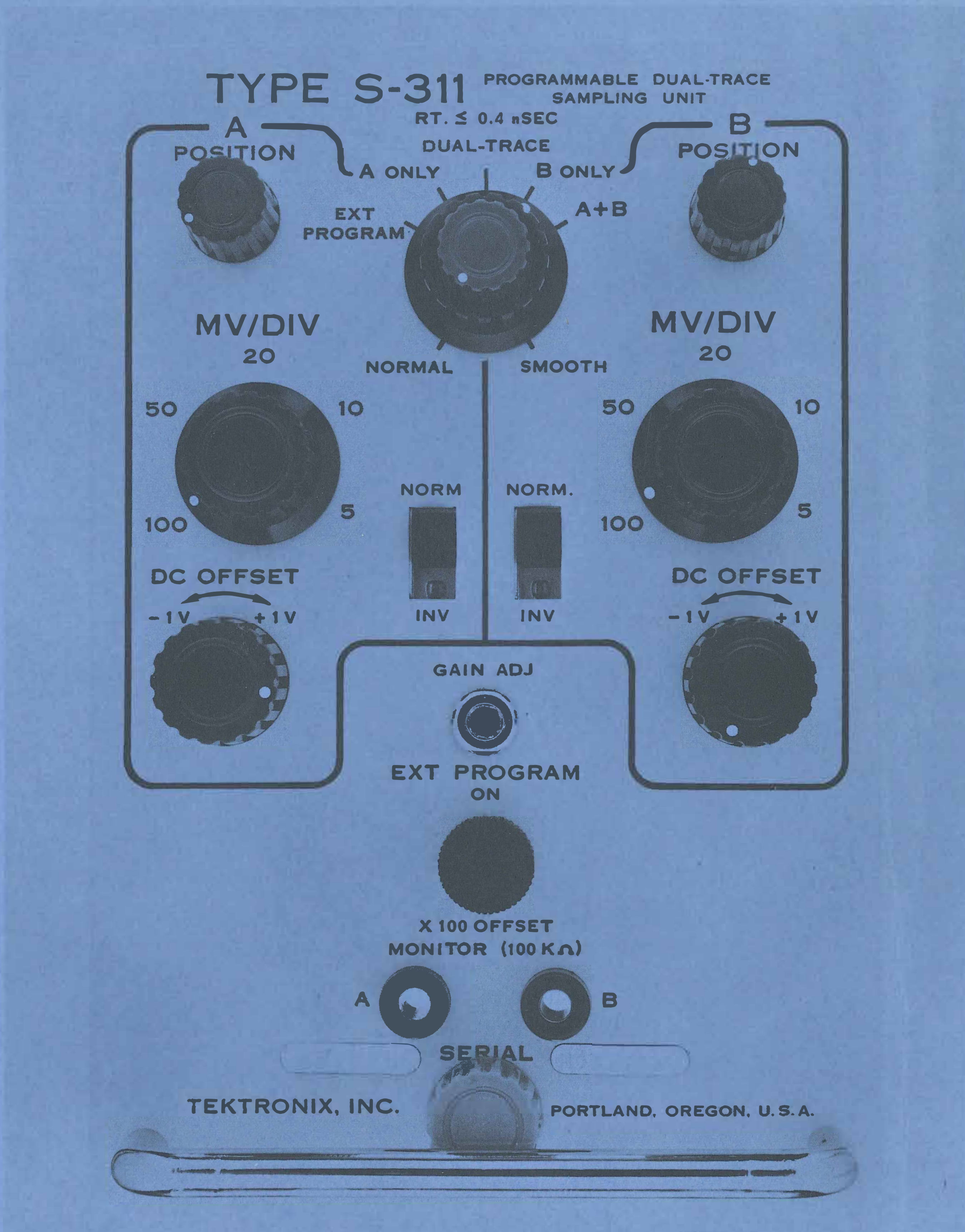
Type S-311

Programmable Dual-Trace

Plug-In Unit

070-0468-01

965


TYPE S-311
PROGRAMMABLE DUAL-TRACE SAMPLING UNIT
RT. ≤ 0.4 nSEC
A
POSITION
DUAL-TRACE
A ONLY
B ONLY
EXT PROGRAM
A+B
B
POSITION
MV/DIV
20
50
10
100
5
NORMAL
SMOOTH
MV/DIV
20
50
10
100
5
NORM
INV
NORM.
INV
DC OFFSET
-1V
+1V
DC OFFSET
-1V
+1V
GAIN ADJ
EXT PROGRAM
ON
X 100 OFFSET
MONITOR (100 KΩ)
A
B
SERIAL
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

SECTION 1

CHARACTERISTICS

General Information

The Type S-311 Programmable Dual-Trace Sampling Plug-In Unit is designed for use with the Tektronix S2000 and S3000-Series Systems. In the system the Type S-311 provides vertical deflection of the Type 567 Readout Oscilloscope, and voltage and decimal information to the Type 6R1A Digital Unit. A sampling sweep plug-in unit (such as the Tektronix Type S-300, S-301, or 3T77) must be used with the Type S-311.

The Type S-311 permits observation of low-level signals of fractional nanosecond duration or risetime. These observations can be made at frequencies up to 875 megacycles. The dual-trace feature of the Type S-311 permits simultaneous displays of two signals.

The Type S-311 takes a small sample of successive input signals. Each sample is completed in a fraction of a nanosecond. Each sample is initiated by the sweep plug-in unit, slightly later in time with respect to the last sampled pulse. The samples are reconstructed on a relatively slow time base provided by the sampling sweep plug-in unit.

The sampling process is unaffected by the characteristics of the device under test or by changes in sensitivity settings. Low noise and absence of jitter provide a high-resolution display comparable to conventional oscilloscopes.

Internal and External Control

Internal control of all functions is accomplished by normal setting of front panel knobs. The Ext. Program position of the Mode switch allows all A and B MV/DIV ranges, A and B DC Offset functions, and the A Only, Dual Trace; and B Only Mode functions to be programmed externally through a rear panel connection on the plug-in. MV/DIV ranges are controlled by connecting combinations of six wires at P81 to ground; DC Offset ranges are controlled by connecting two wires through 200 k potentiometers to power supply voltages brought out from the S-311; and the Mode functions are controlled by connecting combinations of three wires to a power supply voltage brought out from the S-311.

NOTE

An external 25 VDC, 200 mA supply must be connected to pin 13 of the S-311 rear panel program connector P81 to supply operating power for the MV/DIV relays (K1 through K6).

Risetime

0.4 nsec (corresponding to an upper 3-db frequency of about 875 mc), each channel.

Input Impedance

50 ohms, ±1%, each channel.

Deflection Factor

Programmable or manually adjustable in five fixed steps. of 5, 10, 20, 50 and 100 mv/div, each channel. For 10 to 100 mv/div, accuracy is ±3%. For 5 mv/div, accuracy is ±5%.

Maximum Allowable Signal Input

±2 volts, combined dc and peak ac, with respect to ground.

Noise (Referred to Input)

1 mv, peak-to-peak, with SMOOTH-NORMAL switch at SMOOTH.

2 mv, peak-to-peak, with SMOOTH-NORMAL switch at NORMAL.

Operating Modes

External Program: Allows A and B channel mv/div ranges, DC Offset functions, and the A only, Dual Trace, and B only Mode functions to be programmed via a connector on the rear panel of the S-311.

Single-Channel Operation: Channel A display or Channel B display only.

Dual-Trace Operation: Both channels display signals simultaneously.

A + B: Display of the algebraic sum or difference (±A±B) of two signals. Common-mode rejection ratio is 50:1 provided neither display exceeds ±8 divisions of deflection.

Dynamic Range

±8 major graticule divisions.

Dc Offset; programmable or manually adjustable

±1 volt, referred to input, available in each channel. Monitor voltage is ±100 volts through 100 kilohms.

Signal Delay

No internal signal delay is provided. If a pre-trigger is not available in the system a good, low loss, delay cable of about 55 nsec (such as the Type 113) should be used in series with the A and B signal inputs.

Mechanical

Construction: Aluminum-alloy front panel and chassis.

Finish: Painted front panel (Federal Standard 595 265-21)

Weight: 4 3/4 lbs.

Accessories Supplied With the Type S-311

	Tektronix Part Number
2 Instruction manuals	070-468

SECTION 2

OPERATING INSTRUCTIONS

Introduction

This section covers the operation of the front-panel controls and connectors of the Type S-311. Certain general items are included to help the operator obtain the best results from the system.

The Type S-311 (with a programmable sampling sweep plug-in unit) is designed for use only with the Type 567 or RM567 Oscilloscope in a programmable sampling system. External triggering is required; also an external programmer and power supply is required to make it a complete system.

The basic front-panel deflection factors of 5 to 100 millivolts, coupled with plug-on external attenuators, adapt to a wide range of input signal levels.

Functions of Front-Panel Controls and Connectors

Vertical Mode Switch

Selects one of five operational modes:

EXT. PROGRAM: This disables both front panel MV/DIV and Dc Offset controls and allows external programming of those functions; also it allows external programming of the A only, Dual Trace, and B only functions.

