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7A22 DIFFERENTIAL AMPLIFIER

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

070-0931-00
Product Group 42

Serial Number 703477

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INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

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WARNING

The remaining portion of this Table of Contents lists the servicing instructions. These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that called out in the operating instructions unless qualified to do so.

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Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

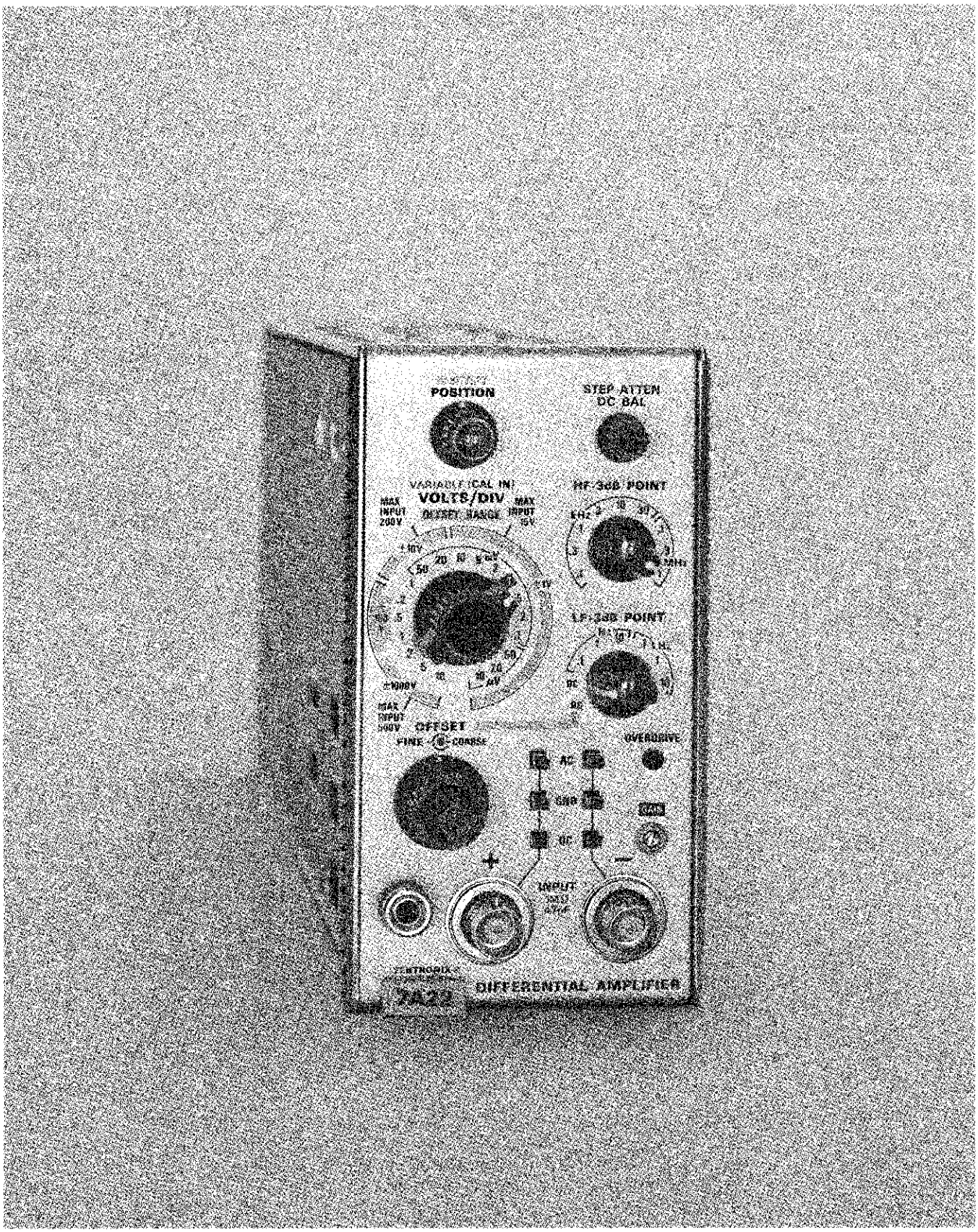


Fig. 1-1. Type 7A22 Differential Amplifier.

SECTION 1
SPECIFICATION

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

Introduction

The Type 7A22 Vertical Plug-in is a DC coupled differential amplifier with excellent common-mode rejection characteristics and high gain for low level applications.

The DC Offset capability of the Type 7A22 allows the display of the very small low-frequency signals containing a large DC component, at deflection factors not possible with AC coupling. The vertical deflection factor range of the Type 7A22 is from 10 μV to 10 V. The high and low frequency −3 dB points can be selected at the front panel, to set the bandwidth of the instrument. Thus, for low frequency applications the signal-to-noise ratio can be improved by restricting the bandwidth of the Type 7A22. The bandwidth selection and excellent drift-with-time characteristics provide measurement capabilities in the biomedical, transducer, and other areas which require stable, low deflection factor, low noise measurements.

The Type 7A22 is designed for use in Tektronix 7000 Series oscilloscopes.

The electrical characteristics described in this section are valid over the stated environmental range for instruments calibrated at an ambient temperature of +20°C to +30°C and after a 5 minute warmup unless otherwise noted.

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirements
Deflection Factor (VOLTS/DIV)	
Gain Ratio Accuracy	Within 2% with GAIN adjusted at 1 mV/div
VAR (CAL IN) Range	Continuously variable; extends deflection factor to at least 25 V/div
GAIN	Permits adjustment of deflection factor at 1 mV/DIV for all mainframes
Differential Signal Range (DC OFFSET not used)	
10 μV/Div to 10 mV/Div	At least ±1 V
20 mV/Div to 0.1 V/Div	At least ±10 V
0.2 V/Div to 1 V/Div	At least ±100 V
2 V/Div to 10 V/Div	At least ±1000 V
DC OFFSET	
COARSE Range from Electrical Zero	
10 μV/Div to 10 mV/Div	At least +1 V to −1 V
20 mV to 0.1 V/Div	At least +10 V to −10 V
0.2 V to 1 V/Div	At least +100 V to −100 V
2 V to 10 V/Div	At least +1000 V to −1000 V
Frequency Response (8 div Reference)	
Overall Frequency Response DC (Direct) Coupled Input	DC to within 10% of 1 MHz at −3 dB
AC (Capacitive) Coupled Input Lower Bandwidth Frequency	2 Hz or less
Bandwidth Limit Accuracy	
HF −3 dB POINT 100 Hz to 1 MHz	9 steps in a 1-3 sequence
Accuracy	Within 10% of selected frequency
LF −3 dB POINT 0.1 Hz to 10 kHz	6 steps in a 1-10 sequence
Accuracy	Within 12% of selected frequency
Recovery Time	10 μs or less to recover to within 0.5% of zero level after the removal of a + or − test input applied for 1 s. Test signal not to exceed Differential Signal Range. Specified aberration (0.5%) based on test signal amplitude
Common Mode Signal	
10 μV/Div to 10 mV/Div	At least +10 V and −10 V
20 mV/Div to 0.1 V/Div	At least +100 V and −100 V
0.2 V/Div to 10 V/Div	At least +500 V and −500 V
Common-Mode Rejection Ratio	
DC (Direct) Coupled	See Verification Points on graph, Fig. 1-2.
AC (Capacitive) Coupled	See Verification Points on graph, Fig. 1-2.

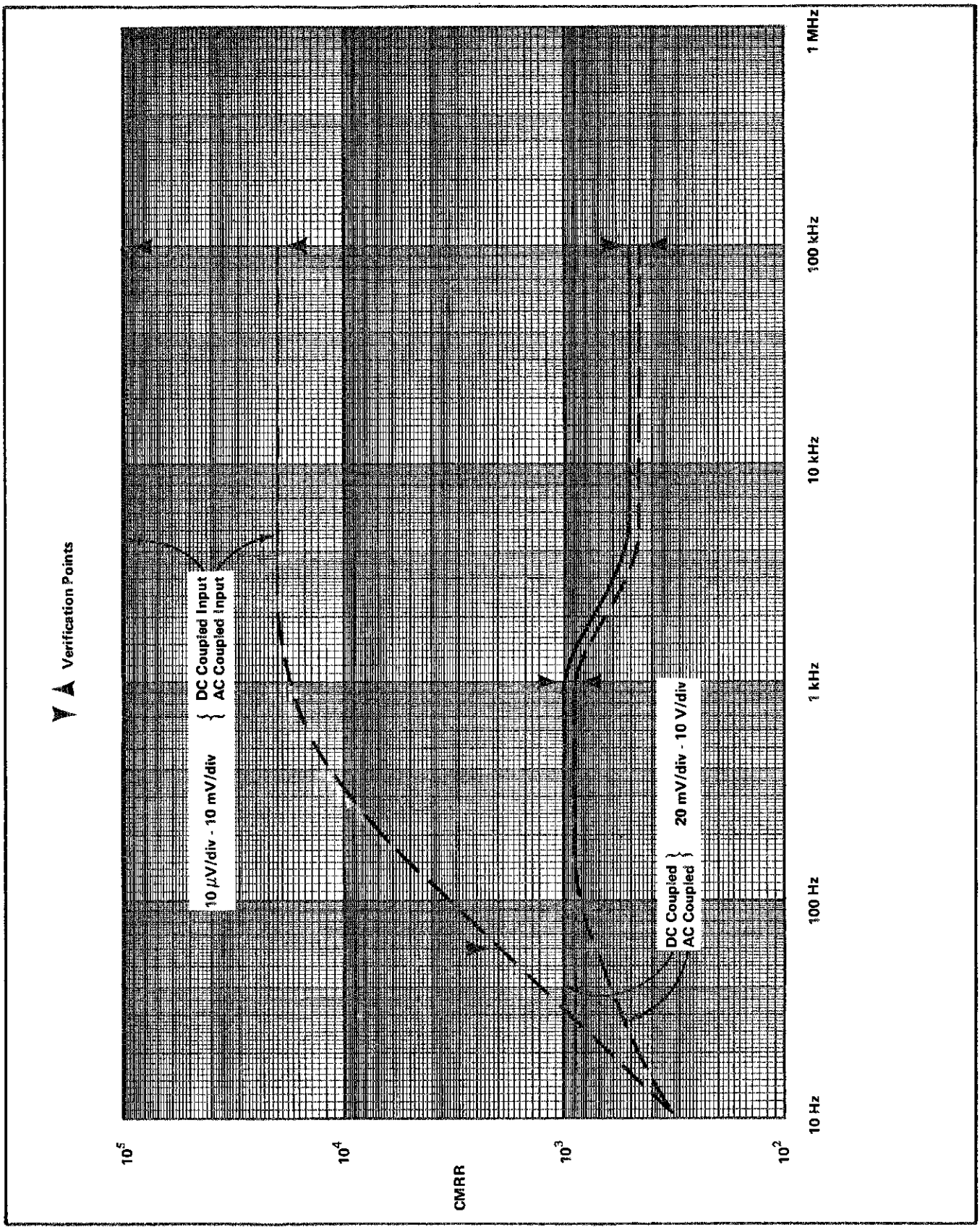


Fig. 1-2. CMRR vs. Frequency for signals not exceeding Common Mode Signal Range.

ELECTRICAL CHARACTERISTICS (cont)

Characteristic	Performance Requirements
Maximum Input Voltage (each input)	
DC (Direct) Coupled, DC + Peak AC, AC Component 1 MHz or less	
10 μV/Div to 10 mV/Div	±15 V
20 mV/Div to 0.1 V/Div	±200 V
.2 V/Div to 10 V/Div	±500 V
AC (Capacitive) Coupled Input DC Voltage	±500 V, each input
AC (Capacitive) Coupled Input DC Rejection	At least 4×10^5 :1
Input R and C	
Resistance	1 MΩ ± 1%
Capacitance	Approximately 47.0 pF
R & C Product	Within ±1% between all deflection factors
Maximum Input Gate Current	+25°C +50°C
10 μV/Div to 10 mV/Div	±20 pA ±100 pA each input ±40 pA ±200 pA Differentially
20 mV/Div to 10 V Div	±10 pA ±20 pA
Display Shift at 10 μV/Div (AC Coupled)	±4 div ±20 div
Variable Balance	0.2 div or less shift with VARIABLE control turned from fully cw to fully ccw position
Displayed Noise (Tangetially Measured)	16 μV or 0.1 Div (whichever is greater), 1 MHz HF —3 dB POINT, source resistance 25 Ω or less
DC Drift	
Drift with Time (Ambient Temperature and Line Voltage Constant)	
Short Term	5 μV (P-P) or 0.1 div (whichever is greater) in any minute after 1 hour warmup
Long Term	10 μV (P-P) or 0.1 div (whichever is greater) in any hour after 1 hour warmup
Drift with Ambient Temperature (Line Voltage Constant)	50 μV/°C or less
Isolation between + and — Inputs (+ INPUT to an Open — INPUT, — INPUT to an Open + INPUT)	At least 200:1, DC to 1 MHz

ENVIRONMENTAL

PLUG-IN TESTED OUT OF INDICATOR OSCILLOSCOPE

ITEM	CHARACTERISTIC
Altitude	
Non-operating	To 50,000 feet and —55° C
Transportation	Qualified under National Safe Transit Committee test procedure 1A, Category II

PHYSICAL

ITEM	CHARACTERISTIC
Finish	Front panel is anodized aluminum
Dimensions	≃ 14⅝ inch L × 2⅝ inch W × 4⅞ inch H
Weight	≃ 2⅝ lbs

SECTION 2
OPERATING INSTRUCTIONS

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

Introduction

This section opens with a brief functional description of the front-panel controls, input overdrive lamp, and input connectors. Following the front-panel description is a familiarization procedure and finally a general discussion of the operation of the Type 7A22.

CONTROLS AND CONNECTORS

INPUT OVERDRIVE	Input overdrive indicator lamp turns on to indicate excessive differential drive to the input amplifier stage. Lights when the differential dynamic range between input connectors is exceeded.
VOLTS/DIV	Volts per displayed division. Nineteen position switch used to select the calibrated deflection factors.
VARIABLE (CAL IN)	Two-position switch activated by the VARIABLE knob to select calibrated or uncalibrated deflection factors. At the IN position, the VARIABLE control is inoperative and the deflection factor is calibrated. When pressed and released, the knob moves outward to activate the VARIABLE control for uncalibrated deflection factors. The uncalibrated position provides continuously variable uncalibrated attenuation between the calibrated deflection factors and extends the deflection factor to at least 25 VOLTS/DIV.
GAIN	Screwdriver adjust control to set the CRT display scale factor to agree with the VOLTS/DIV switch indication. Adjusted for proper deflection with the VOLTS/DIV switch set to the 1 mV position.
POSITION	The control that vertically positions the trace or display.
IDENTIFY	Momentary contact, push-button switch, concentric with POSITION. Will cause the trace, representing the output of the Type 7A22, to move a small amount when pressed. Aids in identifying the Type 7A22 trace when multiple traces are displayed.
HIGH FREQUENCY —3 dB POINT	Nine position switch to select the approximate high frequency —3 dB point. The switch positions are: 100 Hz, 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz, and 1 MHz.
LOW FREQUENCY —3 dB POINT	Eight position switch to select DC coupling or the approximate low frequency —3 dB points. The switch positions are: DC OFFSET, DC, .1 Hz, 1 Hz, 10 Hz, 100 Hz, 1 kHz, and 10 kHz.
+ INPUT	Signal input connector. Positive input produces deflection upward (see Fig. 2-1).
— INPUT	Signal input connector. Positive input produces deflection downward (see Fig. 2-1).

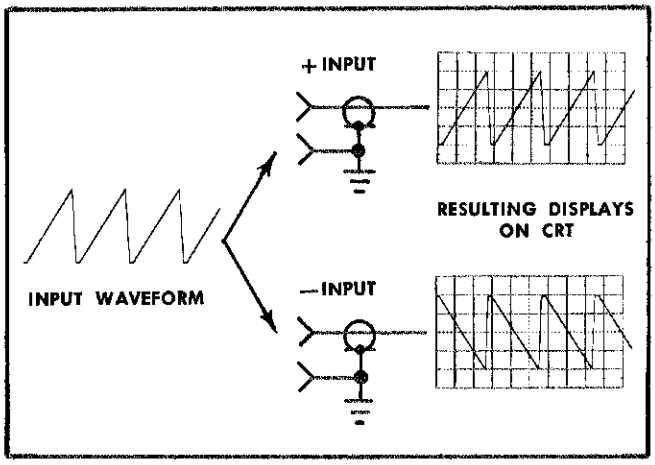


Fig. 2-1. Signals applied to the + INPUT connector produces an upright display, while signals applied to the — INPUT are inverted.

+ AC-GND-DC	A miniature illuminated push-button type switch. The buttons are interlocked so that only one button may be depressed at one time. When the 'AC' button is depressed the signal is coupled through 0.1 μF to the Input Amplifier and only the varying component of the input signal is amplified. When the 'DC' button is depressed the signal is coupled directly to the Input Amplifier and the entire input signal, both AC and DC, is amplified. When the 'GND' button (or none of the buttons) is depressed, the signal is coupled through 0.1 μF and through 1 MΩ to ground. The Amplifier Input is grounded in this condition.

	Each push-button is illuminated from behind when the button is depressed.
— AC-GND-DC	Same function as the + AC-GND-DC switch but applied to the — INPUT.

IMPORTANT

The following two controls are operative only when the LOW FREQUENCY —3 dB POINT switch is set to DC or DC OFFSET.

STEP ATTEN DC BAL (DC MODE ONLY)	Front panel control for DC balancing the amplifier input stage. With no signals applied to the input connectors, the control is adjusted for no trace shift as the VOLTS/DIV switch is moved from the 10 mV position to the 10 μV position.
DC OFFSET (DC OFFSET mode only)	Coarse and fine controls to provide internal offset bias while maintaining the differential capability. Available range of the offset bias depends upon the settings of the VOLTS/DIV switch, and is indicated by shaded gray bands (OFFSET RANGE) around the VOLTS/DIV switch.
RELEASE LATCH	Gray rectangular knob near the bottom left of the front panel. Pull out to remove Plug-In from Plug-In compartment.

OPERATING INSTRUCTIONS

First-Time Operation

Steps 1 through 5 in the following procedure are intended to help place the trace on the screen quickly and prepare the unit for immediate use. Steps 6 through 8 are used to check the GAIN adjustment. These steps along with those remaining are intended to demonstrate some of the basic functions of the Type 7A22.

1. Insert the unit into the oscilloscope plug-in compartment.

2. Set the Type 7A22 front-panel controls as follows:

VOLTS/DIV	1 mV
VARIABLE	IN (CAL)
POSITION	Midrange
HIGH FREQUENCY —3 dB POINT	1 MHz
LOW FREQ —3 dB POINT	DC
AC-GND-DC (+ INPUT)	GND
AC-GND-DC (— INPUT)	GND
STEP ATTEN DC BAL	Midrange

3. Turn the oscilloscope Intensity control fully counterclockwise and turn the oscilloscope Power ON. Preset the time-base and triggering controls for a .5 ms sweep rate and automatic triggering.

4. Wait about five minutes for the Type 7A22 and the oscilloscope to warm up.

NOTE

About five minutes is sufficient time for warmup when using the Type 7A22 for short-term DC measurements. For long-term DC measurements using the lower deflection factors, allow at least one hour.

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

6. Using the POSITION control, position the trace 2 divisions below graticule center.

CAUTION

If the maximum input voltage rating in the 10 μV to 10 mV range of the VOLTS/DIV switch is exceeded, the inputs are diode-clamped to fixed voltages of approximately +16.5 volts and/or —16.5 volts and damage to the signal source is possible. If the signal source can supply more than 1/16 A of current, the input protective fuse(s) will open. An open input fuse is indicated by the lighting of the INPUT OVERDRIVE indicator with the input coupling switches set to GND.

7. Apply a 4 mV peak-to-peak calibrator signal through a coaxial cable to the + INPUT connector on the Type 7A22.

8. For DC coupled, single-ended operation, set the + INPUT AC-GND-DC coupling switch to DC. The display should be square waves 4 divisions in amplitude with the bottom of the display at the reference established in step 6.

9. For AC coupled, single-ended operation, reposition the display with the Type 7A22 POSITION control to place the bottom of the display at the graticule center line.

10. Set the + INPUT AC-GND-DC coupling switch to AC and note that the display shifts downward about 2 divisions to its average level.

11. Disconnect the coaxial cable from the + INPUT connector. Connect a dual input connector to the + INPUT and — INPUT connectors. Connect the coaxial cable from the Calibrator to the dual input connector.

12. For AC coupled differential operation, set the —INPUT AC-GND-DC coupling switch to AC. 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 is being rejected.

Operational Adjustments

NOTE

Most of the following checks and adjustments may be made after a 5 minute warmup; however due to the DC drift of the amplifier during subsequent warmup, the STEP ATTEN DC BAL should be readjusted for each check or adjustment, and a warmup of at least one hour should be allowed before a final adjustment of the STEP ATTEN DC BAL is attempted. Insure that the oscilloscope used in conjunction with the Type 7A22 is correctly calibrated (refer to the oscilloscope manual) and that the calibrated output voltage is correct.

1. AC ATTEN BAL (internal adjustment). When the LOW FREQ —3 dB POINT switch is used to limit the low frequency response of the Type 7A22, the unit employs AC stabilization. This means that when the switch is set to any position except DC or DC OFFSET, the STEP ATTEN DC BAL and DC OFFSET controls become inoperative. VOLTS/DIV balance is then controlled with the AC ATTEN BAL, an internal adjustment (see Fig. 2-2).

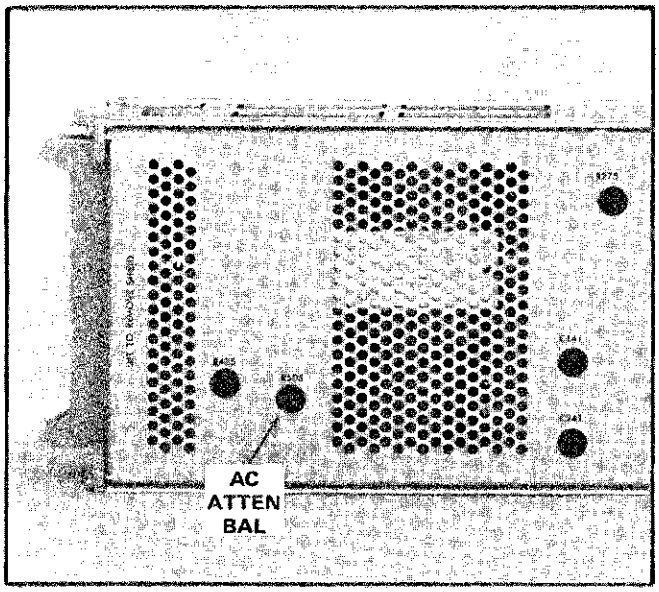


Fig. 2-2. Location of AC ATTEN BAL control.

When transferring the Type 7A22 from one oscilloscope to another, it may be necessary to perform a minor readjustment of this control, due to normal power supply variations between oscilloscopes.

NOTE

An unbalance of up to 30 μV is normal and cannot be reduced by adjusting the AC ATTEN BAL control.

a. With the Type 7A22 inserted into the oscilloscope, remove the left side panel of the oscilloscope and set the Type 7A22 controls as follows:

VOLTS/DIV	1 mV
AC-GND-DC (+INPUT)	GND
AC-GND-DC (—INPUT)	GND
LOW FREQ —3 dB POINT	10 Hz
HIGH FREQ —3 dB POINT	100 Hz

b. Using the POSITION control, position the trace to graticule center.

c. Set the VOLTS/DIV switch to 20 μV.

d. Adjust the AC ATTEN BAL control, R505, to position the trace to within 1.5 divisions of graicule center. (See note in step 1).

INTERACTION: If this adjustment is made out of sequence, steps 2 and 3 must also be performed.

2. VAR BAL R425. (Internal adjustment).

a. Set the Type 7A22 controls as in step 1-a.

b. Position the trace to graticule center with the POSITION control.

c. With the VAR (CAL IN) in the out position, rotate the VARIABLE control from stop to stop. Check for no movement of trace.

d. Adjust R425 for no movement of trace as the VARIABLE control is rotated from stop to stop. (See Fig. 2-2 for location of adjustment.)

3. STEP ATTEN DC BAL. With zero input voltage and the LF —3 dB POINT selector at DC, if the STEP ATTEN DC BAL is not properly adjusted the CRT trace will shift vertically as the VOLTS/DIV switch is rotated throughout its range. The shift is more noticeable at the most sensitive positions.

a. Set the Type 7A22 front-panel controls as follows:

VOLTS/DIV	10 mV
VARIABLE (CAL IN)	CAL
POSITION	Midrange
HIGH FREQ —3 dB POINT	1 MHz
LOW FREQ —3 dB POINT	DC
AC-GND-DC (+INPUT)	GND
AC-GND-DC (—INPUT)	GND
STEP ATTEN DC BAL	Midrange

b. Using the Type 7A22 POSITION control, position the CRT trace to the center of the graticule.

c. Set the VOLTS/DIV switch to 10 μV.

d. Return the trace to graticule center by adjusting the STEP ATTEN DC BAL control.

NOTE

The adjustment of the STEP ATTEN DC BAL control should be checked periodically during the use of the instrument. If the Type 7A22 is used DC coupled or in significantly varying ambient temperatures in the 10 μV/DIV to .1 mV/DIV ranges, the STEP ATTEN DC BAL should be checked quite frequently. It is good practice to check this control and readjust, if necessary, before any critical measurement is made under the above conditions.

4. GAIN

a. Perform steps 1 through 8 in the First-Time Operation Procedure.

b. Adjust the GAIN control for exactly 4 divisions of display.

NOTE

Accuracy of this adjustment is dependent upon the voltage accuracy of the calibration source.

GENERAL OPERATING INFORMATION

Trace Drift

The environment in which the Type 7A22 is operated and the inherent characteristics of the Type 7A22 influence trace drift. Therefore, to determine trace drift for a specific environment refer to the Specification Section. In environment in which the ambient temperature does not vary much (such as an air-conditioned building) the trace drift generally will not exceed 10 μV in one hour.

Input Gate Current

When using the .1 mV/DIV to 10 μV/DIV ranges for measurement with an AC coupled input, for DC measurements where the source impedance is high (in excess of 1 MΩ) the input gate current should be checked and allowed for, or adjusted to zero. This is particularly desired at high temperatures (above 40°C). Steps 7 and 8 in the Performance Check/Calibration Procedure describe the check and adjust procedures for setting the gate current to zero.

Voltage Measurement

To obtain accurate DC measurements at maximum sensitivity, it is necessary to ground the input and DC balance the amplifier just before making the measurement. This is accomplished by adjusting the STEP ATTEN DC BAL as described under operational adjustment number 3.

When measuring DC voltages, use the largest deflection factor (10 V/DIV) when first connecting the Type 7A22 to an unknown voltage source. Then, 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. See CAUTION after item 6 of First Time Operation.

Where only the AC component of a signal having both AC and DC components is to be measured, use the AC-GND-DC switches to take advantage of the pre-charging circuit incorporated in the unit. The pre-charging circuit permits the coupling capacitor to charge to the DC source voltage when the AC-GND-DC switch is set to GND. Procedure for using this circuit is as follows:

a. Before connecting the Type 7A22 to a signal containing a DC component, set the AC-GND-DC input coupling switch to GND. Then connect the input to the circuit under test.

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

b. Set the input coupling switch to AC. The display will remain on the screen and the AC component can be measured in the usual manner.

d. On completion of the measurement, set the AC-GND-DC switch to GND and short the input connector to ground.

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

CAUTION

If the Type 7A22 is connected to a large DC voltage source without using the pre-charge provision, the peak charging current (into 0.1 μF capacitor) will be limited only by the signal source, and this source may be damaged or destroyed.

When a large DC voltage has been applied to the Type 7A22 with the input AC coupled, the input coupling capacitor acquires a charge due to dielectric polarization and acts as a low voltage, high impedance voltage source with a very slowly decaying output voltage. This can offset subsequent AC coupled measurements at other DC voltages and drive the trace off-screen. A period of at least 10 minutes, with input set to GND, should be allowed to assure reasonable recovery from polarization, and a longer period may be necessary for critical measurements. If the input connectors are shorted to ground the depolarization process will require less time.

Signal Input Connectors

When connecting signals to the +INPUT and −INPUT connectors on the Type 7A22, consider the method of coupling that will be used. Ordinary unshielded test leads can sometimes be used to connect the Type 7A22 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 are 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, be sure to establish a common ground between the device under test and the Type 7A22. The shield of a coaxial cable is normally used for this purpose.

In some cases differential measurements require no common ground[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 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 Type 7A22. The circuit at the input connectors can normally be represented by a 1 megohm resistance to ground paralled by 47 pF. A few feet of shielded cable 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 and capacitive loading of a signal source, but also extend the measurement range of the Type 7A22 to include substantially higher voltages. Passive attenuator probes having attenuation factors of 10×, 100×, and 1000×, 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 Type 7A22 with very little source loading or sig-

[1]**The DC plus peak AC voltages on the test points with respect to the chassis potential of the Type 7A22 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.**

nal attenuation. In such a situation a passive attenuator probe cannot be used. However, this problem may be solved by using an active probe or the high input impedance provision of the Type 7A22.

High Input Impedance

The high input impedance provision applies only to DC coupled signals which permit the use of 10 mV through 10 μV positions of the VOLTS/DIV switch, (DC coupled). Since no input attenuator is used at these switch positions, the internal gate return resistor alone establishes the 1 megohm input resistance.

The high input impedance is obtained by unsoldering the wire strap (see Fig. 2-3) between the input line and the internal gate return resistance. The signal source must then provide a DC path for the FET gate current.

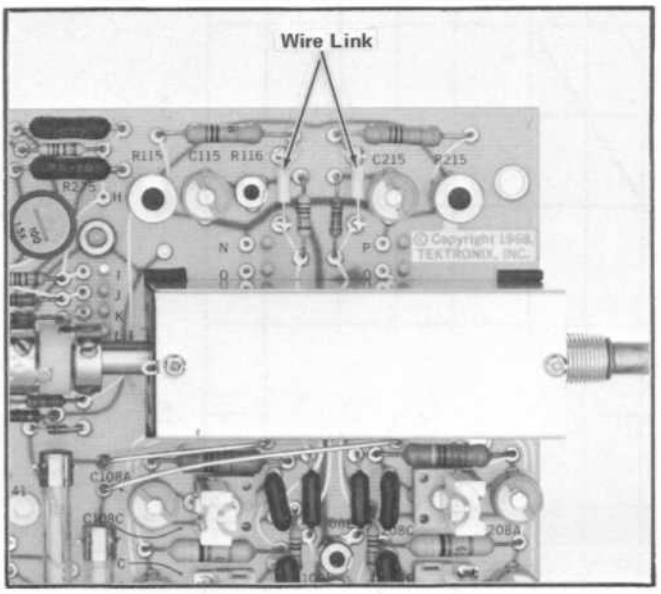


Fig. 2-3. Location of wire strap between input line and internal gate return resistor.

The uncompensated gate current is typically less than 100 picoamperes, but may be several times higher depending upon the operating temperature. The signal-source impedance is therefore an important factor since gate current will produce a DC offset. For example, a 100 picoampere gate current through 10 megohms produces a 1 mV offset; this may result in a significant error where small voltages are of concern.

NOTE

When the wire straps are removed, R111 and R211 are disconnected. The deflection factor in the 20 mV/DIV to 10 V/DIV range will be incorrect.

The high-frequency response will also depend upon the signal-source impedance, since various shunt capacitances between the source and the 7A22 input as well as the 47 pF input capacitance, must charge and discharge through that impedance (see Fig. 2-4).

Display Polarity

Single-ended signals can be applied to either the +INPUT or —INPUT connector. If the +INPUT is chosen, positive-going changes in the input signal will cause the trace to be deflected upward, and negative-going changes will cause the trace to be deflected downward. If the —INPUT is chosen, input-to-display polarity relationship will be reversed as shown previously in Fig. 2-1.

Deflection Factor

The amount of trace deflection produced by a signal is determined by the signal amplitude, the attenuation factor of the probe, the setting of the VOLTS/DIV switch and the setting of the VARIABLE control. The calibrated deflection factors indicated by the VOLTS/DIV switch apply only when the VARIABLE control is pushed "in" to the CAL IN 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 25 volts/div.

Noise

To reduce noise and obtain a more usable display when the VOLTS/DIV switch is operated in the 10 μV, 20 μV, and 50 μV positions or when the signal source is noisy, it is suggested that the HIGH FREQ —3 dB POINT selector be set to use the lowest bandwidth setting which does not appreciably distort the desired features of the signal under observation. Refer to Fig. 2-6 for the high frequency rolloff for each setting of the HIGH FREQ —3 dB POINT selector.

Bandwidth Selection

In addition to the differential rejection of unwanted signals, many times an undesired signal can be attenuated by varying the bandwidth of the unit. The LOW FREQ —3 dB POINT and HIGH FREQ —3 dB POINT selectors on the front panel of the 7A22 control the low-frequency and high-frequency —3 dB points of the amplifier. The LOW FREQ —3 dB POINT selector provides low-frequency response to DC or to approximate —3 dB points at .1 Hz, 1 Hz, 10 Hz, 100 Hz, 1 kHz, and 10 kHz. Refer to Fig. 2-5. The HIGH FREQ —3 dB POINT selector controls the high-frequency rolloff from 1 MHz to 100 Hz in a 1-3-10 sequence. Beyond the —3 dB points the frequency response falls off at a 6 dB per octave rate. Refer to Fig. 2-6.

Varying the bandwidth of the Type 7A22 is useful, for example, when displaying a low-frequency signal. By reducing the high-frequency response the noise can, in many cases, be considerably reduced without distorting the desired signal (see Fig. 2-7). Likewise, undesired line-frequency signals can be filtered out by restricting the low-frequency response of the unit. When using the LOW FREQ —3 dB POINT and HIGH FREQ —3 dB POINT selectors, care must be taken not to distort non-sinusoidal waveforms by overly restricting the amplifier bandwidth.

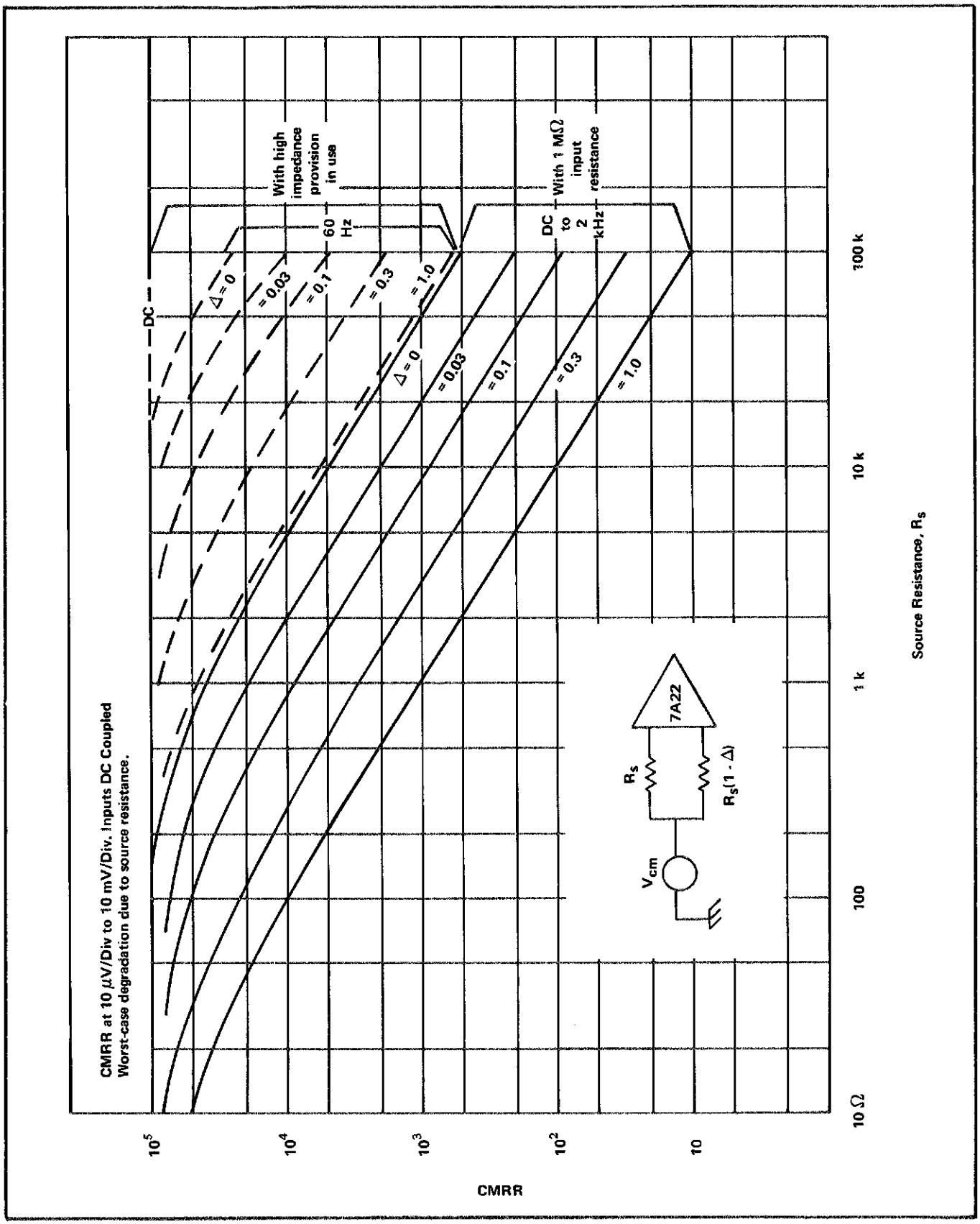


Fig. 2-4A. 7A22 CMRR at 10 μV/Div to 10 mV/Div. Inputs DC Coupled. Worst-case degradation due to source resistance.

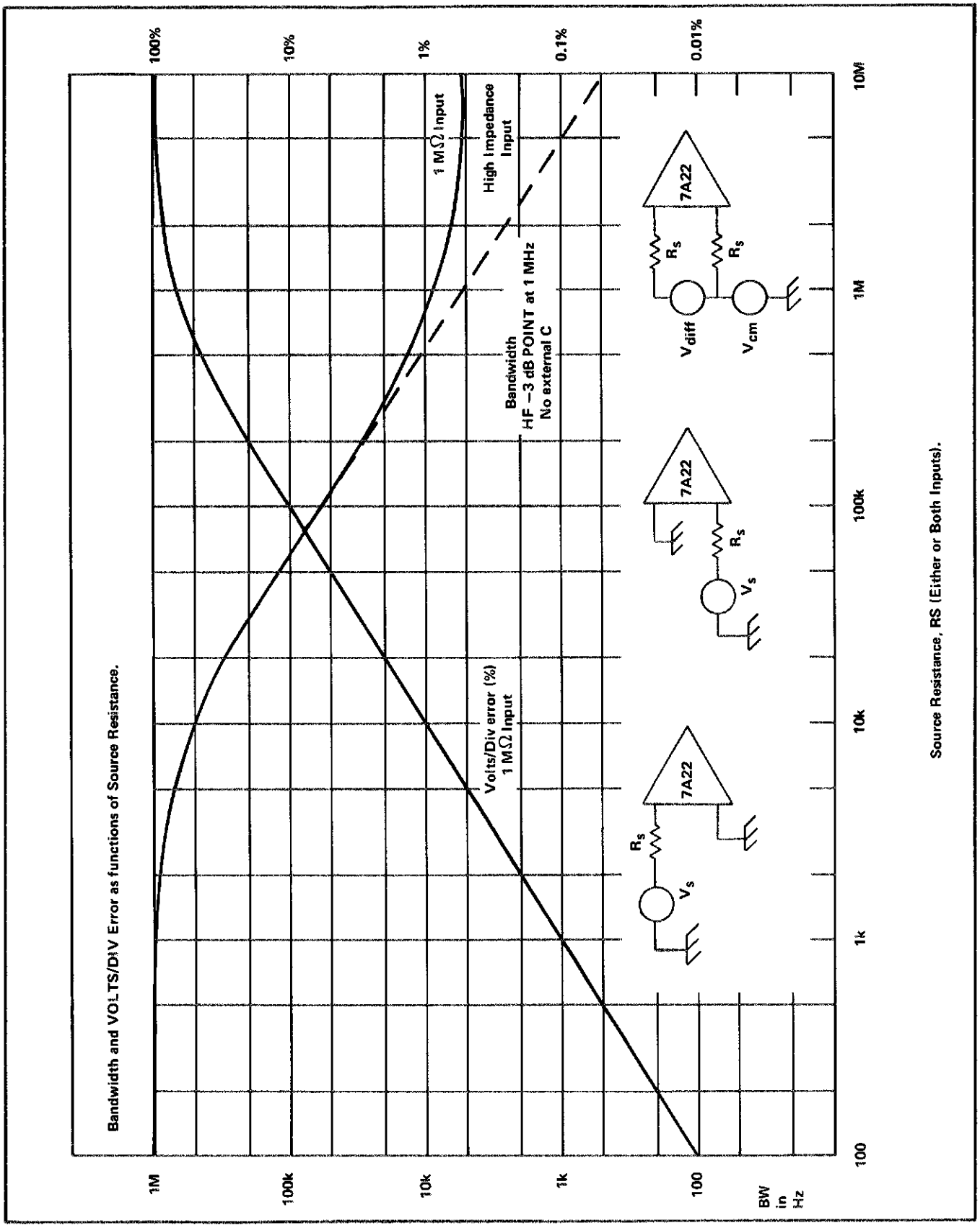


Fig. 2-4B. 7A22 Bandwidth and VOLTS/DIV Error as functions of Source Resistance.

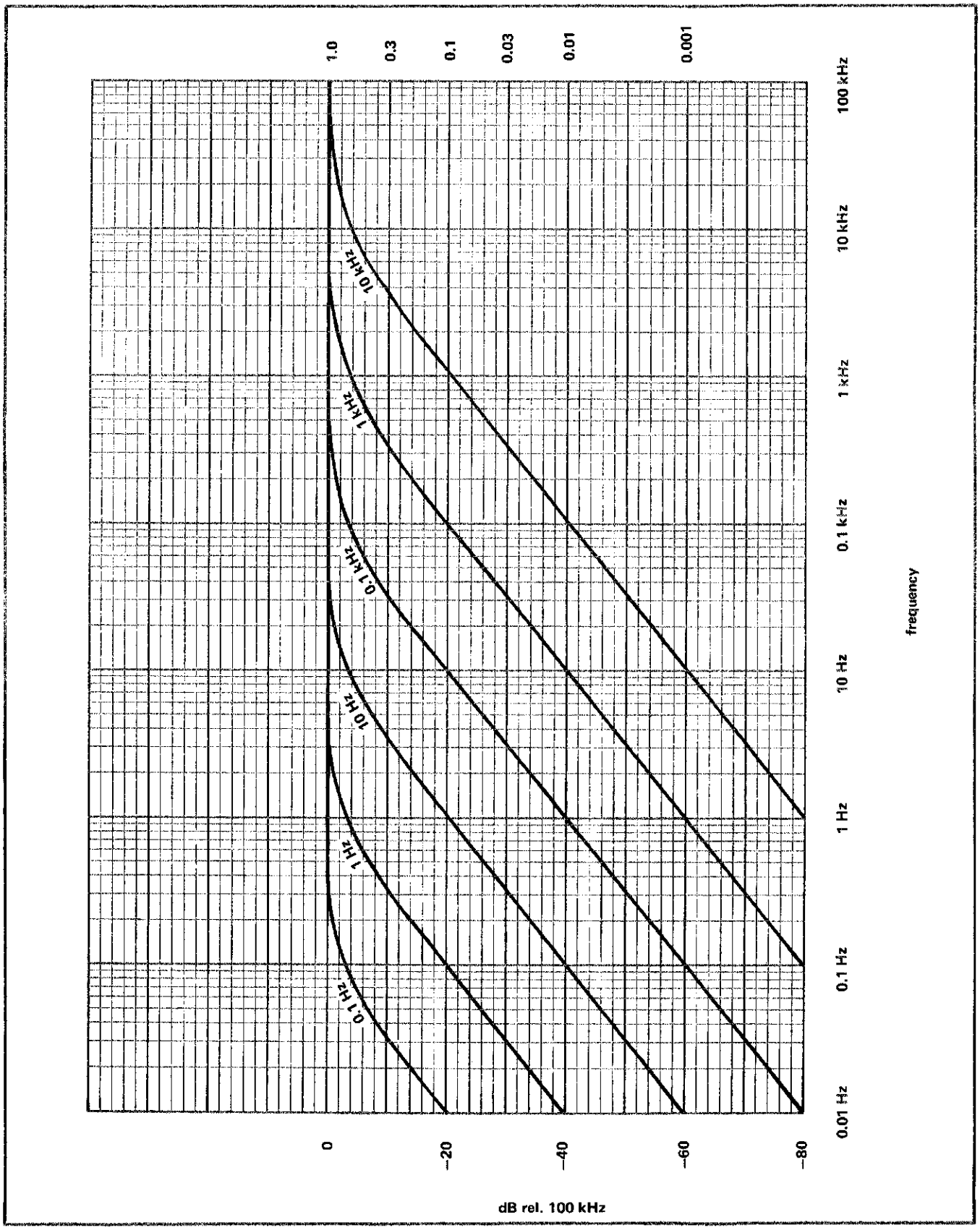


Fig. 2-5. 7A22 FREQUENCY RESPONSE as a function of LF —3 dB POINT SETTING (HF —3 dB POINT at 1 MHz).

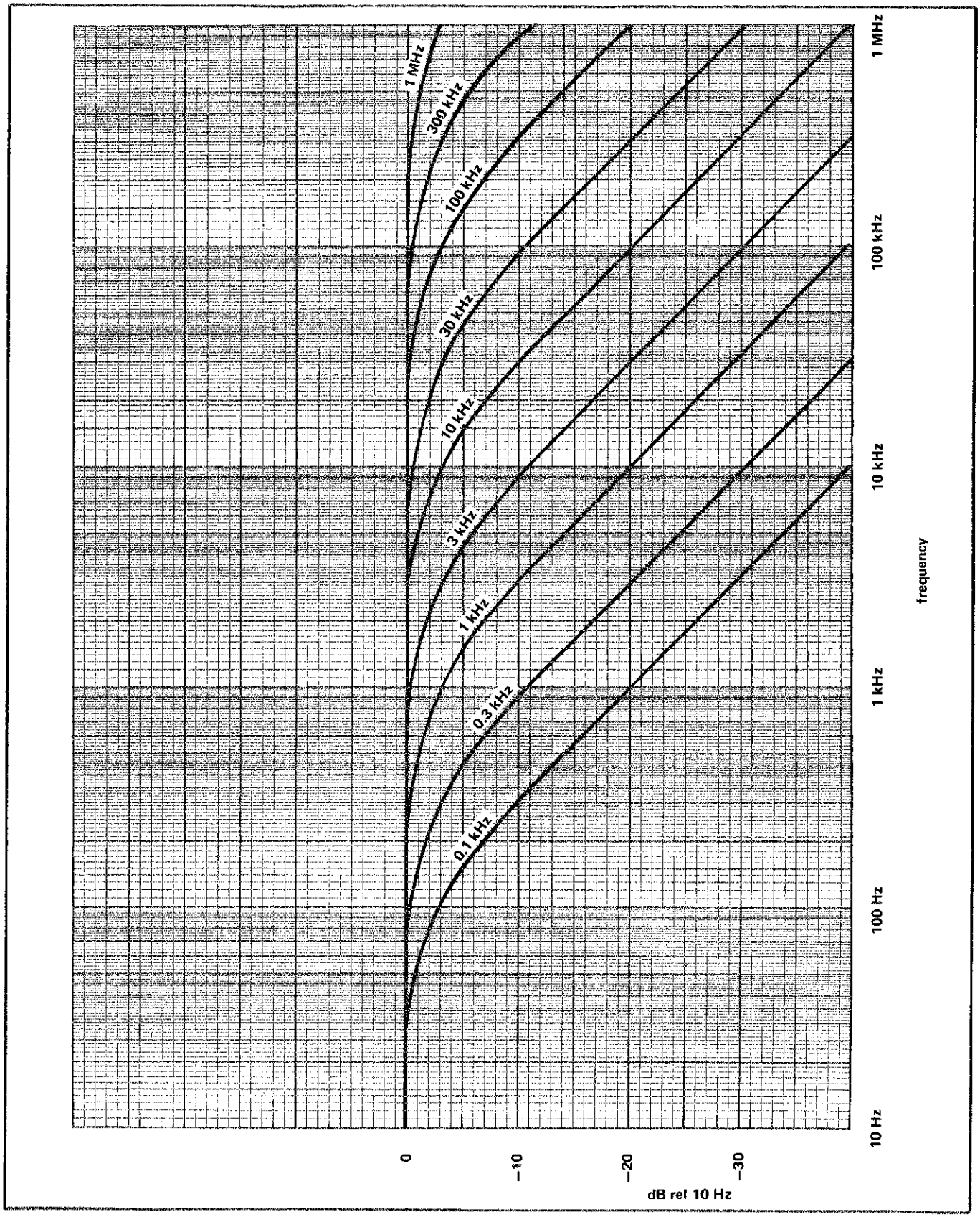


Fig. 2-6. 7A22 FREQUENCY RESPONSE as a function of HF —3 dB POINT settings (LF —3 dB POINT of DC).

