR135 12V
C135 1μF
F148 1/16A
R130 100K
R118 47
C152 18
CR136
CR138
CR139
CR137
C138 1μF
VR138 12V
R148 47
C150 2.2
R150 3.4K
Q150A
2mA
R152 5.1K
R153 200
C154 3.3
Q190A
R190 7.32K
C190 4.7
+30V
R206 1.91K
R204 1K
R202 20
C200 8
R200 100
Q200A
2.5mA
C208 0.001
TO R290 2
R208 4.7M
+30V
R210 20K
DC STEP ATTEN BAL
CMR 3 C210 0.2-1.5
CMR 1 C220 1.3-5.4
C205 C209
S210 LF-3dB
(SEE 3 FOR DETAILS)
C229 6.25-1.5pf
R155 249
R165 249
R163 200
R162 5.1K
Q150B
C162 18
R160 3.4K
CMR 2 C160 1.3-5.4
+30V
R172 330
R171 27
C171 1μF
R181 5.6K
Q170
R182 100
R180 100
R173 100
C170 4.7
Q180
C182 10
C173 33μF
VR173 6.2V
C175 33μF
VR175 6.2V
VR176 6.2V
C176 33μF
R178 20K
R179 10K
-30V
R177 1.21K
-30V
4.5mA
2.5mA
4.5mA
Q190B
C192 4.7
R192 7.32K
Q200B
C221 8
R220 100
C228 0.001
TO R270 2
R222 20
R224 1K
C224 0.01
-30
R240 100K
Q240
C240 25
Q246A
R246 499
-30V
R244 100K
Q244
C244 25
Q246B
R248 499
C246 1μF
S210 LF-3dB
(SEE 3 FOR DETAILS)
R249 200K
C214 0.01
VR251 5.1V
R251 2K
R261 3.24K
R252 150
R250 DC BAL 250 (COARSE)
R253 150
R254 2K
R255 143
R262 100K
R267 1M
R263 100K
R260 5K
R264 3.24K
R266 50K
DC OFFSET FINE
DC OFFSET COARSE
C256 0.01
R256 5.6K
C257 0.01
R257 909
-30V
Q258
R258 1.13K
-30V
10 20 50 μV
.1 .2 .5 1 2 5 10 20 50 mV
.1 .2 .5 1 2 5 V
NOTE:
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
PART OF A1 AMPLIFIER BOARD
5A22N
A
PRE-AMP 1 GRS 1071
PRE-AMP
1