A ONLY: The channel A signal is displayed.

B ONLY: The channel B signal is displayed.

DUAL-TRACE: Both channels display signals simultaneously.

A+B: The algebraic sum (±A±B) of the two channels is displayed as a single trace.

SMOOTH-NORMAL Switch (Red knob concentric with Vertical Mode switch)

In the SMOOTH position, display noise is not more than 1 millivolt, peak-to-peak. In the NORMAL position display noise is not more than 2 millivolts, peak-to-peak.

POSITION Controls

Adjust vertical position of the display.

MV/DIV. Switches (Disabled when the Vert. Mode switch is in the Ext. Program position.)

Selects desired deflection factor for either channel. For example, with the channel A MV/DIV. switch set at 100, each major division of channel A vertical deflection corresponds to 100 millivolts of applied signal.

DC OFFSET Controls (Disabled when the Vert. Mode switch is in the Ext. Program position.)

Varies the offset voltage between +1 volt and -1 volt. These controls may be used to offset the effects of a dc input level, or to display any portion of a high amplitude signal. By monitoring the voltage at the appropriate X100 OFFSET MONITOR jack, highly accurate (±2%) voltage difference measurements can be taken.

X100 OFFSET MONITOR (100 KΩ) Jacks

The output voltage at these jacks is always 100 times the internal offset voltage which is variable with the DC OFFSET controls.

INPUT A and INPUT B connectors (on rear panel of S-311)

Connectors for applying the input signal. Connectors are BNC type with a 50-ohm input impedance.

NORM.-INV Switches

In the NORM. position, the displayed signal has the same polarity as the applied signal (positive up, negative down).

In the INV. position, the display is inverted. When the Vertical Mode switch is set to A+B, algebraic addition is obtained with both NORM.-INV. switches set in the same position. Algebraic subtraction is obtained with the NORM.-INV. switches set in opposite positions.

GAIN ADJ.

Matches the amplifier gain to the oscilloscope crt deflection factor.

Installing the Type S-311 Into the Oscilloscope

CAUTION

Turn the oscilloscope off when inserting or removing plug-in units. Otherwise, power supplies in the oscilloscope may fail to regulate momentarily as the plug-in units are removed or replaced.

The Type S-311 is designed to drive the vertical deflection plates of the oscilloscope crt and therefore must be used in the left-hand compartment of the oscilloscope.

Connect input and programming cables at rear before installing.

To insert the Type S-311 into the compartment, place the latch at the bottom of the front panel in a horizontal position. Then slide the Type S-311 completely into the compartment. Once the plug-in unit is seated, turn the latch knob a few turns clockwise until it is hand-tight.

Cable Considerations

If transmission lines or terminations are improper, reflections, standing waves, or undue loading on the device under test may cause signal distortion. If it is necessary to use other than the 50-ohm cables supplied, use suitable matching devices to couple between cables or inputs. Be sure to use only low loss transmission lines and keep all connections as short as practical to minimize cable losses.

Time delay of cables varies with length and construction. Time delay is especially important when making time-difference measurements between two signals, as in dual-trace operation. In this case, each signal should travel through cables that produce equal delay to preserve the true time relationship.

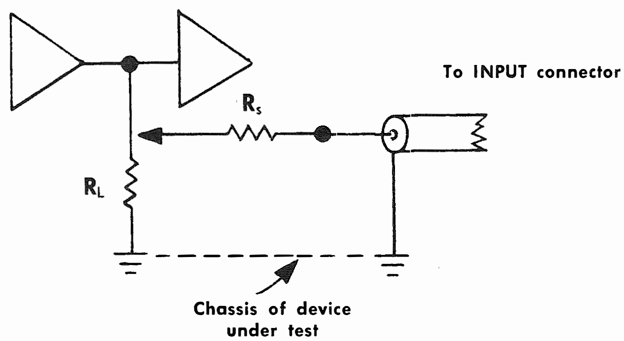
Connect the signal to be displayed to either the INPUT A or INPUT B connector on the rear panel of the Type S-311. Both connectors are BNC 50-ohm connectors.

Coupling a Signal into the 50-Ohm Input

To observe the output signal of an instrument having a 50-ohm output impedance, connect a 50-ohm coaxial cable directly between the output of the instrument and either the INPUT A or INPUT B connector. GR Type 874 adapters are available that will mate with most common connectors. If the output of the instrument is other than 50 ohms, use a suitable matching device.

To observe a signal at some point within a given circuit, other factors must be considered. First, to avoid distortion, the circuit must not be heavily loaded by the coupling method. Second, the coupling method should be equally responsive to all frequencies within the limits of the Type S-311. In constructing coupling networks, it is common practice to use 1/4- or 1/8-watt resistors for their small size. In general, resistors tend to be inductive below 50 ohms, and capacitive above 500 ohms. Good shielding, short, solid grounds, and short leads are essential.

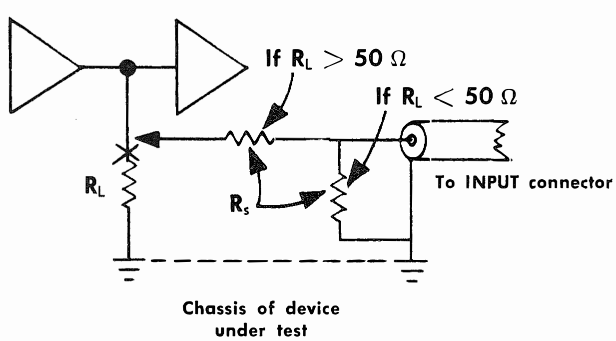
Figs. 2-2 and 2-3 show two coupling methods. In the parallel method (Fig. 2-2), a resistor R_s is connected in series with the 50-ohm input of the Type S-311. R_s + 50 ohms is then placed across the impedance of the circuit under test. A reasonable maximum circuit loading might be when the



$$5\ (R_s + 50) > R_L$$

Fig. 2-2. Parallel method for coupling a signal from a circuit under test.

resistance of R_s plus the 50-ohm input of the Type S-311 is at least 5 times greater than the impedance of the circuit under test R_L, thus requiring only 20% correction.



$$R_s + 50 \cong R_L$$

Fig. 2-3. Series method for coupling a signal from a circuit under test.

In the series coupling method (Fig. 2-3), the 50-ohm input resistance of the Type S-311 becomes part of the impedance of the circuit under test. If the impedance of the circuit under test equals 50 ohms, simply connect directly to the Type S-311 input. However, if the impedance of the circuit under test (shown as R_L in Fig. 2-3) exceeds 50 ohms, place a resistance in series with the Type S-311 input. The size of this resistance, plus 50 ohms, should equal the original impedance of the circuit under test. If R_L is less than 50 ohms, R_s must be placed in parallel with the input of the Type S-311. The equivalent parallel resistance of R_s and the 50-ohm input resistance of the Type S-311 should equal the impedance of the circuit under test.

The probe network shown in Fig. 2-4 is an example of the parallel method in Fig. 2-2. The probe network is highly versatile and will require less than 20% correction when used

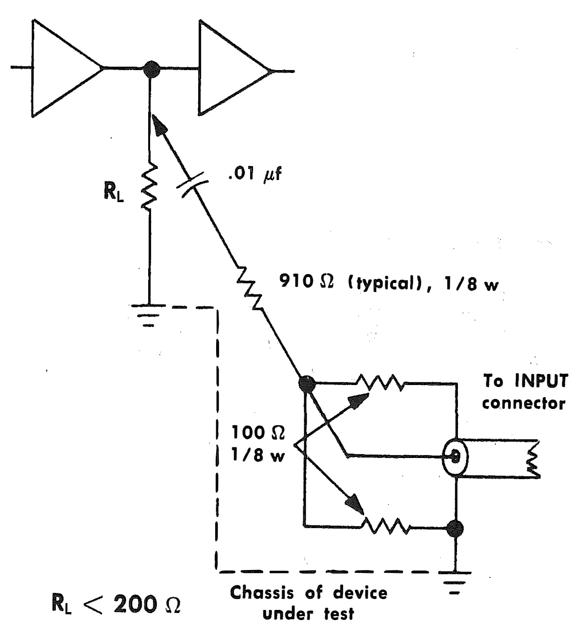


Fig. 2-4. Probe method for coupling a signal from a circuit under test.

across impedances below 200 ohms. The 0.01-µf capacitor in the probe network will block any dc component and protect the 910-ohm resistor. Use of the capacitor is optional. The two 100-ohm resistors placed directly across the cable input serve to back-terminate any small reflections from the output circuit due to imperfect coupling. When observing signals of short duration, the reflections may occur off the crt or, if reflections of a few percent are unimportant, the two resistors can be deleted with about a two times increase in signal amplitude at the Type S-311 input. Attenuation of the probe network shown in Fig. 2-4 with the two 100-ohm resistors is about 40; without the resistors, it is about 20.