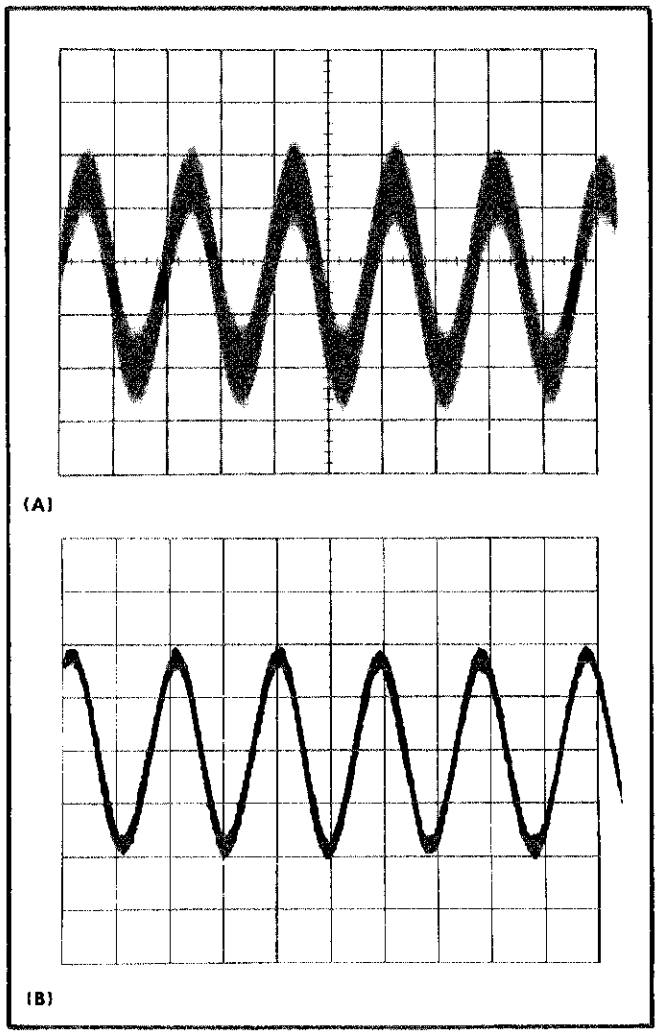


Fig. 2-7. Improving signal-to-noise ratio by setting bandwidth. (A) Lower —3 dB FREQUENCY selector to DC, UPPER —3 dB FREQUENCY 1 MHz. (B) Lower —3 dB FREQUENCY selector to DC, UPPER —3 dB FREQUENCY, 10 kHz.

Voltage Comparison Measurements

Some applications require a set of 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 Type 7A22. Set the VOLTS/DIV switch and 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 position as ratio factors rather than voltages.

Differential Operation

Differential voltage measurements are made by applying the signals to the +INPUT and —INPUT connectors. Then, both AC-GND-DC switches should be set to the same positions: AC or DC, depending on the method of signal coupling desired. When using the Type 7A22 for differential operation, only the voltage difference between the two signals is amplified and displayed on the CRT. Common-mode signals (signals that are common in amplitude, frequency and phase) are rejected (see Fig. 2-8).

The Type 7A22 differential input provision may be used to eliminate interfering signals such as AC line-frequency hum. Single-ended measurements often yield unsatisfactory information because of interference resulting from ground-loop currents between the oscilloscope 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 would limit low-frequency response. These limitations of single-ended measurements are virtually eliminated in differential measurements.

A differential measurement is made by connecting each of the two inputs to selected points in the test circuit. The input to the amplifier will then be the difference in voltage of the two selected points (see Fig. 2-9).

The ability of the Type 7A22 to reject common-mode signals is indicated by the common-mode rejection ratio (CMRR). This ratio is at least 100,000:1 at the input connectors for the lower deflection factors (10 μV to 10 mV per division) when signals between DC and 100 kHz are DC-coupled to the inputs. To show the significance of this characteristic, assume that a single-ended input signal consists of an unwanted 60 Hz signal at 1 volt P-P plus a desired signal at 1 mV P-P. If an attempt is made to display the desired signal with the VOLTS/DIV switch set to .2 mV, the 60 Hz signal would produce a deflection equivalent to 5000 div, and thus little useful information about the 1 mV signal could be obtained.

If, however, the same 1 mV signal is monitored differentially so that the 60 Hz signal is common-mode at the inputs, no greater than one part in one hundred thousand of the common-mode signal will appear in the display. Thus, the desired signal produces a display amplitude of 5 div with only .05 div of interference due to the common-mode signal.

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 presicely 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 an adjustable resistance may reduce the rejection ratio to 100:1 or less.

Outside influences such as electrostatic and magnetic fields can also degrade the performance, particularly when low level signals are involved. Electrostatic interference can be minimized by using shielded signal transporting leads of the same type to the two inputs, and by twisting the leads together throughout most of their length.

Care should be taken to minimize the movement of the signal transporting leads, as any movement of a lead, in the presence of a magnetic field, will tend to induce a signal into that lead. Where an interfering magnetic field cannot be avoided, the pickup loop formed by the two leads should be minimized by taping or twisting them together throughout most of their length. Low-frequency measurements can be similarly protected by using a shielded cable which contains a twisted pair of conductors.

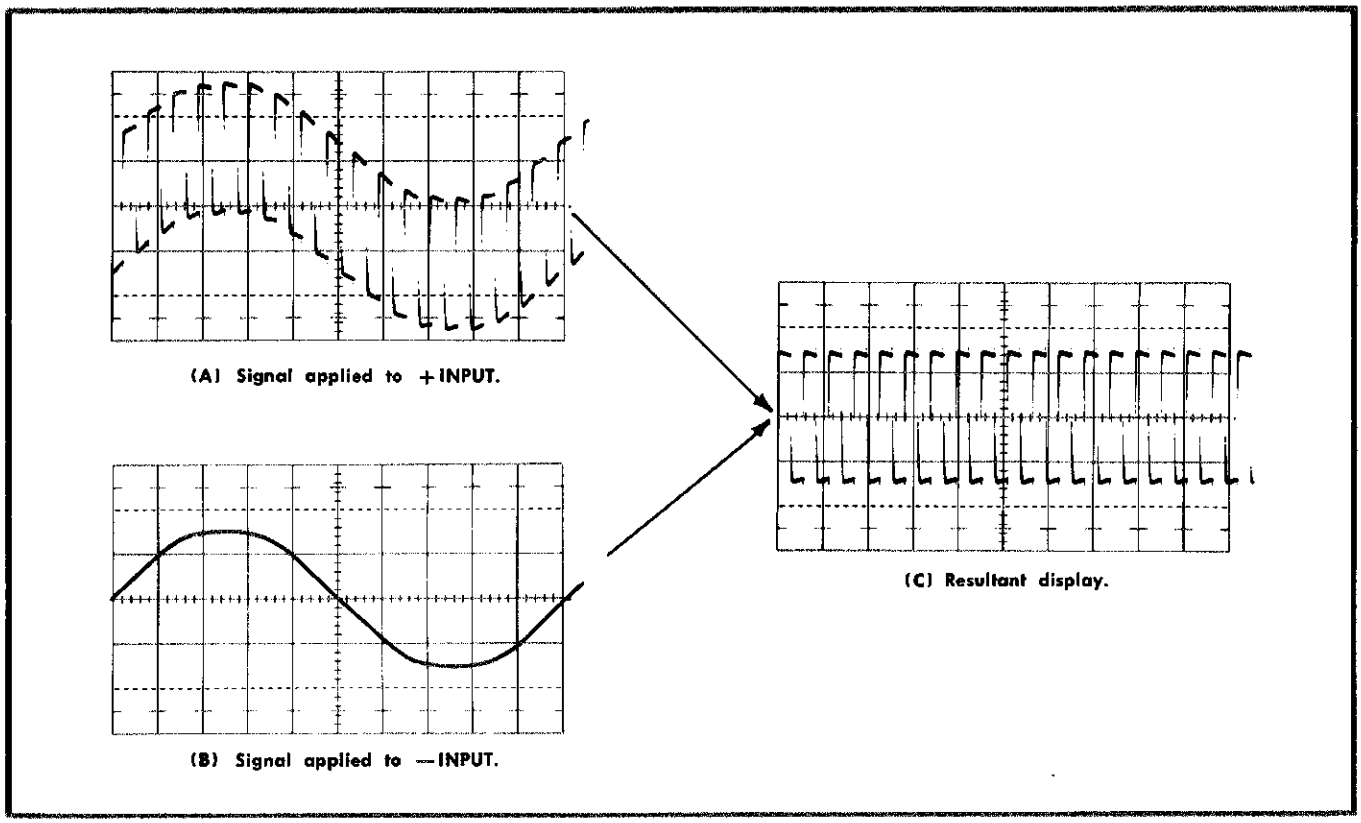


Fig. 2-8. Waveforms showing differential rejection of a common-mode signal. Resultant waveform (c) shows the difference between the two signals.

DC Offset Operation

By using the DC OFFSET controls, it is possible to use the Type 7A22 differentially in a slide-back mode, to observe small signal whose DC potential difference may be considerable. The offset is continuously adjustable from +1 V to —1 V when the VOLTS/DIV switch is in the 10 μV to 10 mV positions. In the 20 mV, 50 mV and .1 V positions of the VOLTS/DIV switch, the 1 V offset is effectively multiplied by the input attenuator to a range of ±10 V. Table 2-1 summarizes the effective DC offset voltages internally available for all the VOLTS/DIV switch positions. The table also lists the input attenuator that is switched into the amplifier circuit for the various VOLTS/DIV switch positions.

TABLE 2-1

VOLTS/DIV setting	OFFSET RANGE	ATTENUATOR in
10 μV to 10 mV	± 1 V	1×
20 mV to 0.1 V	± 10 V	10×
0.2 V to 1 V	± 100 V	100×
2 V to 10 V	± 1000 V[2]	1000×

[2]**CAUTION— ±500 volts is the maximum allowable signal voltage of each input.**

Using the DC OFFSET functions:

Set the Type 7A22 controls as follows:

VOLTS/DIV	10 V
VARIABLE (CAL IN)	CAL
POSITION	Midrange
AC-GND-DC (+ and — INPUT)	GND
HF —3 dB POINT	1 MHz
LF —3 dB POINT	DC
STEP ATTEN DC BAL	Adjusted for DC balance

1. Position the trace to graticule center (or some other convenient reference line) using the POSITION control.

2. Connect a coaxial cable from the signal source to the +INPUT.

3. Set the +INPUT AC-GND-DC switch to DC and measure the DC level to be offset.

4. Set the VOLTS/DIV to the largest deflection factor in an offset range which will encompass the DC level measured in step 3. See Table 2-1 and front panel color bands.

5. Set the LF —3 dB POINT selector to DC OFFSET.

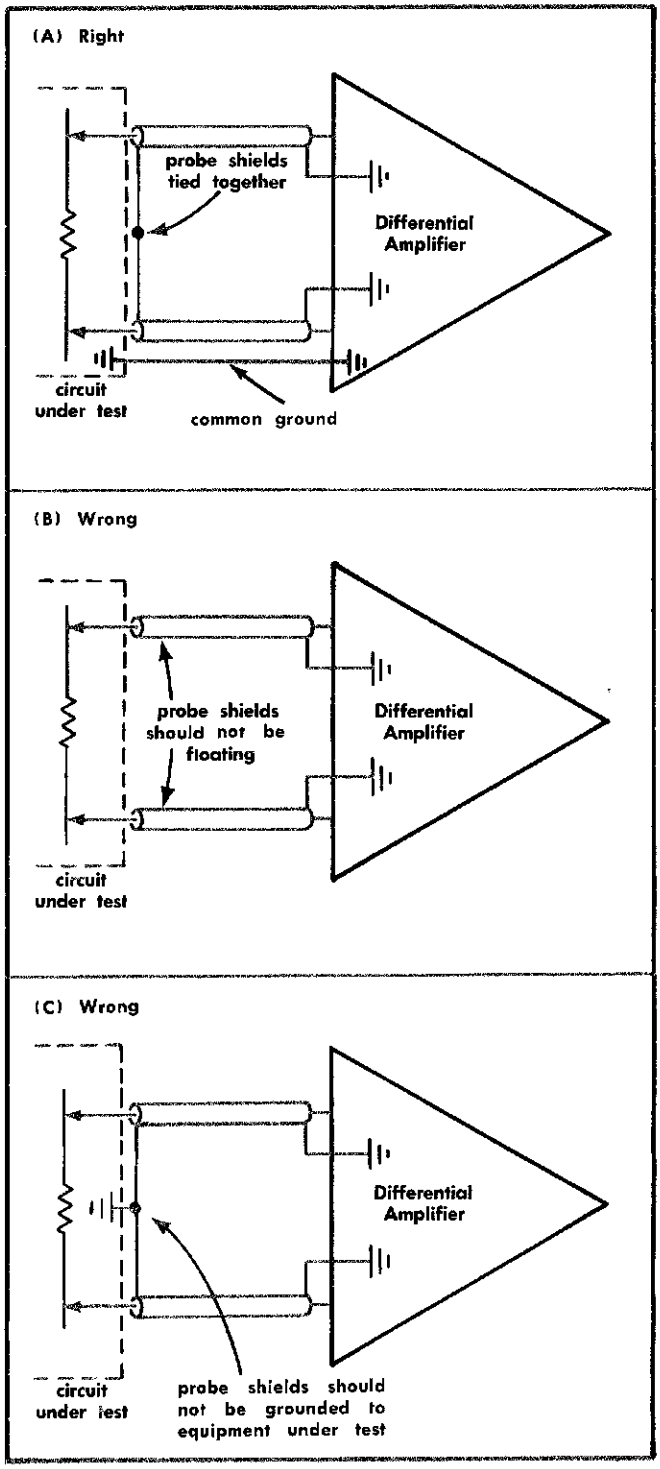


Fig. 2-9. Connecting a differential amplifier across a circuit.

6. Use the COARSE and FINE controls to move the portion of the signal to be observed to the reference line established in step 1.

7. If a different size display is needed, the deflection factor may be changed in the same offset range.

NOTE

If switching into another offset range, the OFFSET controls will need to be readjusted. If switching into a smaller offset range, check that the available range is sufficient to encompass the DC level present (see steps 3 and 4 above).

Input Overdrive Indicator

The INPUT OVERDRIVE indicator turns on when the signal to the input FETs approaches the differential dynamic range of the amplifier. The 7A22 should not be left connected to a circuit if this light is on, as this may mean that a damaging voltage is present.

The INPUT OVERDRIVE indicator serves another important function. If the amplifier is direct-coupled at the input, a DC differential signal could overdrive the input stage and cause a reduction in gain. The small voltages to be measured will not be distorted, but will be reduced in amplitude. As a result, amplitude measurements made under such conditions will not be accurate. The Type 7A22 INPUT OVERDRIVE indicator provides an indication that such a signal is present by lighting before the gain calibration changes by 1%.

If the INPUT OVERDRIVE lamp turns on, there are two possible ways to continue:

1. Switch the LF —3 dB POINT selector to DC OFFSET. DC differential signals may then be balanced out as indicated in Table 2-1.

2. Switch the AC-GND-DC switch to AC. DC differential signals up to 1000 V (either input not to exceed 500 V) may be removed by using AC coupling at the input. This necessarily limits the low frequency response to 1.6 Hz (or 0.16 Hz with a 10× probe).

The INPUT OVERDRIVE lamp is insensitive to common-mode overdrives, and it is possible to overload the Type 7A22 without lighting the input overdrive light.

In summary the overdrive indicator will turn on under the following conditions:

a. The input signal exceeds the differential dynamic range of the amplifier (see Section 1 for table of dynamic ranges).

b. An input protective fuse is blown. In this case, the light will remain on even if the AC-GND-DC switches are set to GND.

c. There is a circuit malfunction.

Readout

If the Type 7A22 is to be used in an oscilloscope having readout capabilities, special probes which correct the readout deflection factor for probe attenuation may be used. Divider probes not having the sensing capability may be used with the instrument, but they will not operate the sensing system, and the deflection factor of the plug-in only (as read on the VOLTS/DIV knob) will be displayed.

The +INPUT and —INPUT connectors have an outer ring which is connected to the readout probe sensing device. This allows the main-frame readout to display the correct deflection factor from the probe tip for any probe attenuation. For

example: if a 10× probe is used it will increase the deflection factor, in the readout display, by a factor of 10. Then the actual deflection factor at the probe tip is displayed (see Table 2-2).

NOTE

If only one divider probe (or two probes with equal divider ratios) is connected, the deflection factor at the probe tip will be displayed; if probes with different divider ratios are connected (e.g., 10× and 100×), the readout will display the deflection factor at the tip of the probe with the larger division ratio (100×).

TABLE 2-2

TYPE 7A22 Plug In	Main-Frame Displayed Readout		
VOLTS/DIV Setting	Probe Atten used 1×	Probe Atten used 10×	Probe Atten used 100×
.5 mV	500 μV	5 mV	50 mV
50 mV	50 mV	500 mV	5 V

Trace Identify. With the oscilloscope turned on and a sweep displayed on the CRT, check for approximately 0.2 div of vertical movement of the trace when the IDENTIFY pushbutton is depressed. The vertical scale factor readout associated with the 7A22 will change to the word IDENTIFY.

NOTE

An incorrect CRT readout will occur in the 10V/div position when using the 100X Readout coded probe (P6009, Tektronix Part No. 010-0264-01). When used in 10V/div setting, reading will show 1V instead of 1KV.

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO. REFER TO OPERATORS SAFETY SUMMARY AND SERVICE SAFETY SUMMARY PRIOR TO PERFORMING ANY SERVICE.

SECTION 3
CIRCUIT DESCRIPTION

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

Introduction

A block diagram description covering the general configuration of each circuit in the Type 7A22 is included in this section. Following the block diagram description is a detailed description of each circuit and the functions of specific components.

Simplified drawings are provided where necessary for easier circuit understanding. Complete schematic diagrams are included in the Diagrams section. These should be referred to throughout the detailed circuit descripttion.

The values of resistors on the schematics are in ohms unless otherwise specified. Capacitor values are indicated in the following manner unless otherwise specified: whole numbers indicate that the value is in pF, decimal numbers indicate that the value is in μF. For example, 33 pF and 0.1 μF.

BLOCK DIAGRAM DESCRIPTION (see Block Diagram Pullout preceding schematics)

Input Coupling

A signal applied to the + or —Input connector passes through the input coupling selector switch to the input attenuator circuit. The signals can be AC coupled, DC coupled or disconnected internally. (See Schematic Diagram Number 1).

Input Attenuators

The input attenuators for the + and —inputs are identical and are conventional RC type attenuators. Common resistive elements are adjustable to facilitate matching the — and + attenuators to obtain optimum DC common-mode signal rejection.

The attenuators (Schematic Diagram number 3) are frequency-compensated voltage dividers which provide constant attenuation at all frequencies within the passband of the instrument, while maintaining a constant input time constant (47 μs) for all positions of the VOLTS/DIV switch.

Each attenuator contains an adjustable capacitor to provide correct attenuation at high frequencies, and adjustable shunt capacitance to provide correct input capacitance. The attenuators are used, in conjunction with gain switching in the output amplifier, only in the 20 mV/DIV through 10 V/DIV switch positions. From 10 μV/DIV through 10 mV/DIV, only the output amplifier gain switching is used to set the deflection factor.

Preamp

From the input attenuators, the signal is coupled to the preamp. The preamp consists of two identical feedback amplifiers connected in a differential configuration. The overall differential gain is approximately 15.

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

Each input is equipped with an overdrive protection circuit consiting of fuses and clamping diodes. For deflection factors from 10 μV/DIV through 10 mV/DIV the fuse will open if the current exceeds $^1/_{16}$ A (approximately 16.5 volts at the input), preventing damage to the input circuitry.

CAUTION

The input protection circuit clamps the input to a fixed voltage when too large an input signal is applied. In the 10 μV to 10 mV positions there is no resistance through the ATTENUATOR switch. There is a possibility of damage to the signal source, since a very large current surge can flow before the fuse opens.

When the LOW FREQ —3 dB POINT selector is in any position other than DC or DC OFFSET and the Input Coupling switch is in DC, there is no on-screen indication of the DC conditions in the preamp. If the differential dynamic range of the amplifier is exceeded and the amplifier is driven into non-linearity or overdrive, an erronerous display is likely.

An overdrive detector circuit is provided to indicate when the preamp is approaching the limits of its differential dynamic range. A front-panel indicating lamp lights when overdrive occurs.

An offset generator is provided to balance out any current in the preamp resulting from signals containing differential components. Offset (variable) allows the varying component to be amplified, and at the same time maintains the amplifier differential capabilities.

Low Frequency —3 dB Point

The push-pull output of the preamp is coupled through a LOW FREQ —3 dB POINT selector. The selector switches the components of the coupling network in each half of the preamp to select the low frequency —3 dB points (.1 Hz, 1 Hz, 10 Hz, 100 Hz, 1 kHz and 10 kHz). The DC position of the selector bypasses the low frequency selection circuitry and direct-couples the preamp to the Output Amplifier.

Output Amplifier

The signal from the LF —3 dB POINT selector is coupled to the gain-switching section of the Ouput Amplifier. This section of the Output Amplifier is a pair of feedback amplifiers similar to that of the preamp. The VOLTS/DIV switch changes the amplifier gain.

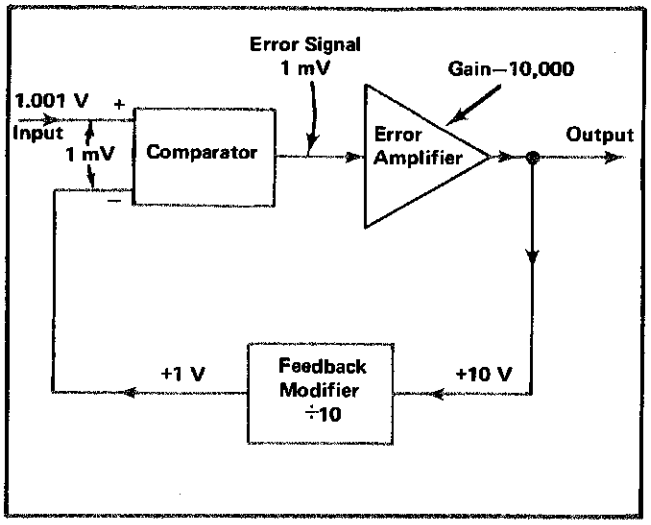


Fig. 3-1. Generalized feedback system showing the relation between input and output.

High Frequency —3 dB Point

The HF —3 dB POINT selector switches capacitance across the output of the Gain Switching Amplifier to set the high frequency —3 dB point at any of 9 frequencies; 100 Hz, 300 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz, 100 kHz, 300 kHz, and 1 MHz. The capacitance used in the 1 MHz position is adjustable to set the bandwidth to normal value.

Positioning of the trace, and VARIABLE VOLTS/DIV, are provided in the stage following the HF —3 dB POINT selector.

Overall amplifier gain is adjusted in the signal output stage of the Output Amplifier by adjusting the common emitter resistance.

GENERAL INFORMATION

Feedback Amplifiers

Since the Type 7A22 utilizes several multi-stage feedback amplifiers, a brief review of feedback systems in general is given.

Fig. 3-1 represents a generalized feedback system in which it is desired to produce an output signal accurately and stably related to the input. The arrangement of Fig. 3-1 causes the modified output to be nearly equal to the input. Any difference between these is detected by the comparator, which produces an error signal equal to the difference, and applies this error to the amplifier, which amplifies the error and feeds back a correction to reduce the original error.

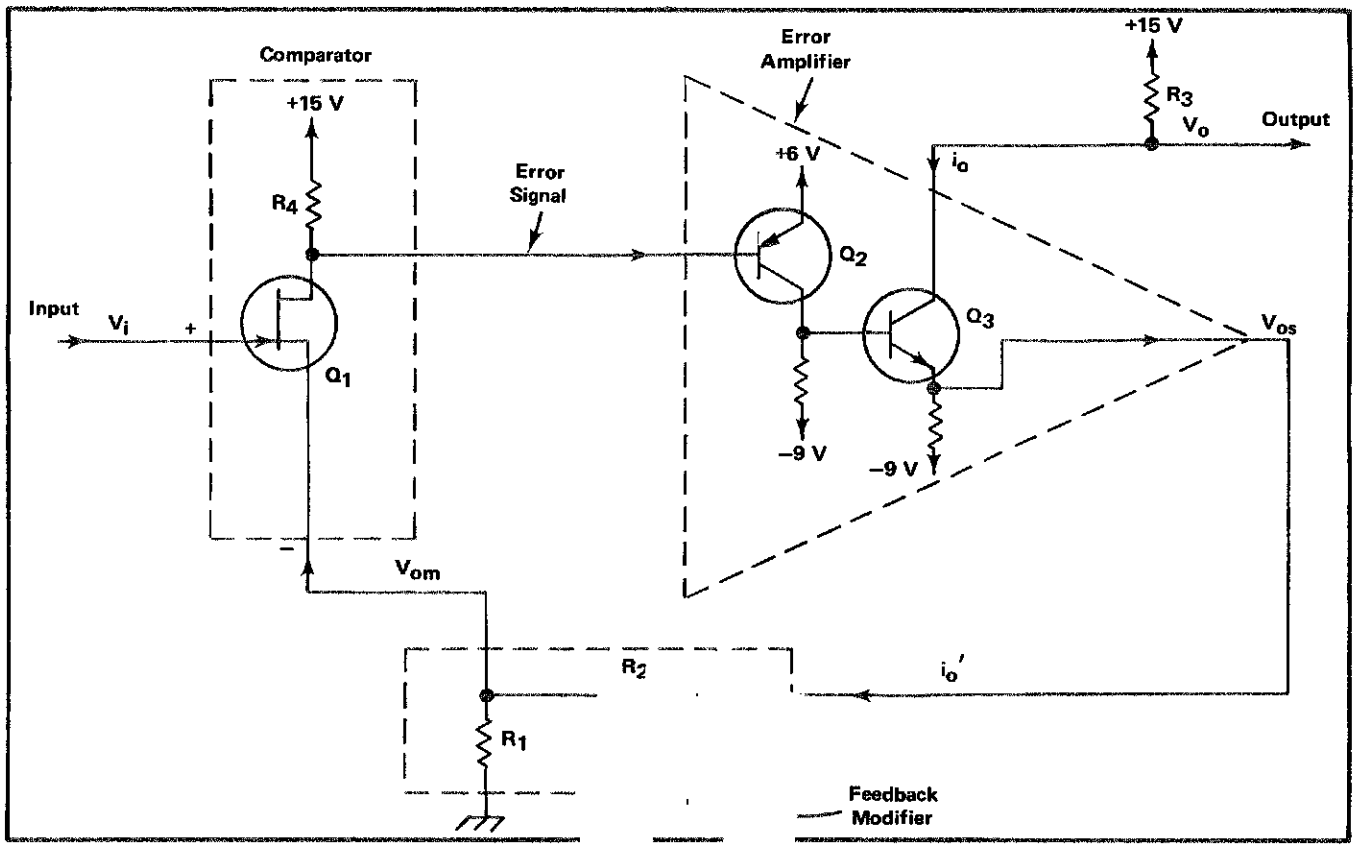


Fig. 3-2. Feedback amplifier (Single-ended version).

The input to the modifier (the system output) is also accurately related to the system input, provided the modifier is constructed of stable components.

Another way of looking at the system is to start at the output and work backward. Specifically, assume an amplifier gain of 10,000 and a feedback modifier which is a 10× divider. Assume a 10 volt output. The modifier output is 1 volt, and the error signal (output ÷ gain) is 1 mV, so that the input is 1.001 volts. In this case, the error between the desired output (10× input) of 10.01 volts and the actual output of 10.00 volts is only 10 mV, or 1 part in 1,000.

In practice the comparator and error amplifier are often combined in a differential amplifier. A single-ended version of the basic configuration used in the Type 7A22 is illustrated in Fig. 3-2, with the basic blocks of Fig. 3-1 identified. The comparator is FET Q_1. Any change in the gate-to-source bias voltage (dictated by the standing current established by R_4 and the supply voltages) will cause a change in drain current, the change being applied as an error signal to the input of the error amplifier.

The error amplifier consists of grounded emitter stage Q_2 driving emitter follower Q_3. The internal output appears at the emitter of Q_3 and is fed back to the comparator input via modifier (voltage divider) R_2, R_1. For this amplifier, the system output, V_{os}, can be determined by:

$$V_{os} = \left(1 + \frac{R_2}{R_1}\right) V_{om}.$$

Since V_{om} is approximately equal to the input voltage V_i, then the system gain, $\frac{V_i}{V_{os}}$, is approximately equal to $1 + \frac{R_2}{R_1}$.

The useful output of the amplifier is the Q_3 collector signal current i_o', which flows through R_1 (in addition to the relatively small error current from Q_1). $V_{om} = i_o R_1$ and since V_{om} is approximately equal to V_i, and i_o is approximately equal to i_o' then i_o is approximately equal to $\frac{V_i}{R_1}$. Thus the output current vs. the input voltage depends primarily on the gain-setting resistor, R_1.

An output voltage can also be obtained by passing i_o through the load resistor, R_3. The overall voltage gain is then $\frac{V_o}{V_i}$, which is approximately equal to $\frac{R_3}{R_1}$.

Differential Configuration

If the lower end of R_1 is connected to the same point in another identical circuit instead of being returned to ground, the result is a differential feedback amplifier with push-pull output, which is the configuration in the Type 7A22. A differential feedback amplifier, such as is used in the 15× preamp, is shown in Fig. 3-3.

From the previous description, the Q_{1a} and Q_{1b} source voltages V_{om} (a and b) follow the input voltages V_{ia} and V_{ib} respectively, hence any differential input voltage, V_i will result in a nearly equal source to source voltage V_{om}, which in turn is due to an output signal current $i_o' = \frac{V_{om}}{R_{1a} + R_{1b}}$

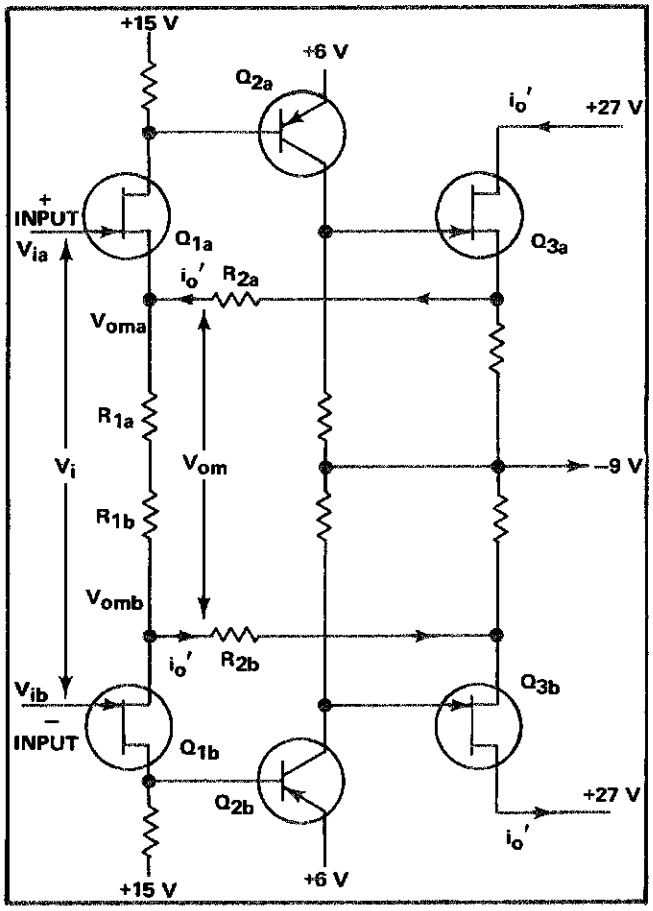


Fig. 3-3. Feedback amplifier (Differential configuration).

$= \frac{V_i}{R_{1a} + R_{1b}}$.

Note that FETs have been used in Q_3, rather than NPN bipolars as in Fig. 3-2 to avoid loss of signal current from the base lead. The operation of the amplifier remains unchanged.

DETAILED CIRCUIT DESCRIPTION

Input Coupling (See Schematic 1)

Input signals applied to the + input connector can be AC coupled or internally disconnected. When the input coupling switch, S101 (see ×15 preamp diagram), is in the DC position, the input signal is coupled directly to the input attenuator. In the AC position, the AC signal is coupled through coupling capacitor C101, and the DC component is blocked from the input amplifier. The GND position internally connects the gate of the input amplifier to ground. This provides a ground reference for the amplifier without removing the input leads or otherwise disconnecting the input signal.

Resistor R103 allows C101 to be precharged in the GND position so that when S101 is switched to the AC position with a high DC level applied, there is no charging current surge into the input of the amplifier. Excessive loading is also avoided for the circuit under test, since the normal im-

pedance of 1 MΩ-47 pF is still seen by the signal source. The —input switch, S201, functions in the same manner as the +input.

Input Attenuators (See Schematic 3)

To produce the vertical deflection factor indicated on the front panel by the VOLTS/DIV switch, the gain of the feedback amplifier in the gain switched amplifier circuit is changed by switching the source resistor (R407) of Q404 A and B (See Schematic 2) for switch positions 10 μV to 10 mV. For switch positions above 10 mV, input attenuators are switched by S108 into the input circuit of the Type 7A22, in conjunction with the gain switching resistors, R407, to produce the selected deflection factors.

These attenuators are frequency-compensated voltage dividers. For DC and low frequency signals, they are primarily resistive dividers (e.g., R108C, R108D) and the voltage attenuation is determined by the resistance ratio in the circuit. The reactance of the capacitors in the circuit is so high at the lower frequencies that their effect is negligible. However, at higher frequencies, the reactance of the capacitors decreases and the attenuator becomes primarily a capacitive voltage divider (e.g., C108C, C108D).

In addition to providing constant attenuation at all frequencies within the bandwidth of the instrument, the input attenuators are designed to maintain the same input RC characteristics (1 megohm in parallel with 47 pF) for each setting of the VOLTS/DIV switch. Each attenuator contains an adjustable capacitor (e.g. C108C) to provide correct attenuation at high frequencies, and an adjustable shunt capacitor to provide correct input capacitance.

Gate Current Compensation

The leakage current associated with the gates of the input FETs may be as high as 100 pA. This 100 pA of leakage current (through 1 megohm to ground, R111 or R211) will produce an offset of 100 μV, which at high input sensitivities is not acceptable. To compensate this effect, the gates of the input FETs may be adjusted to zero volts by returning R111, R211 through variable controls R115 and R215 to a slightly negative supply voltage (see Fig. 3-4).

Leakage current associated with the gates of the input FETs 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 R111 and R211 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.

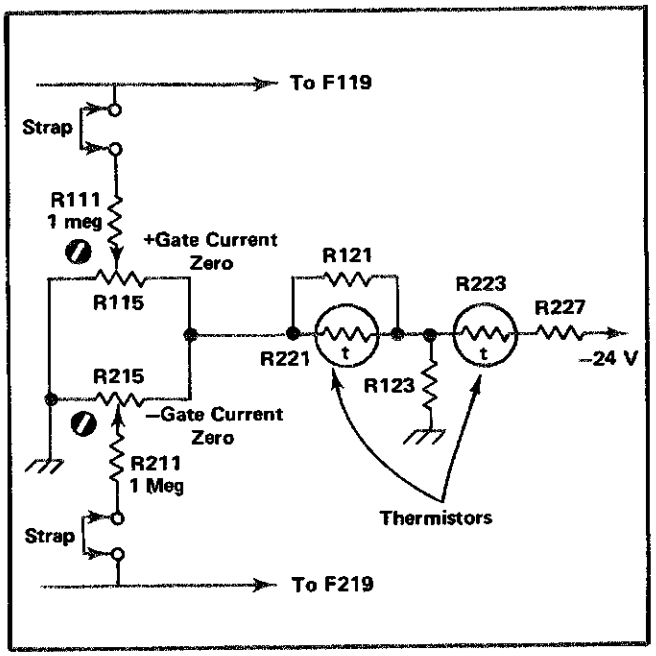


Fig. 3-4. Gate Current Compensation.

Input Amplifier

The input amplifier circuit in the Type 7A22 is made up of two identical feedback amplifiers connected in a differential configuration with a push-pull output. The power supply voltages (except at the output) for each feedback amplifier are obtained from a power supply that is bootstrapped to the common-mode input signal. This improves the CMRR of the amplifier. Input overdrive protection is provided in the input circuit to prevent damage to the semiconductors if a large overdrive is inadvertently applied to the input.

Any amplifier of this type, in which the feedback is taken to the input element, is likely to exhibit a negative resistance component of impedance at higher frequencies. If the input signal source impedance is inductive with a sufficiently high "Q", the amplifier could oscillate. C115, R116, R117 and C215, R217 compensate for this negative input resistance.

×15 Preamp. The feedback amplifiers in the + and — inputs are identical except for circuit numbers, and operate in a coupled differential mode as described previously under feedback amplifiers.

In the actual circuit (see Schematic 1) the + feedback amplifier consists of the comparator Q133A, error amplifier Q144A, Q153, feedback modifier R151, R153 and output load resistor R159. R151 is the gain setting resistor for the amplifier, and the approximate gain of the amplifier can be determined by dividing R159 by R151, $(\frac{R_o}{R_i})$.

Diode CR131 is used for temperature compensation of the base-emitter junctions of Q144A and Q144B. This keeps the total voltage across the input stage current-setting resistors R133, R233 constant with temperature. Diode CR144 connected between base-emitter of Q144A, protects the transistor against reverse base-emitter breakdown. C144 and C244 stabilize the circuit at the higher frequencies.

DC Balance. The DC level at the output of Q153, Q253 is balanced by R258, STEP ATTEN DC BAL. The STEP ATTEN

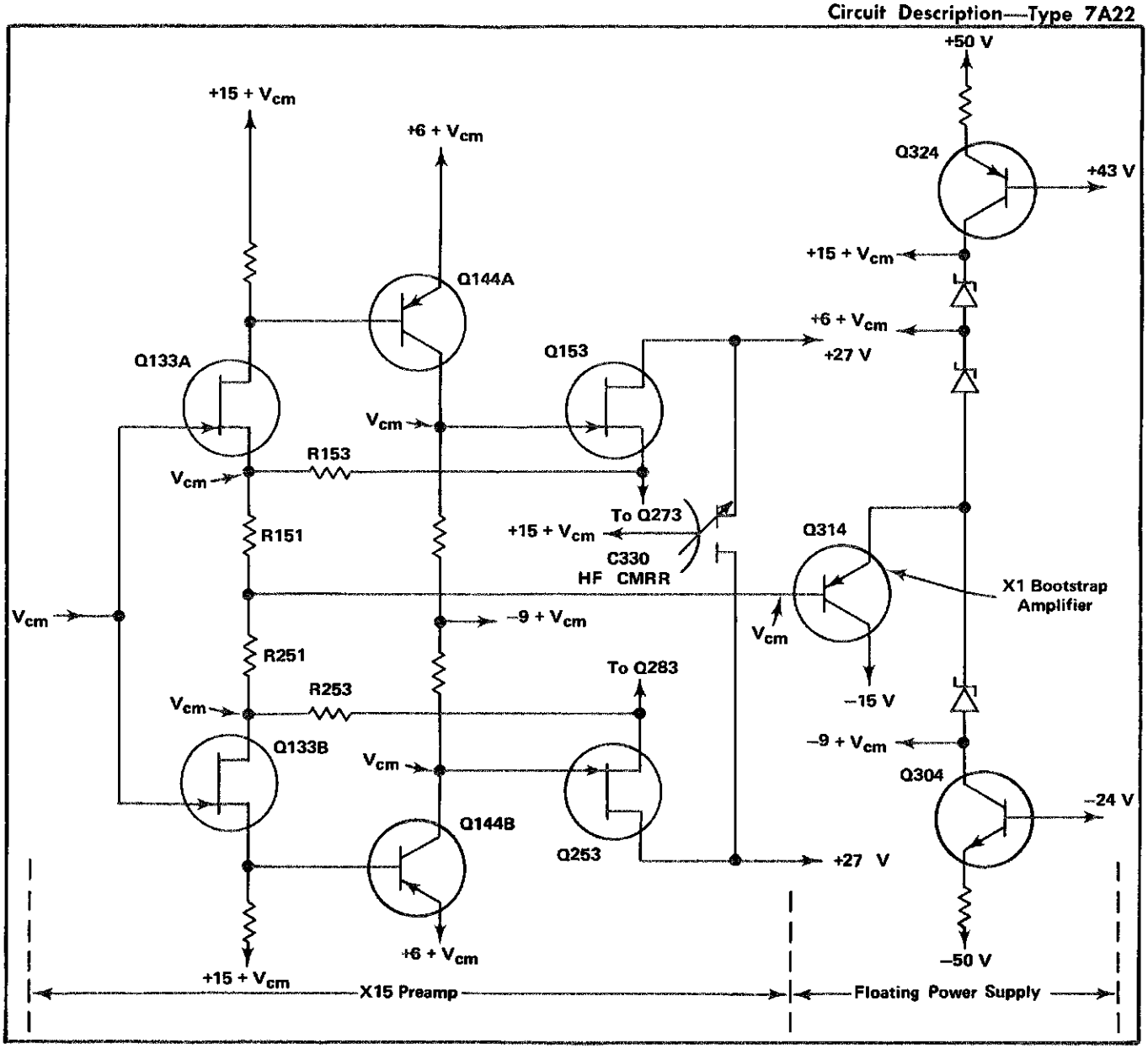


Fig 3-5. Common-mode Rejection using floating power supply.

DC BAL control changes the current through R257, R259, thereby changing the DC balance. It is used to adjust the difference in potential across the output of the ×15 Preamp (pins Z and W) to zero with the input coupling switches at GND and the LOW FREQ −3 dB POINT switch set to DC.

With high frequency common-mode signals the wiring stray capacitance of the ×15 preamp can inject undesirable current into the two output lines at high frequencies. C330 is adjusted to equalize these currents, thus extending the frequency range over which useful CMRR can be obtained.

Floating Power Supply. The supply voltages for the ×15 preamp are obtained from a chain of Zener diode shunt regulators, VR305, VR320 and VR325 connected in series. Current is supplied by two current sources, Q304 and Q324. C307, C317 and C325 filter out the Zener noise. C315 increases the bootstrap stability at higher frequencies.

Any common-mode changes that occur in the input amplifier, except at the output, are coupled to the power supply through Q314. Q314 is an emitter follower whose gain is maintained very close to unity by the minimum loading presented to its output by the high collector impedance of Q304 and Q324, thus achieving good bootstrap efficiency.

Common Mode Rejection. One of the primary functions of the ×15 preamp is to reject any common-mode component in the input signals, and amplify only the difference. In the extreme case of the inputs tied together and a common voltage applied, the output of the amplifier is ideally zero, and would actually be zero provided that the characteristics

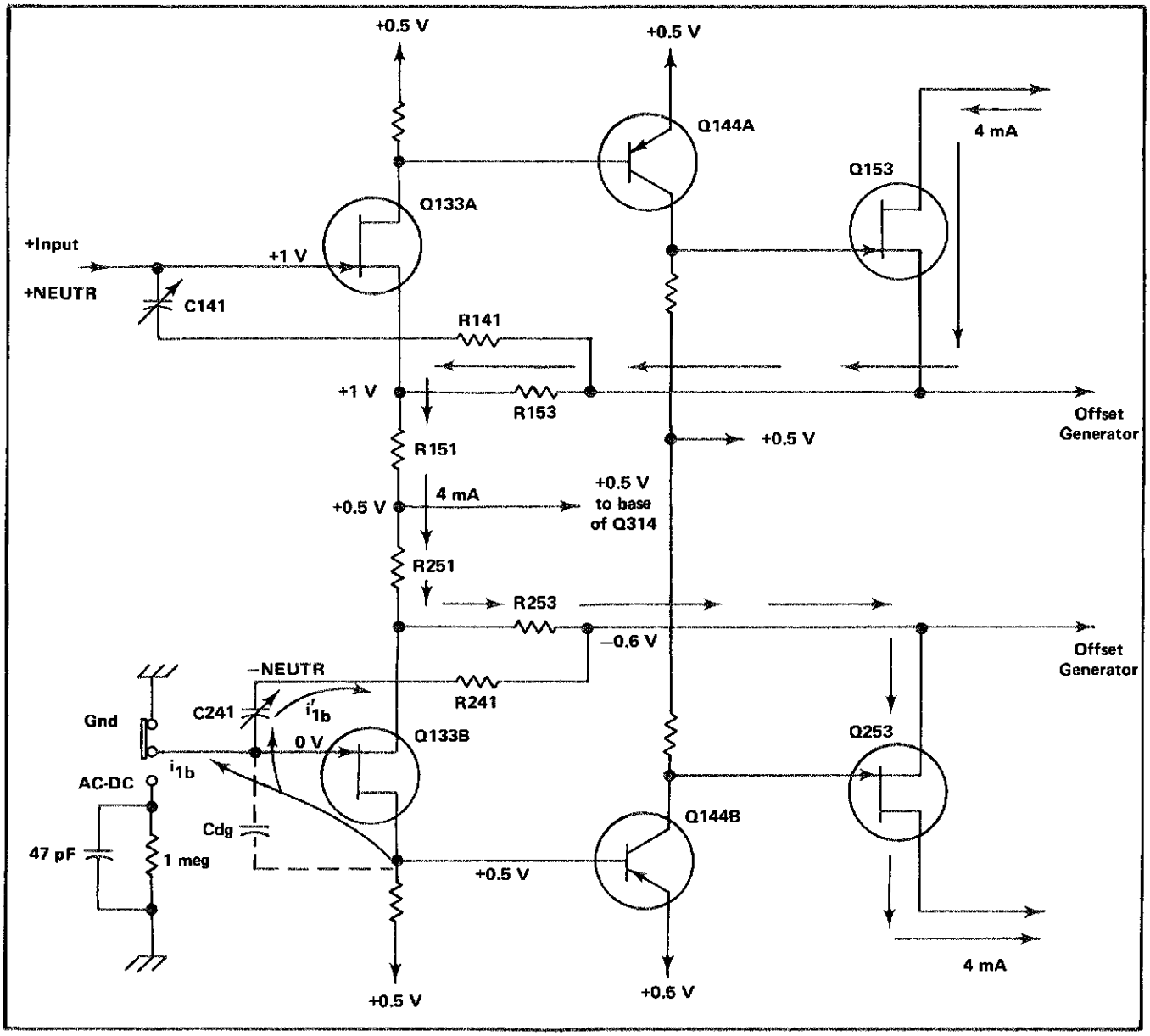


Fig. 3-6. Input cross neutralization.

of all corresponding elements on the two sides of the amplifier (see Fig. 3-5) were exactly matched. In practice any mismatch will cause a differential output. Even with perfect matching, there is still a common-mode output current resulting in an undersirable common-mode signal applied to the subsequent stages of the amplifier (common mode gain).

The floating power supply eliminates these difficulties and improve the CMR. Suppose the input to the bootstrap amplifier is connected to the junction of R151 and R251 (see Fig. 3-5). It can be seen that now the entire power supply and amplifier moves an amount equal to Vcm (ie: follows Vcm) and that no changes in voltage or current levels occur anywhere within the amplifier as a result of Vcm, except for Q153 and Q253 drain to gate voltage. Thus the only mismatch of importance is that of Q153, Q253 amplification factors, and being in the third stage of the amplifier at a point of relatively large differential signal level, this causes only a small degradation in CMR.

At higher frequencies the inevitable stray capacitances from various points in the ×15 preamp to ground begin to inject significant current into the amplifier as a result of common mode signals. The differential capacitor C330, (Fig. 3-5 or Schematic ⓵) connected from a point in the floating power supply to the two output lines, is used to inject adjustable currents into the output. It can be adjusted to equalize the net output currents resulting from high frequency common mode signals and so extend the range of frequencies over which useful CMRR can be obtained.