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

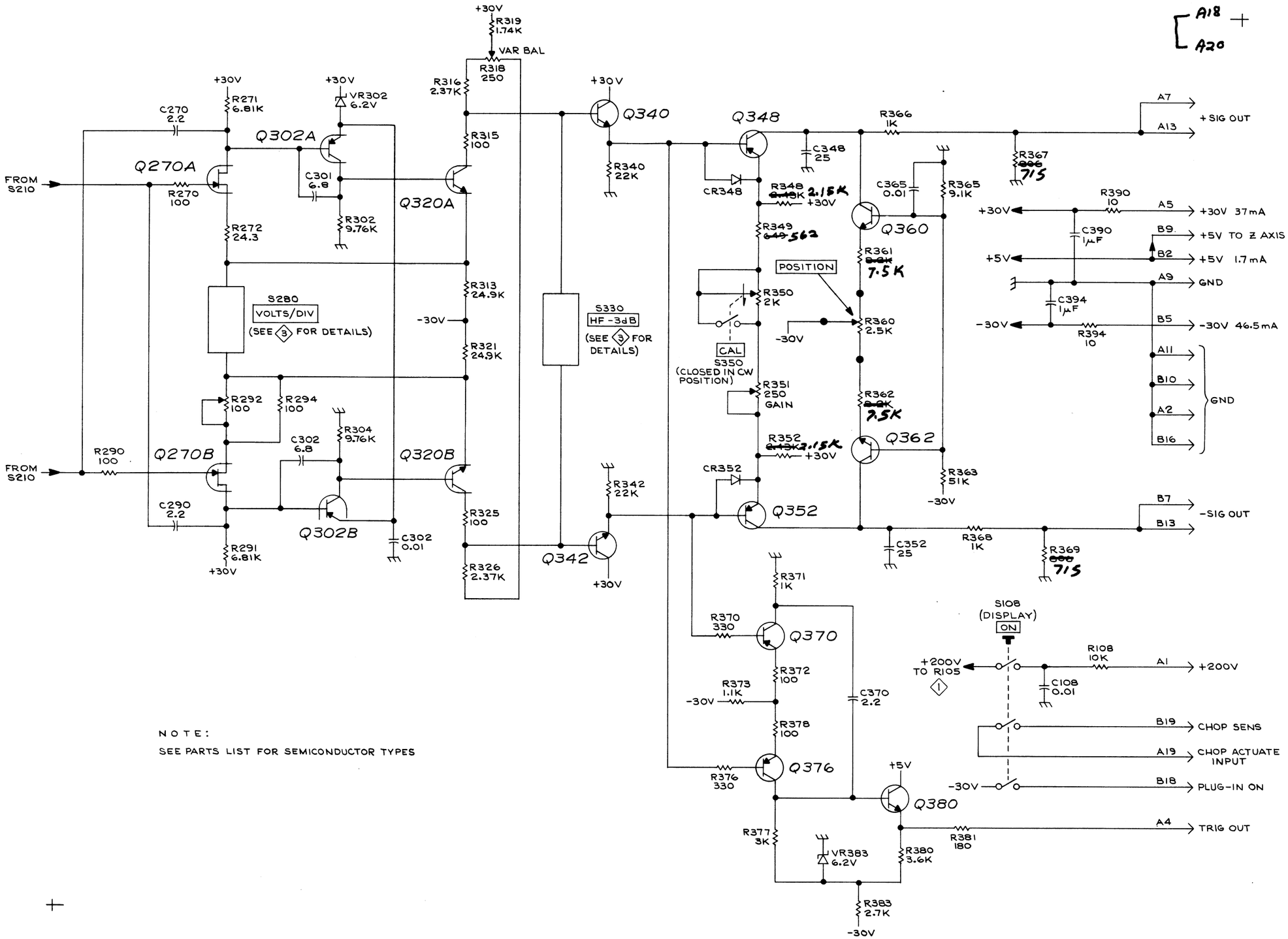
A	Assembly, separable or repairable	FL	Filter	PTM	paper or plastic, tubular molded
AT	Attenuator, fixed or variable	H	Heat dissipating device (heat sink, etc.)	R	Resistor, fixed or variable
B	Motor	HR	Heater	RT	Thermistor
BT	Battery	J	Connector, stationary portion	S	Switch
C	Capacitor, fixed or variable	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.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ASSEMBLY					
A1		670-1894-00			MAIN Circuit Board Assembly (part of)
CAPACITORS					
C108	C2	283-0002-00			0.01 µF, Cer, 500 V
C270	E3	281-0604-00			2.2 pF, Cer, 500 V, ±0.25 pF
C290	E3	281-0604-00			2.2 pF, Cer, 500 V, ±0.25 pF
C301	F3	281-0572-00			6.8 pF, Cer, 500 V, ±0.5 pF
C302	F2	283-0002-00			0.01 µF, Cer, 500 V
C303	E2	281-0572-00			6.8 pF, Cer, 500 V, ±0.5 pF
C348	B2	281-0552-00			25 pF, Cer, 500 V
C352	B2	281-0552-00			25 pF, Cer, 500 V
C365	B2	283-0002-00			0.01 pF, Cer, 500 V
C370	B3	281-0604-00			2.2 pF, Cer, 500 V, ±0.25 pF
C390	A5	290-0534-00			1 µF, Elect., 35 V, 20%
C394	B5	290-0534-00			1 µF, Elect., 35 V, 20%
SCD, DIODES					
CR348	B3	152-0185-00			Silicon, selected from 1N4152 or 1N3605
CR352	C3	152-0185-00			Silicon, selected from 1N4152 or 1N3605
VR302	E2	152-0166-00			Zener, selected from 1N753A, 0.4 W, 6.2 V, 5%
VR383	C3	152-0166-00			Zener, selected from 1N753A, 0.4 W, 6.2 V, 5%
TRANSISTORS					
Q270A,B	E3	151-~~1054~~ 1050-00			Silicon, FET, replaceable by FD1644, dual
Q302A,B	E2	151-0354-00			Silicon, PNP, replaceable by QD400, dual
Q320A,B	E2	151-0353-00			Silicon, NPN, replaceable by QD100, dual
Q340	C3	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q342	C3	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q348	B3	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q352	B3	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q360	B2	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q362	B2	151-0341-00			Silicon, NPN, replaceable by 2N3565
Q370	B3	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q376	B3	151-0342-00			Silicon, PNP, replaceable by 2N4249
Q380	B3	151-0341-00			Silicon, NPN, replaceable by 2N3565

Electrical Parts List (cont)

Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
RESISTORS					
R108	C2	316-0103-00			10 kΩ, 1/4 W, 10%
R270	E3	315-0101-00			100 Ω, 1/4 W, 5%
R271	F3	321-0630-00			6.81 kΩ, 1/8 W, 1/2%
R272	F3	321-0038-00			24.3 Ω, 1/8 W, 1%
R290	E3	315-0101-00			100 Ω, 1/4 W, 5%
R291	E3	321-0630-00			6.81 kΩ, 1/8 W, 1/2%
R292	E2	311-1120-00			100 Ω, Var
R294	F2	315-0101-00			100 Ω, 1/4 W, 5%
R302	D3	321-0288-00			9.76 kΩ, 1/8 W, 1%
R304	E3	321-0288-00			9.76 kΩ, 1/8 W, 1%
R313	D3	321-0327-03			24.9 kΩ, 1/8 W, 1/4%
R315	D2	315-0101-00			100 Ω, 1/4 W, 5%
R316	D2	321-0229-00			2.37 kΩ, 1/8 W, 1%
R318	E2	311-1124-00			250 Ω, Var
R319	E2	312-0216-00			1.74 kΩ, 1/8 W, 1%
R321	D3	321-0327-03			24.9 kΩ, 1/8 W, 1/4%
R325	E2	315-0101-00			100 Ω, 1/4 W, 5%
R326	E2	321-0229-00			2.37 kΩ, 1/8 W, 1%
R340	C3	316-0223-00			22 kΩ, 1/4 W, 10%
R342	C3	316-0223-00			22 kΩ, 1/4 W, 10%
R348	D2	321-0~~230~~-00			~~2.43~~ kΩ, 1/8 W, 1%
R349[1]	C2	321-0~~175~~-00			~~649~~ Ω, 1/8 W, 1%
R350[1]	C3	311-1121-00			2 kΩ, Var
R351	C2	311-1124-00			250 Ω, Var
R352	D2	321-0~~230~~-00			~~2.43~~ kΩ, 1/8 W, 1%
R360		311-0994-00			2.5 kΩ, Var
R361	B2	315-~~0822~~-00			~~8.2~~ kΩ, 1/4 W, 5%
R362	B2	315-0~~822~~-00			~~8.2~~ kΩ, 1/4 W, 5%
R363	B2	315-0513-00			51 kΩ, 1/4 W, 5%
R365	B2	315-0912-00			9.1 kΩ, 1/4 W, 5%
R366	B3	316-0102-00			1 kΩ, 1/4 W, 10%
R367	A4	321-0~~184~~-00			~~806~~ Ω, 1/8 W, 1%
R368	B3	316-0102-00			1 kΩ, 1/4 W, 10%
R369	A3	321-0~~184~~-00			~~806~~ Ω, 1/8 W, 1%
R370	C3	315-0331-00			330 Ω, 1/4 W, 5%
R371	C3	316-0102-00			1 kΩ, 1/4 W, 10%
R372	B3	315-0101-00			100 Ω, 1/4 W, 5%
R373	B3	315-0112-00			1.1 kΩ, 1/4 W, 5%
R376	B3	315-0331-00			330 Ω, 1/4 W, 5%
R377	C4	315-0302-00			3 kΩ, 1/4 W, 5%
R378	B3	315-0101-00			100 Ω, 1/4 W, 5%
R380	B3	315-0362-00			3.6 kΩ, 1/4 W, 5%
R381	A4	316-0181-00			180 Ω, 1/4 W, 10%
R383	C5	315-0272-00			2.7 kΩ, 1/4 W, 5%
R390	A5	316-0100-00			10 Ω, 1/4 W, 10%
R394	B5	316-0100-00			10 Ω, 1/4 W, 10%
SWITCHES					
S108[2]	J2	260-1209-00			Push, ON
S350[2]	C3				

[1] Furnished as a unit with S350.
[2] Furnished as a unit with R350.