More versatile passive probes are available from Tektronix, such as the P6026, P6034, and P6035 Probes. Probes are also available with less loading effect, such as the Tektronix P6032 Cathode Follower Probe.

First-Time Operation

NOTE

Be sure 25 vdc power is applied to pin 13 of program connector. MV/DIV setting remains at 100 unless power is applied.

To display a signal, set the Type S-311 front-panel controls as follows:

Vertical Mode Switch	A ONLY
A and B POSITION	Midrange
A and B MV/DIV.	100
A and B DC OFFSET	2 1/2 turns from either end
A and B NORM.-INV.	NORM.

Connect a suitable pre-trigger to the Sampling Sweep plug-in unit. If a pre-trigger is not available, the signal source may be used by connecting a signal pickoff transformer (such as a Type CT-3) and a 55 nsec signal delay cable (such as a Type 113).

Apply the signal you wish to observe to the Type S-311 INPUT A connector. Free run the triggering circuit of the sweep plug-in unit. Center the trace on the graticule with the A POSITION control (and the DC OFFSET control, if necessary). Adjust the triggering controls of the sweep plug-in unit for a stable display and set the channel A MV/DIV. switch for the desired amount of vertical deflection.

Now check channel B by applying the input signal to the INPUT B connector.

Experiment with the various front-panel controls and notice the effect of each. For example, notice that the DC OFFSET control changes the vertical position of the trace, as does the POSITION control. Also, the DC OFFSET control varies the voltage at the X100 OFFSET MONITOR jacks. The display may be inverted by placing the NORM.-INV. switch to INV.

Positioning the Display

When making accurate time or amplitude measurements, it is usually advantageous to align the display with the graticule markings. Vertical positioning of the display can be controlled with the appropriate POSITION or DC OFFSET control.

The effect of the DC OFFSET control is most significant at low deflection factors. As the MV/DIV. switch is set to a lower number, the display may be deflected entirely off the crt. In this case, use the DC OFFSET control to return the display to the crt. The POSITION control may be used for more precise positioning.

Precise pulse-height measurements can be made by measuring the voltage change at the X100 OFFSET MONITOR jacks as the setting of the DC OFFSET control is changed from one point on the pulse (such as the baseline) to another (such as peak height).

Smooth-Normal Switch

Display noise can be reduced from 2 millivolts to 1 millivolt by setting the SMOOTH-NORMAL switch to SMOOTH. This reduces the gain of the sample amplifier by 4. However, when observing the rising or falling edge of a waveform, it is desirable to use at least 100 dots. Otherwise, the dispersion of dots cannot faithfully follow the input signal. Therefore, if there are fewer than 100 dots in a rising or falling portion of the display, use the NORMAL position of the SMOOTH-NORMAL switch.

Dual-Trace Operation

The dual-trace feature of the Type S-311 effectively permits observing signals from both channels simultaneously. This is useful for comparing amplitude, risetime, waveshape, and time delay of two signals. However, to obtain a stable display of both signals, the signals must be related in frequency or repetition rate. When the dual-trace feature is used, be sure to trigger from the channel with the earliest signal event. Use equal length input cables to preserve the time relationships.

To set the controls of the Type S-311 for dual-trace operation, proceed as follows:

1. Set the Vertical Mode switch to DUAL-TRACE.

2. Set the MV/DIV. switches to the positions that will provide about two or three divisions of display for each channel.

Gain Adjustment

The GAIN ADJ. control (a front-panel screwdriver adjustment) matches the gain of the Type S-311 to the oscilloscope crt deflection factor. The gain must be checked and adjusted (if necessary) each time the Type S-311 is used with a different oscilloscope. The setting of the GAIN ADJ. control should also be checked occasionally during regular use of the instrument.

To check and/or adjust the Type S-311 GAIN ADJ. control, proceed as follows:

1. Make sure the equipment has warmed up for at least five minutes.

2. From the Calibrator of the Type 567 or RM567, apply the 0.1-volt signal (that is intended to work into 50 ohms; see the following note) to the INPUT A connector.

NOTE

For a Type 567 or RM567 Oscilloscope, a resistor R890 should be located between the 0.5-volt Calibrator jack and the junction of R887 and R888. The resistor has a value of 100 ohms, 1/2-watt, 1%. If your oscilloscope does not have this resistor, install one at the point indicated (in series with the 0.5-volt Calibrator jack). This jack will then provide 0.1 volt into 50 ohms.

3. Free run the triggering circuit of the sweep plug-in unit (i.e., set the TRIGGER SENSITIVITY control fully clockwise).

4. On the Type S-311, set the Vertical Mode switch to A ONLY, and the A MV/DIV. to 20; other controls may be set to any position.

5. With the channel A POSITION and DC OFFSET controls, align the display with the appropriate graticule lines and check for exactly five major graticule divisions of vertical deflection on the crt. If the amount of vertical deflection is not exactly five major divisions, adjust the GAIN ADJ. control.

6. Connect the Calibrator signal to the INPUT B connector, set the Vertical Mode switch to B ONLY, and MV/DIV. to 20; other controls may be set to any position.

7. With the channel B POSITION and DC OFFSET controls, align the display with the appropriate graticule lines and check for exactly five major graticule divisions of deflection on the crt. If the vertical deflection is not exactly five major divisions, the Type S-311 needs calibration; refer to the Calibration section of this manual.

External Programming

The S-311 is designed to be used as part of an S-2000 or S-3000 Series System. In the system, a programming device such as the Type 262 is normally used to provide the 25 vdc power source, two 200 k potentiometers, and the contact closures needed to select the desired S-311 operation functions; however other devices may be adapted to accomplish this programming.

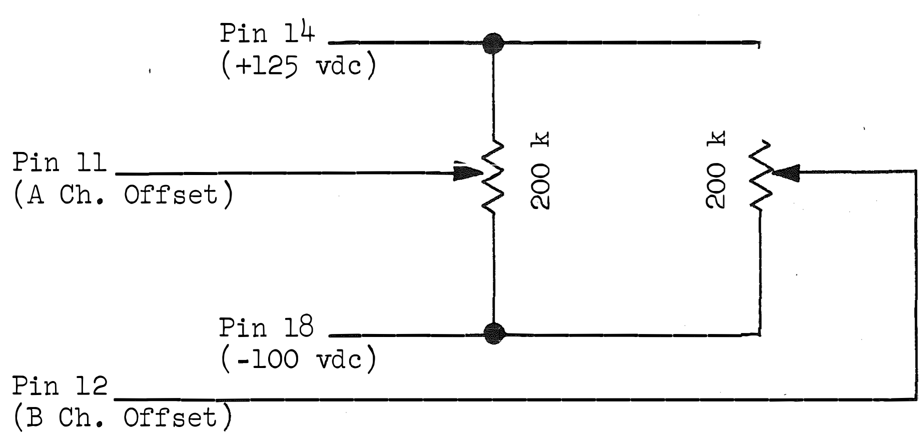
MV/DIV Programming

Channel A and B MV/DIV ranges are programmed by grounding the proper pins of the S-311 rear panel program connector per the following table. Normally this would be done through contact closures in the Type 262.

A Channel MV/DIV Range	Ground P81 Conn. Pin
100	None
50	3
20	2, 3
10	1
5	1, 2
B Channel MV/DIV Range	**Ground P81 Conn. Pin**
100	None
50	6
20	5, 6
10	4
5	4, 5

DC Offset Programming

Programming of the A and B DC Offset functions are normally accomplished as follows. Pin numbers refer to the S-311 rear panel program connector (P81):



This configuration gives a DC Offset range of ±1 volt at the sampling bridge. It should not be increased (by using higher voltage supplies) but may be decreased if desired for better resolution.

Mode Function Programming

Programming of the A only, Dual Trace, and B only Mode functions are accomplished by contact closures in the Type 262 which connect proper pins of the S-311 rear panel connector to pin 7 (-12.2 vdc internal supply) of this same connector. These connections are as follows:

Mode	Prog. Conn. Pin
A only	8
Dual Trace	8, 9, 10
B only	9

SECTION 3

APPLICATIONS

Voltage Measurements

Vertical displacement of the trace on the crt is directly proportional to the voltage at an INPUT connector. The amount of displacement for a given voltage can be selected with the MV/DIV. switch. To provide sufficient deflection for best resolution, set the MV/DIV. switch so the display spans a large portion of the graticule. Also, when measuring between points on a display, be sure to measure consistently from either the bottom, middle, or top of the trace. This prevents the width of the trace from affecting your measurements.

To make a voltage-difference measurement between two points on a display, proceed as follows:

1. Note the vertical deflection, in major graticule divisions, between the two points on the display.

2. Multiply the major divisions of vertical deflection by the setting of the MV/DIV. switch and the attenuation factor (if any) of external attenuators or probe. The product is the voltage difference between the two points measured.