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. 3-6).

The results are (a) an output current of 4 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 R151, R251 operating into the bootstrapped power supply system. Specifically, the drain of Q133B also rises +0.5 V and injects a current i_{1b} through the drain to gate capacitance of Q133B 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 (see Fig. 3-7).

Note that the output current flowing through R253 causes its output end (Q253 source) to go to —0.6 V. A capacitor, C241, connected from this point to the —input can be adjust to 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. R141 and C141 perform a similar function for the +input.

Input Overdrive Protection. Since the input FETs Q133A and B, being semiconductors can be destroyed by sufficiently large overdrive applied directly to them, some input protection is a necessity. The important components of the protection system used in the Type 7A22 are shown in Fig. 3-8A.

There are two different kinds of overdrive associated with the Type 7A22, (a) single-ended overdrive, with one input grounded, and (b) common-mode overdrive, with approximately equal input voltages.

(a) Assume the —input grounded and a steadily increasing voltage on the +input. The chart in Fig. 3-8B indicates the sequence of events: F119 will open if the + signal source can supply 1/16 amp of current. If this much current is not present, the +input remains at +16.5 V, with the overdrive current flowing to ground as shown in Fig. 3-8.

Now assume the +input grounded and a steadily increasing —voltage on the —input. The sequence of events is shown in Fig. 3-8C.

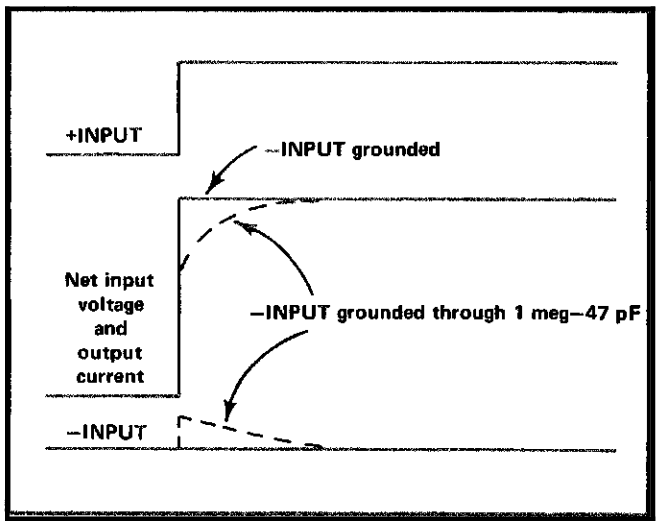


Fig. 3-7. Effects of high impedance to ground in the —INPUT.

(b) For common-mode overdrives the clamping sequence is essentially similar, except the ×15 amplifier does not overload, and the current i_2 does not flow until the input reaches approximately —13 V. The fuse opening current paths are shown in Fig. 3-8A.

For differential overdrive the action is a combination of the + and — single-ended sequences, with the —input supplying i_2. (In effect a 5 kΩ resistor is connected across the inputs when the differential voltage reaches 3 V). The fuses will not open until one or both inputs reach +16.5 V or —16.5 V.

DC Offset. The purpose of the DC offset system is to allow a differential slideback measurement, i.e.: to buck out small DC components of input signals and allow the amplifier to amplify only the varying components, while keeping the differential capability. This means that when a DC voltage is applied across the inputs, some means must be found to balance out the resultant output current. Fig. 3-9 illustrates how this is done.

Fig. 3-9A shows the standing currents for zero input. Fig. 3-9B shows the currents with a 0.25 V DC input applied to the +input. This would cause an i_o' of 1 mA to flow through R151, R251. However, if this 1 mA is supplied as shown by the offset generator, then no net output current results. Both the Q133A and Q133B source currents and the output standing currents, i_o', remain at their zero signal value, 2 mA and 5 mA respectively.

Offset Generator. The offset generator produces the adjustable balanced offset current for use in the ×15 preamp. Due to the wide range of the offset system (200,000 div at 10 μV per div) stable components are used and circuit techniques which minimize drift and noise are employed in the offset generator. A 10 turn coarse and 1 turn fine OFFSET control is used to obtain adequate resolution at low deflection factors.

The functional arrangement of the offset generator is shown in Fig. 3-10. In the reference voltage generator the OFFSET control, R270, taps an adjustable portion (V_{1b}) of the voltage across the reference Zener VR270, and a fixed voltage (V_{1a}) is taken from the voltage divider formed by R271, R279 (approximately 50% of the reference voltage); thus, the difference voltage (V_{1b}—V_{1a}) is adjustable over the range of at least —4 V to +4 V.

This adustable difference voltage is applied to the inputs of a balanced feedback amplifier conceptually similar to that described previously under differential configuration. In amplifier "A", the feedback action forces the —input voltage (also the output voltage) V_{2a} to follow the +input V_{1a}. In a similar manner, V_{2b} follows V_{1b} in amplifier "B". The differential input (V_{1b}—V_{1a}) is therefore reproduced across resistors R287, R289. The resultant current, $\frac{V_{2b}-V_{2a}}{R287+R289}$, which is "$i_{offset}$", flows through the FET (Q273, Q283) output stages of the amplifier and out their drains to the ×15 preamp.

When the offset is not in use V_{1b} is switched to the fixed divider (R273, R277) by the OFFSET ON/OFF switch (part of the LF —3 dB POINT switch). V_{1a} is adjustable over a small range with respect to V_{1b} by the COARSE DC BAL control, whose purpose is to adjust out any initial DC unbalance in the ×15 preamp, and to bring its output to zero with zero input.

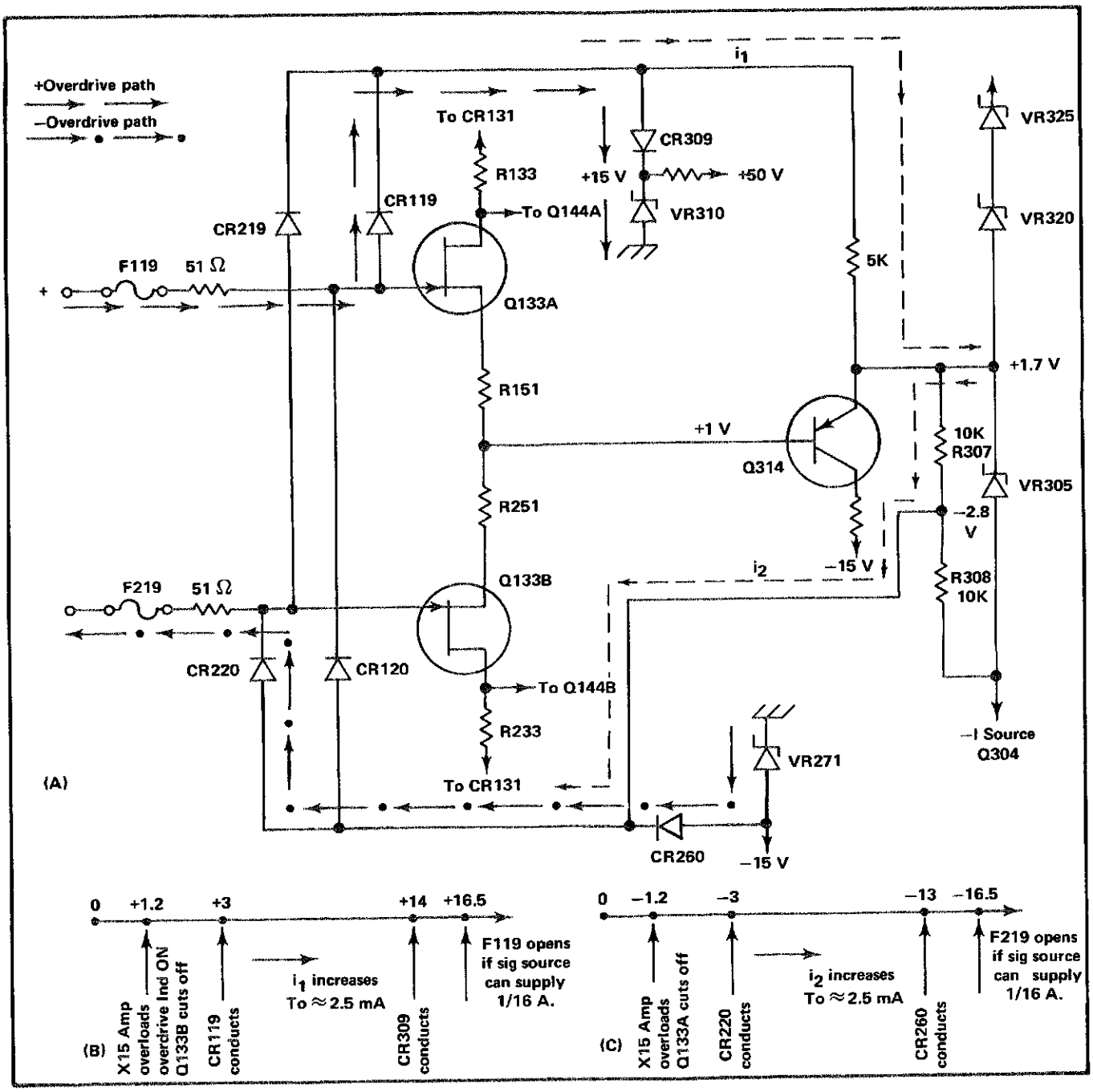


Fig. 3-8. (A) Overdrive Protection System showing current paths. (B, C) Sequence of events leading to excessive overdrive.

In the actual circuit, the reference voltage generator is modified by the addition of a FINE OFFSET control (R265), which changes the effective range of the 10 turn COARSE potentiometer by means of two voltage dividers, one connected to each end of the COARSE control. A capacitor filters out Zener noise from the reference voltage.

The feedback amplifiers A and B are composed of Q264A, Q273 and Q264B, Q283 respectively, with the reference input applied to the emitters of dual transistor Q264 and the feedback to its bases. Current source Q284 supplies operating current for the amplifiers.

Input Overdrive Indicator. When the LF –3 dB POINT selector is in a position other than DC, there is no on-screen indication of the DC conditions in the ×15 preamp, and it may be driven into non-linearity or overload by a DC component, leading to erroneous displays. The input overdrive indicator detects this condition and indicates by means of a warning light that the ×15 preamp is approaching the limits of its dynamic range.

The indicator consists of a threshold detector (CR341, CR343, Q344) and a monostable lamp driver (Q334, Q354). In the quiescent state, while no overdrive exists, CR341,

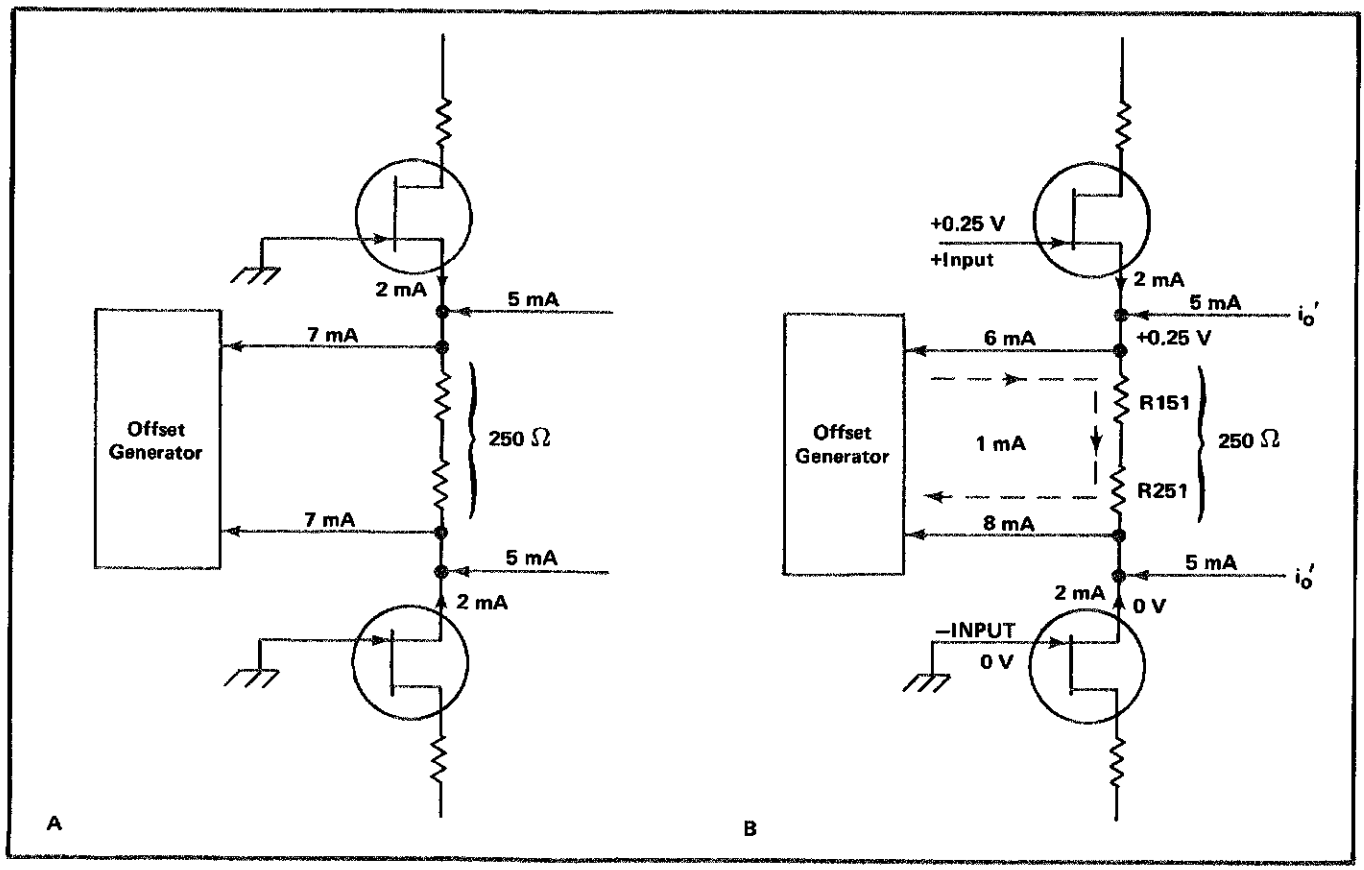


Fig. 3-9. Offset system showing (A) Conditions with zero offset, (B) 0.25 V DC offset.

CR343, Q344, Q334 and Q354 are all cut off. R341 and R343 form a voltage divider to set the emitter of the threshold detector, Q344, at approximately +32 V.

Now suppose one of the ×15 preamp output lines exceeds +33.4 V; CR341 (or CR343) and Q344 collector current turns on Q334 via R347. Q334 collector current turns on Q354 via R333, and the resulting negative going step at Q354 collector turns on the lamp. This causes current in R349 to turn Q334 on harder. If the overdrive is removed immediately, Q344 turns off. However, the current through C349, R349 keeps Q334, Q354 and the lamp on until C349 is charged to its new voltage (approximately 1 second) and the current through R337 exceeds that in R349, R337. This keeps Q334 off for approximately 1 second, even if Q344 receives another overdrive signal.. Thus for repetitive overdrives, (up to about 10 kHz), the monostable free-runs and the lamp flashes at approximately a 2 second rate. (Above 10 kHz the high speed AC effectively charges up the stray capacitance and makes the circuit act as if it had a DC overload.) If, however, a DC overload keeps Q344 on, the end of C349 discharge does not turn Q334 off since it is kept on by current through R347. Thus, the lamp stays on until the overdrive is removed.

LF —3 dB POINT Selector. This switch selects the low frequency —3 dB point of the amplifier and has a range of 0.1 Hz to 10 kHz in decade steps. Selection is done by switching the resistor and capacitor of a pair of capacitor couplings in each leg of the amplifier. Fig. 3-11 shows half of the selector, with the switch split up into its functional elements.

For the 100 Hz to 10 kHz positions, C156 is used and resistors R353C, R353B and R353A are switched to the output in the following combinations:

—3 dB frequency	100 Hz	1 kHz	10 kHz
output resistors	R353C	R353 & R353B	R353C & R353A

Whenever R353A or R353B is not on the output side of C156, it is placed across the input, to keep the high frequency load resistance seen by Vin constant.

C353A is switched across C156 for the lower 3 ranges, (0.1 Hz, 1 Hz and 10 Hz) and C156 is shorted out for DC coupling. Resistor R157 adds a small increment in gain when C156 is used to compensate for the loss of gain through the capacitive divider formed by C156 and stray capacitance C_s.

When the 0.1 Hz to 10 Hz positions are in use, C353A may be rapidly pre-charged by switching to the 10 Hz position momentarily.

OUTPUT AMPLIFIER (See Schematic ◇2◇)

Gain Switching Amplifier

The gain switching amplifier (Q404, Q414, Q424, Q524) is a balanced differential configuration very similar to the ×15 preamp but with a fixed power supply. Gain switching is accomplished by switching R407.

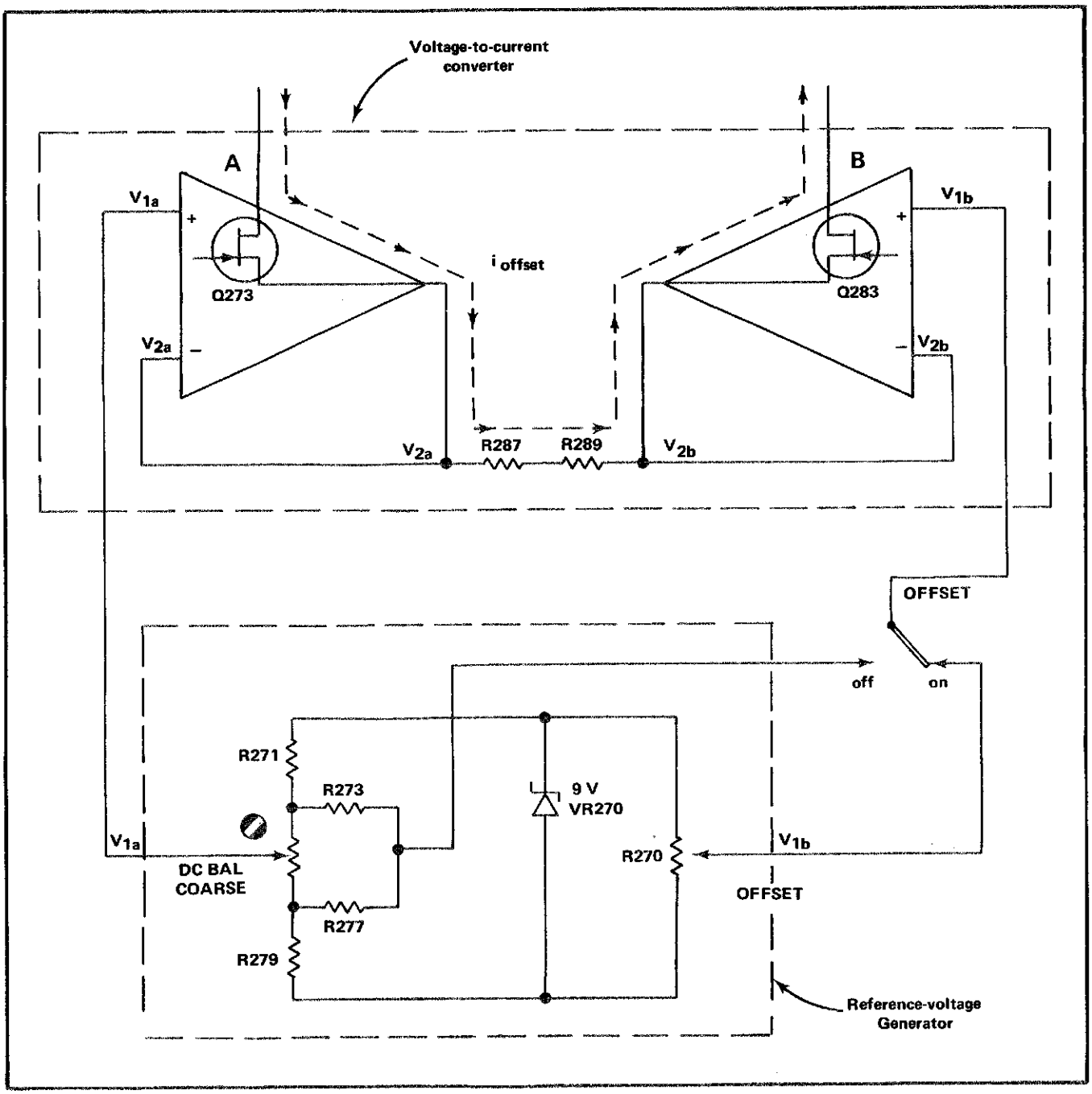


Fig. 3-10. Functional arrangement of the offset generator.

Diodes CR413, CR513 prevent base-emitter reverse breakdown in Q414 under overdrive conditions: CR419, CR519 limit the output current that can flow through Q424, Q524. CR415, CR417 and CR515, CR517 prevent the bases of Q424, Q524 from swinging too far from the emitter, preventing breakdown and ensuring a fast, clean overdrive recovery. The AC STEP ATTEN BAL adjustment (R505) in series with the source of Q404B, develops a small adjustable voltage which removes any initial unbalance in the gate-to-source voltages of Q404 A & B. The AC STEP ATTEN BAL also sets the voltage across gain-setting resistor R407 to zero when the differential input (gate-to-gate) voltage is zero.

VAR BAL (R425) is used to balance the output currents of Q424 and Q524 with zero input to the amplifier.

The gain switched amplifier has excellent overdrive characteristics so that the full dynamic range of the input amplifier can be used. It is gain-switched over a range of about 1,000:1 with no significant change in bandwidth or any other characteristics.

HF —3 dB POINT Selector. The HF —3 dB POINT selector simply switches different values of capacitance across the output of the gain-switched stage to set the high frequency —3 dB point of the amplifier. The —3 dB point is adjusted in the 1 MHz position by C425.

Variable Output Stage

The variable output stage (Q434, Q534) does not contribute much voltage gain, but it performs a number of other functions. The configuration is a collector loaded, common emitter amplifier with emitter degeneration, the gain (collector signal current vs. input voltage) being determined by the total emitter to emitter resistance. This resistance is adjusted over a 2.5:1 range by the VAR control, R535, which provides a fine control of gain in the uncalibrated position, and interpolates between the steps of the VOLTS/DIV switch.

POSITION control is obtained by feeding adjustable currents into the emitters of Q434, Q534, via resistors R431, R531. This current adds to or subtracts from the signal current developed in the emitter resistors R432, R535, R532, and flows out of the collectors into the signal and trigger output amplifiers.

Signal Output Amplifier

The signal output amplifier (Q444, Q544) is a push-pull common emitter configuration with emitter degeneration to improve the stability and linearity of the circuit. The gain of the stage is determined by the total emitter-to-emitter resistance, which is adjustable by GAIN control (R540) to facilitate calibration of the instrument. The gain of the amplifier is set in the 1 mV position of the VOLTS/DIV switch.

R443, R543 equalize the power in Q444, Q544 under dynamic conditions, thereby eliminating thermal distortion. C443, C543 are high-frequency by-pass capacitors.

Trigger Output Amplifier

The trigger output stage (Q454, Q554) is almost identical to the signal output stage, except the stage gain is not adjustable, so that the output, while nominally the same as the signal output level, can in fact have quite a wide tolerance.

INDICATOR OSCILLOSCOPE READOUT

General

The readout block consists of switching resistors and a probe sensing device. The switching resistors are used to signal to the Indicator Oscilloscope the setting of the VOLTS/DIV switch. R618A, R618B, and R618G select the number 1, 2, or 5 depending upon the combination that is switched in. R618C, R618D, R618L, and the output of the probe sensing device (Q614) select the decimal point (number of zeroes) again depending on the switched-in resistor combination. R618E, R618F, and R618N select the Volts sub-unit, either m (milli), μ (micro), or no sub-unit. R618H and R618K select

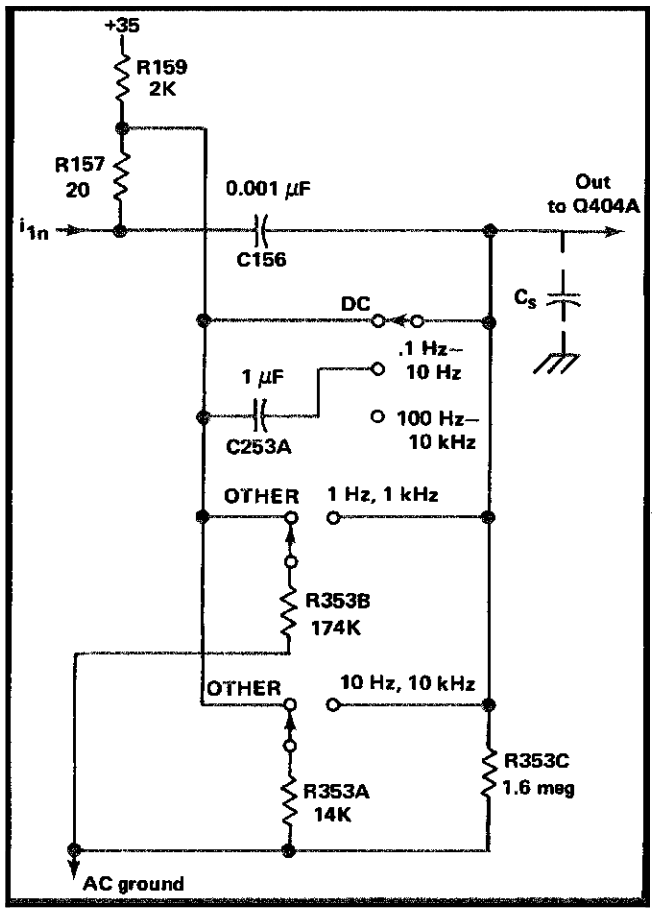


Fig. 3-11. Partial Low Frequency —3 dB Point selector for + Input amplifier.

the symbol V (volts). R618J and R618M select the symbol > when the VARIABLE VOLTS/DIV knob is in the uncalibrated position. Refer to the Schematic Diagram of the VOLTS/DIV Switch to find the resistors associated with a particular setting of the VOLTS/DIV switch.

Probe Sensing

The probe sensing device (Q614) identifies the attenuation of the probe connected to the front panel connector, by sensing the amount of current flowing from the current sink through the probe coding resistance, and adjusts the readout display so that the actual probe tip deflection factor is displayed.

The probe connected to the + (or —) INPUT connector forms a voltage divider with R610 (R620) through CR615 to the —15 V supply. This forward biases CR610 (CR620) allowing current to flow through R630, reducing the bias on Q614. The bias voltage, applied to the base of Q614, is set by the probe coding resistance of the divider probe.

When the —15 V clock pulse is applied to interface connector B33, Q614 is interrogated and its collector currents (detrmined by the base voltage and emitter resistor, R614) is added to the column current through interface connector A37.

With a 1× probe (or no probe) connected, Q614 is turned off, and the deflection factor, in the readout display, is determined by the setting of the Readout Switch, S407, (part of the VOLTS/DIV switch) only.

With a 10× probe connected to the input (+ or —), the bias on Q614 will allow 100 μA of collector current to flow. This increases the deflection factor (in the readout display) by a factor of 10.

When different-attenuation divider probes are connected to the + and — INPUT connectors, the displayed readout will be the probe tip deflection factor of the larger divider. For example: if a 10× probe is connected to the +INPUT and a 100× probe is connected to the —INPUT the readout will display the deflection factor at the tip of the 100× probe. The 100× probe will set the bias on Q614 to allow 200 μA of collector current which will increase the deflection factor (in the readout display) by a factor of 100.

This means that the Indicator Oscilloscope displayed readout will give the correct deflection factor from the probe tip, for a single probe or two probes having the same attenuation factor, whereas the VOLTS/DIV knob on the plug-in will display only the plug-in deflection factor.

Trace Identify

The TRACE IDENTIFY button, when pressed, does two things:

1. It causes the trace, representing the output of the Type 7A22, to move a small amount by inserting a 2 kΩ resistor, R622, from ground through CR630 to the junction of R632 and R634. This shunts a small amount of the output current causing the trace to move.

2. Forms a voltage divider from the —15 V supply through R630 and R622, placing the base of Q614 at approximately —1.5 V. This low value of bias will cause Q614 to turn on hard (1,000 μA collector current) when interface connector B33 is interrogated, erasing the readout display and causing the word "IDENTIFY" to appear.

These two actions aid in identifying the Type 7A22 trace when multiple traces are displayed. When the IDENTIFY button is released, the readout is restored to its previous display.

For more specific information on the operation of the system, refer to the appropriate Indicator Oscilloscope manual.

SECTION 4
MAINTENANCE

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

Introduction

Information which will aid in keeping the Type 7A22 operating at its peak performance is contained in this section. Cleaning, lubricating and visual inspection hints are included under preventative maintenance. The section on corrective maintenance includes troubleshooting and corrective procedures. Parts identification and soldering techniques are included where necessary.

PREVENTIVE MAINTENANCE

General

The instrument should be cleaned, inspected and recalibrated at regular intervals. The recommended interval for average operating conditions is every 6 months or every 1000 hours of operation, whichever occurs first.

Cleaning the Front Panel

Loose dust may be removed with cloth and a dry paint brush. Water and mild detergents such as Kelite or Spray White may be used.

CAUTION

Avoid the use of chemical agents which might damage the plastics used in this unit. Avoid chemicals such as benzene, toluene, xylene, acetone or similar solvents.

Cleaning the Interior

Cleaning of the interior of the unit should precede calibration, since the cleaning process might alter the settings of the calibration adjustments.

To clean the interior, use low-velocity compressed air to blow off the accumulated dust. High velocity air streams should be avoided to prevent damage to components.

WARNING

Use an eye-shield when cleaning with pressurized air. Hardened dirt can be removed with a paint brush, cotton tipped swab or cloth dampened with a water and mild detergent solution. Avoid the use of chemical cleaning agents that might damage the plastic parts.

Visual Inspection

The unit should be inspected occasionally for such defects as poor connections, broken or damaged circuit boards, improperly seated transistors and heat-damaged parts. The remedy for most visible defects is obvious. However, damage from overheating is usually a symptom of less obvious trouble; and unless the cause is determined before parts are replaced the damage may be repeated.

Transistor Checks

Periodic preventive maintenance checks on the transistors used in the unit are not recommended. The circuits within the unit generally provide the most satisfactory means of checking transistors usability. Performance of the circuits is thoroughly checked during recalibration, and substandard transistors will usually be detected at that time.

Calibration

To insure accurate measurements, the Type 7A22 calibration should be checked after each 1000 hours of operation or every six months if used intermittently. Complete calibration instructions are contained in Section 5.

The calibrated procedure can be helpful in isolating major troubles in the unit. Moreover, minor troubles not apparent during regular operation may be revealed and corrected during calibration.

CORRECTIVE MAINTENANCE

General

Replacement of some parts in the unit should be done by following a definite procedure. Some procedures, such as soldering and replacing components on the circuit boards, are outlined in this portion of the manual.

Many electrical components are mounted in a particular way to reduce or control stray capacitance and inductance. When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance at high frequencies. When a repair is made, calibration and performance of the relevant portions of the circuit should be checked. Refer to Table 4-1 and to the Performance Check/Calibration procedure in Section 5 and perform the applicable steps.

TABLE 4-1

Areas of Repair	Checks and Adjustments Affected	Section 5 Calibration Step
Input Coupling switches and cables Input Attenuators	Input R and C, Attenuator compensation, CMRR, LF response, Gain	6, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22
Preamp	1X input C, Cross Neutralization, DC BAL, CMRR Common-Mode dynamic range, Differential dynamic range, Offset range, Noise, Input protection system Gain, 1 MHz freq. response, Overdrive indicator	3, 6, 10, 11, 12 13, 14, 20, 22, 23, 24
LF —3 dB POINT	Gain, LF freq. response, 1 MHz freq. response	6, 20, 21
Overdrive Indicator	Dynamic range	23, 24
Gain Switched Amp	Gain, Deflection factor tracking, AC Atten Bal, HF —3 dB POINT, 1 MHz freq. response, Overdrive recovery Variable Balance	1, 2, 6, 8 20, 26
Offset Generator	Offset Range, DC Bal, CMRR	3, 10, 22
Output Amplifier	HF —3 dB POINTS, Var balance, Variable range, Gain	2, 6, 7, 20

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part replacements for the Type 7A22 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts lists for value, tolerance, rating and description.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of the component may affect its performance in the instrument, particularly at high frequencies. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

Special Parts. Some parts are manufactured or selected by Tektronix to satisfy particular requirements, or are manufactured for Tektronix to our specifications. These and most mechanical parts should be ordered through your Tektronix Field Engineer or Field Office. See Parts Ordering Information and Special Notes and Symbols on the page immediately preceding Section 6.

Soldering Techniques

Circuit Boards. Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the etched wiring from the base material.

The following technique should be used to replace a component on the circuit board. Most components can be replaced without removing the board from the unit.

1. Grip the component lead with long-nosed pliers. Touch the soldering iron to the lead at the solder connection. Do not touch the soldering iron tip directly on the board, as it may damage the board.

2. When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object, such as a toothpick or pointed tool, into the hole to clean it out.

3. Bend the leads of the new component to fit the holes in the board. Cut the leads of the new component to the same length as those of the old component. Insert the leads into the board until the component is firmly seated against the board, or as positioned originally. If it does not seat properly, heat the joint, and gently press the component into place.

4. Apply the iron and a small amont of solder to the connection to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink (see Fig. 4-1).

5. Clip the excess lead that protrudes through the board.

6. Clean the area around the soldered connection with flux-remover solvent to maintain good environmental characteristics and appearance. Be careful not to remove information printed on the board.

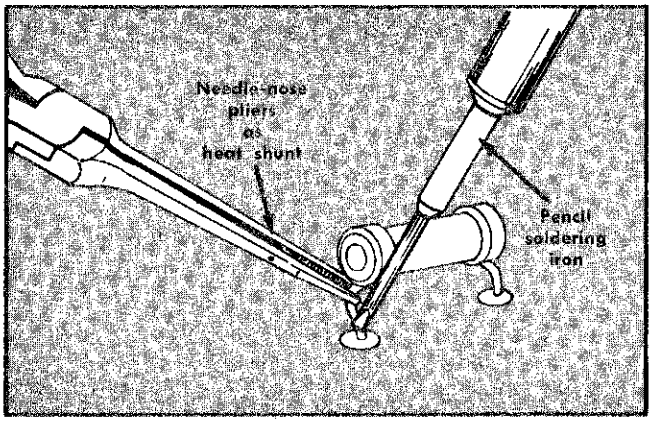


Fig. 4-1. Removing or replacing component on circuit board.

CAUTION

Silk-screen lettering dissolves when contacted by flux-remover.

Metal Terminals. When soldering metal terminals (interconnecting plug pins, switch terminals, potentiometers, etc.) ordinary 60/40 solder can be used. The soldering iron should have a 40- to 75-watt rating with a 1/8 inch wide chisel-shaped tip.

Observe the following precautions when soldering to metal terminals:

1. Apply heat only long enough to make the solder flow freely.

2. Apply only enough solder to form a solid connection; excess solder may impair the function of the part.

3. If a wire extends beyond the solder joint, clip the excess close to the joint.

4. Clean the flux from the solder joint with a flux-remover solvent to maintain good environmental characteristics and appearance.

Specific Component Replacement Information

WARNING

Disconnect the instrument from the power source before removing or replacing components.

The pushbutton switches are not repairable and should be replaced if defective. Components which are mounted on the circuit board associated with the pushbutton switch can be replaced using the normal replacement procedure. See the information under Light-Bulb Replacement for bulb replacement. Use the following procedures to replace the +INPUT and —INPUT pushbutton switches.

1. AC-GND-DC (+INPUT) Switch

a. Set the front panel controls as follows:

POSITION	Midrange
STEP ATTEN DC BAL	Midrange
VOLTS/DIV	10 V
HF —3 dB POINT	1 MHz
LF —3 dB POINT	DC OFFSET
DC OFFSET (FINE)	Midrange
DC OFFSET (COARSE)	5 turns from either extreme

b. Remove all front panel knobs.

c. Remove the GND binding post assembly.

d. Remove the nut and washer from the POSITION and DC OFFSET shafts.

e. Remove the plastic bushing from the VOLTS/DIV shaft.

f. Remove the front panel overlay.

g. Without unsoldering any leads, carefully push the dual DC OFFSET potentiometers out of the front panel and lift them out of the way.

h. Unsolder and unplug the connecting leads from the AC-GND-DC switch.

i. Remove four corner screws and remove the front sub-panel.

j. Remove the two screws securing the AC-GND-DC switch to the front sub-panel and remove the switch.

k. Replace by reversing the above procedure.

2. AC-GND-DC (—INPUT) Switch

a. Perform step 1, parts a through f, of Specific Component Replacement.

b. Loosen the setscrew on the collar connecting the GAIN shaft to the pot coupler and pull the shaft out of the front panel.

c. Unsolder and unplug the connecting leads from the AC-GND-DC switch.

d. Remove the four corner screws and remove the front sub-panel.

e. Remove the two screws securing the switch to the front panel.

f. Remove the switch.

g. Replace by reversing the above procedure.

3. Light-Bulb Replacement, +INPUT and —INPUT Push-Button Switches

Two types of pushbutton switches which have different light designs are in use. One switch design uses a metal cover over the light bulb(s) on the back of the switch; the other type does not. Either or both types of switches may be used in the 7A22.

To replace light bulbs in the pushbutton switches, use the following procedure:

a. Remove the applicable INPUT switch as described in steps 1 and 2.

b. On switches with the metal cover, remove the screw holding the cover and remove the cover.

c. Clip off the bulb leads near the bulb body.

d. Remove the leads from the circuit board.

e. Remove the excess solder from the circuit board with a vacuum-type desoldering tool.

f. Solder the new bulb to the circuit board (replace cover).

g. Replace the switch in the instrument.

4. Bandwidth Circuit Board

a. Set the LF and HF —3 dB POINT Selectors to either extreme.

b. Loosen the setscrews securing the LF —3 dB POINT shaft to the collar on the cam switch. Pull the shaft forward until it clears the collar.

c. Loosen the setscrews securing the HF —3 dB POINT shaft to the collar on the cam switch. Pull the shaft forward until it clears the bandwidth board.

d. Loosen the setscrew securing the GAIN shaft to the collar on R540. Pull the shaft forward until it clears the bandwidth circuit board. Loosen the setscrew securing the collar to R540 and remove the collar.

e. Loosen the four circuit board retaining screws and lift out the Bandwidth Circuit Board.

f. Unclip the leads from solderless connectors A, AN, AP, AO, and D.

g. Replace by reversing the above procedure.

CAUTION

Repair of cam-type switches should be undertaken only by experienced personnel. Switch alignment and spring tension of the contacts must be carefully maintained for proper operation of the switch. For assistance in maintenance of the cam-type switches, contact your local Tektronix Field Office or representative.

5. Cam-Type Switches

NOTE

A cam-type switch repair kit including necessary tools, instructions and replacement contacts is available from Tektronix, Inc. Order Tektronix Part No. 040-0541-00.

The cam-type switch consists of a rotating cam, which is rotated by a front-panel knob, and a set of contacts mounted on the adjacent circuit board. These switch contacts are actuated by lobes on the cam. The VOLTS/DIV, LF —3 dB POINT and HF —3 dB POINT cam-type switches can be disassembled for inspection, cleaning, repair or replacement, as follows:

A. LF —3 dB POINT and HF —3 dB POINT Switches

1. Remove the Bandwidth board as described in step 4.

2. Remove the two screws which hold the metal covers in place. (The front switch on the Bandwidth board is the LF —3 dB POINT Selector and the rear switch is the HF —3 dB POINT Selector). The switches are now open for cleaning or inspection.

3. To completely remove either of the two switches from the board, remove the four screws (from the back side of the board) which hold the cam assembly to the circuit board.

4. To remove the cam from the front support block, remove the retaining ring from the shaft on the front of the switch and slide the cam out of the support block. Be careful not to lose the small detent roller (between detent and detent spring).

5. To replace defective switch contacts, unsolder the damaged contact and clean solder from the hole in the circuit board. Position the new contact in the hole in proper alignment relative to the other switch contacts and with the mating area on the circuit board (alignment tool provided in switch repair kit). Solder the new contact into place; be sure that the spring end of the contact has adequate clearance from the circuit board.

6. To re-install the switch assembly, reverse the above procedure.

B. VOLTS/DIV Switch

1. Remove the Bandwidth board as described in step 4.

2. Remove the two screws which hold each of the metal switch covers in place.

3. Push the VARIABLE (CAL IN) to the 'IN' position.

4. Loosen the set screw which secures the VARIABLE shaft to the VARIABLE control assembly.

5. Pull the VARIABLE shaft through the front of the instrument.

6. Remove the 4 screws (from the rear side of the board) which hold the rear cam assembly to the circuit board.

7. Remove the rear cam assembly.

To remove the front cam-switch assembly, perform the preceding steps and then proceed as follows:

1. Remove the VOLTS/DIV knob.

2. Loosen the ½-inch hex bushing nut which secures the front support block.

3. Remove the plastic bushing from front of panel.

4. Remove the retaining ring from the shaft at the front of the switch.

5. Remove the 4 screws which secure the support blocks to the board.

6. Loosen the 2 set screws in the half of the flexible coupling and remove coupling.

7. Remove the rear support block by carefully lifting the block away from the circuit board far enough to clear the alignment projection on the bottom of the block. Carefully slide the rear block toward the rear (off the shaft).

8. Slide the cam shaft carefully (keep cam lobes clear of contacts) out of the front support block and bushing assembly.

9. To re-assemble, reverse the above procedure.

6. Interconnecting Pins

Interconnecting pins are used on the Type 7A22 to interconnect circuit boards. When interconnection is made at a circuit board, the pin is soldered into the board. Two types of mating connectors are used for these interconecting pins. If the mating conector is mounted on a plug-on circuit board, a special socket is soldered into the board. If the mating connector is on the end of a lead, an end-lead pin connector (which mates with the interconnecting pin) is used. The following information provides the replacement procedures for the types of interconnecting methods.

A. CIRCUIT-BOARD PINS

NOTE

A pin replacement kit including necessary tools, instructions and replacement pins is available from Tektronix, Inc. Order Tektronix Part No. 040-0542-00.

To replace a pin which is mounted on a circuit board, first disconnect any pin connectors. Then unsolder the damaged pin and pull it out of the circuit board with a pair of pliers. Be careful not to damage the wiring on the board with too much heat. Ream out the hole in the circuit board with a 0.031-inch drill. Then remove the ferrule from the new interconnecting pin and press the new pin into the hole in

the circuit board. Position the pin in the same manner as the old pin. Then, solder the pin on both sides of the circuit board. If the old pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins.

B. CIRCUIT-BOARD PIN SOCKETS

The pin sockets on the circuit boards are soldered to the rear of the board. To replace one of these sockets, first unsolder the pin (use a vacuum-type desoldering tool to remove excess solder). Then straighten the tabs on the socket and remove it from the hole in the circuit board. Place the new socket in the circuit board hole and press the tabs down against the board. Solder the tabs of the socket to the circuit board; be careful not to get solder into the socket.

NOTE

The spring tension of the pin sockets ensures a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as connecting points for spring-loaded probe tips, alligator clips, etc.

C. END-LEAD PIN CONNECTORS

The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the associated leads. To replace damaged end-lead pin connectors, remove the old pin connector from the end of the lead and clamp the replacement connector to the lead.

Some of the pin connectors are grouped together and mounted in a plastic holder; the overall result is that these connectors are removed and re-installed as a multi-pin connector when it is replaced. An arrow is stamped on the circuit board and a matching arrow is molded into the plastic housing of the multi-pin connector. Be sure these arrows are aligned as the multi-pin connector is replaced. If the individual end-lead pin connectors are removed from the plastic holder, note the color of the individual wires for replacement.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the Type 7A22. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is very helpful in locating troubles. See the Circuit Description Section for complete information.

General

If trouble occurs in the Type 7A22, the following procedure is recommended to accomplish rapid and effective repairs.

1. Check that the plug-in unit and the oscilloscope connectors are not damaged, and that the plug-in unit is properly inserted.

2. Inspect the front panels of the Type 7A22 and indicator oscilloscope to be sure that the trouble is not from an incorrect control setting.

3. Insure that the indicator oscilloscope is not at fault by inserting a known-good plug-in unit and checking its operation.

4. Determine all trouble symptoms.

5. Perform a visual inspection of the Type 7A22.

6. Repair or replace obviously defective parts.

7. Troubleshoot the Type 7A22 as necessary.

8. Recalibrate the Type 7A22.

Indicator Oscilloscope

The quickest check of the oscilloscope is to use it with a good plug-in unit, or check the questionable plug-in with another oscilloscope. Refer to the oscilloscope manual to verify proper operation of the oscilloscope.

Operating Procedures and Control Settings

Refer to the Operating Instructions Section of this manual to verify operating procedures and front panel control settings of the Type 7A22.

Trouble Symptoms

The Type 7A22 response to all front panel controls should be observed. The first-time operation in Section 2 or the Performance Check in Section 5 may be used for this purpose. All trouble symptoms should be evaluated and compared against each other. A casualty will often create a combination of symptoms that, when considered together, will pinpoint the trouble.

Visual Inspection

In physically examining the Type 7A22, take special note of the area indicated by evaluation of symptoms. Look for loose or broken connections, improperly seated transistors and burned or otherwise damaged parts. Repair or replace all obviously defective components.

Calibration Check

Troubles can frequently be located and corrected by recalibrating the instrument. Unless the casualty has definitely been isolated to a specific circuit, it is recommended that the calibration procedure contained in Section 5 be performed to provide a logical circuit troubleshooting sequence.

DETAILED TROUBLESHOOTING

General

If the casualty has not been disclosed and corrected through the procedure outlined, a detailed troubleshooting

analysis will have to be performed. The Circuit Description Section, the Schematic Diagrams, and the troubleshooting aids contained in this section are designed to expedite troubleshooting.

The Circuit Description Section provides a fundamental understanding of circuit operation and is referred to the Schematic Diagrams. The Schematic Diagrams contain voltage and resistance values and signal waveforms. The specified operating conditions should be duplicated before making voltage or waveform comparisons.

NOTE

Voltages and waveforms may vary slightly between instruments. Those given in the schematics should be checked against each instrument while it is operating properly. Deviations should be noted on the schematics for later reference.

Test Equipment Recommended for Troubleshooting

The test equipment listed here should suffice for most troubleshooting jobs. Test equipment required for calibration is listed in the Calibration Section.

High Impedance Voltmeter (20,000 Ω/V DC or greater)
Ohmmeter (2 mA or less current on the ×1 kΩ scale)
Test Oscilloscope and Probes
Flexible Plug-in Extension Cable
Dynamic Transistor Tester

DC Balance Check

A properly operating oscilloscope will have its trace centered vertically on the CRT only when the Type 7A22 has a balanced output. The Type 7A22 is a balanced amplifier connected in a differential configuration, with the +INPUT circuit being electrically identical to the —INPUT circuit. With no signal or comparison voltage applied to the FET gates, any point in the +INPUT circuit should have a potential equal to an identical point in the —INPUT circuit.

If the CRT trace is deflected as a result of a Type 7A22 problem, unbalances will exist between the two circuits. The unbalance can be detected by connecting a high impedance voltmeter between identical points in the two circuits.

An aid to this process is to short together the inputs of the stage being checked as shown in this example.

Stage	Devices	Short Together
Signal Output	Q444, Q544	Q444, Q544 bases
Trigger Output	Q454, Q554	Q454, Q554 bases
Variable Stage	Q434, Q534	Q434, Q534 bases
Gain Switching Amplifier	Q404A, Q404B, Q414A, Q414B, Q424, Q524	Front ends of R401 and R501
Input Amplifier		AC-GND-DC switches to GND

If the output balance is checked first and is in error, work toward the front until an unbalance no longer exists. This localizes the trouble to the circuitry between the points which are balanced and the points which are unbalanced. The individual components must then be checked.

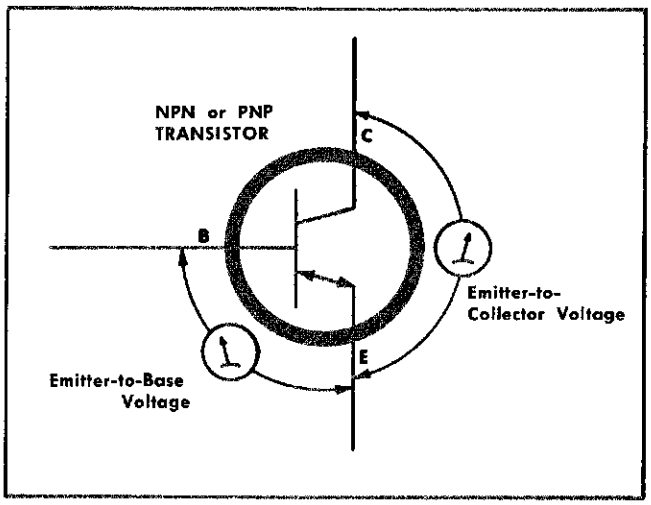


Fig. 4-2. Transistor junction-voltage measurements.