NOTE:
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

PART OF **A1** AMPLIFIER BOARD

ELECTRICAL PARTS LIST

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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.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
ASSEMBLY					
A1		670-1894-00			MAIN Circuit Board Assembly (part of)
CAPACITORS					
C212	F5	285-0809-00			1 µF, PTM, 50 V, 10%
C216	D5	285-0809-00			1 µF, PTM, 50 V, 10%
C330	C5	281-0093-00			5.5-18 pF, Var, Cer
C331	C5	281-0571-00			82 pF, Cer, 500 V, 20%
C333	C5	283-0604-00			304 pF, Mica, 300 V, 2%
C334	C5	283-0594-00			0.001 µF, Mica, 100 V, 1%
C335	C4	285-0627-00			0.0033 µF, PTM, 100 V, 5%
C336	C4	285-0569-00			0.01 µF, PTM, 200 V, 20%
C337	C4	285-0620-00			0.033 µF, PTM, 300 V, 20%
C338	B4	285-0622-00			0.1 µF, Plastic, 100 V, 20%
C339	B4	285-0633-00			0.22 µF, PTM, 100 V, 10%
RESISTORS					
R212	E5	301-0165-00			1.6 MΩ, 1/2 W, 5%
R213	E5	321-0408-00			174 kΩ, 1/8 W, 1%
R214	E5	321-0303-00			14 kΩ, 1/8 W, 1%
R216	D5	301-0165-00			1.6 MΩ, 1/2 W, 5%
R217	E5	321-0408-00			174 kΩ, 1/8 W, 1%
R218	E5	321-0303-00			14 kΩ, 1/8 W, 1%
R275	F3	321-0413-00			196 kΩ, 1/8 W, 1%
R276	G3	321-0959-03			24.01 kΩ, 1/8 W, 1/4%
R277	G3	321-0958-03			9.673 kΩ, 1/8 W, 1/4%
R278	G3	321-0957-03			4.408 kΩ, 1/8 W, 1/4%
R279	G3	321-0956-03			1.674 kΩ, 1/8 W, 1/4%
R280	G3	321-0955-03			823 Ω, 1/8 W, 1/4%
R281	G3	321-0912-03			408 Ω, 1/8 W, 1/4%
R282	G3	321-0954-03			162.5 Ω, 1/8 W, 1/4%
R283	G3	321-0953-03			81 Ω, 1/8 W, 1/4%
R284	H3	321-0952-03			40.5 Ω, 1/8 W,
R285	H3	321-0021-03			16.2 Ω, 1/8 W, 1/4%
R286	H4	321-0021-03			16.2 Ω, 1/8 W, 1/4%

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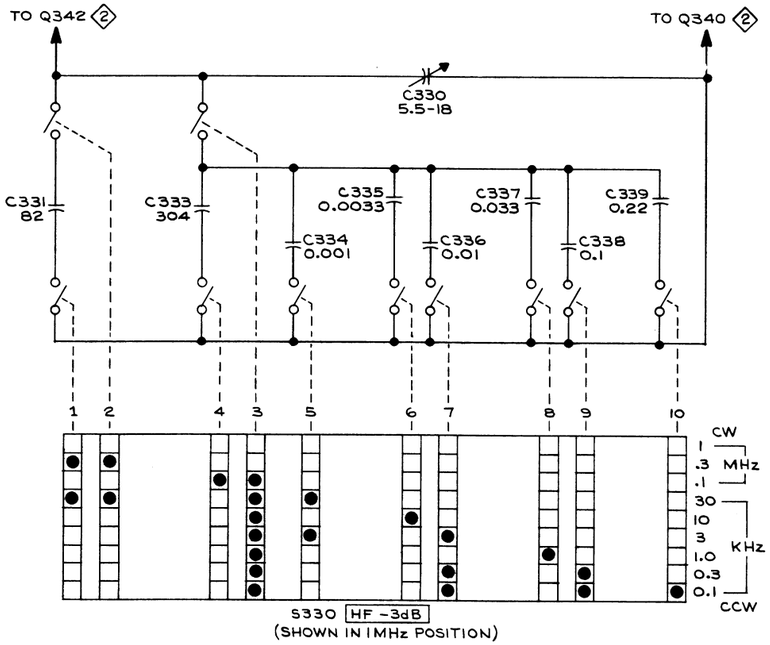
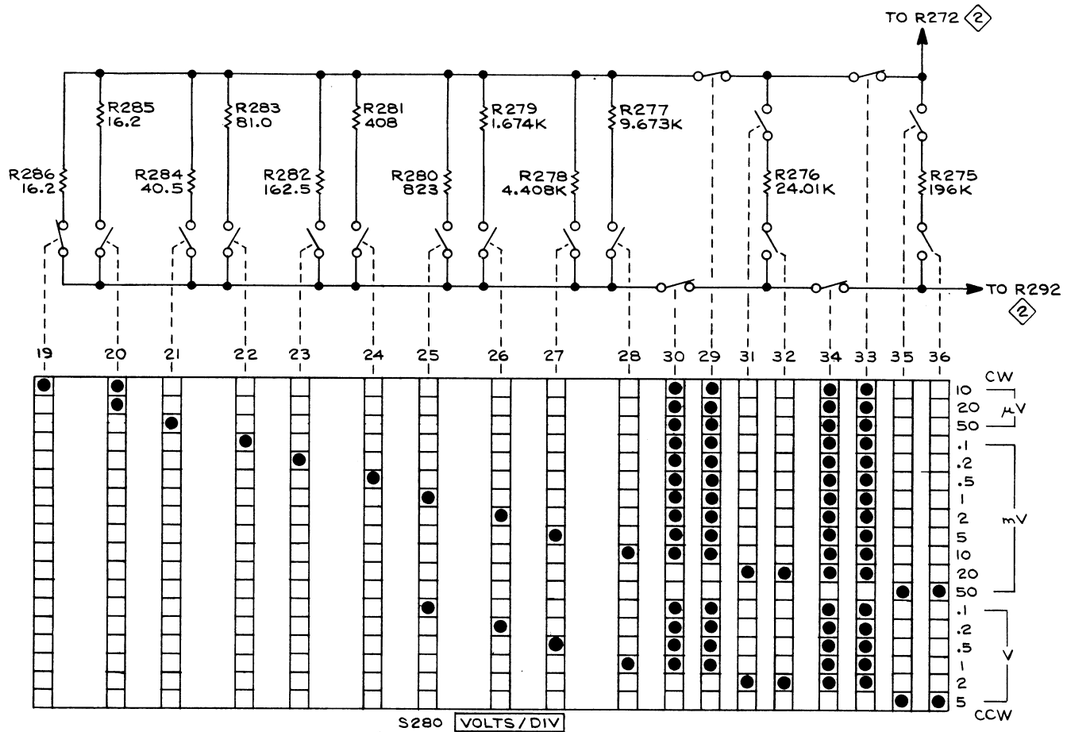
Electrical Parts List (cont)