For example, suppose you measure 4.4 divisions of deflection between two points on the display and the MV/DIV. switch is set at 20. Multiplying 20 millivolts/division by 4.4 divisions, the product is 88 millivolts. This is the voltage at the INPUT connector. Now, assume there is a 10X external attenuator between the INPUT connector and the signal source. To determine the actual signal voltage at the source, multiply 10 (the attenuation factor) by 88 millivolts; this product

(880 millivolts or 0.88 volt) is the actual voltage at the signal source.

If desired, you can measure the instantaneous (or dc) voltage to ground from the display. This measurement is accomplished in the same manner except that, with no signal applied, you must first establish a ground-reference point on the crt. To do this, allow the sweep plug-in unit to free run and present a trace. Then, position the trace so it is exactly aligned with one of the horizontal graticule lines. The actual graticule line you select will be largely determined by the polarity and amplitude of the applied signal. After establishing the ground reference, make no further adjustments with the POSITION controls.

Apply the signal and measure the voltage the same as previously described. Make all measurements from the established ground-reference point.

If the applied signal has a relatively high dc level, the ground-reference point and the actual signal may be so far apart that neither will appear on the crt. In this case, refer to the following discussion on "Dc Offset Voltage Measurements."

Dc Offset Voltage Measurements

The dc offset voltage cancels the effects of an applied dc level (up to ±1 volt) on the display. Also, accurate amplitude measurements of the applied signal can be obtained by positioning the display at various points and measuring the amount of voltage change at the appropriate X100 OFFSET MONITOR (left-hand jack monitors channel A; right-hand jack monitors channel B).

Output impedance of the X100 OFFSET MONITOR jacks is 100 kilohms, therefore, meter loading may be appreciable. The accuracy of the dc offset voltage measurements depends on the accuracy and the loading effect of the measuring device. The following measuring devices are recommended in the order of preference, for measuring the voltage at the X100 OFFSET MONITOR jacks.

(1) Differential, non-loading dc voltmeter with an accuracy of 0.2% or better. This type of device provides 2% accuracy to offset voltage measurements.

(2) Vacuum-tube voltmeter with an input impedance of at least 10 megohms. Accuracy of the vtvm should be as high as practical.

(3) Zero-center ±1-ma milliammeter with as high an accuracy as practical. The milliammeter should be connected directly between the appropriate X100 OFFSET MONITOR jack and ground. When using a milliammeter, 10 microamperes is equivalent to 1 volt at the X100 OFFSET MONITOR jack.

To measure the voltage difference between two points on a waveform (such as peak or peak-to-peak volts), proceed as follows:

1. Set the appropriate DC OFFSET control to about midrange.

2. Apply the signal to be measured to the appropriate INPUT connector. Adjust for a stable display with about 7 divisions of vertical deflection between the two points of the signal to be measured.

3. With the POSITION and DC OFFSET controls, move one of the points to be measured to the centerline of the graticule and measure the voltage at the appropriate X100 OFFSET MONITOR

jack. Use one of the measuring devices mentioned previously. Do not move the POSITION control after this step.

4. With the DC OFFSET control, move the display so the other point to be measured is aligned with the centerline of the graticule and again measure the voltage at the appropriate X100 OFFSET MONITOR jack.

5. Find the difference between the voltage measured in step 3 and the voltage measured in step 4, and divide by 100. The result is the voltage difference, in volts, between the two points measured on the waveform.

Impedance Measurement by Reflection

Pulse reflection are produced by a mismatch in transmission-line systems. The Type S-311 is useful for observing and evaluating the impedance producing these reflections.

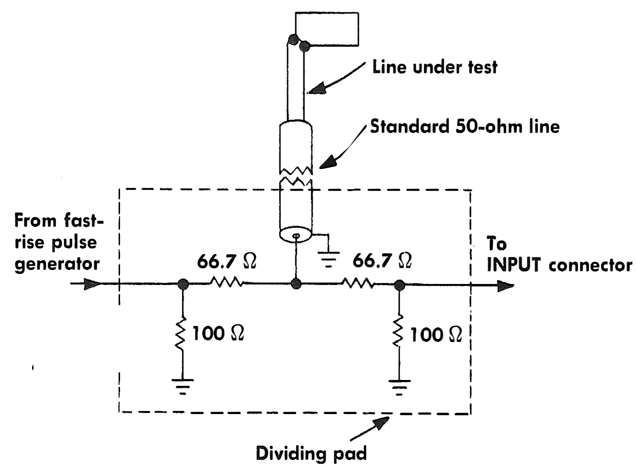


Fig. 3-1. Three-way dividing pad for observation and evaluation of reflections.

The dividing pad shown in Fig. 3-1 supplies a three-way termination for connecting the 50-ohm input of the Type S-311 to a transmission system consisting of a pulse generator and a transmission line under test.

The amplitude of a reflected wave increases with the degree of mismatch. In the two extremes of mismatch (i.e., zero and infinite impedance), the reflection equals the amplitude of the applied pulse. The result, in this case, is that the reflection either cancels or doubles the applied signal at the instant it returns to the dividing pad. The relationship between the amplitude of the reflection and the unknown impedance at the end of a 50-ohm standard-impedance line is

$$Z = \frac{50}{\frac{2\,V_o}{V_x} - 1}$$

where: Z = the unknown impedance.

V_o = the peak amplitude produced by the 50-ohm standard impedance.

V_x = the peak amplitude at the time of the reflection.

Fig. 3-2 shows the result of a 90-ohm shorted transmission line connected on the end of a 50-ohm standard transmission line and the dividing pad of Fig. 3-1. The first upward voltage step on top of the pulse originates from the pulse entering the 90-ohm line. The downward step is produced by the shorted end of the 90-ohm line. The time between the two voltage steps equals twice the delay time of the 90-ohm line.

This method is not limited to transmission line tests. Any impedance can be connected to the 50-ohm standard-impedance line and measured as it changes in time.

Algebraic Addition or Subtraction of Signals

The algebraic sum or difference of two signals is displayed on the crt when the Vertical Mode switch is in the A+B poisition. The sum of the signals is obtained with both NORM.-INV. switches set in the same position. The signal difference is obtained with the NORM.-INV. switches set in opposite positions.

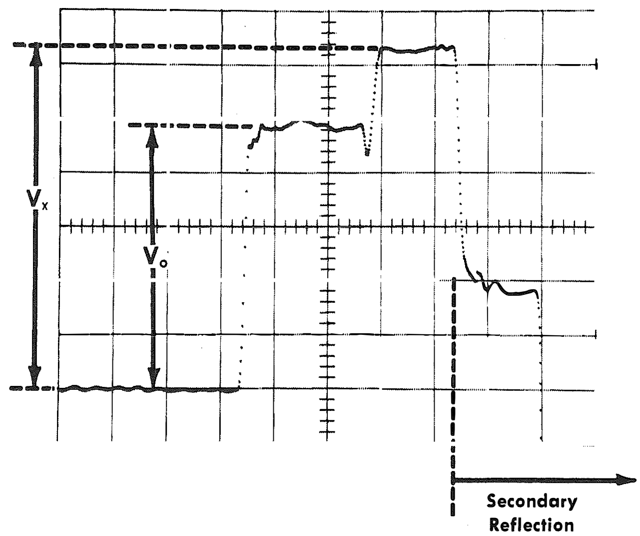


Fig. 3-2. Display from the dividing pad of Fig. 3-1 with a 50-ohm standard line and a shorted 90-ohm line.

This mode of operation is particularly useful for cancelling the effects of an undesired common-mode signal. For example, suppose the signal you wish to observe contains an undesired 60-cycle hum component. In normal operation, this could cause an unstable display. However, in the A+B mode, you can cancel the effect of the hum by applying the signal plus hum to one channel and the hum only to the opposite channel. Then, by experimenting with the hum-only channel MV/DIV., and NORM.-INV. controls you can set the instrument for best hum rejection. However, be sure the hum component you apply to the opposite channel is as far as possible from the signal you wish to observe.

Dual-Trace Applications

The dual-trace mode of operation allows you to view two separate events simultaneously. This is useful if you wish to compare two signals in amplitude or time. To obtain a suitable display of two signals, the signals must bear a fixed time relationship to each other in a period that does not exceed the maximum sweep duration.

The differences in delay time between two coaxial cables, for example, can easily be displayed in dual-trace operation by applying a common signal through two length of coaxial cable to both INPUT connectors. By knowing the delay through one of the cables and comparing the time difference between the displayed signals, you can determine the delay through the unknown cable. For example, suppose your known cable had a delay of 10 nanoseconds. Triggering on the known cable channel, a pulse 5 nanoseconds later on the unknown cable channel would indicate a 15-nanosecond cable.

SECTION 4

CIRCUIT DESCRIPTION

General Operation

Operation of a sampling system is somewhat different from that of conventional oscilloscope circuitry. In a conventional oscilloscope system, the crt beam is continuously deflected vertically by the signal applied to the input; thus, the selected portion of the signal is displayed completely each time the electron beam makes a sweep. This is not the case in a sampling system. Instead, only a very small segment or sample of the input signal is displayed each time the sampling system is triggered. The Type S-311 takes very short samples of the input signal amplitude. Each sample is obtained progressively later in time on successive(but not necessarily consecutive) pulses. The precise time at which the samples are taken is controlled by the sampling sweep plug-in unit. A thorough discussion of the timing technique is contained in the sweep unit instruction manual.