Troubleshooting by Direct Replacement

Semi-conductor failures account for the majority of electronic equipment troubles. The ease of replacing transistors often makes substitution the most practical means of repair. If this method is used, these guide lines should be followed:

Determine that the circuit is safe for the substitute component.

Use only substitute components that are known to be good.

Remove the plug-in from the oscilloscope before substituting components, to protect both you and the equipment.

Be sure components are inserted properly.

Check operation after each component is replaced.

Return good components to their original sockets.

Check calibration after a bad component has been replaced (see Table 4-1).

Component Checks

Transistors

The best means of checking a transistor is by using a transistor curve display instrument such as the Tektronix Type 576. If a transistor checker is not readily available, a defective transistor can be located by signal tracing, by making in-circuit voltage checks, by measuring the transistor resistances or by the substitution method previously described.

When troubleshooting using a voltmeter, measure the emitter-to-base and emitter-to-collector voltages to determine whether the voltages are consisent with normal circuit voltages. Voltages across a transistor vary with the device and its circuit function. Some of these voltages are predictable. The base-emitter voltage of a conducting germanium transistor will normally be approximately 0.2 V and that of a silicon transistor will normally be approximately 0.6 V. The col-

lector-emitter voltage will vary with the circuit and circuit conditions but it should always exceed 0.5 V. The best way of checking these devices is by connecting a voltmeter across the junction, using a sensitive voltmeter setting (see Fig. 4-2).

An ohmmeter can be used to check a transistor if the ohmmeter's voltage source and current are kept within safe limits. 1.5 V and 2 mA are generally acceptable. Selecting the ×1 kΩ scale on most ohmmeters will provide voltage and current below these values.

Table 4-2 contains the normal values of resistance to expect when making an ohmmeter check of an otherwise unconnected transistor.

Fig. 4-3 shows the transistor base and socket arrangements used in this instrument.

TABLE 4-2

Transistor Resistance Checks

Ohmmeter[1] Connections	Resistance Reading That Can be Expected Using the R × 1 k Range
Emitter-Collector	High readings both ways
Emitter-Base	High reading one way, low reading the other way
Base-Collector	High reading one way, low reading the other way

[1]**Test prods from the ohmmeter are first connected to the transistor leads and then the test lead connections are reversed. Thus, the effects of the polarity reversal of the voltage applied from the ohmmeter to the transistor can be observed.**

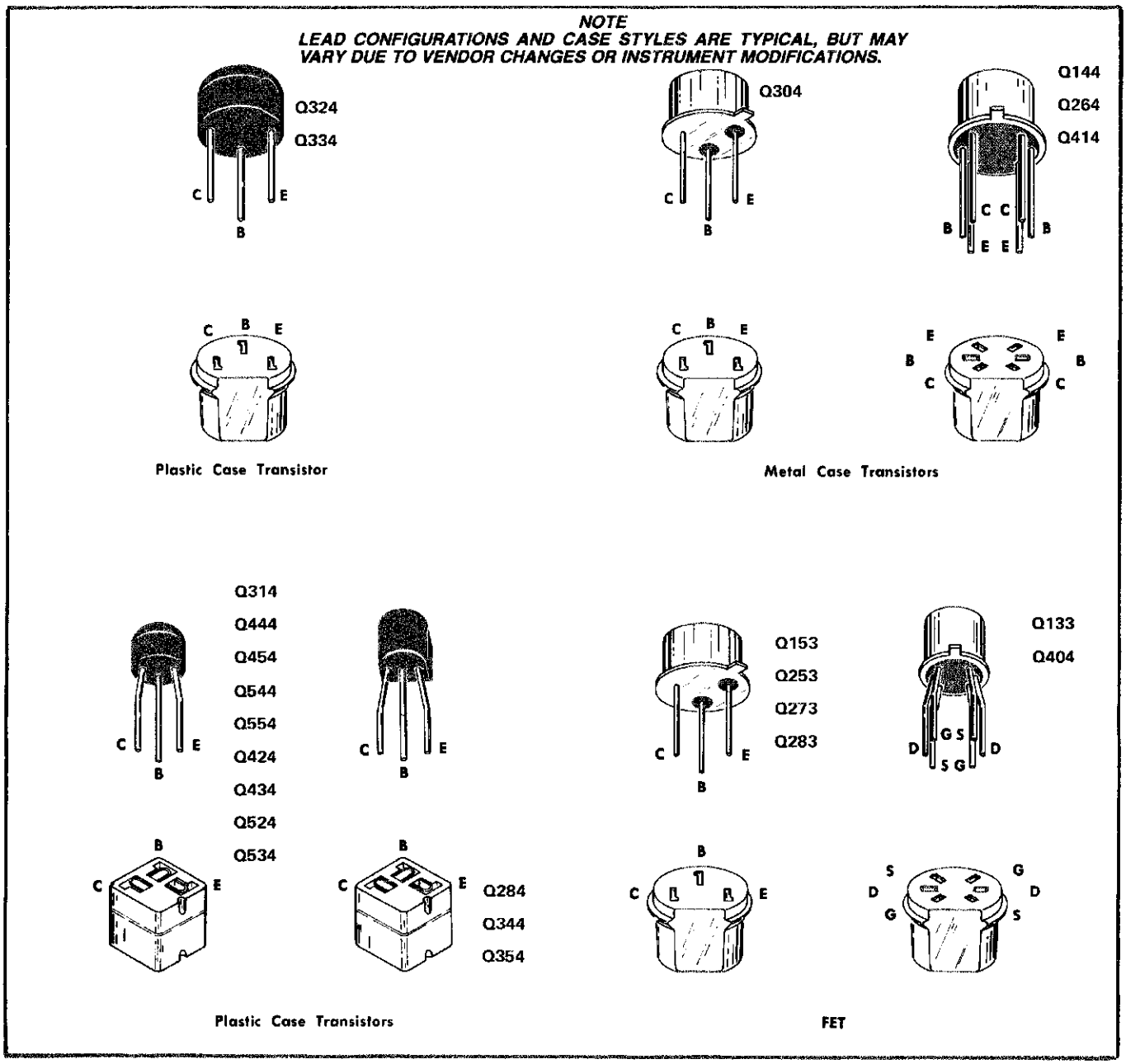


Fig. 4-3. Transistor base pin and socket arrangement.

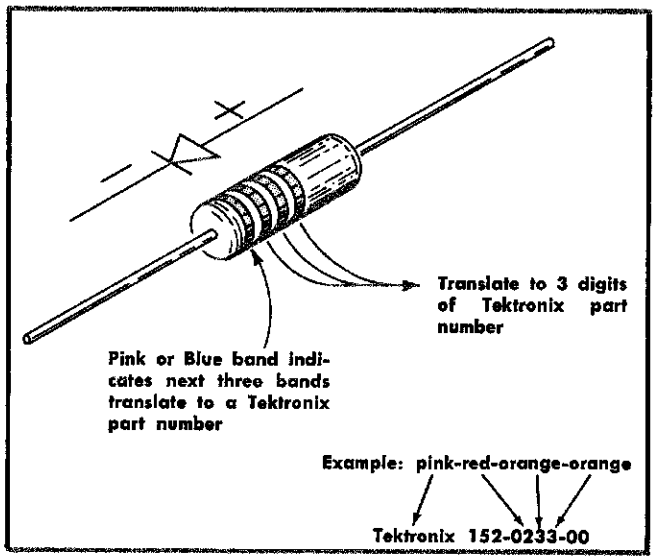


Fig. 4-4. Diode polarity and color code.

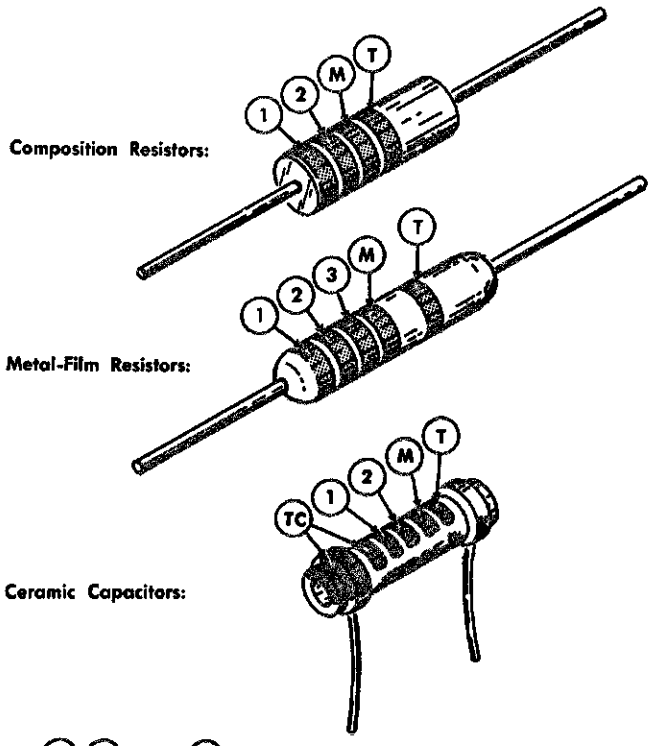
Diodes

A diode can be checked for an open or for a short circuit by measuring the resistance between terminals with an ohmmeter set to the R X 1k scale. The diode resistance should be very high in one direction and very low when the meter leads are reversed. Do not check tunnel diodes or back diodes with an ohmmeter.

Some diodes used in the Type 7A22 are color coded to identify the diode type. The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes or a dot. For most diodes with a series of stripes, the first stripe (either pink or blue) indicates a Tektronix part and the next three stripes indicate the three significant figures of the Tektronix Part Number. Example: a diode color coded blue-brown-gray-green indicates a diode with Tektronix Part No. 152-0185-00. The cathode and anode of a metal-encased diode can be identified by the diode symbol marked on the body. See Fig. 4-4, DIODE POLARITY AND COLOR CODES.

Resistors

The types and accuracies of resistors found in this instrument vary in accordance with the circuit needs. Replacement resistors should be of the same type and must be at least as accurate as those originally contained in the circuit, to maintain the high common-mode rejection ratio. The size, location and lead length are often critical because of frequency considerations.



Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier: Resistors	Multiplier: Capacitors	Tolerance: Resistors	Tolerance: Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^{2}	10^{2}	±2%	±2%
Orange	3	10^{3}	10^{3}	±3%	±3%
Yellow	4	10^{4}	10^{4}	±4%	+100% −0%
Green	5	10^{5}	10^{5}	±0.5%	±5% or 0.5 pF*
Blue	6	10^{6}	10^{6}	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

*For capacitance of 10 pF or less.

NOTE: T and/or TC color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 4-5. Color code for resistors and ceramic capacitors.

Composition, wire-wound and metal film resistors are used in this unit. The stable metal film resistors may be identified by their light blue or gray body color. If a metal film resistor has a value indicated by three significant figures and a multiplier, it will be color coded according to the EIA standard resistor color code. If it has a value of more than three significant figures and a multiplier, the value will be printed on the body of the resistor. For example, a 333 kΩ resistor will be color coded but a 333.5 kΩ resistor will have its value printed on the resistor body. The color code sequence is shown in Fig. 4-5.

Capacitors

A leaky or shorted capacitor can be detected by checking resistance with an ohmmeter using the highest scale that does not exceed the voltage rating of the capacitor. The resistance reading should be high after the initial charge of the capacitor. An open capacitor can be detected with a capacitance meter or by checking whether the capacitor passes AC signals.

The capacitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in the Type 7A22 are color coded in picofarads using a modified EIA code (see Fig. 4-5).

Repackaging for Shipment

If the Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing: owner (with address) and the name of an individual at your firm that can be contacted, complete instrument serial number and a description of the service required.

Save and re-use the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

Surround the instrument with polyethylene sheeting to protect the finish of the instrument. Obtain a carton of corrugated cardboard of the correct carton strength and having inside dimensions of no less than six inches more than the instrument dimensions. Cushion the instrument by tightly packing three inches of dunnage or urethane foam between carton and instrument, on all sides. Seal carton with shipping tape or industrial stapler.

The carton test strength for your instrument is 200 pounds.

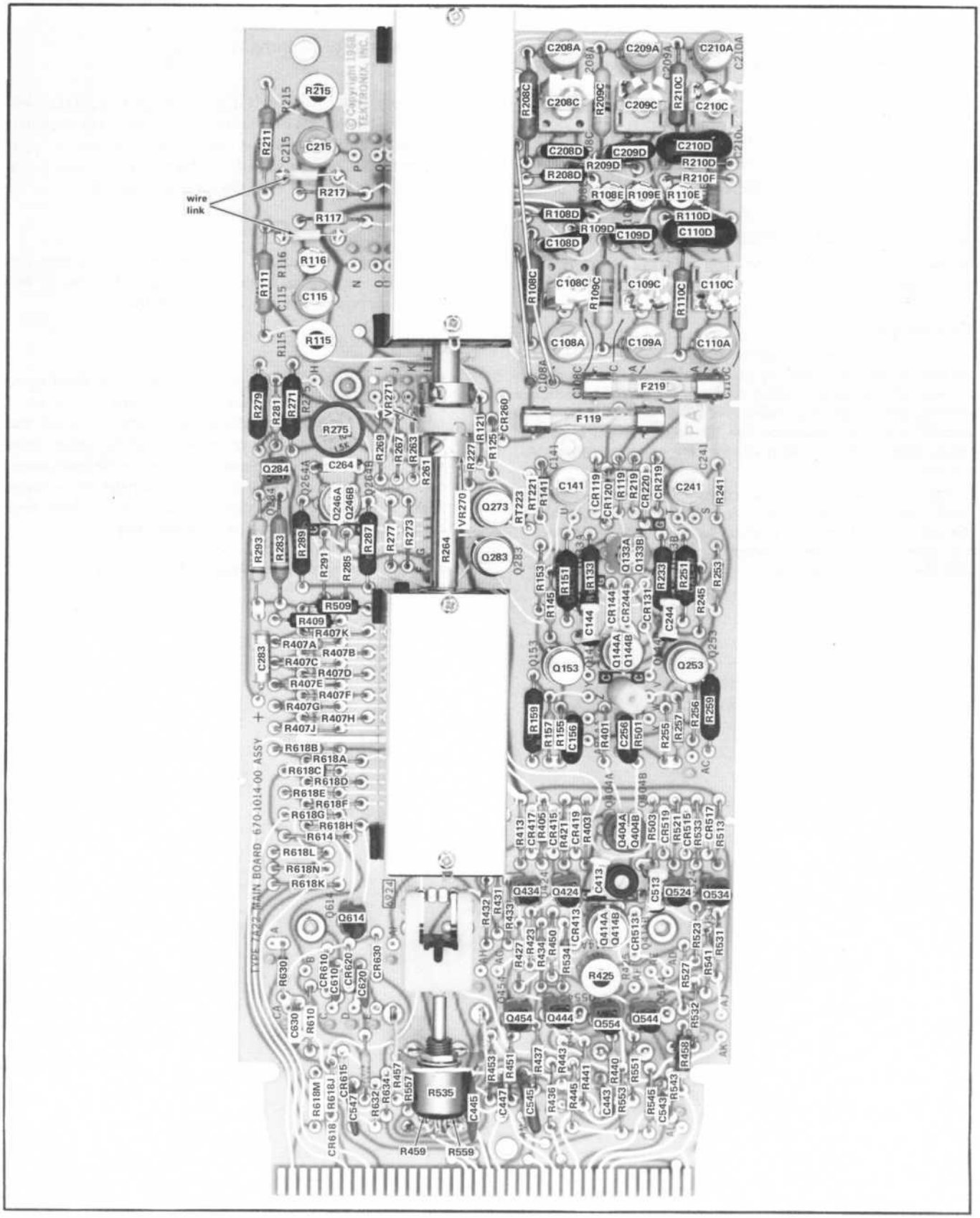


Fig. 4-6 Main circuit board (components).

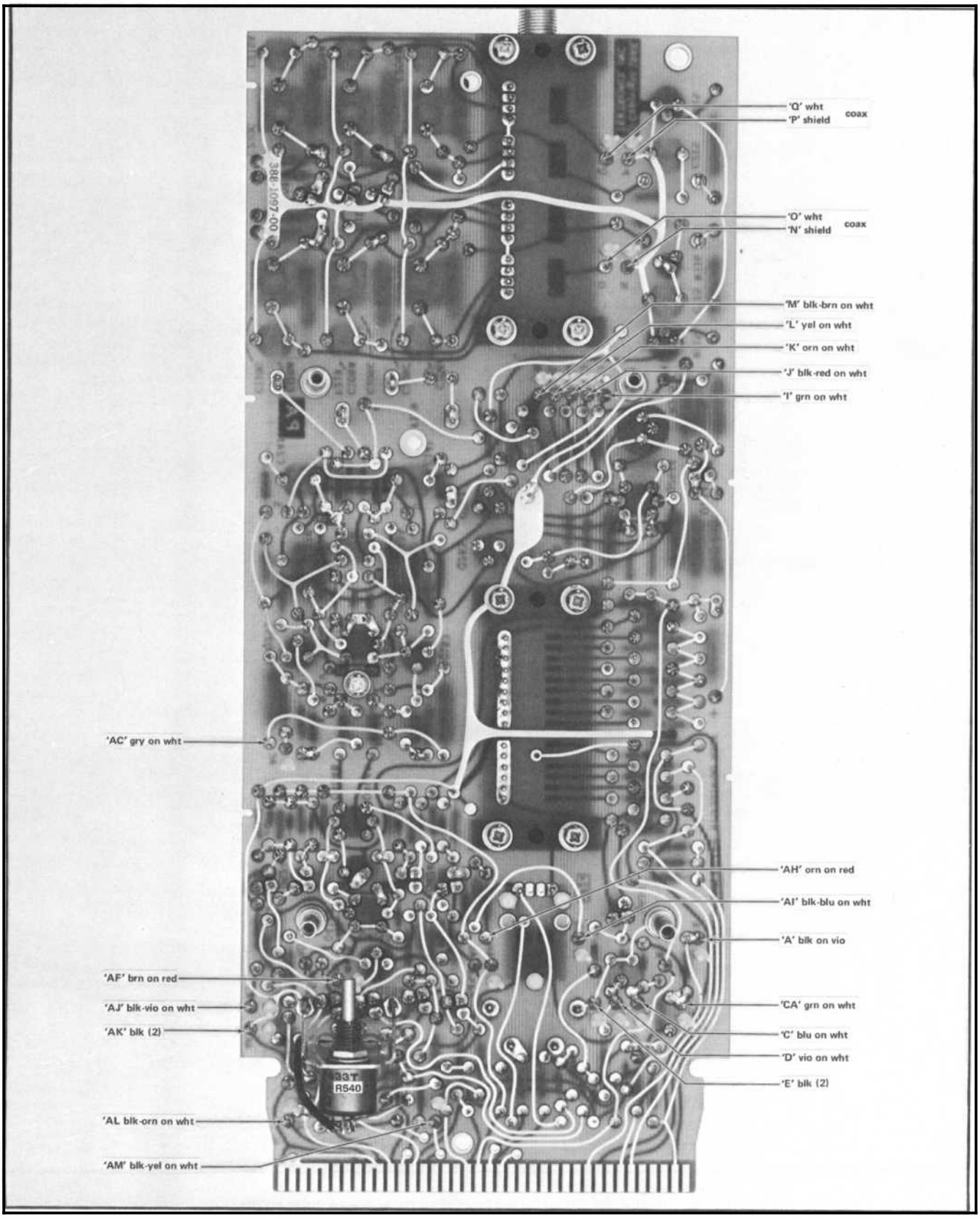


Fig. 4-7. Main circuit board (wire color code).

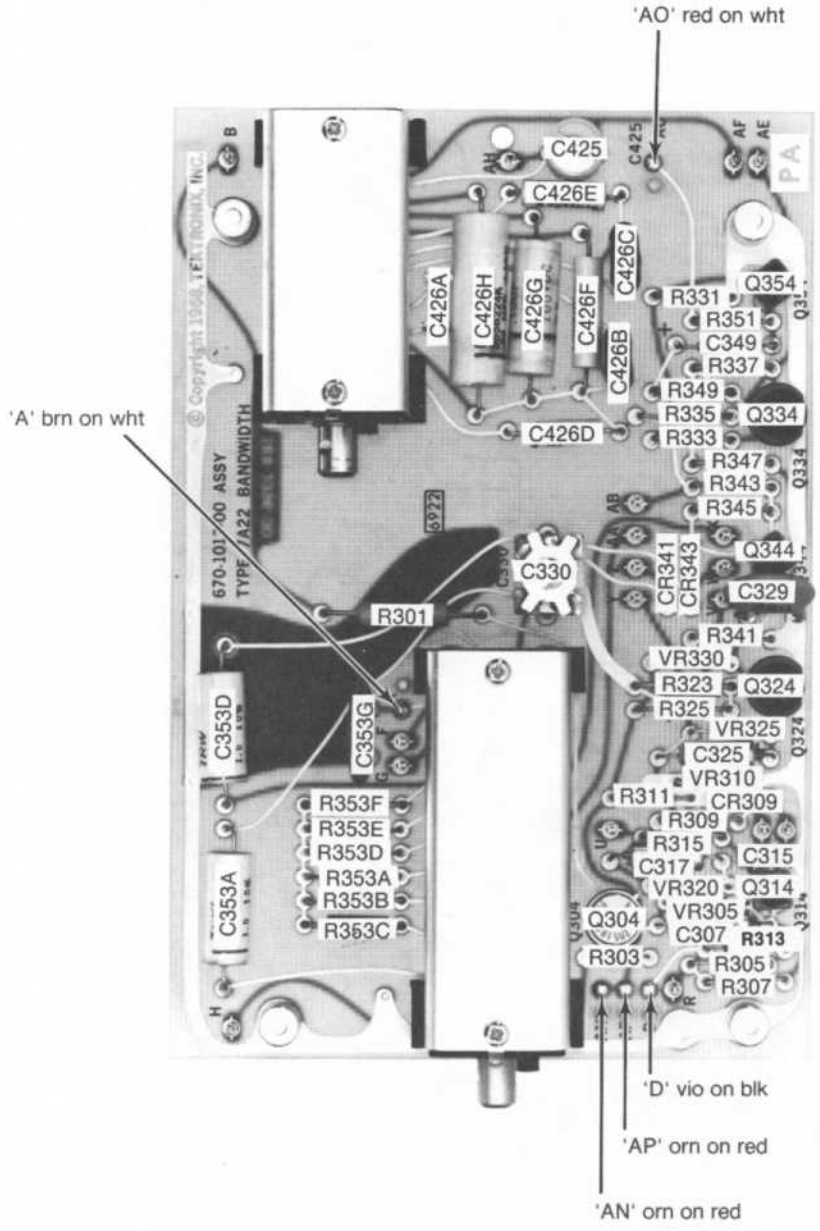


Fig. 4-8. Bandwidth circuit board (components and wire color code).

SECTION 5
PERFORMANCE CHECK/ CALIBRATION PROCEDURE

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

Introduction

Complete information for performing a Performance Check or Calibration of the 7A22 is contained in this section of the manual. The Equipment Required list is needed both for a Performance Check and for calibrating the 7A22. All waveform photographs, equipment setup pictures, and control settings apply whether the instrument is being calibrated or checked for performance.

To conduct a Performance Check, complete all parts of each step in the following procedure, except the part subtitled ADJUST. To check the performance of the 7A22, it is not necessary to remove the oscilloscope side panel or make any internal adjustments. Adjustments located on the front panel of the 7A22 can be performed when checking the performance of the instrument. If the instrument does not meet the performance requirements given in this procedure, the complete procedure including adjustments should be performed. All performance requirements given in this section correspond to the Specifications given in Section 1.

Calibration of the 7A22 requires completion of all parts of each step in the following procedure. Completion of every step in this procedure returns the 7A22 to its original performance standards. To assure accurate measurements and correct operation, the calibration of the 7A22 should be checked after each 1000 hours of operation; or every six months if used infrequently. Before performing a complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories (or their equivalent) are required for a complete performance check or calibration of the 7A22. Specifications given are the minimum necessary for accurate performance of this instrument. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the quickest and most accurate calibration or performance check, special Tektronix calibration fixtures are used where necessary. These special calibration fixtures are available through your local Tektronix Field Office or representative.

1. 7000-series oscilloscope, referred to as "oscilloscope" in this procedure, having a probe-power output connector. Tektronix 7704A or 7904 with a 7B50A Time Base can be used for this procedure.

2. Sine-Wave Generator. Output frequency range of 10 Hz through 1.0 MHz; output amplitude range from 2 V to 20 V peak to peak. Tektronix FG 501 or FG 503 Function Generator recommended.*

3. Standard Amplitude Calibrator. Amplitude accuracy, within 0.25%; signal amplitude, 0.5 mV to 100 V; output signals, 1 kHz square wave and fast-rise, high amplitude signal of 100 ns or less. Tektronix PG 506 Calibration Generator recommended.*

4. DC Power Supply. Adjustable DC output to 1 V. Tektronix PS 501-1 Power Supply recommended.*

5. Reed Pulse Generator. Tektronix Calibration Fixture 067-0608-00 is recommended.

6. Coaxial Cable. Impedance, 50 ohms; length 42 inches; connectors, BNC. Two required. Tektronix Part Number 012-0057-01.

7. Dual Input BNC connector. Provides matched signal paths to both 7A22 input connectors. Tektronix Part Number 067-0525-01.

8. Variable Attenuator. A variable attenuator which has the end terminals of a 100 ohm potentiometer connected from input to ground and the potentiometer divider arm connected to the attenuator output. Tektronix Calibration Fixture 067-0511-00 is recommended.

9. 1000:1 Divider. Tektronix Part Number 067-0529-00 is recommended.

10. Precision Voltage Divider. Provides an output of 0.4 × the PG 506 standard amplitude output. Tektronix Part Number 015-0265-00 is recommended.

11. Input RC Normalizer. RC time constant, 1 megohm × 47 pF; connectors, BNC. Tektronix Part Number 067-0541-00 is recommended.

12. Attenuator. Impedance, 50 Ω; ratio, 10:1; connectors, BNC. Two each, Tektronix Part Number 011-0059-02.

13. Plug-in extender. Tektronix Calibration Fixture 067-0589-00.

14. Termination. Impedance, 50 Ω. Tektronix Part Number 011-0049-01.

15. BNC Tee Connector. Tektronix Part Number 103-0030-00.

16. Adapter, GR to BNC Female. Tektronix Part Number 017-0063-00.

17. Adapter, GR to BNC Male. Tektronix Part Number 017-0064-00.

18. Banana plug-jack to banana plug-jack patch cord. Tektronix Part Number 012-0031-00 (red) or 012-0034-00 (black). Three needed.

*Requires a TM 500-series power module.

19. Female to dual banana adapter, BNC. Tektronix Part Number 103-0090-00.

SHORT-FORM PERFORMANCE CHECK/CALIBRATION PROCEDURE

This short-form procedure is provided to aid in checking the performance or calibration of the 7A22. It may be used as a guide by the experienced operator or calibrator, or it may be reproduced and used as a permanent record of calibration. Since the step numbers and titles used here correspond to those used in the complete procedure, this procedure also serves as an index to locate a step in the complete procedure. Performance requirements listed here correspond to those given in Section 1.

7A22, Serial No. _____

Calibration Date _____

Calibrated By _____

☐ 1. Check or Adjust AC Atten Bal (R505)
Trace within 1.5 div of graticule center as VOLTS/ DIV switch is changed from 10 mV to 20 μV.

☐ 2. Check or Adjust Variable Bal (R425)
Maximum trace shift ±0.2 div as the VARIABLE (VOLTS/DIV) is rotated stop-to-stop.

☐ 3. Check or Adjust Coarse DC Bal (R275)
Trace within 0.1 div of graticule center as LF −3 dB POINT selector is changed from 10 kHz to DC.

☐ 4. Check or Adjust +INPUT Zero (R115)
Maximum trace shift ±2 div as the + INPUT AC-GND-DC switch is switched from GND to AC.

☐ 5. Check or Adjust −INPUT Zero (R215)
Maximum trace shift ±2 div as the −INPUT AC-GND-DC switch is switched from GND to AC.

☐ 6. Check or Adjust GAIN (R540)
Correct vertical deflection in the 1 mV position of the VOLTS/DIV switch (front panel adjustment).

☐ 7. Check VARIABLE (VOLTS/DIV) control Ratio
Display amplitude decreases by a ratio of 2.5:1 when the VARIABLE control (set to the out position) is rotated fully counterclockwise.

☐ 8. Check VOLTS/DIV Gain Switching
Correct vertical deflection from 10 μV through 10 mV.

☐ 9. Check Isolation Between + and −INPUTS
Trace deflection of 0.5 div or less.

☐ 10. Check Total DC OFFSET Range
Check for minimum offset range of + and −1 volt.

☐ 11. Check or Adjust C241—Cross Neutralization
With signal connected to +INPUT, switch the −INPUT AC-GND-DC from GND to DC; aberration should not exceed ±1%.

☐ 12. Check or Adjust C141—Cross Neutralization
With signal connected to −INPUT, switch the +INPUT AC-GND-DC from GND to DC; aberration should not exceed ±1%.

☐ 13. Check or Adjust C115—X1 +INPUT Attenuator
Time Constant Optimum square wave response.

☐ 14. Check or Adjust C215—X1 −INPUT Attenuator
Time Constant Optimum square wave response.

☐ 15. Check Input Attenuator Accuracy
Correct vertical deflection from 10 mV through 10 V.

☐ 16. Check or Adjust Attenuator Differential Balance (R108E, R109E, R110E)
Optimum differential balance.

☐ 17. Check or Adjust +Input Attenuator Compensation
(C108C, C109C, C110C, C108A, C109A, C110A) Optimum square wave response.

☐ 18. Check or Adjust −Input Attenuator Series
Compensation to match + Input (C208C, C209C, C210C) Best common-mode signal rejection (minimum spike amplitude).

☐ 19. Check or Adjust −Input Attenuator Shunt Compensation (C208A, C209A, C210A)
Optimum flat bottom display.

☐ 20. Check or Adjust HF −3 dB POINT (C425)
HIGH FREQ −3 dB POINT bandwidth limit.

☐ 21. Check LF −3 dB POINT
LOW FREQ −3 dB POINT bandwidth limit.

☐ 22. Check or Adjust CMRR (C330)
CMRR must be equal to or better than the specified requirements at the verification points shown in Section 1, Fig. 1-2 of the manual.

☐ 23. Check OVERDRIVE Indicator
Indicator turns on at approximately 1 volt.

☐ 24. Check Differential Signal Range
No change in sine-wave amplitude when + or −1 volt DC is applied.

☐ 25. Check Overall Noise Level Tangentially
Less than 16 μV of displayed noise, measured tangentally.

☐ 26. Check Overdrive Recovery
10 μs or less to recover to within 0.5% of zero level.

PERFORMANCE CHECK/CALIBRATION PROCEDURE

General

The following procedure is arranged in a sequence which allows the 7A22 to be calibrated with the least interaction of adjustments and reconnection of equipment. The steps in which adjustments are made are identified by the symbol following the title. Instrument performance is checked in the "CHECK" part of the step before an adjustment is made. The "ADJUST" part of the step identifies the point at which the actual adjustment is made. Steps listed in the "INTERACTION" part of the step may be affected by the adjustment just performed. This is particularly helpful when only a partial calibration procedure is performed.

NOTE

To prevent recalibration of other parts of the instrument when performing a partial calibration, readjust only if the tolerances given in the "CHECK" part of the step are not met. However, when performing a complete calibration, best overall performance is obtained if each adjustment is made to the exact setting even if the "Check" is within the allowable tolerance.

In the following procedure, a test-equipment setup picture is shown for each major group of checks and adjustments. Each step continues from the equipment setup preceding the desired portion. External controls or adjustments of the 7A22 referred to in this procedure are capitalized (e.g., POSITION). Internal adjustment names are initial capitalized only (e.g., Variable Bal).

All waveforms shown in this procedure are actual waveform photographs taken with a Tektronix Oscilloscope Camera System. The following procedure uses the equipment listed under Test Equipment Required. If equipment is substituted, control settings or test equipment 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. If in doubt as to the correct operation of any of the test equipment, refer to the instruction manual for that unit.

NOTE

It is assumed that performance is checked within a temperature range of 0° C to +50° C and calibration +25° C, ±5° C; the tolerances given in this procedure are for this temperature range. However, if the procedure is performed at some other temperature, check the applicable tolerances for that temperature range.

Preliminary Procedure

1. If the 7A22 is to be calibrated, insert the plug-in extender into the oscilloscope and plug the 7A22 into the plug-in extender. If this procedure is a Performance Check only, insert the 7A22 into the oscilloscope plug-in compartment.

2. Connect the oscilloscope power cord to the design center operating voltage for which the oscilloscope is wired.

3. Turn on the oscilloscope POWER switch. Allow at least 20 minutes warmup before checking the instrument to the given accuracy.

4. Preset the 7A22 front panel controls as follows:

VOLTS/DIV	10 mV
VARIABLE	CAL IN
POSITION	Midrange
HIGH FREQ −3 dB POINT	100 Hz
LOW FREQ −3 dB POINT	10 kHz
AC-GND-DC (+INPUT)	GND
AC-GND-DC (−INPUT)	GND
STEP ATTEN DC BAL	Midrange
DC OFFSET COARSE	5 turns from either extreme
DC OFFSET FINE	Midrange

5. Preset the Time Base front panel controls to these settings:

Time/Div	.5 ms
Variable	In (Calibrated)
Triggering	Auto, AC, Int

6. Set the oscilloscope Focus and Intensity for best viewing.

NOTE

Calibration of the 7A22 must be performed with the side covers in place. All internal adjustments can be made using the access holes provided in the side covers.

1. Check or Adjust AC Step Atten Bal

a. Center the trace on the crt with the POSITION control.

b. Rotate the VOLTS/DIV switch from 10 mV to the 20 μV position.

c. CHECK—The trace should remain within 1.5 div of graticule center.

d. ADJUST—AC Step Atten Bal control, R505, (see Fig. 5-1) to position the trace within 1.5 div of graticule center.

2. Check or Adjust Variable Bal

a. Set the 7A22 VOLTS/DIV switch to 10 mV.

b. Position the trace to graticule center with the POSITION control.

c. Rotate the VARIABLE VOLTS/DIV (in the out position) from stop to stop.

d. CHECK—For maximum trace shift not to exceed ±0.2 div while rotating the VARIABLE control throughout its range.

e. ADJUST—Variable Bal control, R425, (see Fig. 5-1) for no trace shift while rotating the VARIABLE control.

3. Check or Adjust Coarse DC Bal

a. Set the VARIABLE VOLTS/DIV to the CAL IN position.

b. Position the LOW FREQ −3 dB POINT switch to the DC position.

c. CHECK—The trace should be within 0.1 div of graticule center.

d. ADJUST—Coarse DC Bal, R275, (see Fig. 5-1) to position the trace to graticule center.

e. Set the VOLTS/DIV switch to 50 μV.

f. CHECK—The trace should be on screen.

g. ADJUST—If the trace is not on screen, start at the position of the VOLTS/DIV switch where an on screen display is obtained and readjust the Coarse DC Bal, working down to the 50 μV position so the end result is an on-screen trace at 50 μV.

7A22 Controls

VOLTS/DIV	10 μV
VARIABLE	CAL IN
POSITION	Midrange
HIGH FREQ −3 dB POINT	100 Hz

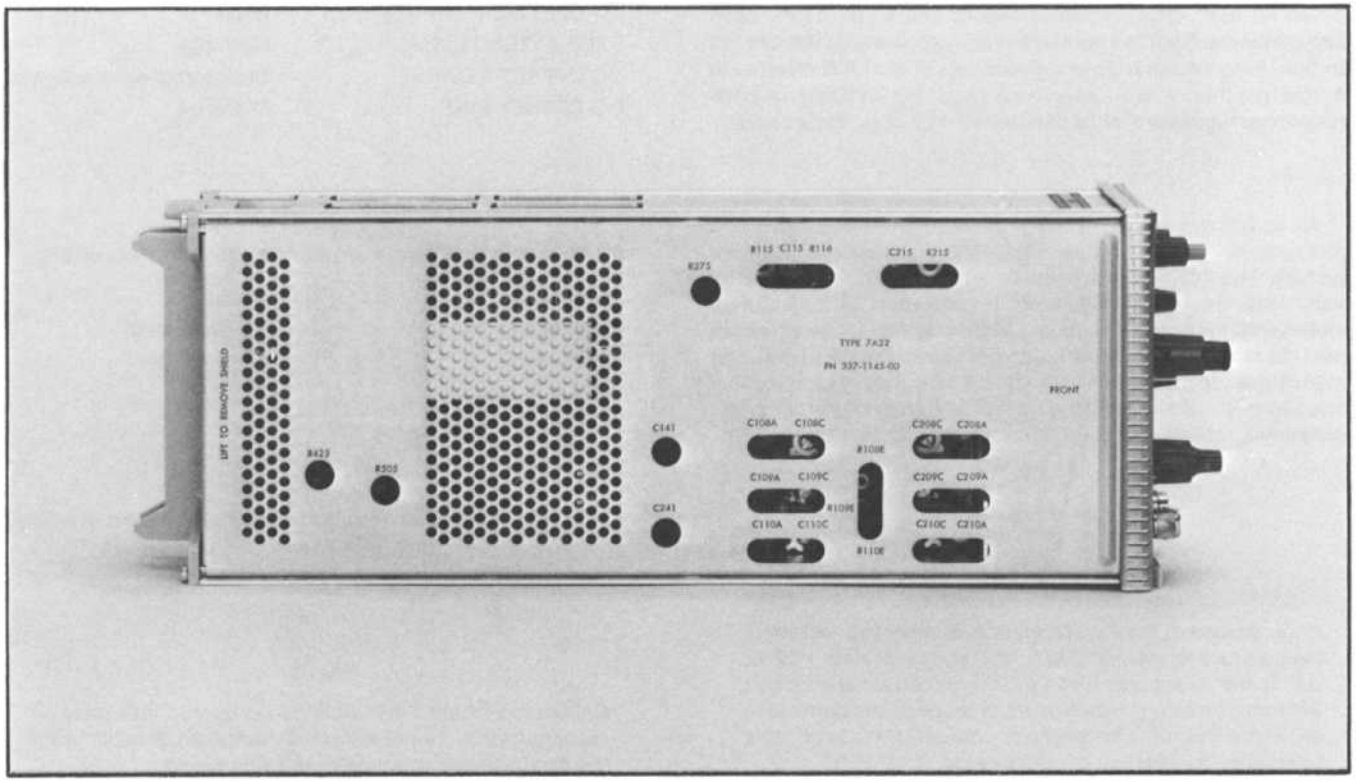


Fig. 5-1. Left side of the 7A22 showing adjustment locations.

LOW FREQ −3 dB POINT	DC
AC-GND-DC (+INPUT)	GND
AC-GND-DC (−INPUT)	GND
STEP ATTEN DC BAL	Adjust for proper dc balance (see Operating Section).

Time Base Controls

Time/Div	.5 ms
Variable (Time/Div)	Cal
Triggering	Auto, AC, Int

4. Check or Adjust +Gate Current Zero

a. Connect a 50 Ω termination to the +INPUT connector.

b. Using the POSITION control, position the trace to graticule center.

c. Set the +INPUT AC-GND-DC switch to AC.

d. CHECK—For maximum trace shift within ±2 div.

e. ADJUST—The +Gate Current Zero control, R115, (see Fig. 5-1), to position the trace to graticule center.

f. CHECK—(only if adjustment has been made). Switch the +INPUT AC-GND-DC switch to GND and back to AC. There should be no movement of the trace.

g. Set the +INPUT AC-GND-DC switch to GND.

5. Check or Adjust −Gate Current Zero

a. Remove the 50 Ω termination from the +INPUT and connect it to the −INPUT connector.

b. Position the trace to graticule center with the POSITION control.

c. Set the −INPUT AC-GND-DC switch to AC.

d. CHECK—For maximum trace shift within ±2 div.

e. ADJUST—The −Gate Current Zero control, R215, (see Fig. 5-1), to return the trace to graticule center.

f. CHECK—(only if adjustment has been made). Return the −INPUT AC-GND-DC switch to GND and back to AC. There should be no trace shift.

g. Disconnect the 50 Ω termination.

h. Set the −INPUT AC-GND-DC switch to GND.

7A22 Controls

VOLTS/DIV	1 mV
VARIABLE	CAL IN
POSITION	Midrange
HIGH FREQ −3 dB POINT	1 MHz
LOW FREQ −3 dB POINT	DC
AC-GND-DC (+INPUT)	DC
AC-GND-DC (−INPUT)	GND
STEP ATTEN DC BAL	Adjust for proper DC balance.

6. Check or Adjust GAIN

a. Connect a 5 mV peak-to-peak square wave signal from a standard amplitude calibrator through a 1000:1 divider and a coaxial cable to the +INPUT connector.

b. Set the 1000:1 divider to ×1.

c. Align the display with the graticule lines using the POSITION control.

d. CHECK—the display for a vertical amplitude of exactly 5 div.

e. ADJUST—The GAIN control (front panel adjustment R540) for exactly 5 div of display amplitude.

7. Check VARIABLE Control Ratio

a. With the VARIABLE in the OUT position, rotate the control fully counterclockwise.

b. CHECK—The display amplitude should be 2 div or less to meet the 2.5:1 ratio requirement.

8. Check VOLTS/DIV Gain Switching

a. Set the HIGH FREQ −3 dB POINT switch to 3 kHz.

b. Set the LOW FREQ −3 dB POINT switch to 1 Hz.

c. Set the standard amplitude calibrator output to 10 mV.

d. Using the VARIABLE VOLTS/DIV control, adjust the display amplitude to exactly 5 div.

e. Set the Time Base Triggering Source to Line.

f. Position the Time/Div switch to .1 μs.

g. Switch the 1000:1 divider to ×1000.

h. CHECK—The vertical deflection factor from 10 μV through 50 μV. Table 5-1 is provided as a guide.

TABLE 5-1

VOLTS/DIV Switch Position	Standard Amplitude Calibrator Output Amplitude	Divisions of Deflection	Accuracy
10 μV	.1 V	5	±2%
20 μV	.2 V	5	±2%
50 μV	.5 V	5	±2%

i. Return the VARIABLE to the CAL IN position.

j. Switch the 1000:1 divider to the ×1 position.

k. CHECK—The vertical deflection factor from .1 mV through 10 mV using Table 5-2 as a guide.

TABLE 5-2

VOLTS/DIV Switch Position	Standard Amplitude Calibrator Output Amplitude	Divisions of Deflection	Accuracy
.1 mV	.5 mV	5	±2%
.2 mV	1 mV	5	±2%
.5 mV	2 mV	4	±2%
1 mV	5 mV	5	±2%
2 mV	10 mV	5	±2%
5 mV	20 mV	4	±2%
10 mV	50 mV	5	±2%

l. Remove the 1000:1 divider from the Standard Amplitude Calibrator signal setup.

7A22 Controls

VOLTS/DIV	1 mV
VARIABLE	CAL IN
POSITION	Midrange
HIGH FREQ −3 dB POINT	1 MHz
LOW FREQ −3 dB POINT	DC OFFSET
AC-GND-DC (+INPUT)	DC
AC-GND-DC (−INPUT)	GND
STEP ATTEN DC BAL	Adjusted for dc balance

Time Base Controls

Time/Div	1 ms
Variable	Calibrated
Slope	+
Coupling	AC
Source	Int
Mode	Auto

9. Check Isolation Between + and −Inputs

a. Set the Standard Amplitude Calibrator for a .1 V square wave.

b. Adjust the DC OFFSET COARSE and FINE controls to position the top of the square wave to the graticule center line.

c. Switch the −AC-GND-DC switch to DC.

d. CHECK—Trace deflection must be 0.5 division or less.

e. Repeat the above procedure for the −INPUT, checking for trace deflection when switching the +AC-GND-DC switch to DC.

f. Disconnect the Standard Amplitude Calibrator.

10. Check Total DC OFFSET Range

a. Set the 7A22 controls as follows:

VOLTS/DIV	10 mV
AC-GND-DC (+INPUT)	DC
AC-GND-DC (−INPUT)	GND

b. Set the DC Power Supply for an output of 1 volt dc.

c. Connect a female to dual banana adapter and a coaxial cable from the DC Power Supply output to the 7A22 +INPUT connector.

d. Turn the COARSE and FINE OFFSET controls fully counterclockwise.

e. CHECK—The trace can be returned to graticule center. (1 V minimum dc offset).

f. Set the +INPUT AC-GND-DC switch to GND.

g. Rotate the FINE and COARSE OFFSET controls clockwise to return the trace to graticule center (approximately 5 turns of the COARSE OFFSET control).

h. Disconnect the DC Power Supply.

NOTE

The ×10, ×100, ×1000 input attenuators will be checked in step 15. Consequently, the remainder of the DC OFFSET ranges stated in Section 1 will be verified by that step.

7A22 Controls

VOLTS/DIV	10 mV
VARIABLE	CAL IN
POSITION	Midrange
HIGH FREQ −3 dB POINT	1 MHz
LOW FREQ −3 dB POINT	DC
AC-GND-DC (+INPUT)	DC
AC-GND-DC (−INPUT)	GND
STEP ATTEN DC BAL	Adjusted for proper balance

Time Base Controls

Time/Div	.5 ms
Variable	In
Triggering	Norm, +Slope, AC, Int

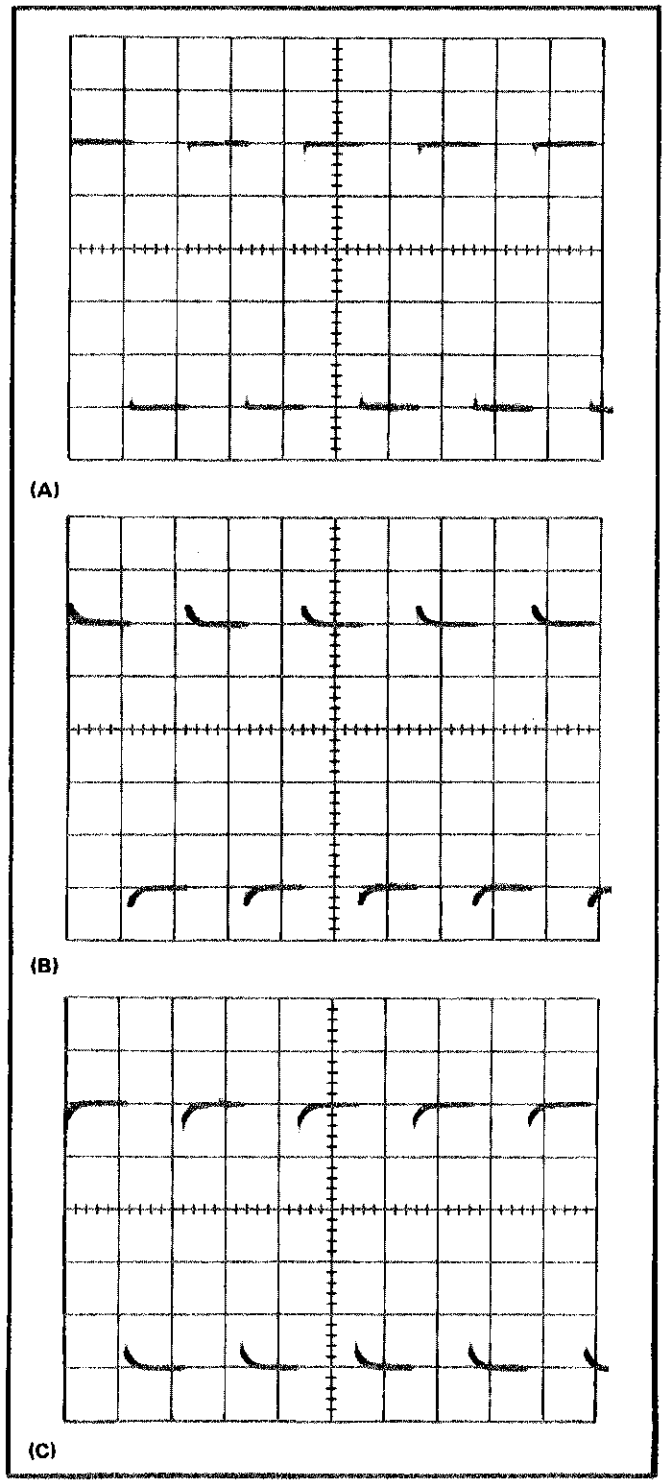


Fig. 5-3. Typical waveform showing (A) Correct adjustment of Input Attenuator Time Constant. (B) and (C) incorrect adjustment.

f. INTERACTION—If C215 is adjusted out of sequence, steps 13 and 16 through 19 must also be performed.

g. Disconnect the signal and the RC Normalizer.