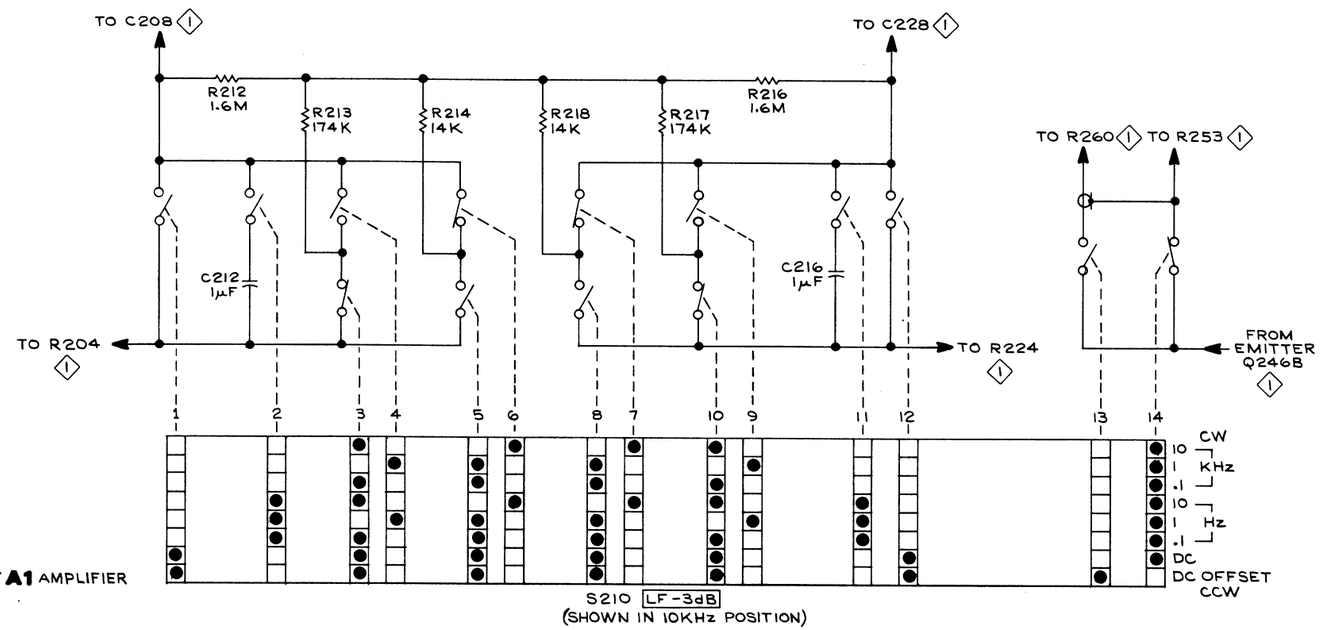
Ckt No.	Grid Loc	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
SWITCHES					
S210		105-0310-00			Cam, LF-3dB
S280		105-0309-00			Cam, VOLTS/DIV
S330		105-0311-00			Cam, HF-3dB