The samples are reconstructed on a slow sweep and appear as dots on the crt. The slow sweep is actually a series of horizontal steps; one for each sample, the rate of the slow sweep depends on how many dots are contained in the total display and the repetition rate of the input signal. Since each sample represents the instantaneous amplitude at the time the sample was taken, the position of the dots on the crt corresponds to sampled points along the input signal.

SNAP-OFF AND MEMORY CIRCUITS

Input Circuitry

The diodes in the four-diode Sampling Gates are special gallium arsenide diodes with very fast switching characteristics. The diodes are quiescently back biased to prevent the incoming signal from reaching the grid of Nuvistors V1073 or V2073. The exact amount of quiescent back-bias voltage is set by the A or B BRIDGE VOLTS adjustment. When properly calibrated, the bridge voltage is normally 1.6 to 2.0 volts with respect to ground. When a sample is taken, the diodes are forward biased for a fraction of a nanosecond by a sharp pulse from the Driver Blocking Oscillator (Q2010 and Snap-Off circuit (D2002). The Driver Blocking Oscillator is, in turn, triggered by a signal from the sweep plug-in unit.

Driver Blocking Oscillator and Snap-Off Circuit

The Driver Blocking Oscillator Q2010 is a triggered (monostable) oscillator which receives a trigger pulse from the sweep unit through pin 18 of the interconnecting plug. The output pulse of the Driver Blocking Oscillator goes to the Snap-Off circuit, the Memory Gate Driver Q2204, and the Dual-Trace Blocking Oscillator Q2230.

The Snap-Off circuit operates from the Driver Blocking Oscillator pulse to produce sharp spikes for application to the Sampling Gate. Snap-Off diode D2002 operates quiescently with a forward current of about 60 milliamps. A positive-going pulse from T2010 tries to reverse this current abruptly. Storage effects in diode D2002 prevent blocking-oscillator current from passing into the bridge-driving circuit during storage time of D2002. Suddenly, storage current through D2002 ends, and no further current flows to ground. This sudden diversion of current through D2002 to the output circuit produces the sharp sampling spike waveshape. T2001 converts the spike to push-pull. The clipping line sets the length of the spike or pulse.

Preamp and Memory Circuit

Operation of the Preamp and Memory circuits is identical for both channel A and B. The following discussion will therefore describe only the operation of channel A.

The Preamp circuits consist of V1073, Q1074, Q1084, and Q1094. The Preamp circuits are permitted at least 10 microseconds to amplify the samples of the input signal, couple the new sample of the Memory circuit, and come to rest again before the next sample.

The Memory circuit consists of V1133A, Q1134, and Q1141 and is a form of gated operational amplifier which remembers the previous sample levels. The signal amplified by the Preamp circuit is proportional to the change in signal voltage between the last sample (remembered by the Memory circuit) and the new sample of signal voltage. Thus, only the error signal, or difference signal, produces an input through the four-diode Sampling Gate to the grid of V1073. The information that passes through the Preamp circuits from the last sample is properly attenuated by the MV/DIV. switch.

To further describe the operation of the individual circuits of the Preamp and Memory, the following discussion traces the path of the sample through each circuit.

During the short time the Sampling Gate is open, the signal voltage is coupled to the grid circuit of cathode-follower V1073. The grid of V1073 is permitted to charge to about 25% of the instantaneous signal voltage.

V1073 has a capacitive input which remembers the signal amplitude for a time after the Sampling Gate is closed. The grid of V1073 receives two signals; the sample information admitted by the Sampling Gate and, shortly afterward, the "feedback" voltage from the Memory circuit developed on C1049. Whenever the feedback voltage equals the instantaneous voltage of the new sample, no error signal passes the Preamp circuit.

The output signal of the cathode follower is coupled directly to the base of transistor Q1074. Ac gain of Q1074 is about 6 when the SMOOTH-NORMAL switch is at NORMAL, and about 1.5 at SMOOTH. With the ac gain of the stage decreased in the SMOOTH position, the error voltage coupled to the Memory circuit is decreased. Consequently, it takes slightly longer for the Memory circuit to respond to changing peak voltages of the incoming samples. Thus, with the SMOOTH-NORMAL switch at SMOOTH, the output of the Memory circuit is only 25% of each sample. Thus, the response to random noise is reduced. This change in gain causes a lag in following the input signal changes which can only be overcome by selecting at least 100 dots during transition time of the input signal. However, the calibrated deflection factor of the Type S-311 is not affected.

The output from Q1074 is coupled through the MV/DIV. switch to the base of Q1084. Precision divider R1081, together with R1147 (both part of the MV/DIV. circuit) select the desired deflection factor.

Q1084 and Q1094 normally amplify the error signal about 100 times. Feedback resistor R1090 and the A PREAMP SENS. adjustment R1088 set the gain of the circuit. Thus, R1088 adjusts for proper error signal gain of the amplifier.

The output of Q1084/Q1094 amplifier is coupled through C1124 to the Memory Gate circuit. Just after each sample is passed into the Memory circuit, C1124 discharges and is again ready to accept the next error signal. The Memory Gate is a form of diode bridge. Zener diode D1124 clamps the voltage across the bridge at 6 volts. R1126 and R1127 provide the proper bridge balance so the voltage on the ends of the bridge is +3 and -3 volts with respect to ground. After the sample is taken and before the error signal passes through the delay of the Preamp circuits, the Memory Gate is opened by a pulse from Memory Gate Driver Q2024. The gating pulse from Q2024 is coupled to the center winding of T1130. This 12-volt drive pulse momentarily turns on D1130 and D1132. This allows the error signal (if any) to pass on to the grid of V1133A. When the output pulse of the Preamp circuits reaches C1124, the charge is transferred from C1124 through the Memory Gate to C1132 of the Memory circuit, according to Q = CE. After the error voltage reaches its peak at C1124, the gate closes from the removal of the Memory Gate Driver pulse and no further charge can be transferred to the Memory circuit until the next Memory Gate Driver pulse.

The Memory circuit, consisting of V1133A, Q1134, and Q1141, is a wide-band operational amplifier with feedback through C1132. With the Memory Gate diodes back biased, its output voltage must equal the sum of the dc voltage at the grid of V1133A and the stored voltage in C1132. The output of the Memory circuit is from the collector of Q1141 which is capable of supplying ±5 milliamps into the following stage.

When a charge (or error signal) is introduced to the grid of V1133A through the Memory Gate, the charge passes through C1132 changing its output voltage according to $E = Q/C$. However, the input voltage of V1133A remains essentially constant due to the high amplifier gain and degenerative feedback through C1132 to the grid of V1133A.

Dc Offset Circuit

The Dc Offset circuit, consisting of V2133A, is a controllabel voltage source. Voltage from this circuit is fed back to three points on the four-diode Sampling Gate. In addition, voltage from this circuit appears at the X100 OFFSET MONITOR jack. This voltage is 100 times the equivalent voltage that is fed back to the Sampling Gate. The voltage division occurs through R1158, R1148 and R1149, and related shunt resistors.

CHANNEL A AND B AMPLIFIERS

Vertical Amplifier

The channel A Amplifier consists of Q1173, Q1184, and Q1183. In addition, the Inversion Stage (Q1163/Q1164) is in the circuit when the NORM.-INV. switch is in the NORM. position. When the NORM.-INV. switch is at NORM., the polarity of the displayed signal is the same as the applied signal. Gain of the Inversion Stage is set to exactly 1 with the A INV. GAIN control R1161.

The A NORM. GAIN control R1172 is adjusted to set the signal amplitude at the base of Q1173. R1172 is adjusted with the NORM.-INV. switch at INV. so the Inversion Stage has no effect.

The output of emitter follower Q1173 is developed across R1173. Gain of this stage is essentially unity. The signal is then coupled through the Vertical Mode switch SW2190 (in all positions except A+B) to the remaining stages of the Vertical Amplifier. In the A+B position, the signal is coupled through R2177 and combined with the signal in channel B. Channel B then produces the algebraic sum of the two signals.

From SW2190, the channel A signal passes through R1175 to the base of Q1184. Q1184 and Q1183 form a feedback amplifier which inverts and amplifies the signal. The A POSITION control R1180 provides a variable dc current through R1181 for positioning the trace on the crt. Emitter follower Q1183 provides an extremely low output impedance to drive the signal pickoff for the digital unit, and the Common Output Amplifier.

DUAL-TRACE SWITCHING AND COMMON OUTPUT AMPLIFIER

Dual-Trace Multivibrator

The Dual-Trace Switching Multivibrator has three states, selected by the Vertical Mode switch SW2190. The state of the Multivibrator determines whether the output of channel A or B is applied to the Common Output Amplifier. The Dual-Trace Switching Multivibrator operates so the outputs of both channels are never applied to the Common Output Amplifier simultaneously. In dual-trace operation, the outputs of channel A and B are applied alternately to the Common Output Amplifier, with switching occurring after each sample.