15. Check Input Attenuator Accuracy

a. Connect a 50 mV peak-to-peak square-wave signal of standardized amplitude from the Standard Amplitude Calibrator through a coaxial cable to the +INPUT.

b. Set the +INPUT AC-GND-DC switch to DC.

c. CHECK—The input attenuators using Table 5-3 as a guide.

TABLE 5-3

VOLTS/DIV Switch Position	CALIBRATOR Output Peak to Peak	VERTICAL DEFLECTION (Accuracy ±2%)
10 mV	50 mV	5 div ± .1 div
20 mV	.1 V	5 div ± .1 div
50 mV	.2 V	4 div ± .08 div
.1 V	.5 V	5 div ± .1 div
.2 V	1 V	5 div ± .1 div
.5 V	2 V	4 div ± .08 div
1 V	5 V	5 div ± .1 div
2 V	10 V	5 div ± .1 div
5 V	20 V	4 div ± .08 div
10 V	50 V	5 div ± .1 div

d. Disconnect the signal from the 7A22.

NOTE

(Applies to calibration only)

If there is a spike or fast rolloff of the leading corner of the square wave when checking from 20 mV to 10 V, ignore these, as they will be corrected in step 17.

16. Check or Adjust Input Attenuator Differential Balance

a. Connect a tee connector to the Output connector of the Standard Amplitude Calibrator and a dual connector to the +INPUT and −INPUT connectors of the 7A22.

b. Connect a coaxial cable from the tee connector to the dual input connector. Connect a coaxial cable from the connector to the Ext In connector on the oscilloscope.

c. Set the 7A22 controls as follows:

VOLTS/DIV	50 mV
AC-GND-DC (+INPUT)	DC
AC-GND-DC (−INPUT)	DC

d. Set the oscilloscope Triggering Source switch to Ext.

e. Set the Standard Amplitude Calibrator output to 50 V.

f. CHECK—For optimum differential balance according to the information given in Table 5-4. When properly adjusted, the waveform should appear as shown in Fig. 5-4. Disregard any spikes on the waveform.

g. ADJUST—R108E, R109E and R110E (see Fig. 5-1) for minimum amplitude as shown in Fig. 5-4, using Table 5-4 as a guide.

11. Check or Adjust C241 +Cross Neutralization

a. Set the Standard Amplitude Calibrator for a 50 mV square-wave output and connect to the 7A22 +INPUT connector.

NOTE

The 7A22 POSITION control and the Time Base horizontal positioning control may not always be mentioned. Use these controls as necessary to position the display for easy viewing.

b. Check—The upper leading corner of the waveform, and note any aberration that occurs while switching the −INPUT AC-GND-DC switch from GND to DC. The waveform should appear similar to the one in Fig. 5-2. The aberration should not exceed ±1%.

c. Set the −INPUT AC-GND-DC switch to DC.

d. ADJUST—C241 (see Fig. 5-1) for best square upper leading corner.

e. INTERACTION—C241 affects the ×1 input capacitance and all other input attenuator adjustments. If C241 is adjusted out of sequence, steps 13, 14 and 16 through 18 must also be performed.

12. Check or Adjust C141 −Cross Neutralization

a. Disconnect the signal from the +INPUT connector and connect it to the −INPUT connector.

b. Set the +INPUT AC-GND-DC switch to GND.

c. CHECK—The lower leading corner of the second cycle of the display and note any aberration that occurs while switching the +INPUT AC-GND-DC switch from GND to DC. The bottom leading corner of the waveform should appear similar to the one shown in Fig. 5-2. The aberration should not exceed ±1%.

d. Set the +INPUT AC-GND-DC switch to DC.

e. ADJUST—C141 (see Fig. 5-1) for best square corner.

f. INTERACTION—C141 affects the ×1 input capacitance and all other input attenuator adjustments. If C141 is adjusted out of sequence, steps 13, 14, and 16 through 18 must be performed.

g. Disconnect the coaxial cable from the −INPUT.

13. Check or Adjust C115—×1 +INPUT Attenuator Time Constant

NOTE

It is important that C141 and C241 be properly adjusted before performing this adjustment. If you have not performed steps 11 and 12, do so at this point.

a. Connect a 47 pF input RC Normalizer to the +INPUT.

b. Connect a coaxial cable from the Standard Amplitude Calibrator to the RC Normalizer.

c. Set the −INPUT AC-GND-DC switch to GND.

d. Set the +INPUT AC-GND-DC switch to DC.

e. Set the Standard Amplitude Calibrator output for high amplitude operation with an output of 0.1 V.

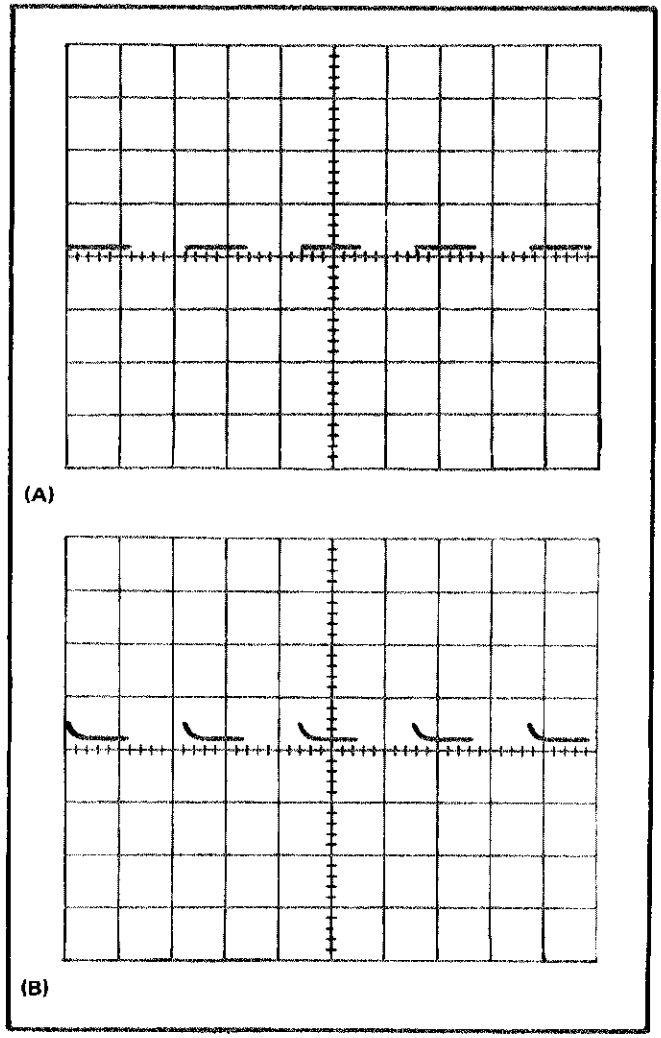


Fig. 5-2. Typical waveform showing (A) Cross neutralization properly adjusted, (B) incorrectly adjusted.

f. CHECK—The square wave display for flat tops (see Fig. 5-3).

g. ADJUST—C115 (see Fig. 5-1) to obtain best square wave response.

h. INTERACTION—If C115 is adjusted out of sequence, steps 14 and 16 through 19 must also be performed.

14. Check or Adjust C215—×1 −INPUT Attenuator Time Constant

a. Disconnect the RC Normalizer from the +INPUT and connect it to the −INPUT.

b. Set the +INPUT AC-GND-DC switch to GND.

c. Set the −INPUT AC-GND-DC switch to DC.

d. CHECK—Each square wave for a flat bottom, using Fig. 5-3 as a guide.

e. ADJUST—C215 (see Fig. 5-1) for best flat bottom square-wave display, as in Fig. 5-3A.

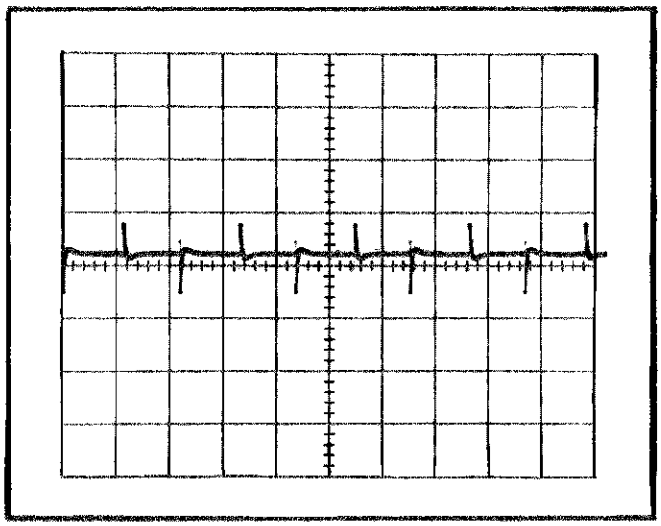


Fig. 5-4. Typical display obtained when Input Attenuators are adjusted for optimum differential balance.

TABLE 5-4

VOLTS/DIV Switch Position	Calibrator Output (Peak to Peak)	Check and Adjust for Null	Input Attenuator
50 mV	50 V	Check/Adjust R108E	
20 mV	50 V	Check	×10
.1 V	50 V	Check	
.5 V	100 V	Check/Adjust R109E	
.2 V	100 V	Check	×100
1 V	100 V	Check	
5 V	100 V	Check/Adjust R110E	
2 V	100 V	Check	×1000
10 V	100 V	Check	

h. Set the Standard Amplitude Calibrator for 0.2 V peak-to-peak output.

i. Disconnect the dual input connector from the 7A22.

Set the 7A22 Controls:

VOLTS/DIV	50 mV
VARIABLE	CAL IN
HIGH FREQ −3 dB POINT	1 MHz
LOW FREQ −3 dB POINT	DC
AC-GND-DC (+INPUT)	DC
AC-GND-DC (−INPUT)	GND
STEP ATTEN DC BAL	Adjusted for proper dc balance

Set the Time Base Controls:

Time/Div	.5 ms
Variable	In (Cal)
Triggering	Auto, AC, Int

17. Check or Adjust +Input Attenuator Compensation

a. Connect 0.2 V of high amplitude signal from the Standard Amplitude Calibrator through a coaxial cable to the +INPUT of the 7A22.

b. CHECK—The +INPUT Attenuator compensation for good square wave response.

c. ADJUST—The +INPUT Attenuator compensation for best square wave response using Table 5-5 as a guide. Figure 5-1 shows the locations of the adjustments.

TABLE 5-5

CALIBRATOR Output P-P	VOLTS/DIV Switch Position	Check/Adjust for Optimum		+Input Attenuator
		Upper Leading Corner	Flat Top	
.2 V	50 mV	C108C		× 10
.1 V	20 mV	Check		
.5 V	.1 V	Check		
2 V	.5 V	C109C		× 100
1 V	.2 V	Check		
5 V	1 V	Check		
20 V	5 V	C110C		× 1000
10 V	2 V	Check		
50 V	10 V	Check		

Connect the 47 pF input RC normalizer between the +INPUT and the coaxial cable.

50 V	5 V		C110A	× 1000
20 V	2 V		Check	
100 V	10 V		Check	
5 V	.5 V		C109A	× 100
2 V	.2 V		Check	
10 V	1 V		Check	
.5 V	50 mV		C108A	× 10
.2 V	20 mV		Check	
1 V	.1 V		Check	

d. INTERACTION—If this step is performed out of sequence, steps 18 and 19 must be performed.

e. Disconnect the RC normalizer and coaxial cable from the 7A22 and the Standard Amplitude Calibrator.

18. Check or Adjust −Input Attenuator Series Compensation

a. Connect a tee connector to the Standard Amplitude Calibrator output connector and a dual input connector to the 7A22 +INPUT and −INPUT connectors. Connect a coaxial cable from the tee connector to the dual input connector. Connect a coaxial cable from the tee connector to the oscilloscope EXT In connector.

b. Set the oscilloscope Triggering Source switch to Ext.

c. Set the Standard Amplitude Calibrator output for 50 V of high amplitude signal.

d. Set the 7A22 controls as follows:

VOLTS/DIV	50 mV
AC-GND-DC (−INPUT)	DC

e. CHECK—The displayed waveform for good common-mode signal rejection (minimum spike amplitude).

f. ADJUST—The −Input attenuator series compensation for best common-mode signal rejection (minimum spike amplitude) using the information given in Table 5-6. Figure 5-5 illustrates the typical displays obtained and Fig. 5-1 shows the adjustment locations.

TABLE 5-6

Calibrator Output P-P	VOLTS/DIV Switch Position	Check or Adjust for Min. Spike Amplitude	−Input Attenuator
50 Volts	50 mV	C208C	× 10
	20 mV	Check	
	.1 V	Check	
100 Volts	.5 V	C209C	× 100
	.2 V	Check	
	1 V	Check	
	5 V	C210C	× 1000
	2 V	Check	
	10 V	Check	

g. Disconnect all signal leads.

h. Return the oscilloscope Triggering Source switch to Int.

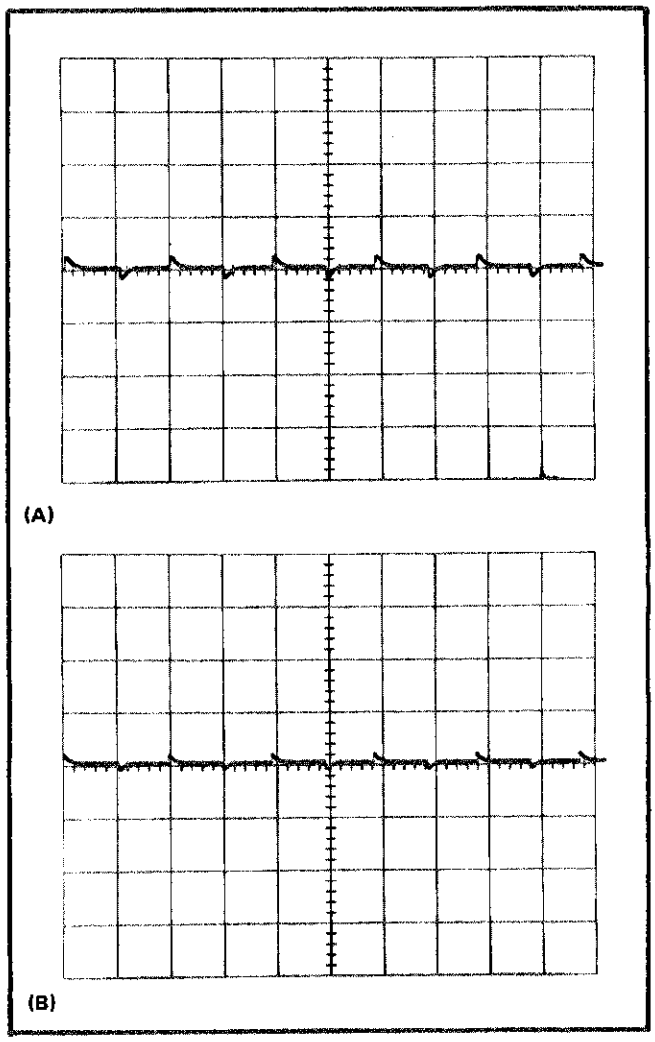


Fig. 5-5. Typical display obtained with −Input attenuator adjusted for optimum Common-Mode signal rejection. (A) C208C adjusted properly (B) C209C adjusted properly.

19. Check or Adjust −Input Attenuator Shunt Compensation

a. Connect a 47 pF RC Normalizer to the −INPUT of the 7A22. Connect a coaxial cable from the Standard Amplitude Calibrator output connector to the RC Normalizer.

b. Set the Standard Amplitude Calibrator output for .5 V of high amplitude signal.

c. Set the 7A22 controls as follows:

VOLTS/DIV	50 mV
AC-GND-DC (+INPUT)	GND

d. CHECK—Using Table 5-7 as a guide, check the display for a square wave response similar to the display illustrated in Fig. 5-3.

e. ADJUST—C208A, C209A, and C210A (see Fig. 5-1) for best flat bottom on the display, according to the information given in Table 5-7.

Table 5-7

Standard Amplitude Calibrator Output P-P	VOLTS/DIV Switch Position	Check or Adjust for Optimum Flat Bottom	−Input Attenuator
.5 Volt	50 mV	C208A	× 10
.2 Volt	20 mV	Check	
1 Volt	.1 V	Check	
5 Volts	.5 V	C209A	× 100
2 Volts	.2 V	Check	
10 Volts	1 V	Check	
50 Volts	5 V	C210A	× 1000
20 Volts	2 V	Check	
100 Volts	10 V	Check	

f. Disconnect the RC normalizer and all coaxial cables.

7A22 Controls

POSITION	Midrange
VOLTS/DIV	1 V
VARIABLE	CAL IN
AC-GND-DC (+INPUT)	GND
AC-GND-DC (−INPUT)	GND
LOW FREQ −3 dB POINT	DC
HIGH FREQ −3 dB POINT	1 MHz
STEP ATTEN DC BAL	Adjusted for dc balance

20. Check or Adjust HIGH FREQ −3 dB POINT

a. Set the 7A22 +INPUT AC-GND-DC switch to DC and use the oscilloscope controls as necessary for easy viewing of display.

b. Connect a coaxial cable and a 50-ohm terminator from the Sine-Wave Generator to the 7A22 + INPUT.

c. Set the output frequency of the Sine-Wave Generator to 1 kHz and adjust for a 6 div display on the oscilloscope.

d. Set the Sine-Wave Generator output frequency to 1 MHz.

e. CHECK—The amplitude of the oscilloscope display should be 4.2 div (this is the −3 dB point at 1 MHz). The 4.2 div display requirement must be met at 1 MHz + or −10% (.9 MHz to 1.1 MHz).

f. ADJUST—With the frequency set to 1 MHz, adjust C425 for 4.2 div of display amplitude. See Fig. 5-6 for location of adjustment.

g. CHECK—The remaining positions of the HIGH FREQ −3 dB POINT selector in the same manner as in part e using Table 5-8 as a guide.

TABLE 5-8

Sine Wave Generator Output Frequency	HIGH FREQ −3 dB POINT Selector Position	Oscilloscope Display Amplitude	Bandwidth Tolerance ±10% of Input Freq
300 kHz	300 kHz	4.2 div	±30 kHz
100 kHz	100 kHz	4.2 div	±10 kHz
30 kHz	30 kHz	4.2 div	±3 kHz
10 kHz	10 kHz	4.2 div	±1 kHz
3 kHz	3 kHz	4.2 div	±.3 kHz
1 kHz	1 kHz	4.2 div	±.1 kHz
300 Hz	300 Hz	4.2 div	±30 Hz
100 Hz	100 Hz	4.2 div	±10 Hz

h. Set the HIGH FREQ −3 dB POINT selector to 1 MHz.

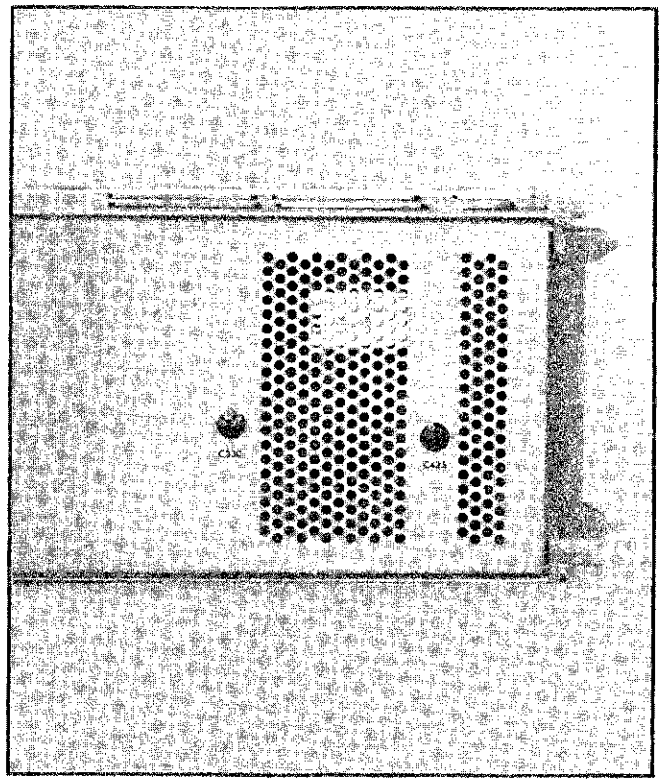


Fig. 5-6. Right side of 7A22 showing location of adjustments.

21. Check LOW FREQ −3 dB POINT

a. CHECK—Using Table 5-9 as a guide, check the LOW FREQ −3 dB POINT in the same manner that was used to check the HIGH FREQ −3 dB POINT.

TABLE 5-9

Sine Wave Generator Output Freq	LOW FREQ −3 dB POINT Selector Position	Oscilloscope Display Amplitude	Bandwidth Tolerance ±12% of Input Freq
10 Hz	10 Hz	4.2 div	±1.2 Hz
100 Hz	100 Hz	4.2 div	±12 Hz
1 kHz	1 kHz	4.2 div	±120 Hz
10 kHz	10 kHz	4.2 div	±1.2 kHz

NOTE

The components that are used in the 0.1 Hz and 1 Hz positions of the LOW FREQ −3 dB POINT selector are also used in the other positions of the selector; therefore, the tolerance of the 0.1 Hz and 1 Hz positions are now checked.

b. Set the LOW FREQ −3 dB POINT selector to DC and disconnect all signal connections to the 7A22, Sine-Wave Generator, and Oscilloscope.

7A22 Controls

VOLTS/DIV	5 V
VARIABLE	CAL IN
HIGH FREQ −3 dB POINT	1 MHz
LOW FREQ −3 dB POINT	DC
AC-GND-DC (+INPUT)	DC
AC-GND-DC (−INPUT)	GND
STEP ATTEN DC BAL	Adjusted for proper dc balance

Time-Base Controls

Time/Div	As necessary for easy viewing of display
Variable	In (Cal)
Triggering	Auto, AC, Int

22. Check or Adjust Attenuator Common Mode Rejection

a. Connect a coaxial cable from the Sine-Wave Generator output to the dual input connector.

b. Connect the dual-input connector to the 7A22 + and − INPUTS.

c. Adjust the Sine-Wave Generator Level control for 20 V p-p at 100 kHz.

NOTE

The Sine-Wave Generator output must be maintained at a constant 20 V p-p for all of the CMRR checks.

d. Switch the 7A22 AC-GND-DC (+INPUT) to GND.

e. Switch the 7A22 VOLTS/DIV to .1 mV.

f. Simultaneously switch the 7A22 + and −AC-GND-DC switches to DC.

g. CHECK—The vertical deflection should not exceed 2 div. The 2 div requirement at 0.1 mV/DIV is equivalent to a CMRR of 100,000:1 (2 div at .1 mV/DIV = .2 mV; 20 V ÷ .2 mV = 100,000).

h. Adjust C330 (and C144 SN B080000 and up) for minimum vertical deflection. See Fig. 5-6 for C330 location. C144 is under the plastic cover near Q153 on the left side of the 7A22 (see Fig. 4-6, page 4-10).

NOTE

These adjustments interact, and a slight readjustment of C330 will be necessary after the cover is replaced over C144.

1. Set the 7A22 VOLTS/DIV to 20 mV.

2. ADJUST—C108C for minimum vertical deflection.

3. ADJUST—R116 for minimum vertical deflection.

i. CHECK—Using Table 5-10 as a guide, check the CMRR at the remaining attenuator positions.

j. Disconnect all test leads and connectors.

7A22 Controls

VOLTS/DIV	10 mV
VARIABLE	CAL IN
POSITION	Midrange
HIGH FREQ −3 dB POINT	1 MHz
LOW FREQ −3 dB POINT	DC
AC-GND-DC (+INPUT)	GND
AC-GND-DC (−INPUT	GND
STEP ATTEN DC BAL	Adjusted for dc balance

Time Base Controls

Time/Div	1 ms
Triggering	+, Auto, AC, Int

23. Check Input OVERDRIVE Indicator

a. Connect a coaxial cable between the Sine-Wave Generator output and the 7A22 +INPUT.

b. Set the Sine-Wave Generator amplitude to minimum and frequency to 1 kHz.

c. Increase the Sine-Wave Generator amplitude until the 7A22 Input OVERDRIVE indicator lights.

d. CHECK—The sine-wave amplitude, peak to peak, and divide by 2 to find the + or − driving signal amplitude. The overdrive signal should be approximately 1 volt.

e. Disconnect coaxial cable from +Input.

7A22 Controls

VOLTS/DIV	1 mV
VARIABLE	CAL IN
POSITION	Midrange
HF −3 dB POINT	1 MHz
LF −3 dB POINT	10 Hz
AC-GND-DC (+INPUT)	GND
AC-GND-DC (−INPUT)	GND
STEP ATTEN DC BAL	Adjusted for dc balance

Time Base Controls

Time/Div	1 ms
Variable	Calibrated
Slope	+
Coupling	AC
Source	Int
Mode	Auto

TABLE 5-10

Sine-Wave Generator		Type 7A22			
Amplitude	Frequency	VOLTS/DIV Switch	+ and − INPUT Switches	Vertical Deflection (max)	CMRR (min)
20 V p-p	100 kHz	1 mV	AC	1 div	20,000:1
	100 kHz	20 mV	AC	2.2 div	450:1
	100 kHz	20 mV	DC	2 div	500:1
	1 kHz	20 mV	DC	1 div	1,000:1
	1 kHz	20 mV	AC	1.1 div	900:1
	60 Hz	2 mV	AC	5 div	2,000:1

24. Check Differential Signal Range

a. Connect a female to dual banana adapter and a coaxial cable between the DC Power Supply and the 7A22 +INPUT.

b. Set the DC Power Supply for an output of 1 volt dc.

c. Connect a coaxial cable between the Sine-Wave Generator output and the 7A22 −INPUT.

d. Switch the −AC-GND-DC switch to DC.

e. Adjust the Sine-Wave Generator amplitude control to give 5 div of 1 kHz display on the crt graticule (if the Sine-Wave Generator minimum amplitude is too large, insert an attenuator between the coaxial cable and the −INPUT).

f. Switch the +AC-GND-DC switch to DC.

g. CHECK—Sine-wave amplitude should not change when dc level from the DC Power Supply is applied.

h. Switch the +AC-GND-DC switch to GND.

i. Reverse the female to dual banana adapter at the DC Power Supply to obtain an output of −DC.

j. Switch the +AC-GND-DC switch to DC.

k. CHECK—Sine-wave amplitude should not change when dc level from the DC Power Supply is applied.

l. Disconnect all test equipment and test leads.

25. Check Overall Noise Level Tangentially

a. Connect a 50 Ω termination to the +INPUT connector of the 7A22. Connect two 10× attenuators to the 50 Ω termination.

b. Connect the Precision Voltage Divider to the Standard Amplitude Calibrator. Connect a GR to BNC adapter to the Precision Voltage Divider and connect the variable Attenuator to the GR connector. Connect a GR to BNC adapter to the Variable Attenuator. Connect a coaxial cable from the 10× attenuators to the Variable Attenuator.

c. Set the standard Amplitude Calibrator for a 4 mV output.

d. Set the 7A22 VOLTS/DIV switch to 10 μV.

e. Turn the Variable Attenuator fully clockwise.

f. Set the Time Base Triggering Mode to Auto and Time/Div to 10 μs.

g. Turn the Variable Attenuator counterclockwise until the darker band between the two noise bands just disappears (see Fig. 5-7).

h. Set the 7A22 VOLTS/DIV switch to 1 mV and the Time Base Time/Div switch to 1 ms.

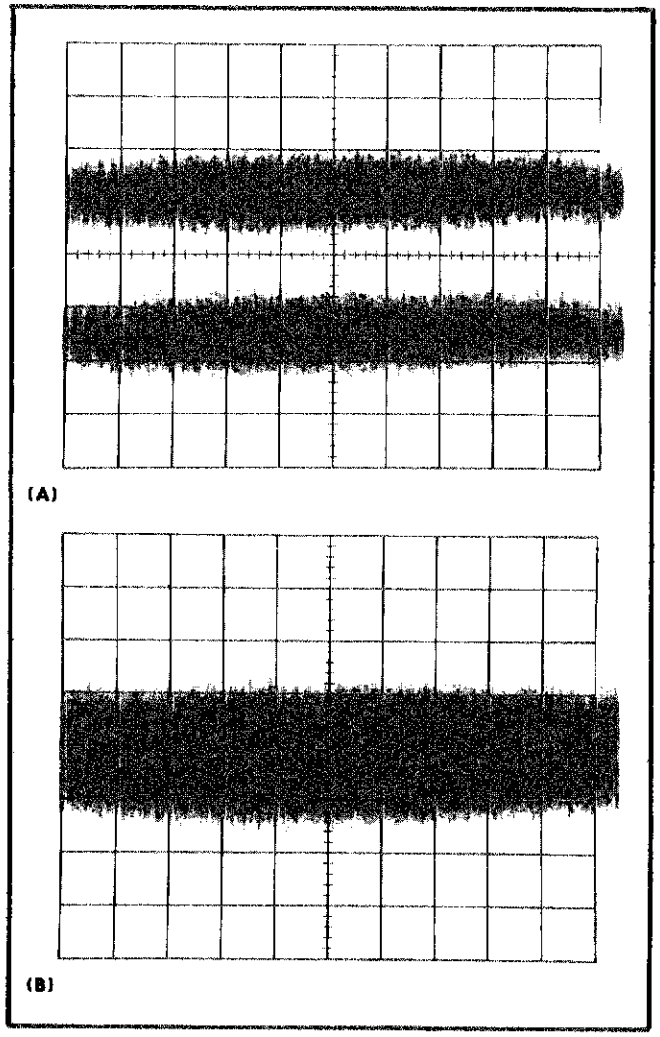


Fig. 5-7. Typical display showing (A) two noise bands and (B) merging noise bands.

i. Remove the two 10× attenuators and connect the coaxial cable to the 50 Ω termination.

j. Measure the square wave amplitude. Calculate the tangentially measured display noise as follows:

$$\frac{\text{square wave amplitude}}{100}$$

The tangentially measured noise should not exceed 16 μV.

7A22 Controls

VOLTS/DIV	.2 V
VARIABLE (VOLTS/DIV)	CAL IN
POSITION	1 division below graticule center
HF −3 dB POINT	1 MHz
LF −3 dB POINT	DC
AC-GND-DC +INPUT	DC
AC-GND-DC −INPUT	GND
STEP ATTEN DC BAL	Adjusted for dc balance

Time Base Controls

Time/Div	2 μs
Variable	Cal In
Level/Slope	—
Coupling	DC
Source	Int
Mode	Auto

26. Check Overdrive Recovery Time

a. Connect the Reed Pulse Generator Output to the 7A22 +INPUT.

b. Connect the Reed Pulse Generator power cable to the oscilloscope probe power connector (rear panel).

c. Switch the Reed Pulse Generator Polarity switch to +.

d. Hold down the Reed Pulse Generator Man switch and adjust the Level control to position the trace to the top graticule line (1 volt).

e. Release the Man switch and switch the Time Base Mode to Norm.

f. Set the 7A22 VOLTS/DIV switch to 1 mV.

g. Increase sweep Intensity to maximum (clockwise).

h. Depress the Reed Pulse Generator Man switch for 1 second.

i. CHECK—The waveform as the Reed Pulse Generator Man switch is released. Readjust the Time Base Level-Slope as necessary for proper triggering. The trace should return to within 5 mV of the reference (1 division below the graticule center) within 10 μs (5 divisions). See Fig. 5-8 for photograph of typical recovery waveform.

j. Switch the Reed Pulse Generator Polarity switch to −.

k. Set the Time Base Level/Slope to +.

l. Decrease sweep Intensity for normal viewing.

m. Reset the Time Base Mode to Auto.

n. Position the trace (7A22 POSITION control) to 1 division above graticule center.

o. Reset the Time Base Mode to Norm.

p. Repeat parts g through i (waveform will be inverted from that in step i).

q. Connect Reed Pulse Generator Output to the 7A22 −INPUT and repeat above procedure.

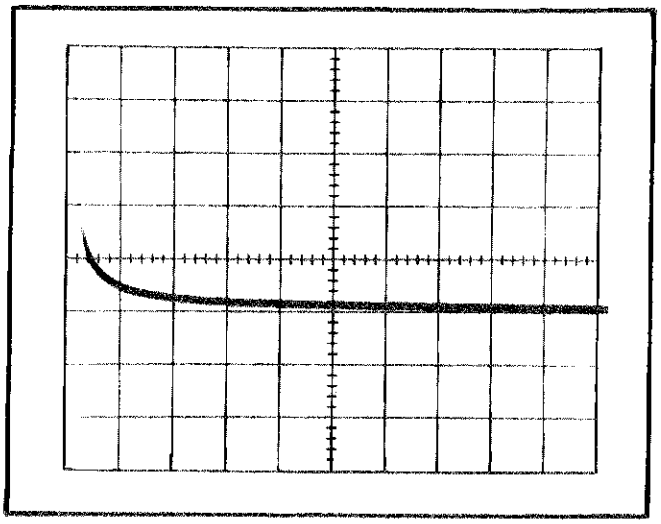


Fig. 5-8. Typical waveform showing overdrive recovery time.

REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

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

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

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

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

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

ACTR	ACTUATOR	PLSTC	PLASTIC
ASSY	ASSEMBLY	QTZ	QUARTZ
CAP	CAPACITOR	RECP	RECEPTACLE
CER	CERAMIC	RES	RESISTOR
CKT	CIRCUIT	RF	RADIO FREQUENCY
COMP	COMPOSITION	SEL	SELECTED
CONN	CONNECTOR	SEMICOND	SEMICONDUCTOR
ELCTLT	ELECTROLYTIC	SENS	SENSITIVE
ELEC	ELECTRICAL	VAR	VARIABLE
INCAND	INCANDESCENT	WW	WIREWOUND
LED	LIGHT EMITTING DIODE	XFMR	TRANSFORMER
NONWIR	NON WIREWOUND	XTAL	CRYSTAL

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
00213	NYTRONICS COMPONENTS GROUP INC SUBSIDIARY OF NYTRONICS INC	ORANGE ST	DARLINGTON SC 29532
00853	SANGAMO WESTON INC SANGAMO CAPACITOR DIV	SANGAMO RD P O BOX 128	PICKENS SC 29671
01121	ALLEN-BRADLEY CO	1201 SOUTH 2ND ST	MILWAUKEE WI 53204
02111	SPECTROL ELECTRONICS CORP SUB OF CARRIER CORP	17070 E GALE AVE P O BOX 1220	CITY OF INDUSTRY CA 91749
03508	GENERAL ELECTRIC CO SEMI-CONDUCTOR PRODUCTS DEPT	W GENESEE ST	AUBURN NY 13021
04222	AVX CERAMICS DIV OF AVX CORP	19TH AVE SOUTH P O BOX 867	MYRTLE BEACH SC 29577
04713	MOTOROLA INC SEMICONDUCTOR GROUP	5005 E MCDOWELL RD	PHOENIX AZ 85008
05397	UNION CARBIDE CORP MATERIALS SYSTEMS DIV	11901 MADISON AVE	CLEVELAND OH 44101
07263	FAIRCHILD CAMERA AND INSTRUMENT CORP SEMICONDUCTOR DIV	464 ELLIS ST	MOUNTAIN VIEW CA 94042
07716	TRW INC TRW ELECTRONICS COMPONENTS TRW IRC FIXED RESISTORS/BURLINGTON	2850 MT PLEASANT AVE	BURLINGTON IA 52601
12697	CLAROSTAT MFG CO INC	LOWER MASHINGTON ST	DOVER NH 03820
12954	MICROSEMI CORP	8700 E THOMAS RD P O BOX 1390	SCOTTSDALE AZ 85252
14193	CAL-R INC	1601 OLYMPIC BLVD	SANTA MONICA CA 90404
14433	ITT SEMICONDUCTORS DIV		WEST PALM BEACH FL
14552	MICRO/SEMICONDUCTOR CORP	2830 S FAIRVIEW ST	SANTA ANA CA 92704
15818	TELEDYNE INC TELEDYNE SEMICONDUCTOR	1300 TERRA BELLA AVE	MOUNTAIN VIEW CA 94043
19396	ILLINOIS TOOL WORKS INC PAKTRON DIVISION	900 FOLLIN LANE S E	VIENNA VA 22180
19701	MEPCO/ELECTRA INC A NORTH AMERICAN PHILIPS CO	P O BOX 760	MINERAL WELLS TX 76067
22229	SOLITRON DEVICES INC SEMICONDUCTOR GROUP SAN DIEGO OPERS	8808 BALBOA AVE	SAN DIEGO CA 92123
24546	CORNING GLASS WORKS	550 HIGH ST	BRADFORD PA 16701
24931	SPECIALTY CONNECTOR CO INC	2620 ENDRESS PLACE P O BOX D	GREENWOOD IN 46142
27014	NATIONAL SEMICONDUCTOR CORP	2900 SEMICONDUCTOR DR	SANTA CLARA CA 95051
31433	UNION CARBIDE CORP ELECTRONICS DIV	PO BOX 5928	GREENVILLE SC 29606
32997	BOURNS INC TRIMPOT DIV	1200 COLUMBIA AVE	RIVERSIDE CA 92507
33095	SPECTRUM CONTROL INC	8061 AVONIA RD	FAIRVIEW PA 16415
52763	STETTNER ELECTRONICS INC	6135 AIRWAYS BLVD PO BOX 21947	CHATTANOOGA TN 37421
56289	SPRAGUE ELECTRIC CO	87 MARSHALL ST	NORTH ADAMS MA 01247
57668	ROHM CORP	16931 MILLIKEN AVE	IRVINE CA 92713
58854	GTE PRODUCTS CORP LIGHTING PRODUCTS GROUP	60 BOSTON ST	SALEM MA 01970
59660	TUSONIX INC	2155 N FORBES BLVD	TUCSON, ARIZONA 85705
59821	CENTRALAB INC SUB NORTH AMERICAN PHILIPS CORP	7158 MERCHANT AVE	EL PASO TX 79915
71400	MCGRAW-EDISON CO BUSSMANN MFG DIV	502 EARTH CITY PLAZA P O BOX 14460	ST LOUIS MO 63178
71590	GLOBE-UNION INC CENTRALAB ELECTRONICS DIV	HWY 20 W P O BOX 858	FORT DODGE IA 50501
71744	GENERAL INSTRUMENT CORP LAMP DIV	4433 N RAVENSWOOD AVE	CHICAGO IL 60640
73138	BECKMAN INSTRUMENTS INC HELIPOT DIV	2500 HARBOR BLVD	FULLERTON CA 92634
74970	JOHNSON E F CO	299 10TH AVE S W	WASECA MN 56093
75042	TRW INC TRW ELECTRONIC COMPONENTS IRC FIXED RESISTORS PHILADELPHIA DIV	401 N BROAD ST	PHILADELPHIA PA 19108
80009	TEKTRONIX INC	4900 S W GRIFFITH DR P O BOX 500	BEAVERTON OR 97077
80294	BOURNS INSTRUMENTS INC	6135 MAGNOLIA AVE	RIVERSIDE CA 92506
91637	DALE ELECTRONICS INC	P O BOX 609	COLUMBUS NE 68601
TK1036	E F JOHNSON CO	299 10TH AVE SW	WASECA MN 56093

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A1	670-1013-00			CIRCUIT BD ASSY:BANDWIDTH	80009	670-1013-00
A2	670-1014-00	B010100	B029999	CIRCUIT BD ASSY:MAIN	80009	670-1014-00
A2	670-1014-01	B030000	B059999	CIRCUIT BD ASSY:MAIN	80009	670-1014-01
A2	670-1014-03	B060000	B069999	CIRCUIT BD ASSY:MAIN	80009	670-1014-03
A2	670-1014-04	B070000	B079999	CIRCUIT BD ASSY:MAIN	80009	670-1014-04
A2	670-1014-05	B080000	B115479	CIRCUIT BD ASSY:MAIN	80009	670-1014-05
A2	670-1014-06	B115480		CIRCUIT BD ASSY:MAIN	80009	670-1014-06
A3	670-1050-00	B010100	B059999	CIRCUIT BD ASSY:INPUT COUPLING SW	80009	670-1050-00
A3	670-1050-01	B060000	B118249	CIRCUIT BD ASSY:INPUT COUPLING SW	80009	670-1050-01
A3	670-1050-02	B118250		CIRCUIT BD ASSY:INPUT COUPLING SWITCH	80009	670-1050-02
A4	670-1051-00	B010100	B059999	CIRCUIT BD ASSY:INPUT COUPLING SW	80009	670-1051-00
A4	670-1051-01	B060000	B118249	CIRCUIT BD ASSY:INPUT COUPLING SW	80009	670-1051-01
A4	670-1051-02	B118250		CIRCUIT BD ASSY:INPUT COUPLING SWITCH	80009	670-1051-02
C101	295-0117-00			CAP SET,MATCHED:(2) 0.1UF,MATCHED 0.1%	80009	295-0117-00
C103	283-0636-00			CAP,FXD,MICA DI:36PF,1.4%,100V (FURNISHED AS A MATCHED SET WITH C201)	00853	D155E360G0
C108	281-0092-00	B010100	B059999	CAP,VAR,CER DI:9-35PF,200V (C108A)	33095	53-717-001 D9-35
C108	281-0131-00	B060000		CAP,VAR,AIR DI:2.4-24.5PF,250V (C108A)	74970	189-0509-075
C108	281-0131-00			CAP,VAR,AIR DI:2.4-24.5PF,250V (C108C)	74970	189-0509-075
C108	283-0638-00			CAP,FXD,MICA DI:130PF,1%,100V (C108D)	00853	D155F131F0
C109	281-0092-00	B010100	B059999	CAP,VAR,CER DI:9-35PF,200V (C109A)	33095	53-717-001 D9-35
C109	281-0131-00	B060000		CAP,VAR,AIR DI:2.4-24.5PF,250V (C109A)	74970	189-0509-075
C109	281-0081-00			CAP,VAR,AIR DI:1.8-13PF,375VDC (C109C)	74970	189-0506-075
C109	283-0594-00			CAP,FXD,MICA DI:0.001UF,1%,100V (C109D)	00853	D151F102F0
C110	281-0092-00	B010100	B059999	CAP,VAR,CER DI:9-35PF,200V (C110A)	33095	53-717-001 D9-35
C110	281-0131-00	B060000		CAP,VAR,AIR DI:2.4-24.5PF,250V (C110A)	74970	189-0509-075
C110	281-0079-00			CAP,VAR,AIR DI:1.5-9.1PF,375V (C110C)	74970	189-0504-075
C110	283-0617-00	B010100	B119999	CAP,FXD,MICA DI:4700PF,10%,300V (C110D)	00853	D195F472K0
C110	283-0756-00	B120000		CAP,FXD,MICA DI:4700 PF 5%,300V (C110D)	00853	D195F472J0
C115	281-0092-00	B010100	B059999	CAP,VAR,CER DI:9-35PF,200V	33095	53-717-001 D9-35
C115	281-0131-00	B060000		CAP,VAR,AIR DI:2.4-24.5PF,250V	74970	189-0509-075
C141	281-0093-00			CAP,VAR,CER DI:5.5-18PF,350V	59660	538-011A5.5-18
C144	281-0544-00	B010100	B079999	CAP,FXD,CER DI:5.6PF,+/0.5PF,500V	52763	ZR0PLZ007 270PM0
C144	281-0122-00	B080000		CAP,VAR,CER DI:2.5-9PF,100V	59660	518-000A2.5-9
C156	283-0594-00			CAP,FXD,MICA DI:0.001UF,1%,100V	00853	D151F102F0
C201	295-0117-00			CAP SET,MATCHED:(2) 0.1UF,MATCHED 0.1% (FURNISHED AS A MATCHED SET WITH C103)	80009	295-0117-00
C203	283-0636-00			CAP,FXD,MICA DI:36PF,1.4%,100V	00853	D155E360G0
C208	281-0092-00	B010100	B059999	CAP,VAR,CER DI:9-35PF,200V (C208A)	33095	53-717-001 D9-35
C208	281-0131-00	B060000		CAP,VAR,AIR DI:2.4-24.5PF,250V (C208A)	74970	189-0509-075
C208	281-0131-00			CAP,VAR,AIR DI:2.4-24.5PF,250V (C208C)	74970	189-0509-075
C208	283-0638-00			CAP,FXD,MICA DI:130PF,1%,100V (C208D)	00853	D155F131F0
C209	281-0092-00	B010100	B059999	CAP,VAR,CER DI:9-35PF,200V (C209A)	33095	53-717-001 D9-35

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
C209	281-0131-00	B060000		CAP,VAR,AIR DI:2.4-24.5PF,250V (C209A)	74970	189-0509-075
C209	281-0081-00			CAP,VAR,AIR DI:1.8-13PF,375VDC (C209C)	74970	189-0506-075
C209	283-0594-00			CAP,FXD,MICA DI:0.001UF,1%,100V (C209D)	00853	D151F102F0
C210	281-0092-00	B010100	B059999	CAP,VAR,CER DI:9-35PF,200V (C210A)	33095	53-717-001 09-35
C210	281-0131-00	B060000		CAP,VAR,AIR DI:2.4-24.5PF,250V (C210A)	74970	189-0509-075
C210	281-0079-00			CAP,VAR,AIR DI:1.5-9.1PF,375V (C210C)	74970	189-0504-075
C210	283-0617-00	B010100	B119999	CAP,FXD,MICA DI:4700PF,10%,300V (C210D)	00853	D195F472K0
C210	283-0756-00	B120000		CAP,FXD,MICA DI:4700 PF 5%,300V (C210D)	00853	D195F472J0
C215	281-0092-00	B010100	B059999	CAP,VAR,CER DI:9-35PF,200V	33095	53-717-001 09-35
C215	281-0131-00	B060000		CAP,VAR,AIR DI:2.4-24.5PF,250V	74970	189-0509-075
C241	281-0093-00			CAP,VAR,CER DI:5.5-18PF,350V	59660	538-011A5.5-18
C244	281-0544-00			CAP,FXD,CER DI:5.6PF,+/0.5PF,500V	52763	2RDPLZ007 270PM0
C256	283-0594-00			CAP,FXD,MICA DI:0.001UF,1%,100V	00853	D151F102F0
C264	283-0059-00			CAP,FXD,CER DI:1UF,+80-20%,50V	31433	C330C105M5R5CA
C283	290-0284-00			CAP,FXD,ELCTLT:4.7UF,10%,35V	05397	T1108475K035AS
C307	290-0297-00			CAP,FXD,ELCTLT:39UF,10%,10V	05397	T1108396K010AS
C315	281-0613-00			CAP,FXD,CER DI:10PF,1%,500V	59660	374-018C0G0100F
C317	290-0297-00			CAP,FXD,ELCTLT:39UF,10%,10V	05397	T1108396K010AS
C325	290-0297-00			CAP,FXD,ELCTLT:39UF,10%,10V	05397	T1108396K010AS
C329	283-0002-00			CAP,FXD,CER DI:0.01UF,+80-20%,500V	59821	D103Z40Z5ULADEG
C330	281-0114-00			CAP,VAR,AIR DI:1.3-5.4PF,425V	TK1036	189-0752-075
C349	290-0177-00			CAP,FXD,ELCTLT:1UF,20%,50V	05397	T320A105M050AS
C353	285-0809-00			CAP,FXD,PLASTIC:1UF,10%,50V (C353A)	56289	LP66A1A105K
C353	285-0809-00			CAP,FXD,PLASTIC:1UF,10%,50V (C353D)	56289	LP66A1A105K
C353	283-0058-00			CAP,FXD,CER DI:0.027UF,10%,100V (C353G)	04222	SR301C273KAA
C413	281-0534-00			CAP,FXD,CER DI:3.3PF,+/-0.25PF,500V	52763	2RDPLZ007 3P30CC
C425	281-0093-00			CAP,VAR,CER DI:5.5-18PF,350V	59660	538-011A5.5-18
C426	281-0528-00			CAP,FXD,CER DI:82PF,+/-8.2PF,500V (C426A)	59660	301-000U2M0820K
C426	283-0604-00			CAP,FXD,MICA DI:304PF,2%,500V (C426B)	00853	D155F304060
C426	283-0594-00			CAP,FXD,MICA DI:0.001UF,1%,100V (C426C)	00853	D151F102F0
C426	285-0627-00			CAP,FXD,PLASTIC:0.0033UF,5%,100V (C426D)	07716	TEK44-33251
C426	285-0598-00			CAP,FXD,PLASTIC:0.01UF,5%,100V (C426E)	19396	0U4908103J
C426	285-0702-00			CAP,FXD,PLASTIC:0.033UF,5%,100V (C426F)	19396	0U591/74-16903
C426	285-0703-00			CAP,FXD,PLASTIC:0.1UF,5%,100V (C426G)	19396	104J01PT605
C426	285-0633-00			CAP,FXD,PLASTIC:0.22UF,10%,100V (C426H)	56289	192P22492
C443	283-0000-00			CAP,FXD,CER DI:0.001UF,+100-0%,500V	59660	831-610-Y5U0102P
C445	283-0092-00			CAP,FXD,CER DI:0.03UF,+80-20%,200V	59660	845-534Z5U0303Z
C447	283-0111-00			CAP,FXD,CER DI:0.1UF,20%,50V	05397	C330C104M5U1CA
C513	281-0534-00			CAP,FXD,CER DI:3.3PF,+/-0.25PF,500V	52763	2RDPLZ007 3P30CC
C543	283-0000-00			CAP,FXD,CER DI:0.001UF,+100-0%,500V	59660	831-610-Y5U0102P
C545	283-0059-00			CAP,FXD,CER DI:1UF,+80-20%,50V	31433	C330C105M5R5CA
C547	283-0134-00			CAP,FXD,CER DI:0.47UF,80-20%,50V	05397	C330C474Z5U1CA
C610	283-0080-00			CAP,FXD,CER DI:0.022UF,+80-20%,25V	59821	200U60E223Z