S330 HF -3dB
(SHOWN IN 1MHz POSITION)



S280 VOLTS/DIV
(SHOWN IN 10μV POSITION)



S210 LF -3dB
(SHOWN IN 10KHz POSITION)

PART OF **A1** AMPLIFIER BOARD

5A22N

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SWITCHING DETAILS 3 GRS 1071

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
Fil HB	fillister head brass	lg	length or long	THS	truss head steel
Fil HS	fillister head steel	OD	outside diameter	w	wide or width

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty 1 2 3 4 5	Description
1-1	366-1317-00			1	KNOB, red--CAL
	- - - - - -			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-2	366-1366-00			1	KNOB, charcoal--VOLTS DIVISION
	- - - - - -			-	knob includes:
	213-0153-00			2	SETSCREW, 5-40 x 0.125 inch, HSS
-3	366-0494-00			1	KNOB, charcoal--POSITION
	- - - - - -			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-4	366-1084-00			1	KNOB, charcoal--FINE DC OFFSET, w/setscrew
-5	366-1101-00			1	KNOB, charcoal--COARSE DC OFFSET
	- - - - - -			-	knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-6	366-1163-00			2	KNOB, gray--HF-3dB & LF-3dB
	- - - - - -			-	each knob includes:
	213-0153-00			1	SETSCREW, 5-40 x 0.125 inch, HSS
-7	366-1036-01			1	KNOB, charcoal--STEP ATTEN BAL
-8	366-1286-00			1	KNOB, latch
-9	366-1257-14			1	PUSHBUTTON--ON
-10	366-1257-11			2	PUSHBUTTON--AC (PRECHARGE)
-11	366-1257-12			2	PUSHBUTTON--GND (PRECHARGE)
-12	426-0681-00			5	FRAME, pushbutton
-13	358-0029-00			1	BUSHING, 0.375-32 x 0.50 inch
	- - - - - -			-	mounting hardware: (not included w/bushing)
-14	210-0590-00			1	NUT, hex., 0.375-32 x 0.438 inch
-15	210-0978-00			2	WASHER, flat, 0.375 ID x 0.50 inch OD
-16	344-0195-01			1	CLIP, grounding
-17	131-0679-00			2	CONNECTOR, receptacle, BNC, w/hardware
-18	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-19	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-20	210-0940-00			1	WASHER, flat, 0.25 ID x 0.375 inch OD
-21	210-0046-00			1	WASHER, lock, internal, 0.261 ID x 0.40 inch OD

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-22	- - - - - -			1	RESISTOR, variable
-23	358-0378-00			2	BUSHING, sleeve, front panel trim
-24	333-1519-00			1	PANEL, front
-25	129-0103-00			1	BINDING POST ASSEMBLY
	- - - - - -			-	binding post
	129-0077-00			1	POST, binding
	200-0103-00			1	NUT, knurled
	- - - - - -			-	mounting hardware: (not included w/binding post assembly)
-26	210-0583-00			1	NUT, hex., 0.25-32 x 0.312 inch
-27	210-0223-00			1	TERMINAL, lug, 0.25 inch diameter, SE
-28	136-0431-00			2	LIGHT, indicator
-29	337-1430-00			2	SHIELD, light
-30	214-1513-00			1	LATCH, plug-in securing
	- - - - - -			-	mounting hardware: (not included w/latch)
-31	213-0254-00			1	SCREW, thread forming, 2-56 x 0.25 inch, 100° csk, FHS
-32	386-1914-00			1	SUBPANEL, front
	- - - - - -			-	mounting hardware: (not included w/subpanel)
-33	213-0229-00			4	SCREW, thread forming, 6-32 x 0.375 inch, 100° csk, FHS
-34	337-1540-00			1	SHIELD, electrical, rear
-35	376-0029-00			1	COUPLER, shaft, w/2 setscrews
-36	384-1135-00			1	SHAFT, extension
-37	384-0240-00			1	SHAFT, extension, 8.75 inches long
-38	384-0264-00			1	SHAFT, extension, 6.188 inches long
-39	670-1894-00			1	CIRCUIT BOARD ASSEMBLY--MAIN A1
	- - - - - -			-	circuit board assembly includes:
	388-2454-00			1	CIRCUIT BOARD
-40	131-0566-00			2	LINK, terminal connecting
-41	313-0604-00			46	CONTACT, electrical
-42	136-0252-04			42	SOCKET, pin connector
-43	136-0235-00			1	SOCKET, transistor, 6 pin
-44	200-0687-01			1	COVER, transistor
-45	214-0579-00			9	PIN, test point
-46	344-0154-00			4	CLIP, fuse
-47	260-1207-00			2	SWITCH, push-- + & -AC/GND
-48	361-0384-00			8	SPACER, switch, red
-49	260-1209-00			1	SWITCH, push--DISPLAY
-50	361-0383-00			2	SPACER, switch, gray
-51	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-52	210-0590-00			1	NUT, hex., 0.375-32 x 0.438 inch
-53	210-0978-00			1	WASHER, flat, 0.375 ID x 0.50 inch OD
-54	210-0012-00			1	WASHER, lock, internal 0.375 ID x 0.50 inch OD
-55	407-0894-00			1	BRACKET, component