When the Vertical Mode switch is set to A ONLY, a negative voltage is applied to the base of Q2255 and a positive voltage to the base of Q2245. In this mode, Q2255 is cut offf and Q2245 is conducting. The collector voltage of Q2255 is at its most positive point, and the collector voltage of Q2245 is at its most negative point. The voltage difference between the two collectors is connected directly across the channel A and B diode gates. Current through R1196 and R1197 forward biases the channel A gate, and the channel A signal is passed to the Common Output Amplifier. The diodes in the channel B gate are reverse biased and cannot pass the channel B signal.

If the Vertical Mode switch is set to B ONLY, the polarity of the voltage difference between the collectors of Q2245 and Q2255 is reversed. This forward biases the channel B gate diodes and reverse biases the channel A gate diodes. This, in turn, allows only the channel B signal to pass to the Common Output Amplifier.

If the Vertical Mode switch is set to DUAL-TRACE, R2245 and R2255 are both connected to -12.2 volts. This converts the Multivibrator to a bistable configuration. In dual-trace operation, the Dual-Trace Blocking Oscillator Q2230 is monostable and is triggered by the pulses from the Memory Gate Driver. The output triggering signal of the Dual-Trace Blocking Oscillator passes through diodes D2238 and D2239 to trigger the Switching Multivibrator.

The Dual-Trace Blocking Oscillator is in operation only when the Vertical Mode switch is in the DUAL-TRACE position. At all other times, collector voltage is removed from Q2230 and the circuit is inoperative.

Common Output Amplifier

The Output Amplifier V1224 (A and B), Q1204, and Q1214, is a cathode-emitter-coupled paraphase amplifier. It converts the signal at the base of Q1204 to a push-pull signal between the plates of V1224. The output from the amplifier drives the vertical deflection plates of the crt via pins 17 and 21 of the interconnecting plug. The GAIN ADJ. control R1209 varies the coupling between the emitters of Q1204 and Q1214 and is used to set the gain of the stage. The gain is greatest when R1209 is set for minimum resistance.

+100-Volt Power Source

The +100-Volt Power Source furnishes power to the Bridge Gates (emitter of Q2287) and to the rear panel programming connector for Probe power. The source voltage is held constant by voltage regulator V2289. V2289 maintains a constant voltage drop of about 82 volts over a relatively wide current range. The 20-volt source elevates the total voltage output to about +100 volts with respect to ground.

+20- and +70-Volt Source

The +70 volts is obtained with a voltage divider from the +125-volt supply of the oscilloscope. Transistors Q2274 and Q2277 provide a stable +20-volt supply. Q2277 is a shunt regulator driven by Q2274. The base of Q2274 is at -0.3 volt when the emitter of Q2277 is at +20 volts. If the emitter voltage of Q2277 attempts to change from +20 volts, the base of Q2274 will move in the same direction. The change in voltage at the base of Q2274 forces the collector voltage of Q2274 and the base voltage of Q2277 to move in the opposite direction. This change appears at the emitter of Q2277 and cancels the original attempt of the +20-volt supply to change.

SECTION 5

MAINTENANCE

PREVENTIVE MAINTENANCE

Visual Inspection

The Type S-311 Plug-In Unit should occasionally be inspected for such visual defects as poor connections, broken or damaged ceramic strips, improperly seated tubes or transistors, and heat-damaged parts. The remedy for most visual defects is obvious; however, particular care must be taken if heat-damaged parts are detected. Overheating can be caused by other, less apparent troubles in the circuit. For this reason, it is essential to determine the actual cause of overheating before the parts are replaced; otherwise, the damage may be repeated.

Recalibration

The Type S-311 is a stable instrument that will provide many hours of dependable operation. To maintain the measurement accuracy, however, we suggest a check of the calibration after each 500 hours of operation (or every six months if used intermittently). A complete step-by-step calibration procedure is provided in Section 6 of this manual.

PARTS REMOVAL AND REPLACEMENT

General Information

Removal and replacement procedures for most of the parts in the Type S-311 are obvious. However, some parts require special procedures. Removal and replacement instructions for these parts are contained in the following paragraphs.

Many components in the Type S-311 are mounted in a particular way to reduce stray inductance and capacitance.

Therefore, carefully install replacement components to duplicate lead length, lead dress, and location of the original component. After replacing parts, check the calibration of the instrument.

Switches

Individual wafers are normally not replaced in the switch assemblies used in the Type S-311. If a wafer is defective, the entire switch assembly should be replaced. Switch assemblies can be ordered from Tektronix, either wired or unwired.

The wafer switches shown on the schematics are coded to indicate the position of the wafer on the switch. The wafers are numbered from front to rear (i.e., the number 1 wafer is always closest to the front panel). The letters "F" and "R" indicate the front or rear of the wafer. For example, a code designation of "3R" would mean rear side of the third wafer from the front panel.

Tube and Transistors

The tubes and transistors in the Type S-311 should not be changed unless they are actually defective. If tubes or transistors are removed and found to be acceptable, be sure to return them to their original sockets.

Do not use a tube- or transistor-tester as the only means for determining if a tube or transistor is defective. Testers may indicate that a tube or transistor is defective when it operates satisfactorily in a circuit, or may fail to indicate defects that affect the performance of the circuit. If a tube or transistor operates properly in the circuit, it is usable; if not, it should be replaced. Unnecessary tube or transistor replacement may require that the instrument be recalibrated.

Special precautions should be taken in replacing reed relay switches to avoid bending the leads near the glass. A good method in replacement is to clip off the leads from the defective unit, leaving sufficient length attached to the circuit board so that the replacement switch can be soldered to the old leads without bending.

Soldering Precautions

In the production of Tektronix instruments, a silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond may be broken by repeated use of ordinary tin-lead solder, and by excessive heating of the terminal strip with a soldering iron. Occasional use of ordinary solder is permissible if applied with moderate heat. For general repair work, however, solder used for the ceramic strips should contain about 3% silver. If this type of solder is not available locally, it may be purchased directly from Tektronix in one-pound rolls (part number 251-0514-00.

A wedge-shaped tip on the soldering iron is best for soldering or unsoldering parts on a ceramic strip. This type of tip allows you to apply heat directly to the solder-slot in the strip, reducing the overall heating effect. Use as little heat as possible to establish a good solder bond.

To properly solder and unsolder the short-lead components, the following procedure is recommended. (1) Use long-nose pliers for a heat sink. Attach the pliers between the component and the point where the heat is applied. (2) Use a hot soldering iron for a short time. (3) Carefully manipulate the leads to prevent lead or insulating damage. (4) Use only a small amount of solder; just enough to make a good bond.

Gallium Arsenide Diodes

The diodes in the Sampling Gates and Memory Gates are special gallium arsenide diodes manufactured by Tektronix. Each diode has a colored dot on the cathode end. The color of the dot identifies the diode as indicated in the following table.

Dot Color	Circuit Number	Tektronix Part Number
Red	D1132, D1130, D2132, and D2130	152-0083-00
Orange	D1046, D1047, D2046, and D2047	152-0014-00*
Yellow	D1044, D1045, D2044, and D2045	152-0014-00*

*Supplied in matched pairs.

The circuit number and polarity of each diode is shown on the schematic and is also printed on the etched-circuit board next to the diode clips.

If it is necessary to remove or replace any of the gallium arsenide diodes, use a pair of tweezers or similar tool. Do not solder the diodes into the clips. Heat from the soldering iron could damage a diode.

TROUBLESHOOTING

General Information

If trouble develops, first check all controls for proper settings. For example, an improper setting of the DC OFFSET control can cause the display to be positioned off the crt. Operate the front-panel controls and note their effect. A trouble that occurs only at certain control settings can be immediately attributed to a specific circuit.

NOTE

The S-311 may be manually operated without an external programmer by connecting a 25 vdc, 200 mA power source to pin 13 of the S-311 rear panel programming connector. If this supply is not connected the MV/DIV sensitivity remains in the 100 MV position.

After the trouble symptoms are clearly established, look for obvious causes. Check that line power is applied, the tube heaters are lit, etc. Next, check the power supply voltages in the oscilloscope and plug-in units (+20-, +100-, and +70-volt supplies in the Type S-311).

If you suspect that a tube or transistor is bad, check it by substitution. That is, replace it with a good tube or transistor of the same type. If you find that the suspected tube or transistor is not bad, be sure to return it to the original socket. This will help eliminate unnecessary recalibration because of differences in tube or transistor characteristics.

Troubleshooting Procedure

If trouble occurs in the sampling system, it is usually difficult to determine whether the fault is in the Type S-311 or in the sampling sweep plug-in unit. A trouble in either plug-in unit can cause a complete loss of the display.

To determine which plug-in unit is faulty, refer to the troubleshooting information in the sampling sweep plug-in unit instruction manual. After isolating the trouble to one of the plug-in units, refer to the troubleshooting chart in the appropriate plug-in unit instruction manual.