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C620	283-0080-00			CAP,FXD,CER DI:0.022UF,+80-20%,25V	59821	2DDU60E223Z
C630	283-0080-00			CAP,FXD,CER DI:0.022UF,+80-20%,25V	59821	2DDU60E223Z
CR119	152-0323-00			SEMICOND DVC,DI:SM,SI,35V,0.1A,DO-7	14433	MG1518
CR120	152-0323-00			SEMICOND DVC,DI:SM,SI,35V,0.1A,DO-7	14433	MG1518
CR131	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR144	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR219	152-0323-00			SEMICOND DVC,DI:SM,SI,35V,0.1A,DO-7	14433	MG1518
CR220	152-0323-00			SEMICOND DVC,DI:SM,SI,35V,0.1A,DO-7	14433	MG1518
CR244	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR260	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR309	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR341	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR343	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR413	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR415	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR417	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR419	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR513	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR515	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR517	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR519	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR610	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR615	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR618	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR620	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
CR630	152-0141-02			SEMICOND DVC,DI:SM,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
DS101	150-0093-00	B010100	B039999	LAMP,INCAND:5V,0.06A,6833AS15,WIRE LD	71744	6833AS15
DS101	150-0057-01	B040000	B059999	LAMP,INCAND:5V,0.115A,WIRE LD,AGED & SEL	71744	7153 AS 15
DS101	150-0048-01	B060000		LAMP,INCAND:5V,0.06A,#683,AGED & SEL	58854	683AS15
DS301	150-0046-00			LAMP,INCAND:10V,0.04A,#2107D,WIRE LEAD	71744	CM2107
F119	159-0024-00			FUSE,CARTRIDGE:3AG,0.062A,250V,0.3SEC	71400	MGB 1/16
F219	159-0024-00			FUSE,CARTRIDGE:3AG,0.062A,250V,0.3SEC	71400	MGB 1/16
J101	131-0679-00	B010100	B093219	CONN,RCPT,ELEC:BNC,MALE,3 CONTACT	24931	28JR168-1
J101	131-0679-02	B093220		CONN,RCPT,ELEC:BNC,MALE,3 CONTACT	24931	28JR270-1
J201	131-0679-00	B010100	B093219	CONN,RCPT,ELEC:BNC,MALE,3 CONTACT	24931	28JR168-1
J201	131-0679-02	B093220		CONN,RCPT,ELEC:BNC,MALE,3 CONTACT	24931	28JR270-1
Q133	151-1027-00	B010100	B099999	TRANSISTOR:FET,N-CHAN,SI,TO-71	80009	151-1027-00
Q133	151-1101-00	B100000	B118829	TRANSISTOR:FE,N CHANNEL,SI,TO-71	27014	2N5565
Q133	151-1027-00	B118830		TRANSISTOR:FET,N-CHAN,SI,TO-71	80009	151-1027-00
Q144	151-0261-00			TRANSISTOR:PNP,SI,TO-77	04713	SD441
Q153	151-1028-00			TRANSISTOR:FET,N-CHAN,SI,TO-5	22229	F2975
Q253	151-1028-00			TRANSISTOR:FET,N-CHAN,SI,TO-5	22229	F2975
Q264	151-0261-00			TRANSISTOR:PNP,SI,TO-77	04713	SD441
Q273	151-1028-00			TRANSISTOR:FET,N-CHAN,SI,TO-5	22229	F2975
Q283	151-1028-00			TRANSISTOR:FET,N-CHAN,SI,TO-5	22229	F2975
Q284	151-0195-00			TRANSISTOR:SELECTED	80009	151-0195-00
Q304	151-0260-00			TRANSISTOR:NPN,SI,TO-39	04713	ST1083
Q314	151-0220-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0220-00
Q324	151-0228-00			TRANSISTOR:PNP,SI,TO-105	07263	S21862
Q334	151-0228-00			TRANSISTOR:PNP,SI,TO-105	07263	S21862
Q344	151-0195-00			TRANSISTOR:SELECTED	80009	151-0195-00
Q354	151-0195-00			TRANSISTOR:SELECTED	80009	151-0195-00
Q404	151-1019-00	B010100	B069999	TRANSISTOR:FET,N-CHAN,SI,TO-71	15818	SU2235
Q404	151-1050-00	B070000		TRANSISTOR:FET,N-CHAN,SI,TO-71	04713	SFD1050
Q414	151-0261-00			TRANSISTOR:PNP,SI,TO-77	04713	SD441
Q424	151-0219-00			TRANSISTOR:PNP,SI,R-124	07263	S022650
Q434	151-0219-00			TRANSISTOR:PNP,SI,R-124	07263	S022650
Q444	151-0219-00			TRANSISTOR:PNP,SI,R-124	07263	S022650
Q454	151-0219-00			TRANSISTOR:PNP,SI,R-124	07263	S022650

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Q524	151-0219-00			TRANSISTOR:PNP,SI,R-124	07263	S022650
Q534	151-0219-00			TRANSISTOR:PNP,SI,R-124	07263	S022650
Q544	151-0219-00			TRANSISTOR:PNP,SI,R-124	07263	S022650
Q554	151-0219-00			TRANSISTOR:PNP,SI,R-124	07263	S022650
Q614	151-0254-00	B010100	B116609	TRANSISTOR:DARLINGTON,NPN,SI	03508	X38L3118
Q614	151-0281-00	B116610		TRANSISTOR:NPN,SI,400 MILLIWATTS	03508	X16P4039
R103	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25M	19701	5043CX1M000J
R108	323-0611-07			RES,FXD,FILM:900K OHM,0.1%,0.5M,TC=T9 (R108C)	19701	5053RE9000K08
R108	321-0389-01			RES,FXD,FILM:110K OHM,0.5%,0.125M,TC=T0 (R108D)	19701	5033RD110K00
R108	311-0609-00			RES,VAR,NONWW:TRMR,2K OHM,0.5M (R108E)	32997	3329H-L58-202
R109	323-0614-07			RES,FXD,FILM:990K OHM,0.1%,0.5M,TC=T9 (R109C)	19701	5053RE990K0B
R109	321-0289-00			RES,FXD,FILM:10.0K OHM,1%,0.125M,TC=T0 (R109D)	19701	5033ED10K0F
R109	311-0605-00			RES,VAR,NONWW:TRMR,200 OHM,0.5M (R109E)	32997	3329H-G48-201
R110	323-0623-07			RES,FXD,FILM:999K OHM,0.1%,0.5M,TC=T9 (R110C)	19701	5053RE999K0B
R110	321-0197-00			RES,FXD,FILM:1.10K OHM,1%,0.125M,TC=T0 (R110D)	07716	CEAD11000F
R110	311-0609-00			RES,VAR,NONWW:TRMR,2K OHM,0.5M (R110E)	32997	3329H-L58-202
R110	321-0289-01			RES,FXD,FILM:10.0K OHM,0.5%,0.125M,TC=T0 (R110F)	07716	CEAD10001D
R111	323-0481-07			RES,FXD,FILM:1 MEG OHM,0.1%,0.5M,TC=T9	19701	5053RE1M000B
R115	311-0827-00	B010100	B069999	RES,VAR,NONWW:TRMR,250 OHM,0.5M	01121	SV2511
R115	311-1260-00	B070000		RES,VAR,NONWW:TRMR,250 OHM,0.5M	32997	3329P-L58-251
R116	311-0635-00			RES,VAR,NONWW:TRMR,1K OHM,0.5M	32997	3329H-G48-102
R117	321-0210-00			RES,FXD,FILM:1.50K OHM,1%,0.125M,TC=T0	19701	5033ED1K50F
R119	315-0510-00			RES,FXD,FILM:51 OHM,5%,0.25M	19701	5043CX51R00J
R121	321-0344-00			RES,FXD,FILM:37.4K OHM,1%,0.125M,TC=T0	19701	5033ED 37K40F
R123	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25M	57668	NTR25J-E150E
R133	308-0495-00			RES,FXD,MM:4.5K OHM,0.1%,3M,TC=10PPM	00213	1240S-4500-0.1
R141	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25M	57668	NTR25J-E05K1
R145	321-0289-00			RES,FXD,FILM:10.0K OHM,1%,0.125M,TC=T0	19701	5033ED10K0F
R151	308-0546-00			RES,FXD,MM:125 OHM,0.1%,3M,TC=20PPM	00213	1240S-125-0.1
R153	321-0114-00			RES,FXD,FILM:150 OHM,1%,0.125 M,TC=T0	19701	5033ED150R0F
R155	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25M	57668	NTR25J-E 100E
R157	321-0030-00			RES,FXD,FILM:20.0 OHM,1%,0.125M,TC=T0	57668	CR814FXE 20 OHM
R159	308-0436-00			RES,FXD,MM:2K OHM,0.1%,3M,TC=10PPM,	00213	1240S-2000-0.1
R203	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25M	19701	5043CX1M000J
R208	323-0611-07			RES,FXD,FILM:900K OHM,0.1%,0.5M,TC=T9 (R208C)	19701	5053RE9000K08
R208	321-0389-01			RES,FXD,FILM:110K OHM,0.5%,0.125M,TC=T0 (R208D)	19701	5033RD110K00
R209	323-0614-07			RES,FXD,FILM:990K OHM,0.1%,0.5M,TC=T9 (R209C)	19701	5053RE990K0B
R209	321-0289-00			RES,FXD,FILM:10.0K OHM,1%,0.125M,TC=T0 (R209D)	19701	5033ED10K0F
R210	323-0623-07			RES,FXD,FILM:999K OHM,0.1%,0.5M,TC=T9 (R210C)	19701	5053RE999K0B
R210	321-0197-00			RES,FXD,FILM:1.10K OHM,1%,0.125M,TC=T0 (R210D)	07716	CEAD11000F
R210	321-0289-01			RES,FXD,FILM:10.0K OHM,0.5%,0.125M,TC=T0 (R210F)	07716	CEAD10001D
R211	323-0481-07			RES,FXD,FILM:1 MEG OHM,0.1%,0.5M,TC=T9	19701	5053RE1M000B
R215	311-0827-00	B010100	B069999	RES,VAR,NONWW:TRMR,250 OHM,0.5M	01121	SV2511
R215	311-1260-00	B070000		RES,VAR,NONWW:TRMR,250 OHM,0.5M	32997	3329P-L58-251

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R217	321-0222-00			RES,FXD,FILM:2.00K OHM,1%,0.125W,TC=T0	19701	5033ED2K00F
R219	315-0510-00			RES,FXD,FILM:51 OHM,5%,0.25W	19701	5043CX51R00J
R227	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
R233	308-0495-00			RES,FXD,MM:4.5K OHM,0.1%,3W,TC=10PPM	00213	1240S-4500-0.1
R241	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
R245	321-0289-00			RES,FXD,FILM:10.0K OHM,1%,0.125W,TC=T0	19701	5033ED10K0F
R251	308-0546-00			RES,FXD,MM:125 OHM,0.1%,3W,TC=20PPM	00213	1240S-125-0.1
R253	321-0114-00			RES,FXD,FILM:150 OHM,1%,0.125 W,TC=T0	19701	5033ED150R0F
R255	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
R256	315-0185-00			RES,FXD,FILM:1.8M OHM,5%,0.25W	01121	CB1855
R257	321-0030-00			RES,FXD,FILM:20.0 OHM,1%,0.125W,TC=T0	57668	CRB14FXE 20 OHM
R258	311-0467-00			RES,VAR,NONWW:PNL,100K OHM,0.5W	01121	W7705B
R259	308-0436-00			RES,FXD,MM:2K OHM,0.1%,3W,TC=10PPM,	00213	1240S-2000-0.1
R261	321-0126-00			RES,FXD,FILM:200 OHM,1%,0.125W,TC=T0	19701	5033ED200R0F
R263	321-0385-00			RES,FXD,FILM:100K OHM,1%,0.125W,TC=T0	19701	5033ED100K0F
R264	321-0414-00			RES,FXD,FILM:200K OHM,1%,0.125W,TC=T0	07716	CEAD20002F
R265	311-0887-00			RES,VAR,NONWW:PNL,50K OHM,10%,0.5W	71590	BA215-003
R267	321-0385-00			RES,FXD,FILM:100K OHM,1%,0.125W,TC=T0	19701	5033ED100K0F
R269	321-0126-00			RES,FXD,FILM:200 OHM,1%,0.125W,TC=T0	19701	5033ED200R0F
R270	311-0889-00			RES,VAR,MM:PNL,5K OHM,1W	02111	162-214
R271	308-0436-00			RES,FXD,MM:2K OHM,0.1%,3W,TC=10PPM,	00213	1240S-2000-0.1
R273	321-0114-00			RES,FXD,FILM:150 OHM,1%,0.125 W,TC=T0	19701	5033ED150R0F
R275	311-0532-00			RES,VAR,MM:TRMR,1.5K OHM,1W	75042	100-0000-152
R277	321-0114-00			RES,FXD,FILM:150 OHM,1%,0.125 W,TC=T0	19701	5033ED150R0F
R279	308-0436-00			RES,FXD,MM:2K OHM,0.1%,3W,TC=10PPM,	00213	1240S-2000-0.1
R281	321-0126-00			RES,FXD,FILM:200 OHM,1%,0.125W,TC=T0	19701	5033ED200R0F
R283	323-0220-00			RES,FXD,FILM:1.91K OHM,1%,0.5W,TC=T0	19701	5053RD1K900F
R285	321-0423-00			RES,FXD,FILM:249K OHM,1%,0.125W,TC=T0	19701	5043ED249K0F
R287	308-0633-00			RES,FXD,MM:475 OHM,0.1%,3W	00213	1240S 475-0.1
R289	308-0633-00			RES,FXD,MM:475 OHM,0.1%,3W	00213	1240S 475-0.1
R291	321-0423-00			RES,FXD,FILM:249K OHM,1%,0.125W,TC=T0	19701	5043ED249K0F
R293	323-0214-00			RES,FXD,FILM:1.65K OHM,1%,0.5W,TC=T0	19701	5053RD1K650F
R301	323-0256-00			RES,FXD,FILM:4.53K OHM,1%,0.5W,TC=T0	19701	5053RD4K530F
R303	317-0511-00			RES,FXD,CMPSN:510 OHM,5%,0.125W	01121	BB5115
R305	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
R307	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
R309	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
R311	315-0513-00			RES,FXD,FILM:51K OHM,5%,0.25W	57668	NTR25J-E51K0
R313	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
R315	315-0222-00			RES,FXD,FILM:2.2K OHM,5%,0.25W	57668	NTR25J-E02K2
R323	301-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.5W	19701	5053CX5K600J
R325	321-0160-00			RES,FXD,FILM:453 OHM,1%,0.125W,TC=T0	19701	5033ED453R0F
R331	315-0473-00			RES,FXD,FILM:47K OHM,5%,0.25W	57668	NTR25J-E47K0
R333	315-0433-00			RES,FXD,FILM:43K OHM,5%,0.25W	19701	5043CX43K00J
R335	321-0184-00			RES,FXD,FILM:806 OHM,1%,0.125W,TC=T0	19701	5033ED806R0F
R337	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25W	57668	NTR25J-E100K
R341	315-0364-00			RES,FXD,FILM:360K OHM,5%,0.25W	57668	NTR25J-E360K
R343	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0
R345	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25W	19701	5043CX1M000J
R349	315-0204-00			RES,FXD,FILM:200K OHM,5%,0.25W	19701	5043CX200K0J
R351	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E
R353	321-0303-00			RES,FXD,FILM:14.0K OHM,1%,0.125W,TC=T0 (R353A)	07716	CEAD 14001F
R353	321-0408-00			RES,FXD,FILM:174K OHM,1%,0.125W,TC=T0 (R353B)	07716	CEAD17402F
R353	301-0165-00	B010100	B119999	RES,FXD,FILM:1.6M OHM,5%,0.5W (R353C)	19701	5053CX1M600J
R353	301-0155-00	B120000		RES,FXD,FILM:1.5M OHM,5%,0.5W (R353C)	01121	EB1555

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
R353	321-0303-00			RES,FXD,FILM:14.0K OHM,1%,0.125W,TC=T0 (R353D)	07716	CEAD 14001F
R353	321-0408-00			RES,FXD,FILM:174K OHM,1%,0.125W,TC=T0 (R353E)	07716	CEAD17402F
R353	301-0165-00	B010100	B119999	RES,FXD,FILM:1.6M OHM,5%,0.5W (R353F)	19701	5053CX1M600J
R353	301-0155-00	B120000		RES,FXD,FILM:1.5M OHM,5%,0.5W (R353F)	01121	EB1555
R401	315-0202-00			RES,FXD,FILM:2K OHM,5%,0.25W	57668	NTR25J-E 2K
R403	321-0272-00			RES,FXD,FILM:6.65K OHM,1%,0.125W,TC=T0	19701	5043ED6K650F
R405	321-0039-00			RES,FXD,FILM:24.9 OHM,1%,0.125W,TC=T0	91637	CMF55116G24R90F
R407	321-0001-01			RES,FXD,FILM:10.0 OHM,0.5%,0.125W,TC=T0 (R407A)	19701	5033RD10R00D
R407	321-0762-01			RES,FXD,FILM:20.1 OHM,0.5%,0.125W,TC=T0 (R407B)	91637	CMF55116G20R10D
R407	321-1068-01			RES,FXD,FILM:50.5 OHM,0.5%,0.125W,TC=T0 (R407C)	57668	RB14 DXE 50E5
R407	321-0098-01			RES,FXD,FILM:102 OHM,0.5%,0.125W,TC=T0 (R407D)	07716	CEAD102R0D
R407	321-0127-01			RES,FXD,FILM:205 OHM,0.5%,0.125W,TC=T0 (R407E)	19701	5033RD205R0D
R407	321-1166-01			RES,FXD,FILM:530 OHM,0.5%,0.125W,TC=T0 (R407F)	19701	5033RD530R0D
R407	321-0763-07			RES,FXD,FILM:1.12K OHM,0.1%,0.125W,TC=T9 (R407G)	19701	5033RE1K120B
R407	321-1231-01			RES,FXD,FILM:2.52K OHM,0.5%,0.125W,TC=T0 (R407H)	07716	CEAD252D0D
R407	321-1289-01			RES,FXD,FILM:10.1K OHM,0.5%,0.125W,TC=T0 (R407J)	19701	5033RD10K10D
R407	321-0332-00			RES,FXD,FILM:28.0K OHM,1%,0.125W,TC=T0 (R407K)	07716	CEAD28001F
R409	321-0343-00			RES,FXD,FILM:36.5K OHM,1%,0.125W,TC=T0	07716	CEAD36501F
R413	321-0361-00			RES,FXD,FILM:56.2K OHM,1%,0.125W,TC=T0	07716	CEAD56201F
R421	321-0614-00			RES,FXD,FILM:10.1K OHM,1%,0.125W,TC=T0	19701	5043ED10K10F
R423	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
R425	311-0704-00	B010100	B069999	RES,VAR,NONWW:TRMR,500 OHM,0.5W	73138	91-101-0
R425	311-1261-00	B070000		RES,VAR,NONWW:TRMR,500 OHM,0.5W	32997	3329P-L58-501
R427	321-0227-00			RES,FXD,FILM:2.26K OHM,1%,0.125W,TC=T0	07716	CEAD22600F
R430	311-0888-00	B010100	B069999	RES,VAR,NONWW:PNL,2X10K OHM,10%,0.5W	12697	381-CM40098
R430	311-0888-01	B070000		RES,VAR,NONWW:PNL,2X10K OHM,0.5W,M/SW	12697	CM40098
R431	321-0334-00			RES,FXD,FILM:29.4K OHM,1%,0.125W,TC=T0	07716	CEAD29401F
R432	321-0164-00			RES,FXD,FILM:499 OHM,1%,0.125W,TC=T0	19701	5033ED499R0F
R433	321-0335-00			RES,FXD,FILM:30.1K OHM,1%,0.125W,TC=T0	57668	RB14FXE30K1
R434	321-0211-00			RES,FXD,FILM:1.54K OHM,1%,0.125W,TC=T0	07716	CEAD15400F
R436	321-0197-00			RES,FXD,FILM:1.10K OHM,1%,0.125W,TC=T0	07716	CEAD11000F
R437	321-0260-00			RES,FXD,FILM:4.99K OHM,1%,0.125W,TC=T0	19701	5033ED4K990F
R440	321-0143-00	B010100	B029999	RES,FXD,FILM:301 OHM,1%,0.125W,TC=T0	07716	CEAD301R0F
R440	321-0149-00	B030000		RES,FXD,FILM:348 OHM,1%,0.125W,TC=T0	07716	CEAD348R0F
R441	321-0222-00	B010100	B029999	RES,FXD,FILM:2.00K OHM,1%,0.125W,TC=T0	19701	5033ED2K00F
R441	321-0202-00	B030000		RES,FXD,FILM:1.24K OHM,1%,0.125W,TC=T0	24546	NA5501241F
R443	317-0561-00	B010100	B029999	RES,FXD,CMPSN:560 OHM,5%,0.125W	01121	BB5615
R443	317-0391-00	B030000	B089999	RES,FXD,CMPSN:390 OHM,5%,0.125W	01121	BB3915
R443	315-0391-00	B090000		RES,FXD,FILM:390 OHM,5%,0.25W	57668	NTR25J-E390E
R445	321-0251-00	B010100	B029999	RES,FXD,FILM:4.02K OHM,1%,0.125W,TC=T0	19701	5033ED4K020F
R445	321-0231-00	B030000		RES,FXD,FILM:2.49K OHM,1%,0.125W,TC=T0	19701	5033ED2K49F
R450	321-0147-00	B010100	B029999	RES,FXD,FILM:332 OHM,1%,0.125W,TC=T0	07716	CEAD332R0F
R450	321-0149-00	B030000		RES,FXD,FILM:348 OHM,1%,0.125W,TC=T0	07716	CEAD348R0F
R451	321-0222-00	B010100	B029999	RES,FXD,FILM:2.00K OHM,1%,0.125W,TC=T0	19701	5033ED2K00F
R451	321-0202-00	B030000		RES,FXD,FILM:1.24K OHM,1%,0.125W,TC=T0	24546	NA5501241F
R453	321-0251-00	B010100	B029999	RES,FXD,FILM:4.02K OHM,1%,0.125W,TC=T0	19701	5033ED4K020F
R453	321-0231-00	B030000		RES,FXD,FILM:2.49K OHM,1%,0.125W,TC=T0	19701	5033ED2K49F
R457	317-0241-00	B010100	B089999	RES,FXD,CMPSN:240 OHM,5%,0.125W	01121	BB2415

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
R457	315-0241-00	B090000		RES,FXD,FILM:240 OHM,5%,0.25W	19701	5043CX240R0J
R458	301-0470-00			RES,FXD,FILM:47 OHM,5%,0.5W	19701	5053CX47R00J
R459	315-0510-00			RES,FXD,FILM:51 OHM,5%,0.25W	19701	5043CX51R00J
R501	315-0202-00			RES,FXD,FILM:2K OHM,5%,0.25W	57668	NTR25J-E 2K
R503	321-0272-00			RES,FXD,FILM:6.65K OHM,1%,0.125W,TC=T0	19701	5043ED6K650F
R505	311-0639-00	B010100	B099999	RES,VAR,NM:TRMR,50 OHM,0.5W	80294	3305P-1-500
R505	311-1258-00	B100000		RES,VAR,NONM:TRMR,50 OHM,0.5W	32997	3329P-L58-500
R509	321-0343-00			RES,FXD,FILM:36.5K OHM,1%,0.125W,TC=T0	07716	CEAD36501F
R513	321-0361-00			RES,FXD,FILM:56.2K OHM,1%,0.125W,TC=T0	07716	CEAD56201F
R521	321-0614-00			RES,FXD,FILM:10.1K OHM,1%,0.125W,TC=T0	19701	5043ED10K10F
R523	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
R527	321-0227-00			RES,FXD,FILM:2.26K OHM,1%,0.125W,TC=T0	07716	CEAD22600F
R531	321-0334-00			RES,FXD,FILM:29.4K OHM,1%,0.125W,TC=T0	07716	CEAD29401F
R532	321-0164-00			RES,FXD,FILM:499 OHM,1%,0.125W,TC=T0	19701	5033ED499R0F
R533	321-0335-00			RES,FXD,FILM:30.1K OHM,1%,0.125W,TC=T0	57668	RB14FXE30K1
R534	321-0211-00			RES,FXD,FILM:1.54K OHM,1%,0.125W,TC=T0	07716	CEAD15400F
R535	311-0949-00			RES,VAR,NONM:TRMR,2K OHM,0.5W	01121	M-7789
R540	311-0702-00			RES,VAR,NONM:PNL,250 OHM,0.5W	01121	MA1N0485251UZ
R541	321-0222-00	B010100	B029999	RES,FXD,FILM:2.00K OHM,1%,0.125W,TC=T0	19701	5033ED2K00F
R541	321-0202-00	B030000		RES,FXD,FILM:1.24K OHM,1%,0.125W,TC=T0	24546	NA55D1241F
R543	317-0561-00	B010100	B029999	RES,FXD,CMPSN:560 OHM,5%,0.125W	01121	BB5615
R543	317-0391-00	B030000	B089999	RES,FXD,CMPSN:390 OHM,5%,0.125W	01121	BB3915
R543	315-0391-00	B090000		RES,FXD,FILM:390 OHM,5%,0.25W	57668	NTR25J-E390E
R545	321-0251-00	B010100	B029999	RES,FXD,FILM:4.02K OHM,1%,0.125W,TC=T0	19701	5033ED4K02F
R545	321-0231-00	B030000		RES,FXD,FILM:2.49K OHM,1%,0.125W,TC=T0	19701	5033ED2K49F
R551	321-0222-00	B010100	B029999	RES,FXD,FILM:2.00K OHM,1%,0.125W,TC=T0	19701	5033ED2K00F
R551	321-0202-00	B030000		RES,FXD,FILM:1.24K OHM,1%,0.125W,TC=T0	24546	NA55D1241F
R553	321-0251-00	B010100	B029999	RES,FXD,FILM:4.02K OHM,1%,0.125W,TC=T0	19701	5033ED4K02F
R553	321-0231-00	B030000		RES,FXD,FILM:2.49K OHM,1%,0.125W,TC=T0	19701	5033ED2K49F
R557	317-0241-00	B010100	B089999	RES,FXD,CMPSN:240 OHM,5%,0.125W	01121	BB2415
R557	315-0241-00	B090000		RES,FXD,FILM:240 OHM,5%,0.25W	19701	5043CX240R0J
R559	315-0510-00			RES,FXD,FILM:51 OHM,5%,0.25W	19701	5043CX51R00J
R610	321-0223-00			RES,FXD,FILM:2.05K OHM,1%,0.125W,TC=T0	80009	321-0223-00
R614	321-0299-00			RES,FXD,FILM:12.7K OHM,1%,0.125W,TC=T0	19701	5033ED12K70F
R618	315-0154-00			RES,FXD,FILM:150K OHM,5%,0.25W (R618A)	57668	NTR25J-E150K
R618	321-0344-00			RES,FXD,FILM:37.4K OHM,1%,0.125W,TC=T0 (R618B)	19701	5033ED 37K40F
R618	315-0154-00			RES,FXD,FILM:150K OHM,5%,0.25W (R618C)	57668	NTR25J-E150K
R618	315-0753-00			RES,FXD,FILM:75K OHM,5%,0.25W (R618D)	57668	NTR25J-E75K0
R618	315-0753-00			RES,FXD,FILM:75K OHM,5%,0.25W (R618E)	57668	NTR25J-E75K0
R618	315-0154-00			RES,FXD,FILM:150K OHM,5%,0.25W (R618F)	57668	NTR25J-E150K
R618	315-0753-00			RES,FXD,FILM:75K OHM,5%,0.25W (R618G)	57668	NTR25J-E75K0
R618	315-0753-00			RES,FXD,FILM:75K OHM,5%,0.25W (R618H)	57668	NTR25J-E75K0
R618	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W (R618J)	57668	NTR25J-E12K0
R618	321-0344-00			RES,FXD,FILM:37.4K OHM,1%,0.125W,TC=T0 (R618K)	19701	5033ED 37K40F
R618	315-0753-00			RES,FXD,FILM:75K OHM,5%,0.25W (R618L)	57668	NTR25J-E75K0
R618	315-0154-00			RES,FXD,FILM:150K OHM,5%,0.25W (R618M)	57668	NTR25J-E150K
R618	315-0513-00			RES,FXD,FILM:51K OHM,5%,0.25W (R618N)	57668	NTR25J-E51K0
R620	321-0223-00			RES,FXD,FILM:2.05K OHM,1%,0.125W,TC=T0	80009	321-0223-00
R622	315-0222-00			RES,FXD,FILM:2.2K OHM,5%,0.25W	57668	NTR25J-E02K2

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
R630	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25M	57668	NTR25J-E100K
R632	317-0223-00	B030000	B089999	RES,FXD,CMPSN:22K OHM,5%,0.125M	01121	BB2235
R632	315-0223-00	B090000		RES,FXD,FILM:22K OHM,5%,0.25M	19701	5043CX22K00J92U
R634	317-0203-00	B010100	B089999	RES,FXD,CMPSN:20K OHM,5%,0.125M	01121	BB2035
R634	315-0203-00	B090000		RES,FXD,FILM:20K OHM,5%,0.25M	57668	NTR25J-E 20K
RT221	307-0181-00			RES,THERMAL:100K OHM,10%,NTC	14193	K10-10002K
RT223	307-0181-00			RES,THERMAL:100K OHM,10%,NTC	14193	K10-10002K
S101	------ ------			(PART OF A3)		
S108	105-0413-00			ACTR ASSY,CAM S:ATTEN	80009	105-0413-00
S201	------ ------			(PART OF A4)		
S353	------ ------			(PART OF A1)		
S407	------ ------			(PART OF A2)		
S426	105-0109-00			ACTUATOR,CAM SW:H.F.-3DB SEL	80009	105-0109-00
VR270	152-0212-00			SEMICOND DVC,DI:ZEN,SI,9V,5%,0.5W,DO-7	04713	SZ50646RL
VR271	152-0405-00			SEMICOND DVC,DI:ZEN,SI,15V,5%,1W,TO-41	12954	DZ841205A
VR305	152-0306-00	B010100	B029999	SEMICOND DVC,DI:ZEN,SI,9.1V,5%,0.4W,DO-7	12954	1N960B
VR305	152-0168-00	B030000		SEMICOND DVC,DI:ZEN,SI,12V,5%,0.4W,DO-763B	14552	TD331689
VR310	152-0405-00			SEMICOND DVC,DI:ZEN,SI,15V,5%,1W,TO-41	12954	DZ841205A
VR320	152-0280-00			SEMICOND DVC,DI:ZEN,SI,6.2V,5%,0.4W,DO-7	04713	1N753A
VR325	152-0212-00			SEMICOND DVC,DI:ZEN,SI,9V,5%,0.5W,DO-7	04713	SZ50646RL
VR330	152-0280-00			SEMICOND DVC,DI:ZEN,SI,6.2V,5%,0.4W,DO-7	04713	1N753A

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

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

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

Resistors = Ohms (Ω).

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The overline on a signal name indicates that the signal performs its intended function when it goes to the low state.

Abbreviations are based on ANSI Y1.1-1972.

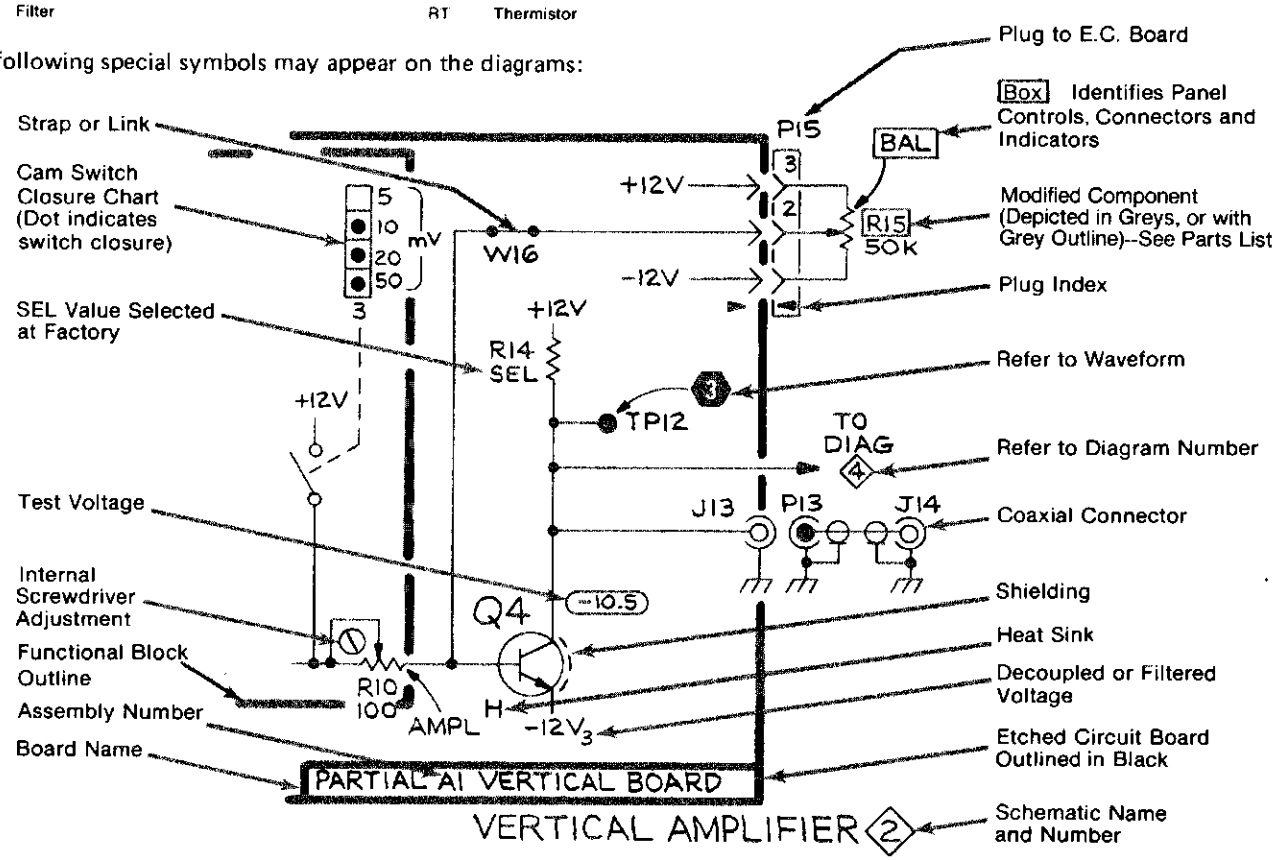
Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

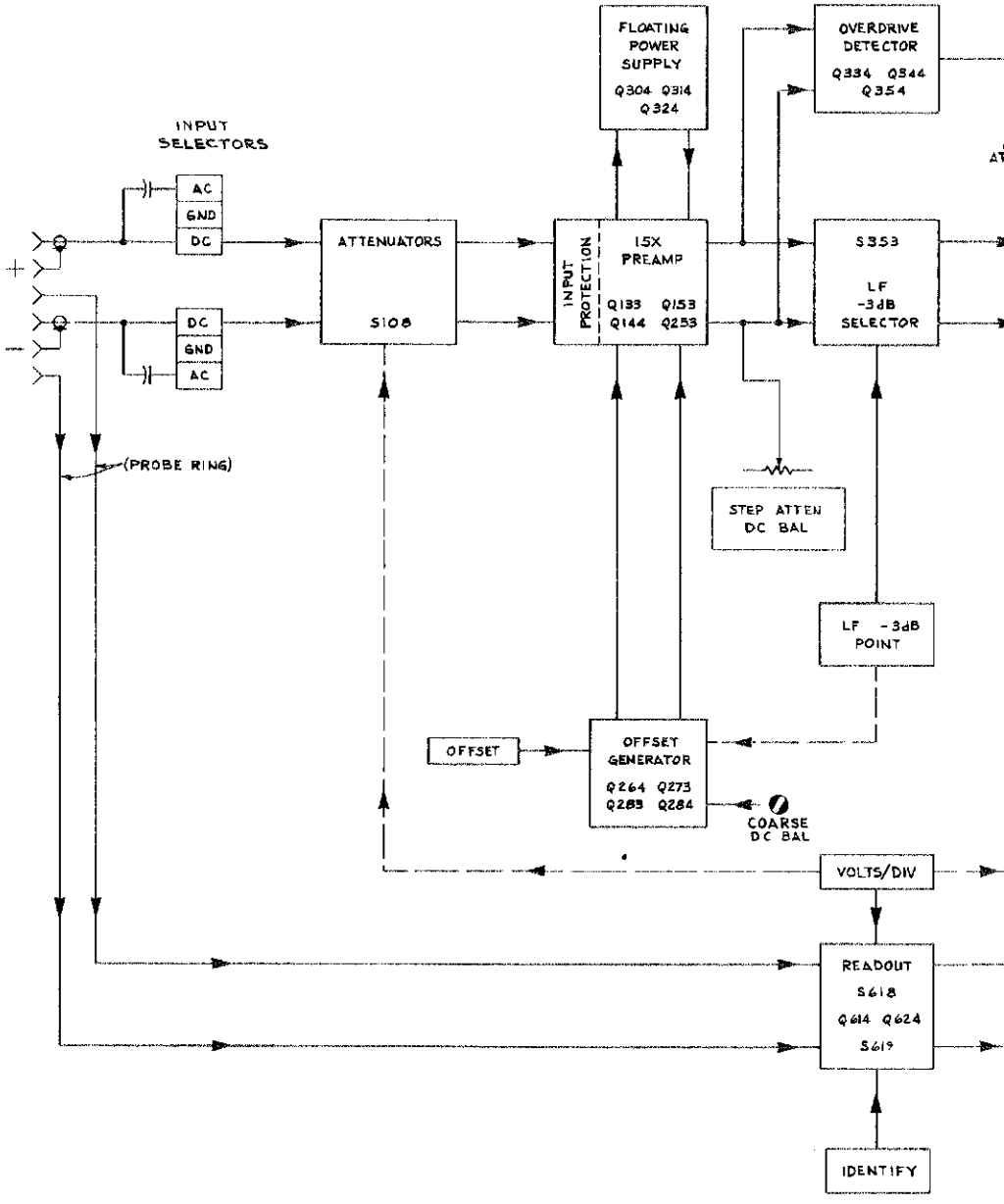
Y14.15, 1966	Drafting Practices.
Y14.2, 1973	Line Conventions and Lettering.
Y10.5, 1968	Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

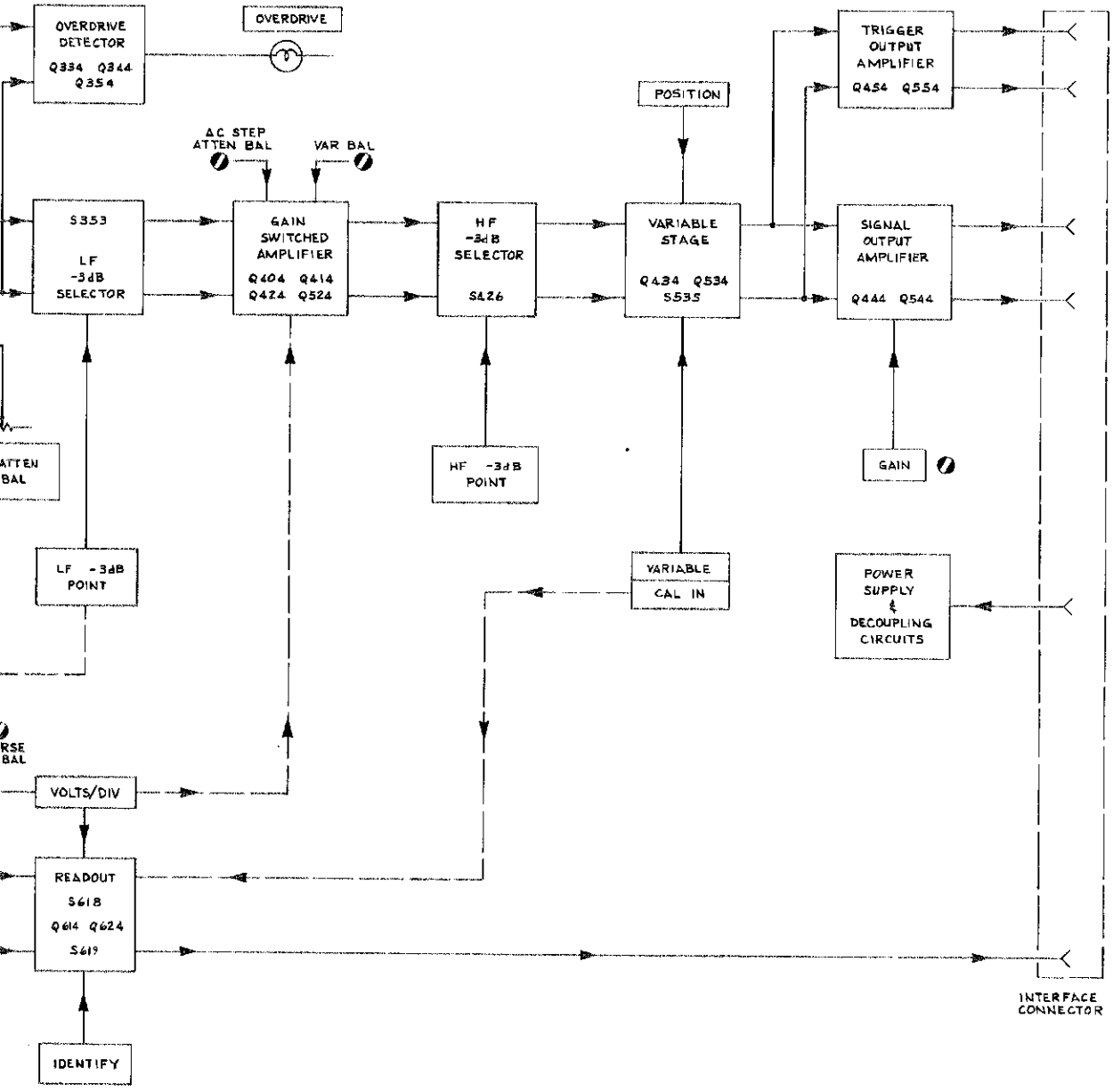
The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

A	Assembly, separable or repairable (circuit board, etc)	H	Heat dissipating device (heat sink, heat radiator, etc)	S	Switch or contactor
AT	Attenuator, fixed or variable	HR	Heater	T	Transformer
B	Motor	HY	Hybrid circuit	TC	Thermocouple
BT	Battery	J	Connector, stationary portion	TP	Test point
C	Capacitor, fixed or variable	K	Relay	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
CB	Circuit breaker	L	Inductor, fixed or variable	V	Electron tube
CR	Diode, signal or rectifier	M	Meter	VR	Voltage regulator (zener diode, etc.)
DL	Delay line	P	Connector, movable portion	W	Wirestrap or cable
DS	Indicating device (lamp)	Q	Transistor or silicon-controlled rectifier	Y	Crystal
E	Spark Gap, Ferrite bead	R	Resistor, fixed or variable	Z	Phase shifter
F	Fuse	RT	Thermistor		
FL	Filter				

The following special symbols may appear on the diagrams:




FLOATING POWER SUPPLY
Q304 Q314 Q324
OVERDRIVE DETECTOR
Q334 Q344 Q354
INPUT SELECTORS
AC
GND
DC
DC
GND
AC
ATTENUATORS
S108
INPUT PROTECTION
15X PREAMP
Q133 Q153 Q144 Q253
S353
LF -3dB SELECTOR
(PROBE RING)
STEP ATTEN DC BAL
LF -3dB POINT
OFFSET
OFFSET GENERATOR
Q264 Q273 Q283 Q284
COARSE DC BAL
VOLTS/DIV
READOUT
S618
Q614 Q624
S619
IDENTIFY