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-56	384-1055-00			1		SHAFT, extension, 8.461 inches long
-57	213-0075-00			2		SETSCREW, 4-40 x 0.094 inch, HSS
-58	- - - - - -			1		RESISTOR, variable
	- - - - - -			-		mounting hardware: (not included w/resistor)
-59	210-0583-00			1		NUT, hex., 0.25-32 x 0.312 inch
-60	210-0940-00			1		WASHER, flat, 0.25 ID x 0.40 inch OD
-61	387-0794-00			1		PLATE, mounting
	105-0309-00			1		ACTUATOR ASSEMBLY--VOLTS DIVISION
	- - - - - -			-		actuator assembly includes:
-62	200-0943-01			1		COVER, cam switch
	- - - - - -			-		mounting hardware: (not included w/cover)
-63	211-0022-00			4		SCREW, 2-56 x 0.188 inch, PHS
-64	210-0001-00			3		WASHER, lock, internal, 0.092 ID x 0.18 inch OD
-65	210-0259-00			1		TERMINAL, lug, 0.099 ID, SE
-66	210-0405-00			4		NUT, hex., 2-56 x 0.188 inch
-67	354-0219-00			1		RING, retaining
-68	401-0057-00			1		BEARING, front, w/ bushing
-69	214-1139-00[1]			-		SPRING, flat, gold
	214-1139-02[1]			-		SPRING, flat, green
	214-1139-03[1]			-		SPRING, flat, red
-70	214-1127-00			1		ROLLER, detent
-71	105-0331-00			1		DRUM ASSEMBLY
-72	407-0653-00			1		BRACKET, plastic
-73	401-0056-00			1		BEARING, rear
-74	210-0406-00			6		NUT, hex., 4-40 x 0.188 inch
	- - - - - -			-		mounting hardware: (not included w/actuator assembly)
-75	211-0116-00			6		SCREW, sems, 4-40 x 0.312 inch, PHB
-76	342-0002-00			2		FUSEHOLDER
	105-0310-00			1		ACTUATOR ASSEMBLY--LF 3dB
	- - - - - -			-		actuator assembly includes:
-77	200-1351-00			1		COVER, cam switch
-78	354-0219-00			1		RING, retaining
-79	401-0155-00			1		BEARING, front
-80	214-1704-00[1]			-		SPRING, flat, gold
	214-1704-01[1]			-		SPRING, flat, green
	214-1704-02[1]			-		SPRING, flat, red
	214-1127-00			1		ROLLER, detent
-81	105-0332-00			1		DRUM ASSEMBLY
-82	401-0156-00			1		BEARING, rear
-83	131-1248-00			1		CONTACT, ground
-84	210-0406-00			4		NUT, hex., 4-40 x 0.188 inch
	- - - - - -			-		mounting hardware: (not included w/actuator assembly)
-85	211-0116-00			4		SCREW, sems, 4-40 x 0.312 inch, PHB