The troubleshooting chart in this manual provides a step-by-step check of the entire plug-in unit. The chart covers most of the troubles that could occur in the Type S-311.

The test points shown on the schematics aid in troubleshooting and calibrating the Type S-311. They simplify reference to particular locations in the circuitry. Each test point is indicated by a bracketed number at its location in the in the circuit.

The schematic on which each test point will be found is as follows:

(2) through (10): Snap-Off and Memory.

(11), (13), (14), (16), and (17): Dual-Trace Switching and Output Amplifiers.

(12) and (15): Channel A and B Amplifiers.

The following equipment is recommended for troubleshooting the Type S-311:

1. Dc volt-ohmmeter with a sensitivity of 20,000 ohms/volt.

2. Test oscilloscope with the following minimum specifications:

Input resistance: 10 megohms.

Deflection factor: 0.5 volt/division.

Bandpass: dc to 10 megacycles.

(Tektronix Type 531A, 533A, 535A, 541A, 543A, 545A, 551, or 555 Oscilloscope recommended with a Type K or L Plug-In Unit and a 10X attenuator probe.)

3. Tektronix Plug-In Extension 561, Tektronix part number 012-0066-00.

4. Sampling Sweep Plug-In Unit and Type 567 Oscilloscope.

5. A 1/2-watt, 10-megohm resistor.

6. An insulated shorting strap with alligator clips. Lead length should be about 4 inches.

7. Tektronix Type 109 or 110 Pulse Generator with a 20-nanosecond charge line.

Preliminary Setup

Remove the Type S-311 from the indicator unit. Set the front-panel controls as follows:

Channel A and B POSITION Controls	Midrange
Channel A and B MV/DIV. Switches	100
Channel A and B DC OFFSET Controls	Midrange
Channel A and B NORM.-INV. Switches	NORM.
SMOOTH-NORMAL Switch	NORMAL
Vertical Mode Switch	DUAL-TRACE

Leave the controls at these settings (unless otherwise noted) throughout the troubleshooting procedure.

Resistance Check of Interconnecting Plugs

Check the resistance-to-ground of each pin on the interconnecting plugs. Table 5-1 and 5-2 show typical resistances-to-ground of P12 and P11. The horizontal interconnecting plug on the rear of the Type S-311 is designated P11. The vertically-mounted interconnecting plug is designated P12.

Before using the troubleshooting chart (Table 5-4), it is best to isolate the trouble to a general circuit or group of circuits. If the trouble symptom is the loss of the display in either or both channels, the general location of the trouble can be isolated by using the following procedure:

1. Install both plug-in units into the oscilloscope, turn on the power and free run the sampling sweep plug-in unit.

2. Set both Type S-311 NORM.-INV. switches midway between positions.

3. With the POSITION controls, try to position both traces onto the crt.

4. Use Table 5-3 to determine the general location of the trouble.

TABLE 5-1

Typical Resistance-To-Ground, P12

Pin Number	Resistance	Pin Number	Resistance	Pin Number	Resistance
1	*900 and 180 ohms	9	infinite	17	infinite
2	infinite	10	infinite	18	infinite
3	*500 and 180 ohms	11	2 k	19	infinite
4	infinite	12	infinite	20	infinite
5	infinite	13	infinite	21	infinite
6	infinite	14	infinite	22	infinite
7	infinite	15	infinite	23	infinite
8	infinite	16	infinite	24	infinite

*Reverse ohmmeter leads to get both values of resistance.

TABLE 5-2

Typical Resistance-To-Ground, P11

Pin Number	Resistance	Pin Number	Resistance	Pin Number	Resistance
1	infinite	9	zero	17	100 k
2	infinite	10	100 k	18	infinite
3	zero	11	zero	19	zero
4	zero	12	50 k	20	2 k
5	infinite	13	infinite	21	100 k
6	100 k	14	infinite	22	zero
7	infinite	15	2 k	23	4 k
8	infinite	16	5 ohms	24	12 k

TABLE 5-3

Symptom	Indication Obtained in Step 3	Circuit at Fault
No display either channel.	Both traces can be positioned onto the crt.	Snap-Off Blocking Oscillator or Memory Gate Driver circuit.
	Neither trace can be positioned onto the crt.	Common Output Amplifier.
No display, one channel only.	Both traces can be positioned onto the crt.	Input circuit, Preamp circuit, Memory Gate or Memory circuit of the channel that will not produce a trace.
	Indication the same as the original trouble.	Vertical Amplifier Driver stages of the channel that will produce a trace, or the Dual-Trace Switching Multivibrator circuit.

Troubleshooting Chart

In Table 5-4, start with step 1 in the "Checks to Make" column. Each step in this column describes a check to make and the normal result. Follow each check in numerical order until there is an abnormal indication. At this point, refer to the "If Abnormal" column.

The "If Abnormal" column tells which components may be faulty or, in some cases, refers to an additional check. At several points in Table 5-4, you will be instructed to check certain diodes or transistors. This can generally be done by substituting these diodes or transistors with ones of the same type in another part of the circuit.

Before using Table 5-4, disconnect the Type S-311 from the oscilloscope and place it on the test bench. Set all front-panel controls as described previously under "Preliminary Setup".

TABLE 5-4

TROUBLESHOOTING CHART

Checks To Make	If Abnormal
Insert the Type S-311 and the sampling sweep plug-in unit into the oscilloscope, turn on the power and allow a few minutes for warm up.	
+20-Volt Power Supply	
1. Check the voltage at test point (17); it should be +20 volts ±1%.	Trouble is excessive loading on the supply or a faulty regulator circuit (Q2274 or Q2277). Make sure the +125-volt supply is regulating.
	A low reading at test point (17) indicates an overload. A high reading indicates faulty regulation.
Snap-Off and Driver Blocking Oscillator Circuits	
2. Set the sweep plug-in unit for free-running operation and, with the test oscilloscope, check the signal at test point 4. The pulse (approximately 10 V amplitude) should disappear as the sampling sweep plug-in unit trigger sensitivity is decreased.	Trouble is in Q2010 circuitry, or the Type S-311 is not receiving a signal from the sampling sweep plug-in unit via pin 18 of P11. Check components and voltages in Q2010 circuit. Then check Q2010, D2018, and D2002. Q2010 is selected for a BV_{CBO} of -21 volts.
Memory Gate Driver Circuit	
3. Set the sampling sweep plug-in unit for maximum trigger sensitivity. With the test oscilloscope, check the signal at test point (6); the most negative (flat) portion of the waveform should be 0.3 μs long.	Trouble is in Q2024 circuitry, or MEMORY GATE LENGTH control R2023 is misadjusted. First, try adjusting R2023 as described in the Calibration section of this manual under "Memory Gate Length Adjustment". If trouble is not corrected, check Q2024 and D2024.

Checks To Make	If Abnormal
Channel A Gate, Preamp, and Memory Circuits	
4. With a shorting strap, connect between the upper end of R1148 and ground. With the test oscilloscope, measure the dc voltage-to-ground at both ends of R1057 (A BRIDGE VOLTS); it should measure ±1.6 to ±2.2 volts. The two voltages should be within 0.2 volt of each other (disregarding polarity).	Trouble is in Sampling Gate diodes or gate voltage circuit. First, check for +100 and -100 volts at the ends of R1060 and R1065. Check the forward to back resistance of each diode in the Sampling Gate (D1044, D1045, D1046, and D1047). If none of these checks reveals the cause of trouble, try adjusting R1057 (A BRIDGE VOLTS) and R1063 (A BRIDGE BAL.) as described in the Calibration section of this manual.
5. Remove diodes D1130 and D1132 from the Memory Gate and shunt across C1132 with a 10-megohm resistor. Measure the voltage at test point (10A); it should be 0 ±0.3 volt. Remove the shunt resistor from C1132.	First, adjust the A MILLER LEVEL control, R1136, and try to bring the voltage on the collector of Q1141 within the specified voltage range. If this is not effective, check the power supply voltages in the Memory circuit (especially the +70 volts on the plate of V1133A). If this does not reveal the trouble, V1133, Q1134, or Q1141 is probably defective.
6. Remove the shorting strap from the upper end of R1148 and ground. Remove Q1141 from its socket. Place the shorting strap between test point (10A) and ground. With the test oscilloscope, check the signal at test point (7A); it should vary in amplitude and polarity as the channel A DC OFFSET control is turned throughout its range. Remove the shorting strap from test point (10A). Replace Q1141.	First, measure voltage at upper end of R1148 and vary the channel A DC OFFSET control throughout its range. The voltage should vary between about +1 volt and -1 volt. If not, the trouble is in the V2133A circuitry. If the voltage on R1148 varies as described, the trouble is in the V1073, Q1074, Q1084, or Q1094 circuitry. Check the dc voltages throughout the Preamp stages.
7. Replace diodes D1130 and D1132 in the Memory Gate. Place the shorting strap between the upper end of R1148 and ground. Measure the voltage at test point (10A); it should be 0 ±0.3 volt.	Trouble is in Memory Gate circuit. Measure voltages at test points (8A) and (9A). Voltage at (8A) should be about -3 volts; voltage at (9A) should be about +3 volts. Check diodes D1124, D1122, D1129, D1130 and D1132.