0931-03
REV AUG 1984

FUNCTIONAL BLOCK DIAGRAM

769
WLB

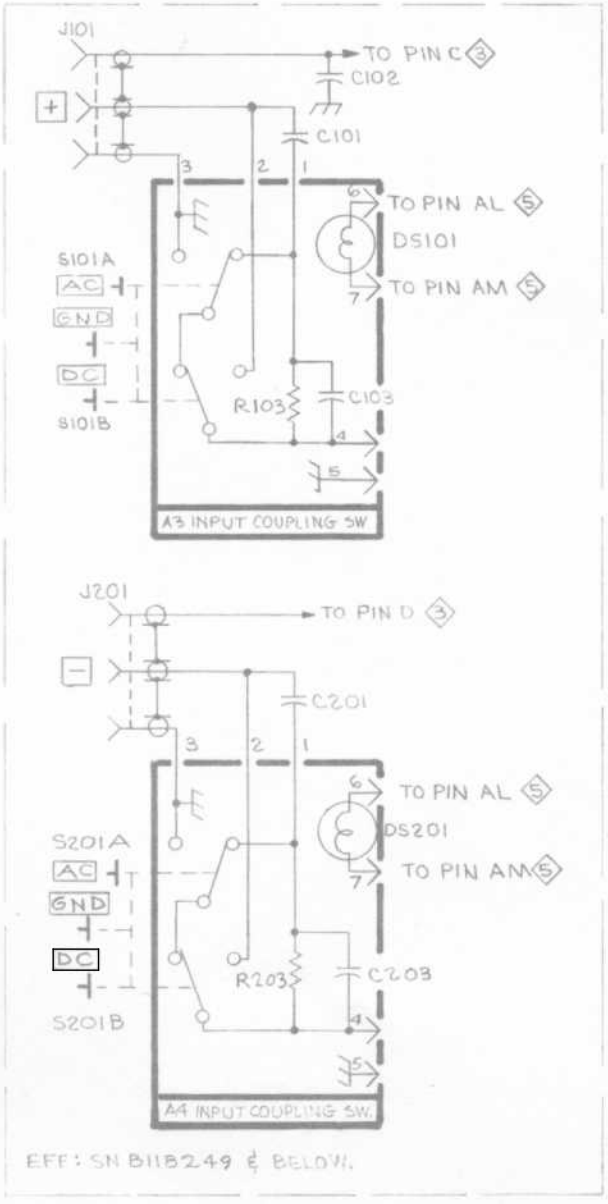
VOLTAGE AND WAVEFORM CONDITIONS

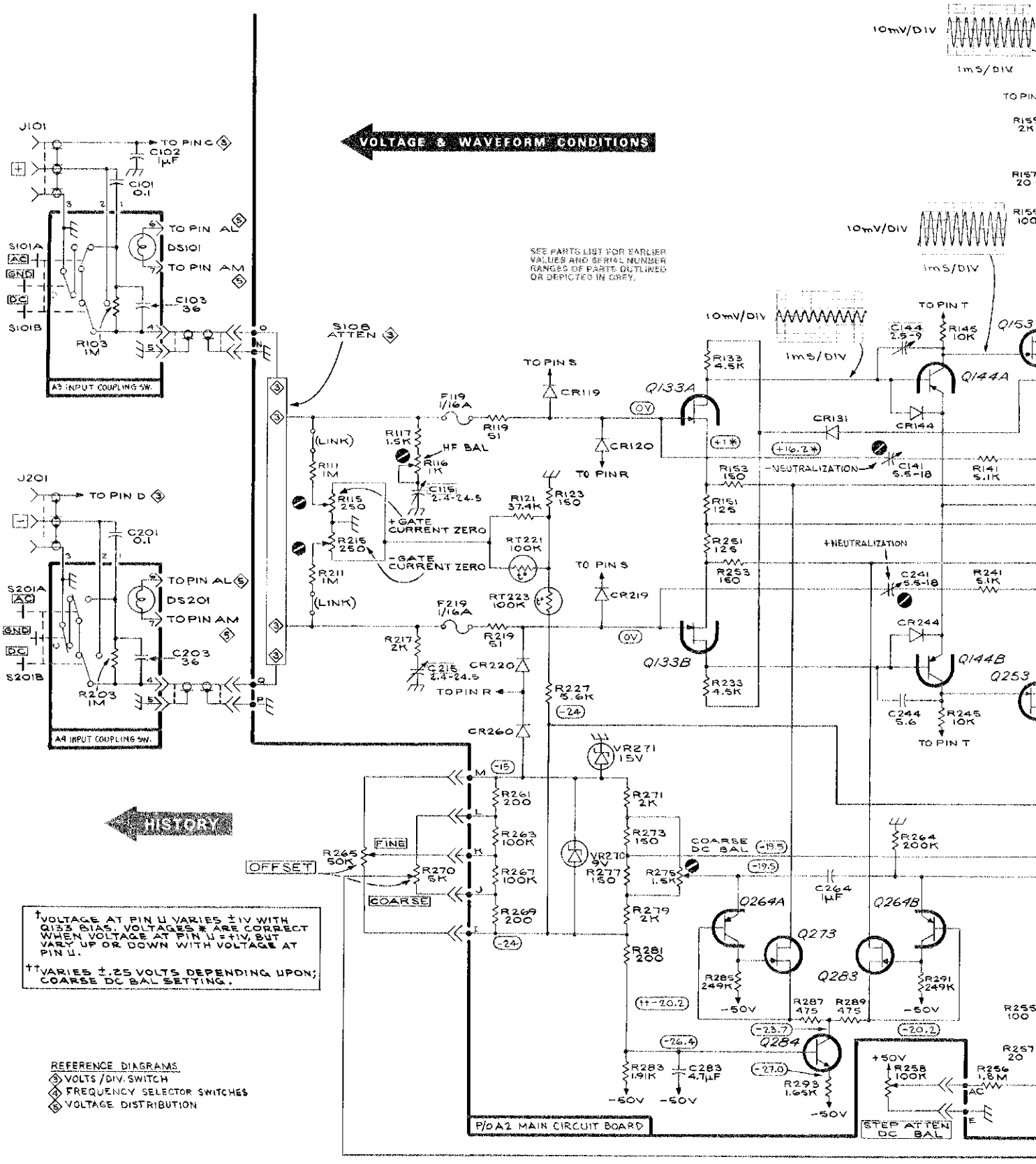
Waveforms show amplitude of signal at various points with –INPUT grounded and 25 mV peak to peak sine wave of approximately 1 kHz applied to + INPUT. Front panel controls set as follows:

LF –3 dB Point	DC
HF –3 dB Point	1 MHz
VOLTS/DIV	As shown at waveform

DC voltages measured with front panel controls set as follows:

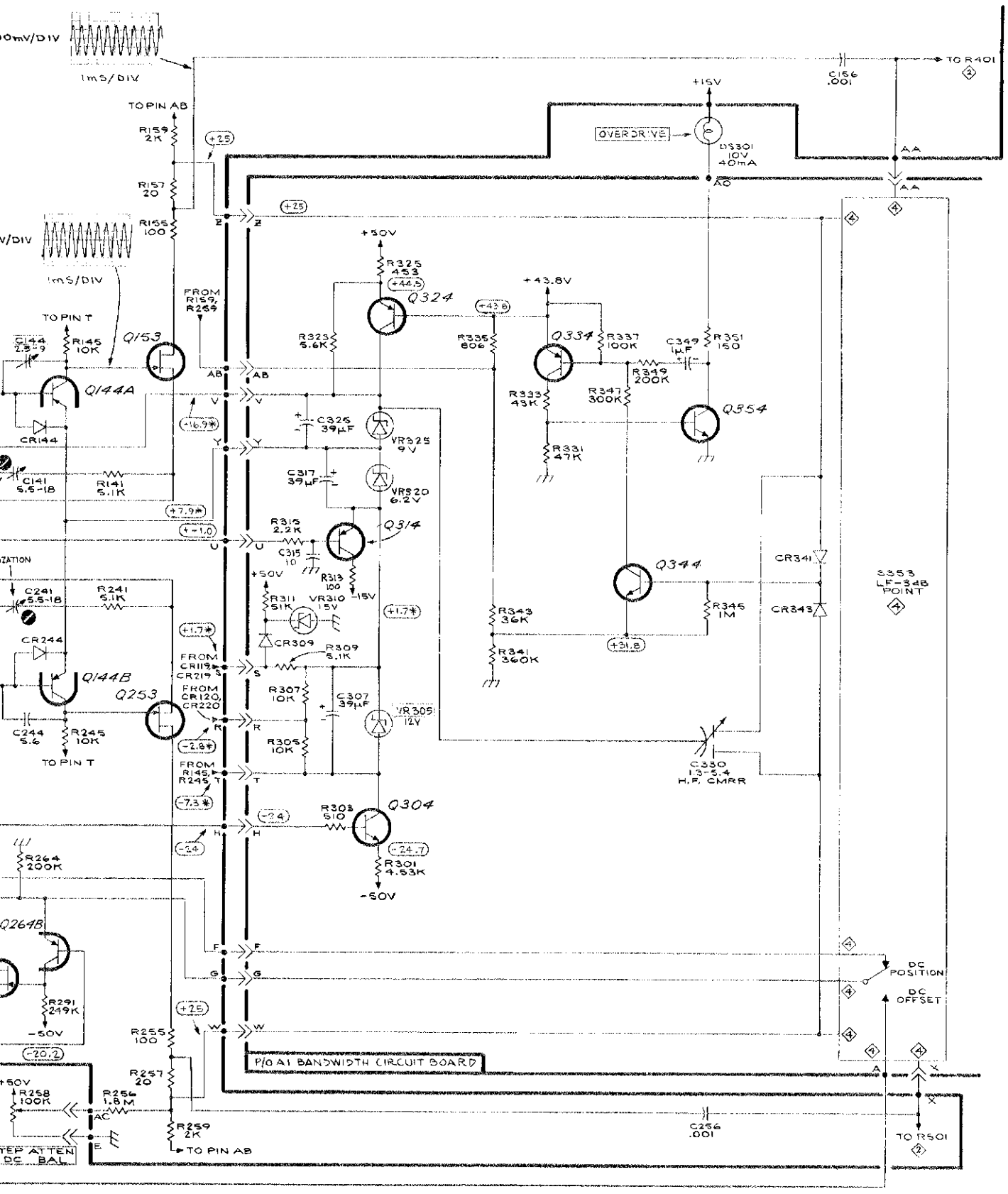
LF –3 dB Point	DC
VOLTS/DIV	1 mV
POSITION	Trace centered vertically
+INPUT AC-GND-DC	GND
–INPUT AC-GND-DC	GND





TYPE 7A22

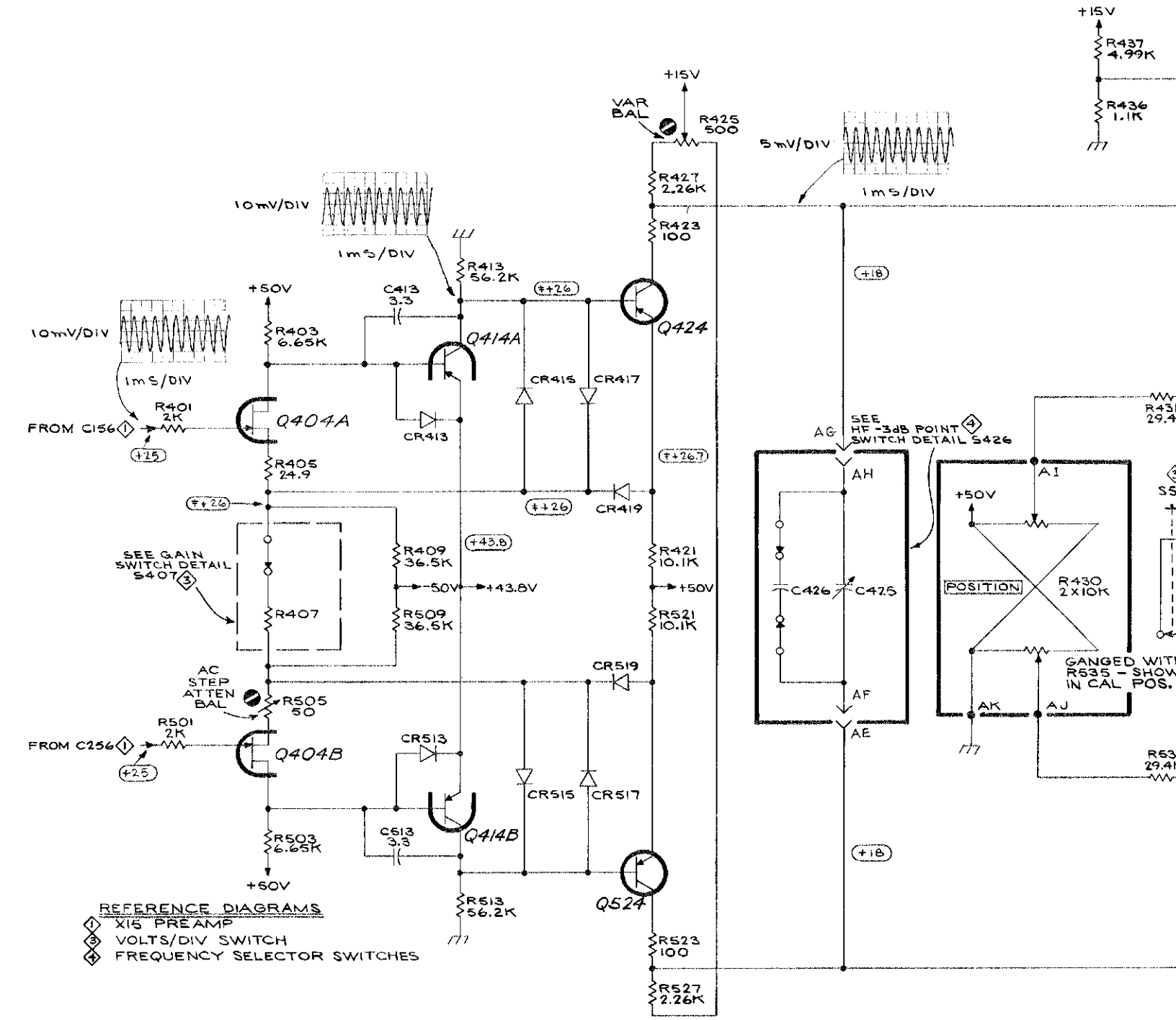
0931-02
REV AUG 1984



0931-02
REV AUG 1984

X15 PREAMP (1)

WRU 672

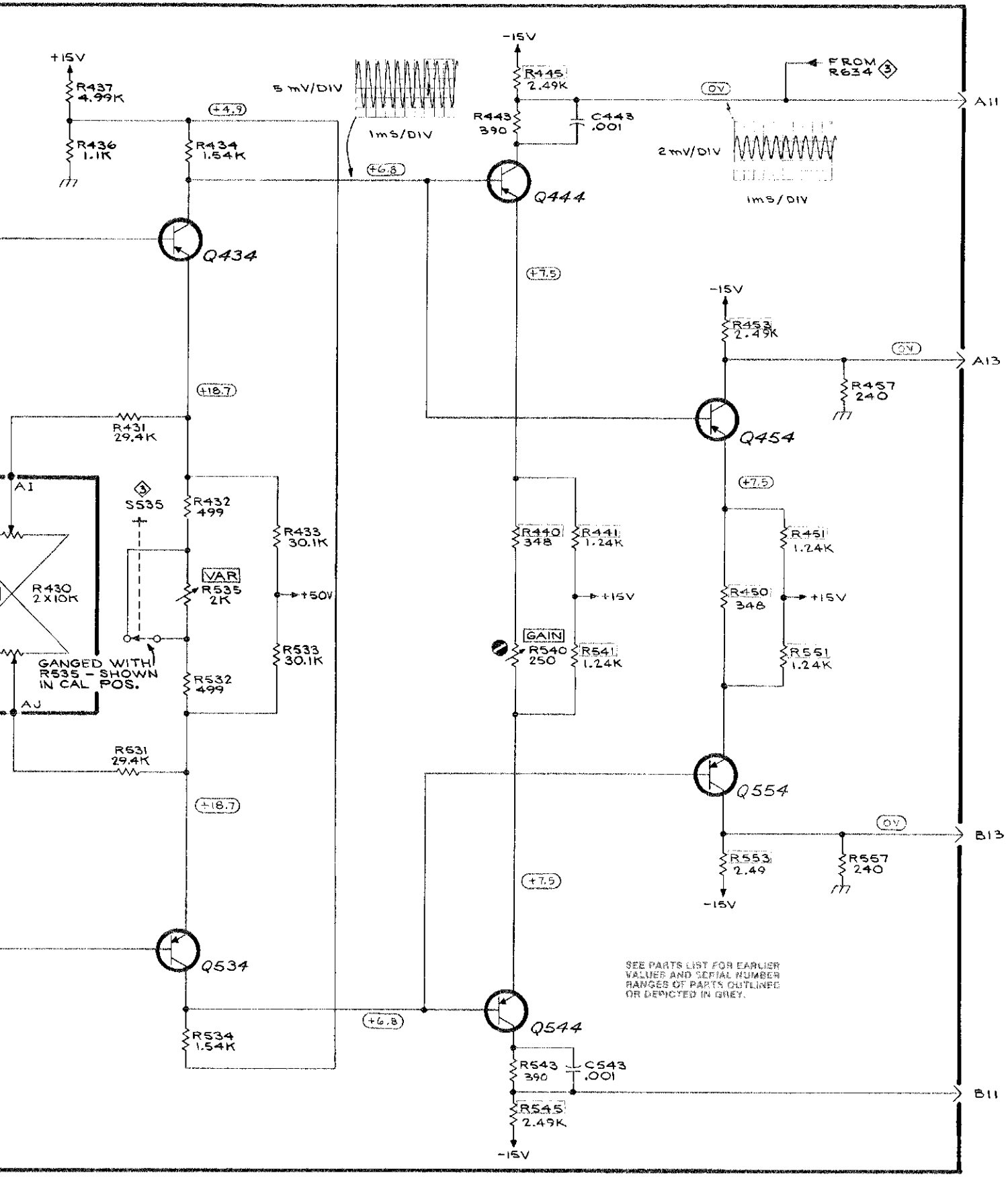


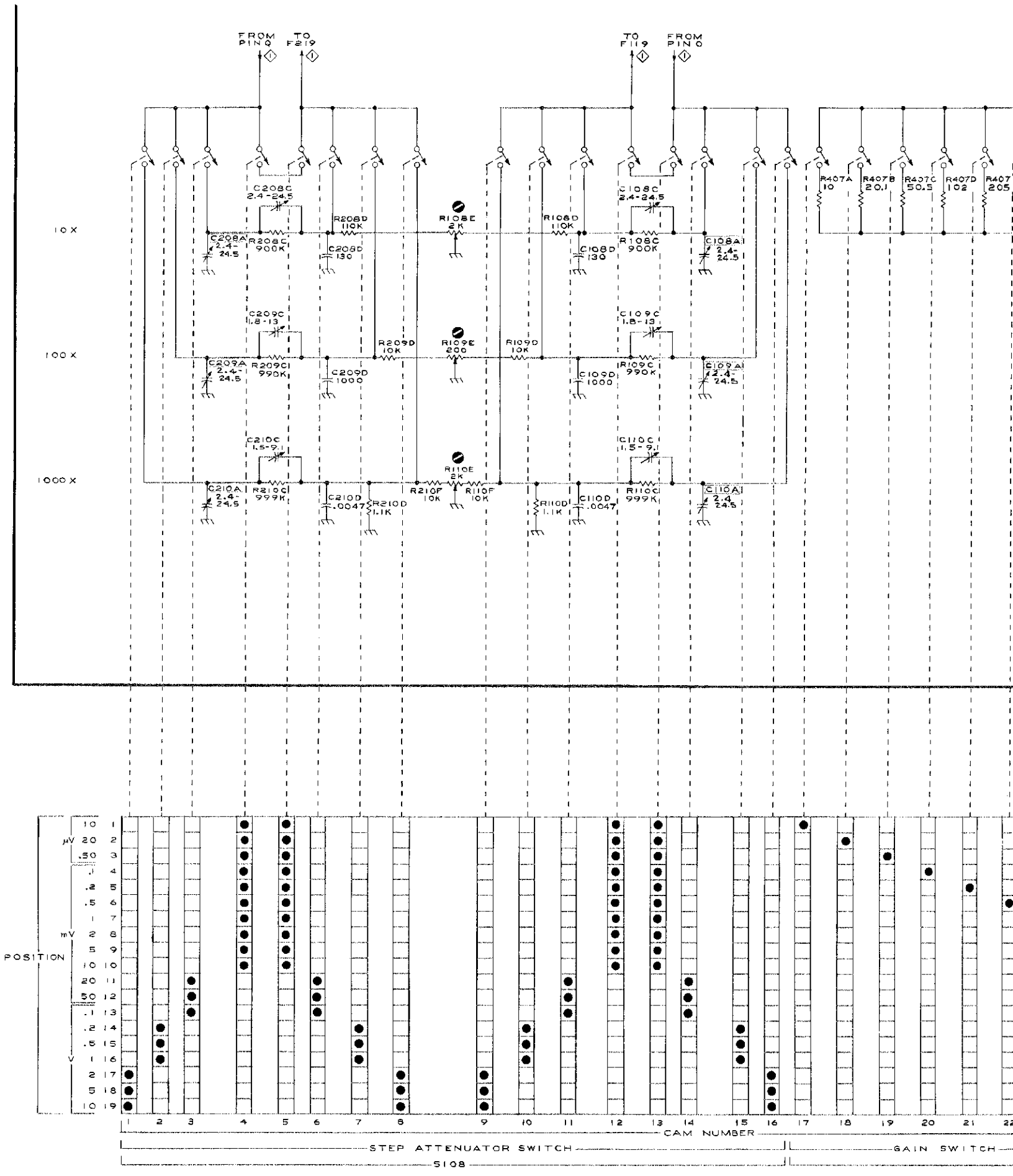
REFERENCE DIAGRAMS
1 X15 PREAMP
3 VOLTS/DIV SWITCH
4 FREQUENCY SELECTOR SWITCHES

VOLTAGE AND WAVEFORM CONDITIONS GIVEN ON DIAGRAM 1.

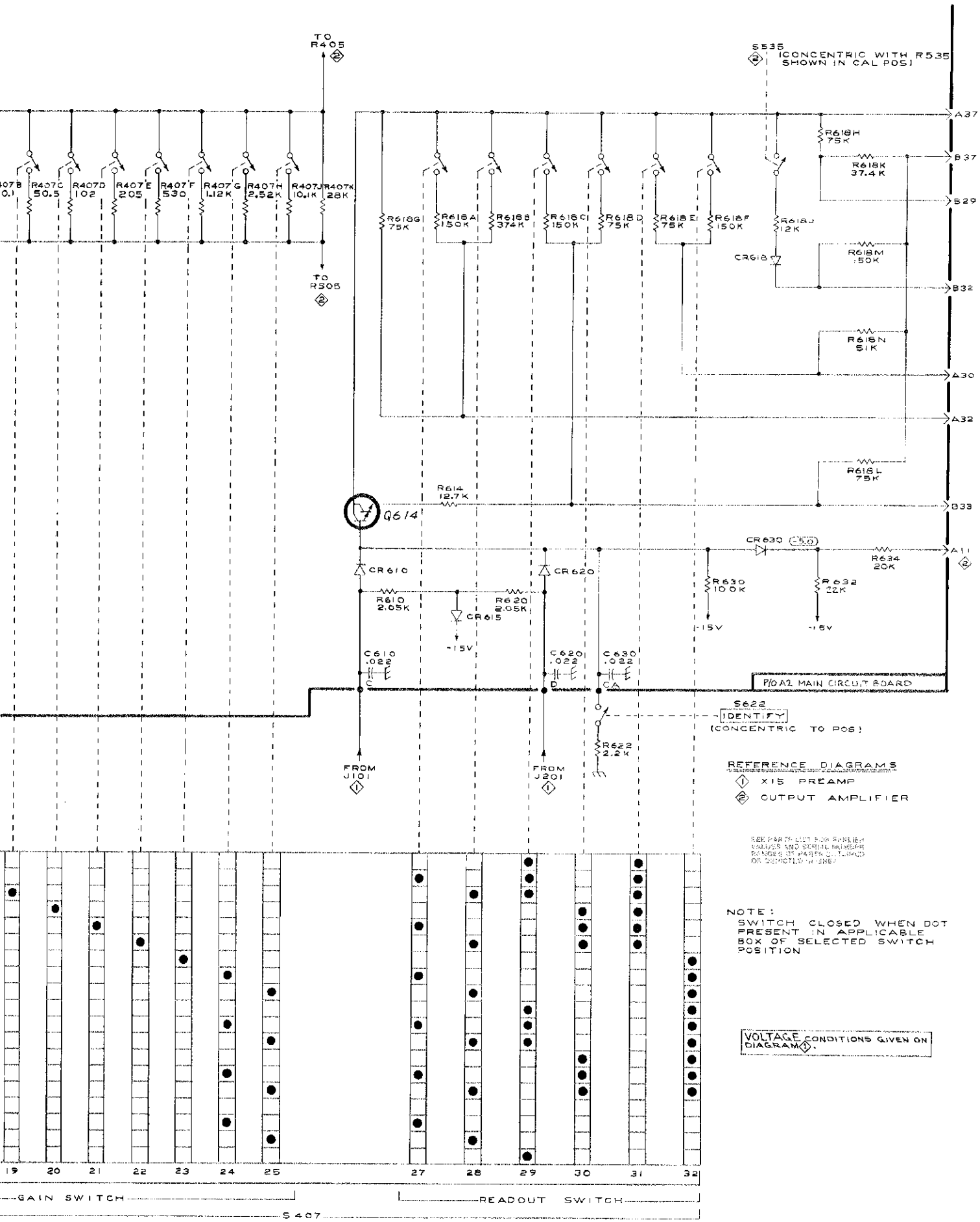
*THESE VOLTAGES WILL VARY WITH THE OPERATING BIAS AT Q404.

P/O A2 MAIN BOARD


+15V
R437 4.99K
R436 1.1K
+4.9
R434 1.54K
5 mV/DIV
1mS/DIV
+6.8
Q434
-15V
R445 2.49K
R443 390
C443 .001
Q444
FROM R634 ③
0V
A11
2mV/DIV
1mS/DIV
+7.5
-15V
R453 2.49K
0V
A13
R457 240
Q454
+18.7
R431 29.4K
A1
③
S535
R432 499
R433 30.1K
VAR
R535 2K
+50V
R533 30.1K
R532 499
GANGED WITH R535 - SHOWN IN CAL POS.
A J
R430 2X10K
R531 29.4K
+18.7
Q534
R534 1.54K
+6.8
R440 348
R441 1.24K
+15V
GAIN
R540 250
R541 1.24K
+7.5
R451 1.24K
R450 348
+15V
R551 1.24K
Q554
0V
B13
R553 2.49
R557 240
-15V
+7.5
Q544
R543 390
C543 .001
R545 2.49K
-15V
B11
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.


FROM PIN Q
TO F219
TO F119
FROM PIN O
10 X
100 X
1000 X
C208C 2.4-24.5
R208D 110K
R208C 900K
C208A 2.4-24.5
C208D 130
R210E 2K
R108E 2K
R108D 110K
C108C 2.4-24.5
R108C 900K
C108D 130
C108A 2.4-24.5
C209C 1.8-13
R209D 10K
R209C 990K
C209A 2.4-24.5
C209D 1000
R109E 200
R109D 10K
C109C 1.8-13
R109C 990K
C109D 1000
C109A 2.4-24.5
C210C 1.5-9.1
R210C 999K
C210A 2.4-24.5
C210D .0047
R210D 1.1K
R210F 10K
R110E 2K
R110F 10K
R110D 1.1K
C110C 1.5-9.1
R110C 999K
C110D .0047
C110A 2.4-24.5
R407A 10
R407B 20.1
R407C 50.5
R407D 102
R407 205
POSITION
10 1
μV 20 2
50 3
.1 4
.2 5
.5 6
1 7
mV 2 8
5 9
10 10
20 11
50 12
.1 13
.2 14
.5 15
V 1 16
2 17
5 18
10 19
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
CAM NUMBER
STEP ATTENUATOR SWITCH
GAIN SWITCH
5108

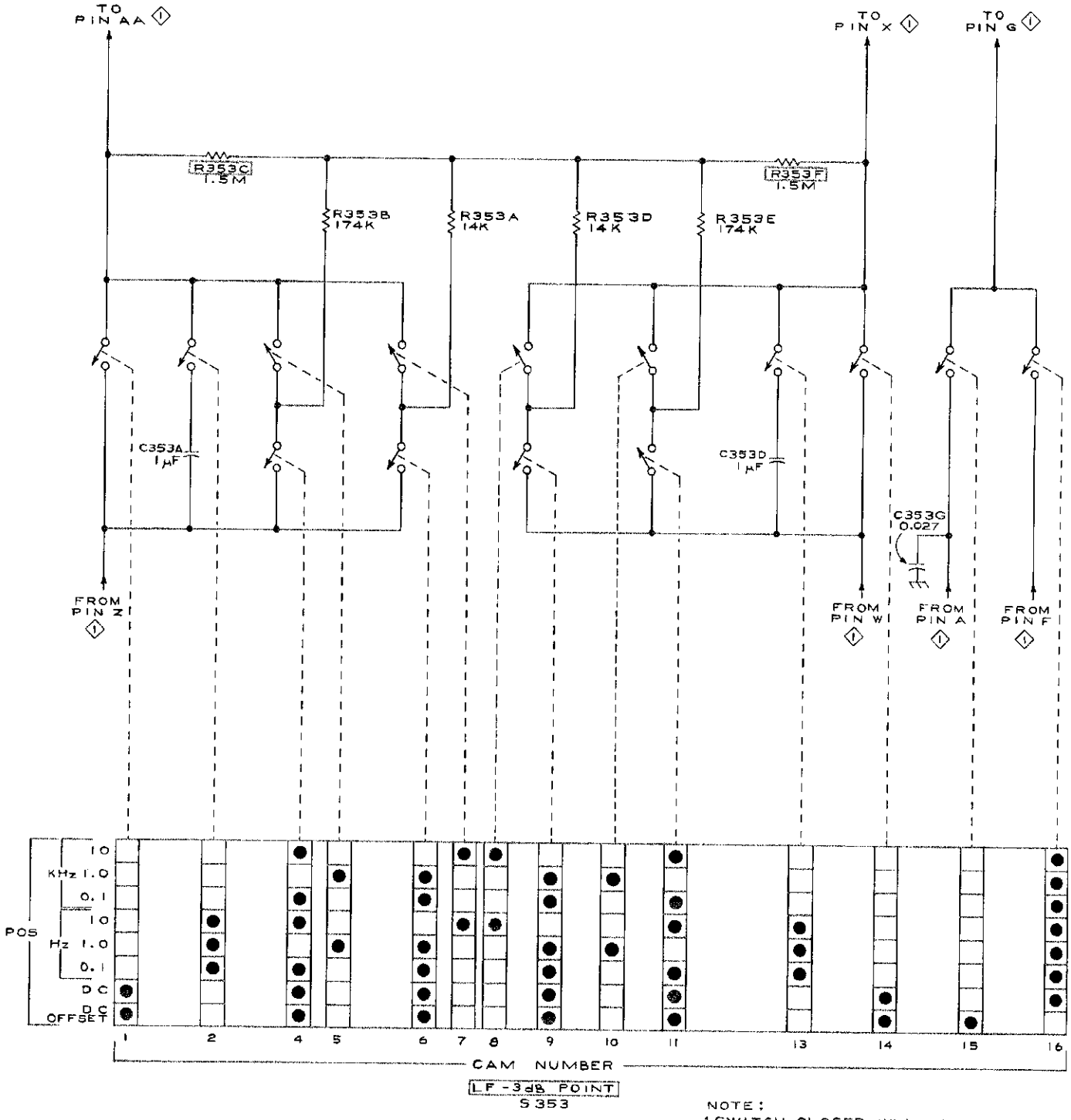
TYPE 7A22



0931-06
REV AUG 1984

VRS
0671

VOLTS / DIV SWITCH (3)

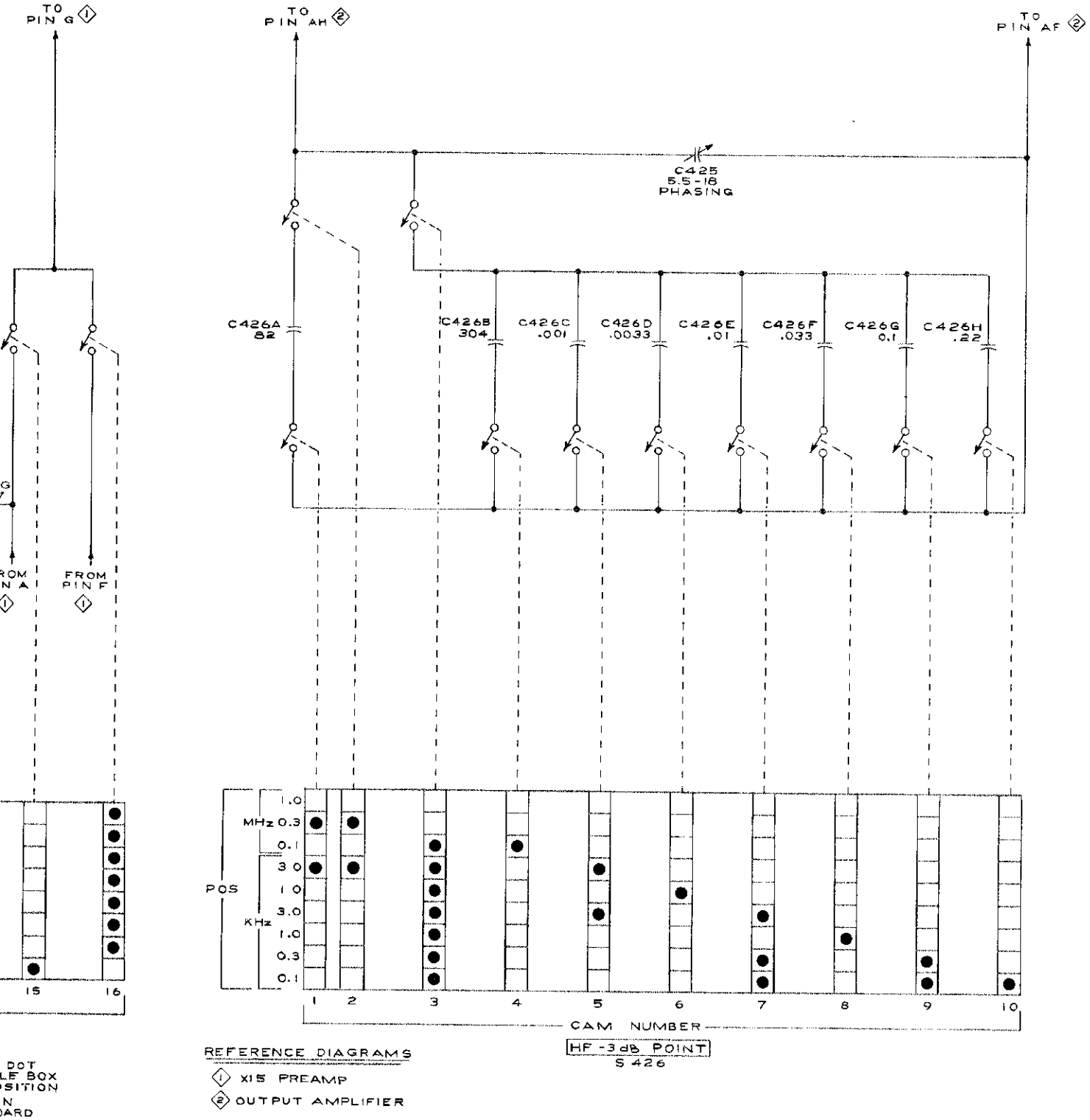


NOTE:
1. SWITCH CLOSED WHEN DOT PRESENT IN APPLICABLE BOX OF SELECED SWITCH POSITION
2. SWITCHES LOCATED ON BANDWIDTH CIRCUIT BOARD

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.

TYPE 7A22

0931-0
REV AUG



REFERENCE DIAGRAMS

① X15 PREAMP

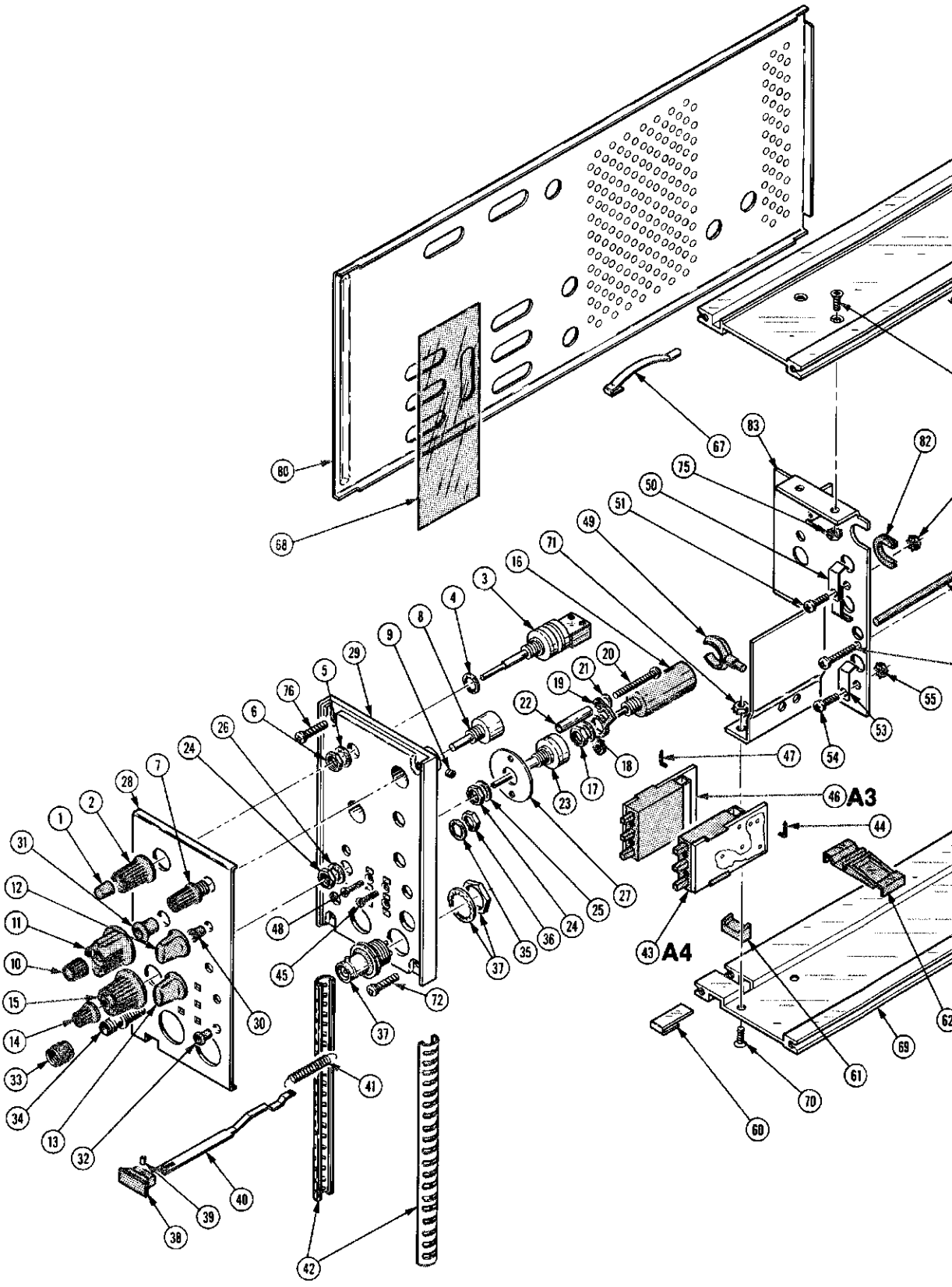
② OUTPUT AMPLIFIER

0931-07
REV AUG-1984

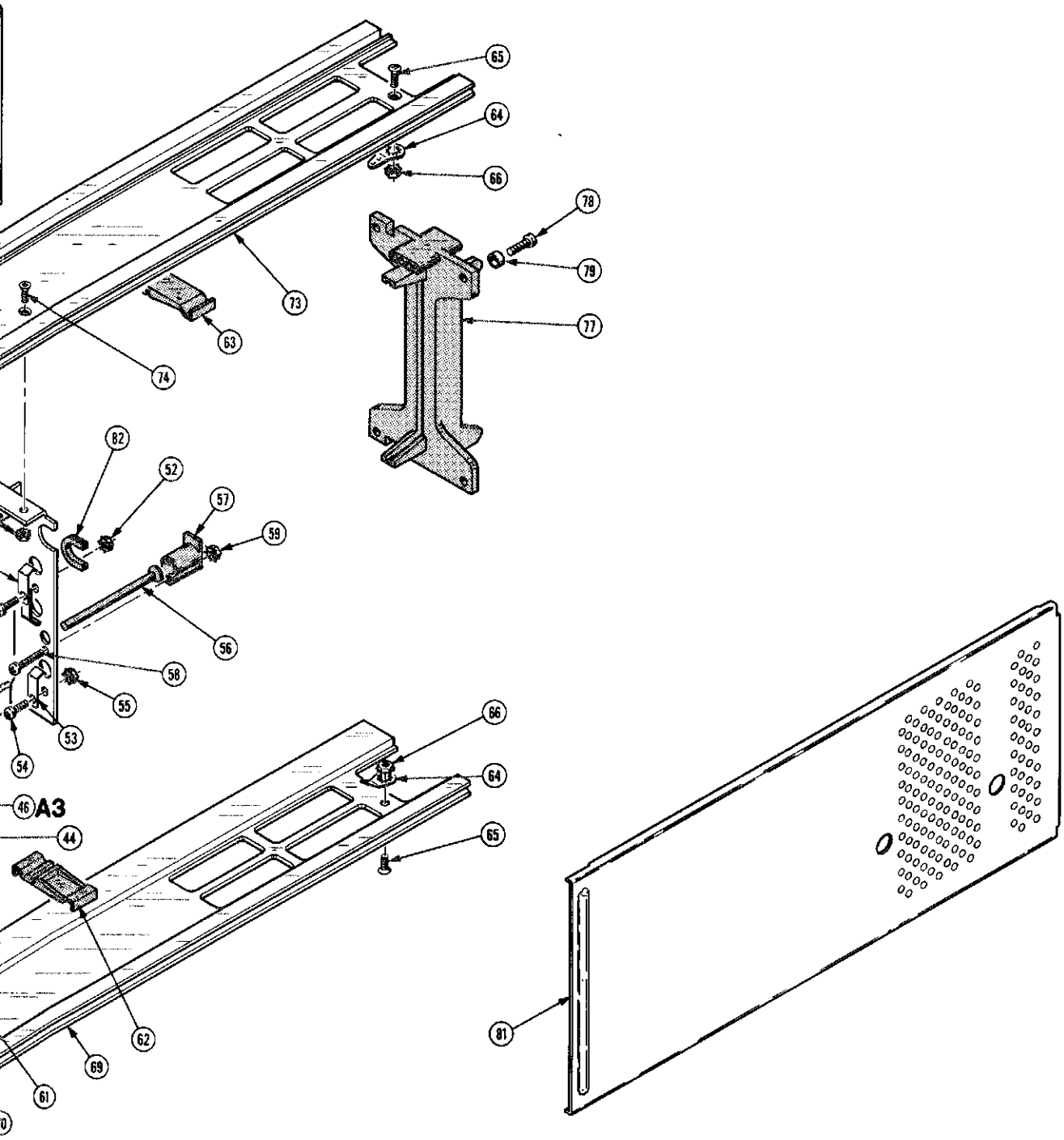
FREQUENCY SELECTOR SWITCHES ④

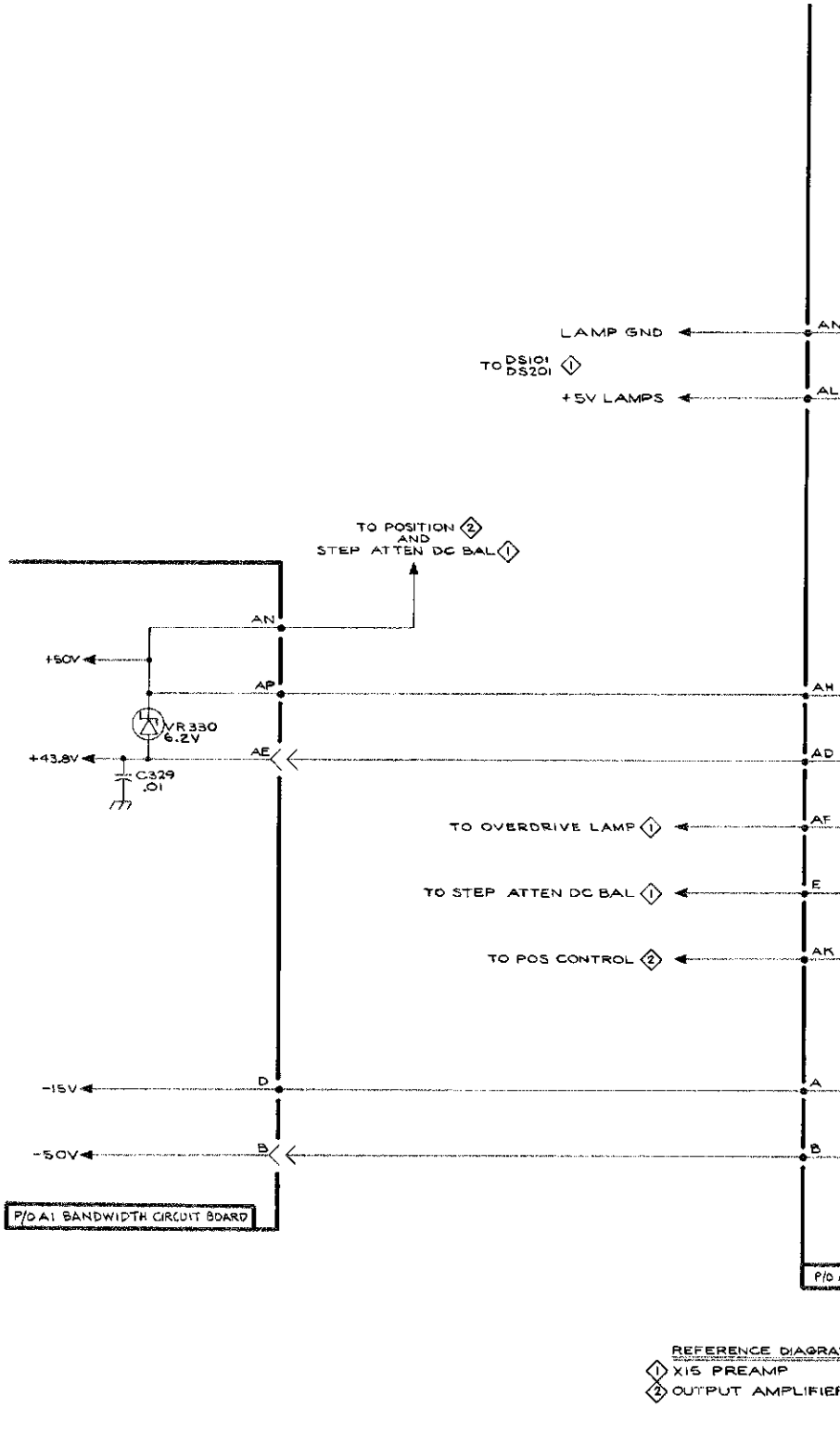
VRS
769

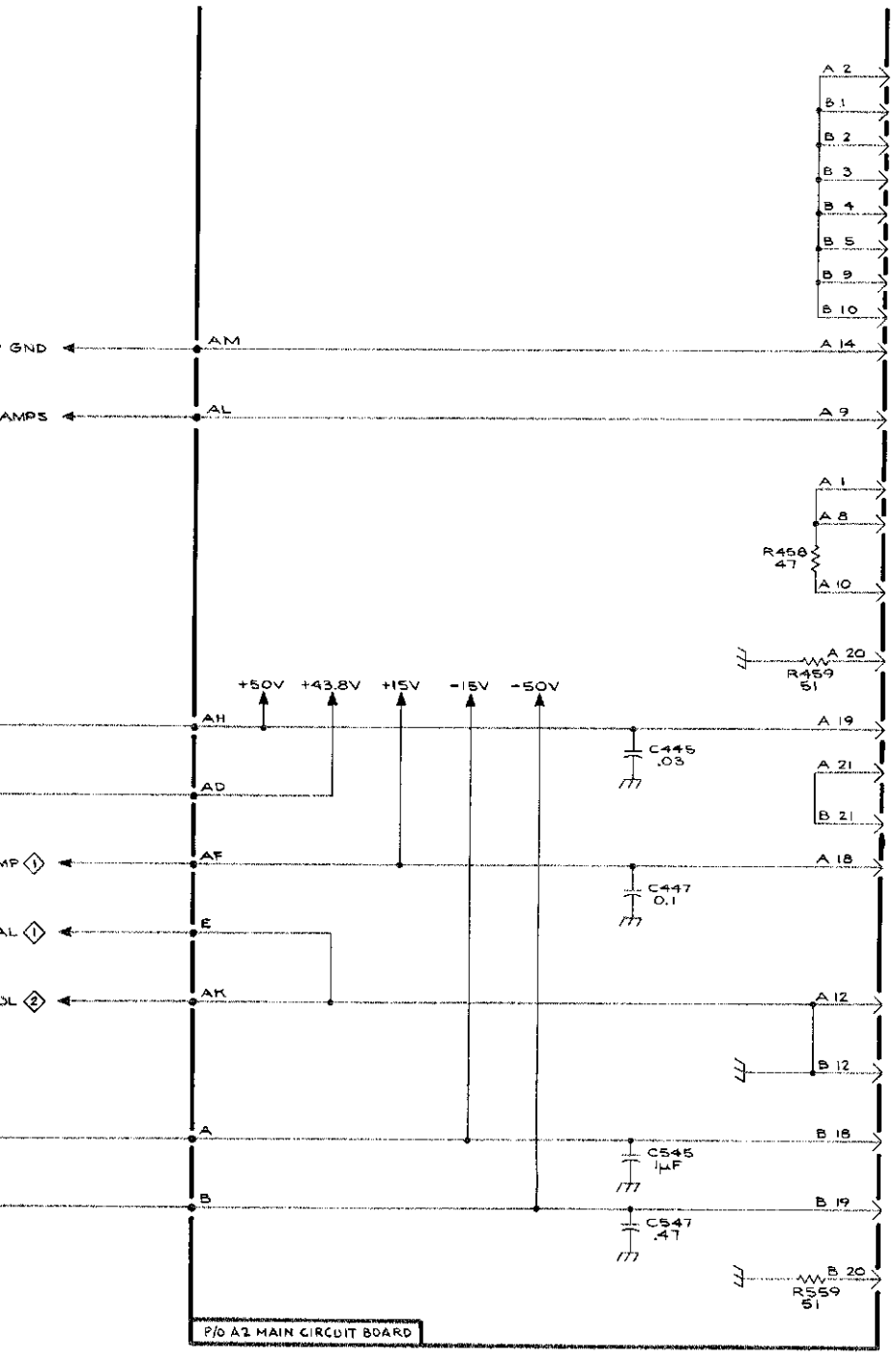
FIG. 1 FRONT & REAR



7A22 DIFFERENTIAL AMPLIFIER

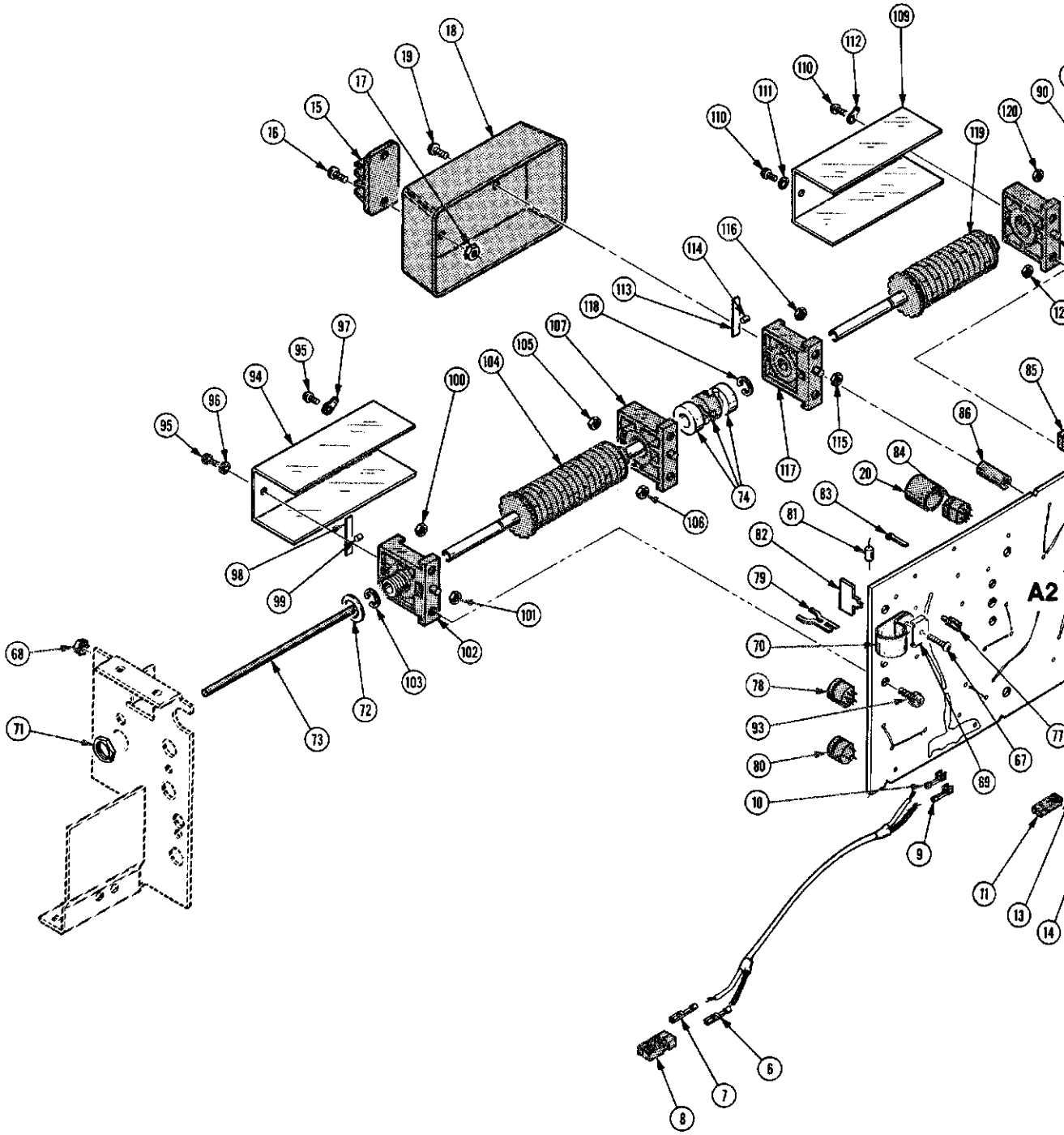

65
64
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66
64
65
46
A3
44
62
69
61
81