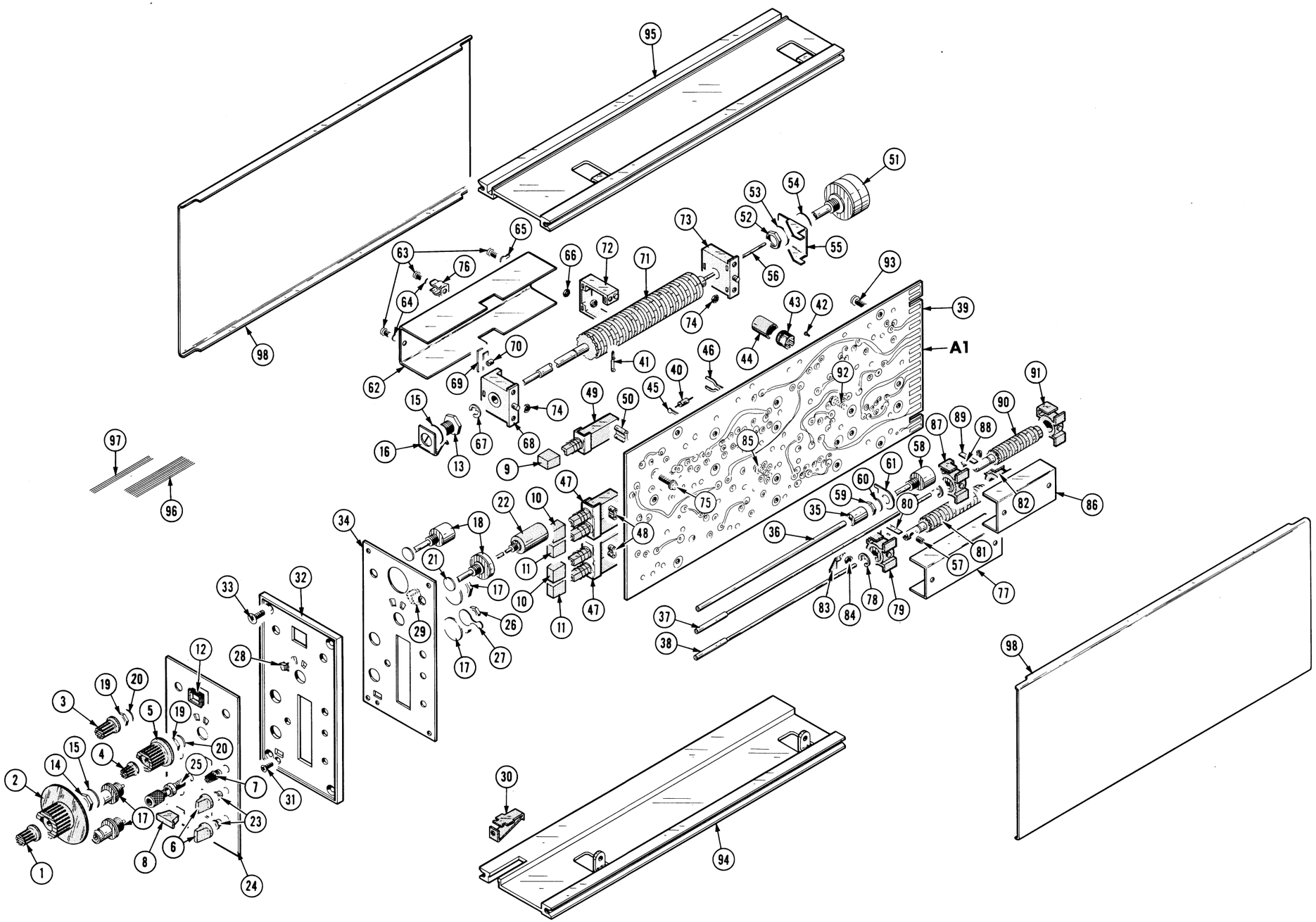
[1]Replace only with part bearing the same color code as the original part in your instrument.

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5	Description
1-	105-0311-00			1		ACTUATOR ASSEMBLY--HF-3dB
	- - - - - -			-		actuator assembly includes:
-86	200-1332-00			1		COVER, cam switch
	354-0219-00			1		RING, retaining
-87	401-0155-00[1]			1		BEARING, front
-88	214-1704-00[1]			-		SPRING, flat, gold
	214-1704-01[2]			-		SPRING, flat, green
	214-1704-01[2]			-		SPRING, flat, red
-89	214-1127-00			1		ROLLER, detent
-90	105-0333-00			1		DRUM ASSEMBLY
-91	401-0156-00			1		BEARING, rear
	131-1248-00			1		CONTACT, ground
	210-0406-00			4		NUT, hex., 4-40 x 0.188 inch
	- - - - - -			-		mounting hardware: (not included w/actuator assembly)
-92	211-0116-00			4		SCREW, sems, 4-40 x 0.312 inch, PHB
	- - - - - -			-		mounting hardware: (not included w/circuit board assembly)
-93	213-0146-00			4		SCREW, thread forming, 6-20 x 0.312
-94	426-0724-00			1		FRAME SECTION, bottom
-95	426-0725-00			1		FRAME SECTION, top
-96	175-0831-00			ft		WIRE, electrical, 8 wire ribbon, 12.50 inches long
-97	175-0826-00			ft		WIRE, electrical, 3 wireribbon 4.50 inches long
-98	337-1399-00			2		SHIELD, electrical, side

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

FIG. 1 EXPLODED



5A22N DIFFERENTIAL AMPLIFIER