LAMP GND
TO DS101 DS201 ⟨1⟩
+5V LAMPS
TO POSITION ⟨2⟩ AND STEP ATTEN DC BAL ⟨1⟩
AN
+50V
AP
VR330 6.2V
+43.8V
AE
C329 .01
TO OVERDRIVE LAMP ⟨1⟩
TO STEP ATTEN DC BAL ⟨1⟩
TO POS CONTROL ⟨2⟩
-15V
D
-50V
B
P/O A1 BANDWIDTH CIRCUIT BOARD
AH
AD
AF
E
AK
A
B
REFERENCE DIAGRA
⟨1⟩ X15 PREAMP
⟨2⟩ OUTPUT AMPLIFIE

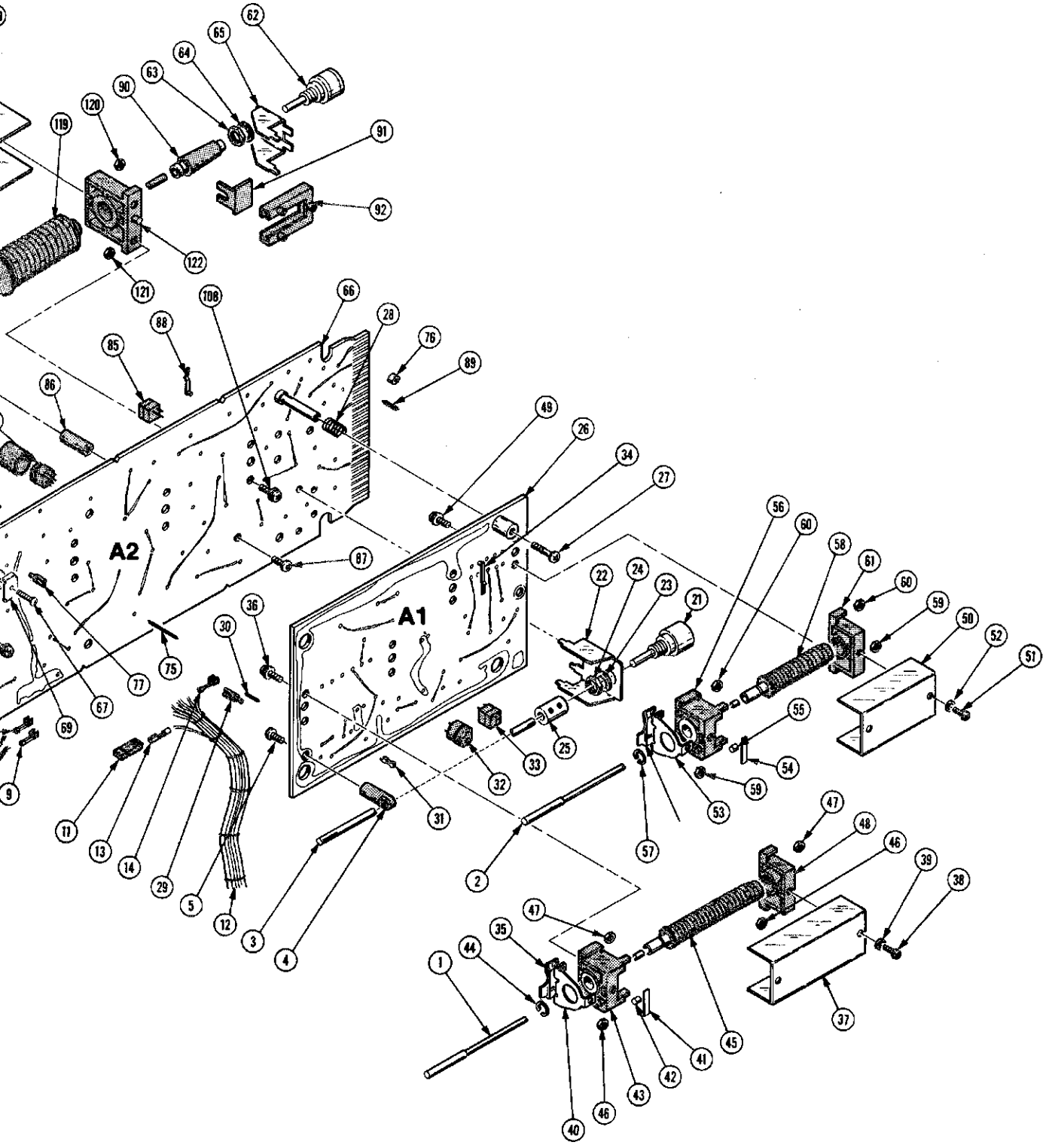


REFERENCE DIAGRAMS
1 X15 PREAMP
2 OUTPUT AMPLIFIER

FIG. 2 CIRCUIT BOARDS



7A22 DIFFERENTIAL AMPLIFIER


A1
A2

REPLACEABLE MECHANICAL PARTS

PARTS ORDERING INFORMATION

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

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

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

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

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

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

1 2 3 4 5 Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
- - - * - - -
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
- - - * - - -
Parts of Detail Part
Attaching parts for Parts of Detail Part
- - - * - - -

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

"	INCH
#	NUMBER SIZE
ACTR	ACTUATOR
ADPTR	ADAPTER
ALIGN	ALIGNMENT
AL	ALUMINUM
ASSEM	ASSEMBLED
ASSY	ASSEMBLY
ATTEN	ATTENUATOR
AWG	AMERICAN WIRE GAGE
BD	BOARD
BRKT	BRACKET
BRS	BRASS
BRZ	BRONZE
BSHG	BUSHING
CAB	CABINET
CAP	CAPACITOR
CER	CERAMIC
CHAS	CHASSIS
CKT	CIRCUIT
COMP	COMPOSITION
CONN	CONNECTOR
COV	COVER
CPLG	COUPLING
CRT	CATHODE RAY TUBE
DEG	DEGREE
DWR	DRAWER
ELCTRN	ELECTRON
ELEC	ELECTRICAL
ELCTLT	ELECTROLYTIC
ELEM	ELEMENT
EPL	ELECTRICAL PARTS LIST
EQPT	EQUIPMENT
EXT	EXTERNAL
FIL	FILLISTER HEAD
FLEX	FLEXIBLE
FLH	FLAT HEAD
FLTR	FILTER
FR	FRAME or FRONT
FSTNR	FASTENER
FT	FOOT
FXD	FIXED
GSKT	GASKET
HDL	HANDLE
HEX	HEXAGON
HEX HD	HEXAGONAL HEAD
HEX SOC	HEXAGONAL SOCKET
HLCPS	HELICAL COMPRESSION
HLEXT	HELICAL EXTENSION
HV	HIGH VOLTAGE
IC	INTEGRATED CIRCUIT
ID	INSIDE DIAMETER
IDENT	IDENTIFICATION
IMPLR	IMPELLER
IN	INCH
INCAND	INCANDESCENT
INSUL	INSULATOR
INTL	INTERNAL
LPHLDR	LAMPHOLDER
MACH	MACHINE
MECH	MECHANICAL
MTG	MOUNTING
NIP	NIPPLE
NON WIRE	NOT WIRE WOUND
OBD	ORDER BY DESCRIPTION
OD	OUTSIDE DIAMETER
OVH	OVAL HEAD
PH BRZ	PHOSPHOR BRONZE
PL	PLAIN or PLATE
PLSTC	PLASTIC
PN	PART NUMBER
PNH	PAN HEAD
PWR	POWER
RCPT	RECEPTACLE
RES	RESISTOR
RGD	RIGID
RLF	RELIEF
RTNR	RETAINER
SCH	SOCKET HEAD
SCOPE	OSCILLOSCOPE
SCR	SCREW
SE	SINGLE END
SECT	SECTION
SEMICOND	SEMICONDUCTOR
SHLD	SHIELD
SHLDR	SHOULDERED
SKT	SOCKET
SL	SLIDE
SLFLKG	SELF-LOCKING
SLVG	SLEEVING
SPR	SPRING
SQ	SQUARE
SST	STAINLESS STEEL
STL	STEEL
SW	SWITCH
T	TUBE
TERM	TERMINAL
THD	THREAD
THK	THICK
TNSN	TENSION
TPG	TAPPING
TRH	TRUSS HEAD
V	VOLTAGE
VAR	VARIABLE
W/	WITH
WSHR	WASHER
XFMR	TRANSFORMER
XSTR	TRANSISTOR

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
00779	AMP INC	P O BOX 3608	HARRISBURG PA 17105
06915	RICHCO PLASTIC CO	5825 N TRIPP AVE	CHICAGO IL 60646
06950	VSI CORP SCREMCORP DIVISION	13001 E TEMPLE AVE	CITY OF INDUSTRY CA 91746
12327	FREEWAY CORP	9301 ALLEN DR	CLEVELAND OH 44125
22526	DU PONT E I DE NEMOURS AND CO INC DU PONT CONNECTOR SYSTEMS	30 HUNTER LANE	CAMP HILL PA 17011
22599	AMERACE CORP ESNA DIV	15201 BURBANK BLVD SUITE C	VAN NUYS CA 91411
24546	CORNING GLASS WORKS	550 HIGH ST	BRADFORD PA 16701
24931	SPECIALTY CONNECTOR CO INC	2620 ENDRESS PLACE P O BOX D	GREENWOOD IN 46142
27238	BRISTOL INDUSTRIES	630 E LAMBERT RD P O BOX 630	BREA CA 92621
28520	HEYCO MOLDED PRODUCTS	147 MICHIGAN AVE P O BOX 160	KENILWORTH NJ 07033
56878	SPS TECHNOLOGIES INC	HIGHLAND AVE	JENKINTOWN PA 19046
71785	TRW INC TRW CINCH CONNECTORS	1501 MORSE AVE	ELK GROVE VILLAGE IL 60007
73743	FISCHER SPECIAL MFG CO	446 MORGAN ST	CINCINNATI OH 45206
74445	HOLO-KROME CO	31 BROOK ST	WEST HARTFORD CT 06110
76854	OAK SWITCH SYSTEMS INC SUB OF OAK TECHNOLOGY INC	100 S MAIN ST	CRYSTAL LAKE IL 60014
77900	SHAKEPROOF DIV OF ILLINOIS TOOL WORKS	SAINT CHARLES RD	ELGIN IL 60120
78189	ILLINOIS TOOL WORKS INC SHAKEPROOF DIVISION	ST CHARLES ROAD	ELGIN IL 60120
79136	WALDES KOHINOOR INC	47-16 AUSTEL PLACE	LONG ISLAND CITY NY 11101
80009	TEKTRONIX INC	4900 S W GRIFFITH DR P O BOX 500	BEAVERTON OR 97077
83385	MICRODOT MANUFACTURING INC GREER-CENTRAL DIV	3221 W BIG BEAVER RD	TROY MI 48098
83486	ELCO INDUSTRIES INC	1101 SAMUELSON RD	ROCKFORD IL 61101
86928	SEASTROM MFG CO INC	701 SONORA AVE	GLENDALE CA 91201
87308	N L INDUSTRIES INC N L FASTENERS	BARKLEY RD P O BOX 1360	STATESVILLE NC 28677
93907	TEXTRON INC CAMCAR DIV	600 18TH AVE	ROCKFORD IL 61101
95987	WECKESSER CO INC	4444 WEST IRVING PARK RD	CHICAGO IL 60641
99934	RENBRANDT INC.	6 PARMELEE STREET	BOSTON, MA 02118
TK0433	PORTLAND SCREW CO	6520 N BASIN	PORTLAND OR 97217
TK0435	LEWIS SCREW CO	4114 S PEORIA	CHICAGO IL 60609

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-1	366-1059-00			1	PUSH BUTTON:GRAY,0.227 OD X 0.3	80009	366-1059-00
-2	366-1077-00			1	KNOB:GRAY W/SETSCREW	80009	366-1077-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	27238	ORDER BY DESCR
-3	------ ------			1	RESISTOR,VAR:(SEE R430 REPL)		
					(ATTACHING PARTS)		
-4	210-0046-00			1	WASHER,LOCK:0.261 ID,INTL,0.018 THK,STL	77900	1214-05-00-0541C
-5	210-0940-00			1	WASHER,FLAT:0.25 ID X 0.375 OD X 0.02,STL	12327	ORDER BY DESCR
-6	210-0583-00			1	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
					(END ATTACHING PARTS)		
-7	366-0392-02			1	KNOB:GY,0.125 ID X 0.375 H X 0.812 H	80009	366-0392-02
-8	------ ------			1	RESISTOR,VAR:(SEE R258 REPL)		
					(ATTACHING PARTS)		
-9	213-0020-00			1	SETSCREW:6-32 X 0.125,STL	TK0433	ORDER BY DESCR
					(END ATTACHING PARTS)		
-10	366-1166-00			1	KNOB:RED,0.127 ID X 0.392 OD X 0.4 H	80009	366-1166-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	27238	ORDER BY DESCR
-11	366-1057-00			1	KNOB:GY,0.252 ID X 0.796 OD X 0.79 H	80009	366-1057-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	27238	ORDER BY DESCR
-12	366-0379-00			1	KNOB:GRAY,0.127 ID X 0.5 OD X 0.93 H	80009	366-0379-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	27238	ORDER BY DESCR
-13	366-0379-00			1	KNOB:GRAY,0.127 ID X 0.5 OD X 0.93 H	80009	366-0379-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	27238	ORDER BY DESCR
-14	366-1084-00			1	KNOB:GY,0.08 ID X 0.392 OD X 0.4 H	80009	366-1084-00
	213-0725-00			1	.SETSCREW:3-48 X 0.094,STL	56878	ORDER BY DESCR
-15	366-1101-00			1	KNOB:GY,0.127 ID X 0.706 OD X 0.6 H	80009	366-1101-00
	213-0153-00			1	.SETSCREW:5-40 X 0.125,STL	27238	ORDER BY DESCR
-16	------ ------			1	RESISTOR,VAR:(SEE R270 REPL)		
					(ATTACHING PARTS)		
-17	210-0583-00			1	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
-18	210-0046-00			1	WASHER,LOCK:0.261 ID,INTL,0.018 THK,STL	77900	1214-05-00-0541C
					(END ATTACHING PARTS)		
-19	426-0474-00			1	MOUNT,RESILIENT:NATURAL ACETAL	80009	426-0474-00
					(ATTACHING PARTS)		
-20	211-0111-00			2	SCREW,MACHINE:2-56 X 1.0,PNH,STL	06950	ORDER BY DESCR
-21	210-0001-00			2	WASHER,LOCK:#2 INTL,0.013 THK,STL	77900	1202-00-00-0541C
					(END ATTACHING PARTS)		
-22	361-0280-00			2	SPACER,SLEEVE:0.75 ID X 0.092 ID,BRS	76854	3-5152-340
-23	------ ------			1	RESISTOR,VAR:(SEE R265 REPL)		
					(ATTACHING PARTS)		
-24	210-0583-00			2	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
-25	210-0046-00			1	WASHER,LOCK:0.261 ID,INTL,0.018 THK,STL	77900	1214-05-00-0541C
-26	210-0940-00			1	WASHER,FLAT:0.25 ID X 0.375 OD X 0.02,STL	12327	ORDER BY DESCR
					(END ATTACHING PARTS)		
-27	386-1095-00			1	PLATE,CMPNT MTG:VAR RESISTOR,STL CD PL	80009	386-1095-00
-28	333-1106-00			1	PANEL,FRONT:	80009	333-1106-00
-29	386-1447-07			1	SUBPANEL,FRONT:	80009	386-1447-07
-30	348-0031-00			2	GROMMET,PLASTIC:0.127 ID,GRAY ACETAL	80009	348-0031-00
-31	358-0216-00			1	GROMMET,PLASTIC:GRAY,ROUND,0.257 ID	80009	358-0216-00
-32	358-0378-00	B010100	B117899	1	BUSHING,SLEEVE:0.131 ID X 0.18 OD X 0.125 L	80009	358-0378-00
	358-0599-00	B117900		1	BUSHING,SLEEVE:0.125 ID X 0.25 OD X 0.234	28520	B-187-125
	129-0053-00			1	POST,BDG,ELEC:5 WAY,UNINSULATED	80009	129-0053-00
-33	200-0103-00			1	.NUT,PLAIN,KNURL:0.25-28 X 0.375"OD BRASS	80009	200-0103-00
-34	355-0507-00			1	.STUD,SHOULDERED:BINDING POST,BRS NP	80009	355-0507-00
					(ATTACHING PARTS)		
-35	210-0046-00			1	WASHER,LOCK:0.261 ID,INTL,0.018 THK,STL	77900	1214-05-00-0541C
-36	210-0583-00			1	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
					(END ATTACHING PARTS)		
-37	131-0679-02			2	CONN,RCPT,ELEC:BNC,MALE,3 CONTACT	24931	28JR270-1
					(ATTACHING PARTS)		
	210-1039-00			2	WASHER,LOCK:0.521 ID,INT,0.025 THK,SST	24931	ORDER BY DESCR
	220-0497-00			2	NUT,PLAIN,HEX:0.5-28 X 0.562 HEX,BRS CD PL	80009	220-0497-00
					(END ATTACHING PARTS)		
-38	366-1058-07			1	KNOB:GRAY,7A22	80009	366-1058-07
					(ATTACHING PARTS)		
-39	214-1095-00			1	PIN,SPRING:0.187 L X 0.094 OD,STL,CD PL	22599	52-022-094-0187
					(END ATTACHING PARTS)		
-40	105-0076-02	B010100	B122379	1	RELEASE BAR,LCH:PLUG-IN UNIT	80009	105-0076-02

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345	Name & Description	Mfr. Code	Mfr. Part No.
1-	105-0076-04	B122380		1		RELEASE BAR,LCH:PLUG-IN UNIT	80009	105-0076-04
-41	214-1280-00			1		SPRING,HLCPS:0.14 OD X 1.126 L,TWIST LOOP	80009	214-1280-00
-42	348-0157-00	B010100	B010180	2		SHLD GSKT,ELEK:C-SHAPED,4.86 L	80009	348-0157-00
	349-0235-00	B010181		2		SHLD GSKT,ELEK:FINGER TYPE,4.734 L	92101	ORDER BY DESCR
-43	----- -----			1		CKT BOARD ASSY:-AC GND DC(SEE A3 REPL)		
-44	131-0589-00			2		.TERM,PIN:0.46 L X 0.025 SQ PH BRZ GLD	22526	48283-029
	131-0722-00	B118250		1		.CONTACT,ELEC:CAM SW,CU BE	80009	131-0722-00
						.(ATTACHING PARTS)		
-45	211-0156-00			2		SCREW,MACHINE:1-72 X 0.250,FLH,82 DEG,STL	93907	ORDER BY DESCR
						(END ATTACHING PARTS)		
-46	----- -----			1		CKT BOARD ASSY:+AC GND DC(SEE A4 REPL)		
-47	131-0589-00			2		.TERM,PIN:0.46 L X 0.025 SQ PH BRZ GLD	22526	48283-029
	131-0722-00	B118250		1		.CONTACT,ELEC:CAM SW,CU BE	80009	131-0722-00
						(ATTACHING PARTS)		
-48	211-0156-00			2		SCREW,MACHINE:1-72 X 0.250,FLH,82 DEG,STL	93907	ORDER BY DESCR
						(END ATTACHING PARTS)		
-49	352-0068-00			2		HOLDER,PROBE:DELRIN	80009	352-0068-00
-50	131-0664-00			2		CONTACT,ELEC:GROUNDING,CU BE ALBALOY PL	80009	131-0664-00
						(ATTACHING PARTS)		
-51	211-0008-00			1		SCREW,MACHINE:4-40 X 0.25,PNH,STL	93907	ORDER BY DESCR
-52	210-0586-00			1		NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
						(END ATTACHING PARTS)		
-53	131-0664-00			1		CONTACT,ELEC:GROUNDING,CU BE ALBALOY PL	80009	131-0664-00
						(ATTACHING PARTS)		
-54	211-0008-00			1		SCREW,MACHINE:4-40 X 0.25,PNH,STL	93907	ORDER BY DESCR
-55	210-0586-00			1		NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
						(END ATTACHING PARTS)		
-56	378-0600-00			1		LENS,LIGHT:AMBER,0.152 DIA	80009	378-0600-00
-57	352-0067-00			1		LAMPHOLDER:(1)MIRE LEAD NEON	80009	352-0067-00
						(ATTACHING PARTS)		
-58	211-0018-00			1		SCREW,MACHINE:4-40 X 0.875,PNH,STL	TK0435	ORDER BY DESCR
-59	210-0406-00			1		NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
						(END ATTACHING PARTS)		
-60	214-1054-00			1		SPRING,FLAT:0.825 X 0.322,SST	80009	214-1054-00
-61	105-0075-00			1		BOLT,LATCH:	80009	105-0075-00
-62	344-0162-00	B010100	B050549	3		CLIP,SPR TNSN:CIRCUIT BOARD,BOT,DELRIN	80009	344-0162-00
	344-0211-00	B050550		3		CLIP,SPR TNSN:CKT BD,BOT,1.473 L,DELRIN MED GRAY	80009	344-0211-00
-63	344-0161-00	B010100	B050549	2		CLIP,SPR TNSN:CIRCUIT BOARD,DELRIN	80009	344-0161-00
	344-0210-00	B050550		2		CLIP,SPR TNSN:CKT BD,TOP,1.675 L,DELRIN MED GRAY	80009	344-0210-00
-64	210-0201-00			2		TERMINAL,LUG:0.12 ID,LOCKING,BRZ TIN PL	86928	A373-157-2
						(ATTACHING PARTS)		
-65	211-0101-00			1		SCREW,MACHINE:4-40 X 0.25,FLH,100 DG,STL	TK0435	ORDER BY DESCR
-66	210-0586-00			1		NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
						(END ATTACHING PARTS)		
	334-3438-00	B121000		1		MARKER,IDENT:MARKED TURN OFF POWER	80009	334-3438-00
-67	214-1061-00			1		CONTACT,ELEC:GROUNDING,CU BE	80009	214-1061-00
-68	337-1243-00			1		SHIELD,ELEC:	80009	337-1243-00
-69	426-0499-03			1		FR SECT,PLUG-IN:BOTTOM	80009	426-0499-03
						(ATTACHING PARTS)		
-70	211-0101-00			2		SCREW,MACHINE:4-40 X 0.25,FLH,100 DG,STL	TK0435	ORDER BY DESCR
-71	210-0586-00			2		NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
-72	213-0192-00	B010100	B120725	2		SCREW,TPG,TF:6-32 X 0.5,SPCL TYPE,FILH,STL	87308	ORDER BY DESCR
	213-0793-00	B120726		2		SCREW,TPG,TF:6-32 X 0.4375,TAPTITE,FILH	83486	239-006-406043
						(END ATTACHING PARTS)		
-73	426-0505-03			1		FR SECT,PLUG-IN:TOP	80009	426-0505-03
						(ATTACHING PARTS)		
-74	211-0101-00			2		SCREW,MACHINE:4-40 X 0.25,FLH,100 DG,STL	TK0435	ORDER BY DESCR
-75	210-0586-00			2		NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
-76	213-0192-00	B010100	B120725	2		SCREW,TPG,TF:6-32 X 0.5,SPCL TYPE,FILH,STL	87308	ORDER BY DESCR
	213-0793-00	B120726		2		SCREW,TPG,TF:6-32 X 0.4375,TAPTITE,FILH	83486	239-006-406043
						(END ATTACHING PARTS)		
-77	386-1402-00			1		PANEL,REAR:	80009	386-1402-00
						(ATTACHING PARTS)		
-78	213-0192-00	B010100	B120725	4		SCREW,TPG,TF:6-32 X 0.5,SPCL TYPE,FILH,STL	87308	ORDER BY DESCR
	213-0793-00	B120726		4		SCREW,TPG,TF:6-32 X 0.4375,TAPTITE,FILH	83486	239-006-406043

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-79	361-0326-00			1	SPACER,SLEEVE:0.1 L X 0.18 ID,AL (END ATTACHING PARTS)	80009	361-0326-00
-80	337-1145-00	8010100	8069999	1	SHIELD,ELEC:LEFT SIDE	80009	337-1145-00
	337-1145-01	8070000		1	SHIELD,ELEC:LEFT SIDE	80009	337-1145-01
-81	337-1146-00	8010100	8069999	1	SHIELD,ELEC:RIGHT SIDE	80009	337-1146-00
	337-1146-01	8070000		1	SHIELD,ELEC:RIGHT SIDE	80009	337-1146-01
-82	348-0115-00			1	GROMMET,PLASTIC:BLACK,U-SHAPE,0.368 ID	80009	348-0115-00
-83	337-1045-00			1	SHIELD,ELEC:INPUT	80009	337-1045-00

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
2-1	384-0255-00			1	EXTENSION SHAFT:5.594 L X 0.125 STEP OD	80009	384-0255-00
-2	384-0306-00			1	EXTENSION SHAFT:9.5 L X 0.125 STEP OD,STL	80009	384-0306-00
-3	384-0444-00			1	EXTENSION SHAFT:10.738 L X 0.125 OD,AL	80009	384-0444-00
-4	351-0159-00			1	GUIDE,SHAFT:U/M 0.125 OD SHAFT,DELRIN	80009	351-0159-00
					(ATTACHING PARTS)		
-5	213-0088-00			1	SCREW,TPG,TF:4-24 X 0.25,TYPE B,PNH,STL	83385	ORDER BY DESCR
					(END ATTACHING PARTS)		
-6	131-0792-02			2	CONNECTOR,TERM:18-20 AWG,CU BE GOLD	80009	131-0792-02
	198-1999-00			1	WIRE SET,ELEC:	80009	198-1999-00
-7	131-0622-00			2	.CONTACT,ELEC:28-32 AWG,BRS & CU BE GLD PL	22526	46241-000
-8	352-0198-00			2	.HLDR,TERM CONN:2 WIRE,BLACK	80009	352-0198-00
-9	131-0740-01			2	.CONNECTOR,TERM:18-20 AWG,CU BE GOLD PL	00779	61942-1
-10	131-0755-01			2	.CONTACT,ELEC:28-32 AWG,BE CU GOLD PL,MOD	00779	61943-1
-11	352-0169-00			2	HLDR,TERM CONN:2 WIRE,BLACK	80009	352-0169-00
-12	179-1407-00			1	WIRING HARNESS:MAIN	80009	179-1407-00
-13	131-0707-00			4	.CONTACT,ELEC:22-26 AWG,BRS,CU BE GLD PL	22526	47439-000
-14	131-0512-00			27	.CONTACT,ELEC:CONNECTOR,CU BE GOLD PL	00779	61507-1
-15	352-0136-00			1	FUSEHOLDER:(2)3AG SPARES	80009	352-0136-00
					(ATTACHING PARTS)		
-16	211-0008-00			2	SCREW,MACHINE:4-40 X 0.25,PNH,STL	93907	ORDER BY DESCR
-17	210-0586-00			2	NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
					(END ATTACHING PARTS)		
-18	200-0902-00			1	COVER,CKT BOARD:BOX PLASTIC	80009	200-0902-00
					(ATTACHING PARTS)		
-19	211-0008-00			1	SCREW,MACHINE:4-40 X 0.25,PNH,STL	93907	ORDER BY DESCR
					(END ATTACHING PARTS)		
-20	200-0687-01			2	COVER,XSTR:TO-5,ACETAL	80009	200-0687-01
-21	----- -----			1	RESISTOR,VAR:(SEE R540 REPL)		
					(ATTACHING PARTS)		
-22	407-0554-00			1	BRACKET,CMPNT:BRASS ALBALOY PL	80009	407-0554-00
-23	210-0046-00			1	WASHER,LOCK:0.261 ID,INTL,0.018 THK,STL	77900	1214-05-00-0541C
-24	210-0583-00			1	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
					(END ATTACHING PARTS)		
-25	376-0029-00			1	CPLG,SHAFT,RGD:0.128 ID X 0.312 OD,AL	80009	376-0029-00
	213-0075-00			2	..SETSCREW:4-40 X 0.094,STL	74445	ORDER BY DESCR
-26	----- -----			1	CKT BOARD ASSY:BANDWIDTH(SEE A1 REPL)		
					(ATTACHING PARTS)		
-27	211-0155-00			4	SCREW,EXT RLV:4-40 X 0.375,PNH,SST,POZ	80009	211-0155-00
-28	210-1140-00			4	WASHER,SHLDR:0.115 ID X 0.375 OD	80009	210-1140-00
					(END ATTACHING PARTS)		
					CKT BOARD ASSY INCLUDES:		
-29	351-0155-00			5	.INSULATOR,STDF:CONNECTOR,DELRIN	80009	351-0155-00
-30	131-0608-00			5	.TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
-31	136-0263-01	B010100	B010180	18	.SOCKET,PIN TERM:U/M 0.025 SQ PIN	00779	85861-2
	136-0263-03	B010181	B094559	18	.SOCKET,PIN TERM:U/M 0.025 SQ PINS	00779	85864-2
	136-0263-04	B094560		18	.SOCKET,PIN TERM:U/M 0.025 SQ PIN	22526	75377-001
-32	136-0183-00	B010100	B121634	3	.SKT,PL-IN ELEK:TRANS,3 CONTACT,PCB MT	80009	136-0183-00
-33	136-0220-00	B010100	B121634	3	.SKT,PL-IN ELEK:TRANSISTOR 3 CONTACT	71785	133-23-11-034
	136-0252-07	B121635		18	.SOCKET,PIN CONN:M/O DIMPLE	22526	75060-012
-34	131-0604-00			24	.CONTACT,ELEC:CKT BD SW,SPR,CU BE	80009	131-0604-00
-35	131-0840-00	B010181		2	.CONTACT,ELEC:GROUNDING,NI BE	80009	131-0840-00
	105-0415-00			1	.ACTR ASSY,CAM S:BANDWIDTH	80009	105-0415-00
					.(ATYACHING PARTS)		
-36	211-0116-00	B010100	B120999	4	.SCR,ASSEM WSHR:4-40 X 0.312,PNH,BRS,NP	77900	ORDER BY DESCR
	211-0292-00	B121000		4	.SCR,ASSEM WSHR:4-40 X 0.29,PNH,BRS NI PL	78189	51-040445-01
					.(END ATTACHING PARTS)		
-37	200-0996-00			1	..COVER,CAM SW:16 ELEMENTS	80009	200-0996-00
					..(ATTACHING PARTS)		
-38	211-0022-00			2	..SCREW,MACHINE:2-56 X 0.188,PNH,STL	TK0435	ORDER BY DESCR
-39	210-0001-00			2	..WASHER,LOCK:#2 INTL,0.013 THK,STL	77900	1202-00-00-0541C
					..(END ATTACHING PARTS)		
-40	407-0714-00			1	..BRACKET,CAM SW:GROUNDING,BRS ALBALOY PL	80009	407-0714-00
-41	214-1126-02			2	..SPRING,FLAT:0.7 X 0.125,CU BE RED CLR	80009	214-1126-02
-42	214-1127-00			1	..ROLLER,DETENT:0.125 DIA X 0.125,SST	80009	214-1127-00
-43	401-0058-00			1	..BEARING,CAM SW:FRONT,0.454 DIA CAM	80009	401-0058-00
					..(ATTACHING PARTS)		
-44	354-0219-00			1	..RING,RETAINING:EXT,CRESCENT,U/O 0.25 DIA	79136	5103-25-S-ZO-R

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
2-					..(END ATTACHING PARTS)		
-45	105-0112-00			1	..ACTUATOR,CAM SW:LOW FREQ	80009	105-0112-00
	213-0075-00			2	..SETSCREW:4-40 X 0.094,STL	74445	ORDER BY DESCR
-46	210-0405-00			1	..NUT,PLAIN,HEX:2-56 X 0.188,BRS CD PL	73743	12157-50
-47	210-0406-00			2	..NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
-48	401-0061-00			1	..BEARING,CAM SW:REAR OR CENTER,0.454 DIA	80009	401-0061-00
	105-0466-00			1	.ACTR ASSY,CAM S:HF-308	80009	105-0466-00
					.(ATTACHING PARTS)		
-49	211-0116-00	B010100	B120999	4	.SCR,ASSEM WSHR:4-40 X 0.312,PNH,BRS,NP	77900	ORDER BY DESCR
	211-0292-00	B121000		4	.SCR,ASSEM WSHR:4-40 X 0.29,PNH,BRS NI PL	78189	51-040445-01
					.(END ATTACHING PARTS)		
-50	200-0995-00			1	..COVER,CAM SW:10 ELEMENTS	80009	200-0995-00
					..(ATTACHING PARTS)		
-51	211-0022-00			2	..SCREW,MACHINE:2-56 X 0.188,PNH,STL	TK0435	ORDER BY DESCR
-52	210-0001-00			2	..WASHER,LOCK:#2 INTL,0.013 THK,STL	77900	1202-00-00-0541C
					..(END ATTACHING PARTS)		
-53	407-0714-00	B010181		1	..BRACKET,CAM SW:GROUNDING,BRS ALBALOY PL	80009	407-0714-00
-54	214-1126-01			1	..SPRING,FLAT:0.7 X 0.125,CU BE GRN CLR	80009	214-1126-01
	214-1126-02			1	..SPRING,FLAT:0.7 X 0.125,CU BE RED CLR	80009	214-1126-02
-55	214-1127-00			1	..ROLLER,DETENT:0.125 DIA X 0.125,SST	80009	214-1127-00
-56	401-0058-00			1	..BEARING,CAM SW:FRONT,0.454 DIA CAM	80009	401-0058-00
					..(ATTACHING PARTS)		
-57	354-0219-00			1	..RING,RETAINING:EXT,CRESCENT,U/O 0.25 DIA	79136	5103-25-S-ZD-R
					..(END ATTACHING PARTS)		
-58	105-0109-00			1	..ACTUATOR,CAM SW:H.F.-308 SEL	80009	105-0109-00
	213-0075-00			2	...SETSCREW:4-40 X 0.094,STL	74445	ORDER BY DESCR
-59	210-0405-00			1	..NUT,PLAIN,HEX:2-56 X 0.188,BRS CD PL	73743	12157-50
-60	210-0406-00			2	..NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
-61	401-0061-00			1	..BEARING,CAM SW:REAR OR CENTER,0.454 DIA	80009	401-0061-00
-62	------ ------			1	RESISTOR,VAR:(SEE R535,S535 REPL)		
					(ATTACHING PARTS)		
-63	210-0583-00			1	NUT,PLAIN,HEX:0.25-32 X 0.312,BRS CD PL	73743	2X-20319-402
-64	210-0046-00			1	WASHER,LOCK:0.261 ID,INTL,0.018 THK,STL	77900	1214-05-00-0541C
					(END ATTACHING PARTS)		
-65	407-0553-00			1	BRACKET,CMPNT:BRASS ALBALOY PL	80009	407-0553-00
	342-0212-00			2	INSULATOR,FILM:CIRCUIT BOARD,MYLAR	80009	342-0212-00
-66	------ ------			1	CKT BOARD ASSY:MAIN(SEE A2 REPL)		
					(ATTACHING PARTS)		
-67	211-0116-00	B010100	B099999	1	SCR,ASSEM WSHR:4-40 X 0.312,PNH,BRS,NP	77900	ORDER BY DESCR
	211-0513-00	B100000		1	SCREW,MACHINE:6-32 X 0.625,PNH,STL	93907	B80-00032-003
-68	210-0586-00	B010100	B099999	1	NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
	210-0457-00	B100000		1	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	78189	511-061800-00
-69	210-0863-00	B100000		1	WSHR,LOOP CLAMP:0.187 ID U/M 0.5 M CLP	95987	C191
-70	343-0002-00	B100000	B115479	1	CLAMP,LOOP:0.187 ID,PLASTIC	06915	E3 CLEAR ROUND
	343-0003-00	B115480		1	CLAMP,LOOP:0.25 ID,PLASTIC	06915	E4 CLEAR ROUND
-71	210-0413-00			1	NUT,PLAIN,HEX:0.375-32 X 0.5,BRS CD PL	73743	3145-402
-72	210-0940-00			1	WASHER,FLAT:0.39 ID X 0.562 OD X 0.02,STL	86928	ORDER BY DESCR
					(END ATTACHING PARTS)		
					CKT BOARD ASSY INCLUDES:		
-73	384-0448-00			1	.EXT SHAFT:11.125 L X 0.123 OD,EPXY-GL	80009	384-0448-00
-74	376-0091-00			1	.CPLG,SHAFT,FLEX:0.251 ID X 0.672 OD,BRS NP	99934	A-201-165
	213-0020-00	B020160		4	..SETSCREW:6-32 X 0.125,STL	TK0433	ORDER BY DESCR
-75	131-0590-00			18	.TERMINAL,PIN:0.71 L X 0.025 SQ PH BRZ	80009	131-0590-00
-76	342-0050-00	B050000		15	.INSULATOR,BSHG:0.03 ID X 0.125 OD X 0.1 L	80009	342-0050-00
-77	351-0155-00			22	.INSULATOR,STUF:CONNECTOR,DELRIN	80009	351-0155-00
-78	136-0235-00	B010100	B121634	4	.SKT,PL-IN ELEK:TRANSISTOR,6 CONTACT	71785	133-96-12-062
	136-0252-07	B121635		60	.SOCKET,PIN CONN:W/O DIMPLE	22526	75060-012
-79	344-0154-00			4	.CLIP,ELECTRICAL:FUSE,CKT BD MT,CU BE	80009	344-0154-00
-80	136-0183-00	B010100	B121634	4	.SKT,PL-IN ELEK:TRANS,3 CONTACT,PCB MT	80009	136-0183-00
-81	131-0566-00			2	.BUS,COND:DUMMY RES,0.094 OD X 0.225L	24546	OMA 07
-82	337-1266-02			1	.SHIELD,ELEC:MAIN CKT BD	80009	337-1266-02
-83	214-0579-00			4	.TERM,TEST POINT:BRS CD PL	80009	214-0579-00
-84	136-0235-01			1	.SKT,PL-IN ELEK:TRANSISTOR,6 CONTACT,PCB MT	80009	136-0235-01
-85	136-0220-00	B010100	B121634	10	.SKT,PL-IN ELEK:TRANSISTOR 3 CONTACT	71785	133-23-11-034
-86	385-0107-00			1	.SPACER,POST:0.75 L W/4-40 THD THRU,NYL	80009	385-0107-00
					.(ATTACHING PARTS)		
-87	211-0008-00			1	.SCREW,MACHINE:4-40 X 0.25,PNH,STL	93907	ORDER BY DESCR

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345	Name & Description	Mfr. Code	Mfr. Part No.
2-						.(END ATTACHING PARTS)		
-88	131-0604-00			33		.CONTACT,ELEC:CKT BD SM,SPR,CU BE	80009	131-0604-00
-89	131-0608-00			22		.TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
-90	214-1190-00			1		.CPLG,SHAFT,RGD:0.125 OD TO 0.125 OD,AL	80009	214-1190-00
	213-0075-00			1		..SETSCREW:4-40 X 0.094,STL	74445	ORDER BY DESCR
-91	214-1136-00			1		.ACTUATOR,SL SM:VARIABLE CAL	80009	214-1136-00
-92	351-0180-00			1		.GUIDE,SLIDE SM:SWITCH ACTUATOR	80009	351-0180-00
	105-0413-00			1		.ACTR ASSY,CAM S:ATTEN	80009	105-0413-00
						.(ATTACHING PARTS)		
-93	211-0116-00			4		.SCR,ASSEM WSHR:4-40 X 0.312,PNH,BRS,NP	77900	ORDER BY DESCR
						.(END ATTACHING PARTS)		
-94	200-0952-00			1		..COVER,CAM SM:20 ELEMENTS	80009	200-0952-00
						..(ATTACHING PARTS)		
-95	211-0022-00			2		..SCREW,MACHINE:2-56 X 0.188,PNH,STL	TK0435	ORDER BY DESCR
-96	210-0001-00			1		..WASHER,LOCK:#2 INTL,0.013 THK,STL	77900	1202-00-00-0541C
-97	210-0259-00			1		..TERMINAL,LUG:0.099 ID,LOCKING,BRS CD PL	80009	210-0259-00
						..(END ATTACHING PARTS)		
-98	214-1139-02			1		..SPRING,FLAT:0.885 X 0.156 CU BE GRN CLR	80009	214-1139-02
	214-1139-03			1		..SPRING,FLAT:0.885 X 0.156 CU BE RED CLR	80009	214-1139-03
-99	214-1127-00			1		..ROLLER,DETENT:0.125 DIA X 0.125,SST	80009	214-1127-00
-100	210-0405-00			1		..NUT,PLAIN,HEX:2-56 X 0.188,BRS CD PL	73743	12157-50
-101	210-0406-00			2		..NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
-102	401-0054-00			1		..BEARING,CAM SM:FRONT,	80009	401-0054-00
						..(ATTACHING PARTS)		
-103	354-0219-00			1		..RING,RETAINING:EXT,CRESCENT,U/O 0.25 DIA	79136	5103-25-S-ZD-R
						..(END ATTACHING PARTS)		
-104	105-0110-00			1		..ACTUATOR,CAM SM:ATTENUATOR	80009	105-0110-00
-105	210-0405-00			1		..NUT,PLAIN,HEX:2-56 X 0.188,BRS CD PL	73743	12157-50
-106	210-0406-00			2		..NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
-107	401-0056-00			1		..BEARING,CAM SM:REAR,0.83 DIA CAM	80009	401-0056-00
	105-0465-00			1		.ACTR ASSY,CAM S:GAIN/READOUT	80009	105-0465-00
						.(ATTACHING PARTS)		
-108	211-0116-00			4		.SCR,ASSEM WSHR:4-40 X 0.312,PNH,BRS,NP	77900	ORDER BY DESCR
						.(END ATTACHING PARTS)		
-109	200-0953-00			1		..COVER,CAM SM:16 ELEMENTS	80009	200-0953-00
						..(ATTACHING PARTS)		
-110	211-0022-00			2		..SCREW,MACHINE:2-56 X 0.188,PNH,STL	TK0435	ORDER BY DESCR
-111	210-0001-00			1		..WASHER,LOCK:#2 INTL,0.013 THK,STL	77900	1202-00-00-0541C
-112	210-0259-00			1		..TERMINAL,LUG:0.099 ID,LOCKING,BRS CD PL	80009	210-0259-00
						..(END ATTACHING PARTS)		
-113	214-1139-00			1		..SPRING,FLAT:0.885 X 0.156 CU BE GLD CLR	80009	214-1139-00
	214-1139-03			1		..SPRING,FLAT:0.885 X 0.156 CU BE RED CLR	80009	214-1139-03
-114	214-1127-00			1		..ROLLER,DETENT:0.125 DIA X 0.125,SST	80009	214-1127-00
-115	210-0406-00			2		..NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
-116	210-0405-00			1		..NUT,PLAIN,HEX:2-56 X 0.188,BRS CD PL	73743	12157-50
-117	401-0057-00			1		..BEARING,CAM SM:FRONT W/0.83 DIA BSHG	80009	401-0057-00
						..(ATTACHING PARTS)		
-118	354-0219-00			1		..RING,RETAINING:EXT,CRESCENT,U/O 0.25 DIA	79136	5103-25-S-ZD-R
						..(END ATTACHING PARTS)		
-119	105-0111-00			1		..ACTUATOR,CAM SM:GAIN/READOUT	80009	105-0111-00
-120	210-0405-00			1		..NUT,PLAIN,HEX:2-56 X 0.188,BRS CD PL	73743	12157-50
-121	210-0406-00			2		..NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
-122	401-0056-00			1		..BEARING,CAM SM:REAR,0.83 DIA CAM	80009	401-0056-00
						STANDARD ACCESSORIES		
	070-0931-00			1		MANUAL,TECH:INSTRUCTION	80009	070-0931-00

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. 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 following this page, your manual is correct as printed.

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MANUAL CHANGE INFORMATION

Date: 9/12/86 Change Reference: 06/986

Product: 7A22 Manual Part No.: 070-0931-00

DESCRIPTION PG 42

FOR EFFECTIVE SERIAL NUMBERS (SEE BELOW)

REPLACEABLE ELECTRICAL PARTS LIST CHANGES

CHANGE TO:

A3	670-1051-00	B010100	B059999	CIRCUIT BD ASSY:INPUT COUPLING SW
A3	670-1051-01	B060000	B118249	CIRCUIT BD ASSY:INPUT COUPLING SW
A3	670-1051-02	B118250		CIRCUIT BD ASSY:INPUT COUPLING SW
A4	670-1050-00	B010100	B059999	CIRCUIT BD ASSY:INPUT COUPLING SW
A4	670-1050-01	B060000	B118249	CIRCUIT BD ASSY:INPUT COUPLING SW
A4	670-1050-02	B118250		CIRCUIT BD ASSY:INPUT COUPLING SW

THE FOLLOWING CHANGES ARE EFFECTIVE FOR ALL SERIAL NUMBERS

MECHANICAL PARTS LIST CHANGES

CHANGE TO:

1-68	342-0212-00	1	INSULATOR,FILM,CIRCUIT BOARD MYLAR
2-28	214-1140-00	1	SPRING,HLCPS,0.251 OD 0.375 L,CLE ENDS,S

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