Checks To Make	If Abnormal
8. Remove the shorting strap from R1148 and measure the voltage at test point (10A). With the channel A DC OFFSET control, adjust the zero volts at test point (10A).	Trouble is in Dc Offset circuitry. Check V2133A and associated components.

Check channel B Gate, Preamp, and Memory circuits by repeating steps 4 through 8. All references to channel A components apply to the corresponding components in channel B.

9. Measure voltage at emitter of Q1183. Set channel A POSITION control to midrange and adjust channel A DC OFFSET control for +10 volts. Vary channel A POSITION control throughout its range. Voltage should vary from about +1.5 volts to about +18 volts. If normal, go to step 11.	Set channel A NORM.-INV. switch to INV. and repeat step 9. If the voltage is now proper, the trouble is the Inversion Stage (Q1163 and Q1164). If the voltage is still not proper, go to step 10.
10. Measure voltage at the emitter of Q1173 (test point (12A)). Adjust DC OFFSET control for zero volts. Leave the DC OFFSET control at this setting. If the voltage can be adjusted to zero with the DC OFFSET control, the trouble is in the Q1183 and Q1184 circuits. First, check transistors Q1183 and Q1184.	Q1173 circuit is faulty.

Check channel B Vertical Amplifier by repeating steps 9 and 10. All references to channel A components apply to the corresponding components in channel B.

Dual-Trace Switching Circuit

11. With test oscilloscope, check for trigger spikes at test point (13).	Dual-Trace Blocking Oscillator is not functioning; check Q2230.
12. With the test oscilloscope, check for a square wave signal at test point (16), amplitude typically 2 volts, 20 μs per cycle. See Fig. 6-1 page 6-5.	Trouble is in the Dual-Trace Switching Multivibrator (Q2255-Q2245). Check the voltages in the multivibrator circuit. When checking the voltages, set the Vertical Mode switch to the positions indicated on the table following. If the voltages are not proper, diode D2244, D2254, D2238 or D2239 may be defective.

Checks To Make	If Abnormal

Dual Trace Switching Circuit (cont'd)

Mode	Test Point	Volts
A Only	Q2255 Base	-9
Dual-Trace	Q2255 Base	-7.5
B Only	Q2255 Base	-0.24
A Only	Q2245 Base	-9
Dual-Trace	Q2245 Base	-7.5
B Only	Q2245 Base	-0.24
A Only	D2244 Cath.	-0.4
Dual-Trace	D2244 Cath.	+10
B Only	D2244 Cath.	+20
A Only	D2254 Cath.	-0.4
Dual-Trace	D2254 Cath.	+10
B Only	D2254 Cath	+20

Blanking Amplifier

Checks To Make	If Abnormal
13. Set Vertical Mode switch to A ONLY. Check the signal at test point (14) with the test oscilloscope.	Blanking Amplifier circuit is faulty. First, check D2203. If this is not the trouble, check V2214.

Common Output Amplifier

Checks To Make	If Abnormal
14. Short between pins 3 and 8 of V1224. Trace should appear on remain on the crt. Remove the short.	V1224 is faulty or there is an improper voltage at one of its elements.
15. Short between the bases of Q1204 and Q1214. Trace should appear or remain on the crt. If trace cannot be positioned onto the crt after the short is removed, the Q1223 circuit is faulty.	Q1204 or Q1214 is faulty. Check voltages.

SECTION 6

CALIBRATION

Introduction

This section of the manual describes the calibration procedure for the Type S-311. The instrument should be calibrated after each 500 hours of use or every six months, whichever comes first.

This procedure can be used in conjunction with the troubleshooting procedure if trouble occurs in the instrument. In many cases, calibration will either isolate or eliminate the trouble.

The steps in this procedure are in the proper sequence for a complete check and calibration of the Type S-311. Since some adjustments interact, the steps should be performed in the order given. Do not attempt to make an individual adjustment without going through a complete calibration.

Equipment Required

The following equipment is required to calibrate the Type S-311.

1. Test oscilloscope with the following characteristics:

Bandpass	dc to 30 mc
Sweep Rate (fastest)	0.1 μsec/cm
Deflection Factor	5 mv/cm
Input Resistance	1 megohm (10 megohms) with 10X probe)

(Tektronix Type 540-Series or 550-Series Oscilloscope, and a Type L Plug-In Unit with a 10X and 1X probe, recommended.)

2. Tektronix Type 567 or RM567 Oscilloscope (in which to operate the Type S-311).

3. Tektronix Type S-300 or 3T77 Sampling Sweep Plug-In Unit.

4. Tektronix Type 109 Pulse Generator.

5. Tektronix Type 105 Square-Wave Generator.

6. A precision, non-loading type of voltmeter (such as the John Fluke Model 801B or 825A).

7. Dc voltmeter with a sensitivity of at least 20,000 ohms/volt, accuracy at least 1%.

8. General Radio "T" connector (General Radio part number GR874-T).

9. Tektronix 24-pin flexible plug-in extension for the sampling system (Tektronix part number 012-0066-00.

10. An insulated shorting lead about 4 inches long with alligator clips.

11. Small screwdriver with an insulated shank.

12. Assortment of RG-8A/U coaxial cables with GR connectors.

13. UHF-to-GR adapter for mating to the Type 105 Generator (Tektronix part number 017-0023-00); also two BNC to GR adapters.

14. 50-ohm 10XT attenuator with GR connectors (Tektronix part number 017-0044-00).

15. A 1/2-watt, 10-megohm resistor.

16. A 500-ohm, 1/4-watt potentiometer.

17. A 1.8 k, 1/2-watt resistor 5%.

18. An Amphenol (type 57-30360 Tek No. 131-0293-00) 36-pin male cable connector with leads attached for connection to external 25 vdc supply.

19. Type 113 55 nsec Delay Cable

Preliminary Procedure

Insert the Sampling Sweep Plug-In Unit into the sweep compartment of a Type 567 or RM567 Oscilloscope, and place the Type S-311 (with flexible plug-in extension connected between the horizontal interconnecting plugs) in the left-hand compartment.

If you suspect that the Type S-311 is extremely misadjusted, turn the A PREAMP SENS. and B PREAMP SENS. adjustments fully counterclockwise, and all other internal controls to midrange. For routine calibration of the Type S-311, the internal controls are probably near their proper positions and should not require preadjustment.

Set the Type S-311 front-panel controls as follows:

A and B POSITION	Midrange
A and B MV/DIV.	100
A and B DC OFFSET	Midrange
A and B NORM.-INV.	INV.
Vertical Mode Switch	DUAL-TRACE
SMOOTH-NORMAL	NORMAL
GAIN ADJ.	Midrange

Set the sweep plug-in front-panel controls as follows:

POSITION	Midrange
TIME/DIV	1 ns
HORIZ. MAG	X1
DOTS PER DIV.	100
DELAY	Fully counterclockwise
TRIGGER SENSITIVITY	Fully clockwise
SWEEP MODE	NORMAL
INT.-EXT.	+EXT.
MANUAL SCAN	Any position
RECOVERY TIME	Any position

Leave all controls in the stated positions until otherwise instructed.

Turn on the oscilloscope power and allow the system to warm up for at least two minutes before proceeding.

Check and Adjustment Procedure

+20-Volt Power Supply Check

1. Connect the dc voltmeter between test point (17) and ground. The voltage should be +20 volts, ±2%.

2. With the test oscilloscope, measure the ripple voltage at test point (17). (Note: Ac couple test oscilloscope, set for 5 mv/cm sensitivity, and use 1X probe.) Ripple voltage should not exceed 3 mv, peak-to-peak.

Snap-Off Blocking Oscillator Check

1. Connect the 10X probe from the test oscilloscope to test point (4).

2. Set the sweep rate of the test oscilloscope to 0.1 μsec/cm and the deflection factor to 10 volts/cm (including probe).

3. Adjust the test oscilloscope triggering controls for a stable display, triggered on the positive slope of the signal. The waveform on the test oscilloscope at test point (4) is typically a 0.1 μs positive pulse approximately 10 volts in amplitude.

Dual Trace and Output Stages Check

1. Set the channel A and B NORM.-INV. switches midway between positions. To check that the switches are between positions, vary both DC OFFSET controls; they should not affect the vertical position of the trace on the 567.

2. Measure the ac voltage swing at the emitter of Q1183 as the channel A POSITION control is turned from one extreme to the other. The voltage should swing between about +5 volts and +15 volts. Repeat this procedure at the emitter of Q2183 with the channel B POSITION control.

3. With the test oscilloscope, display the signals at the collectors or Q2245 and Q2255. The signals should resemble the waveform shown in Fig. 6-1. Vary the RECOVERY TIME control of the sampling sweep, repetition rate of the displayed waveforms should vary. Return both NORM.-INV. switches of the Type S-311 to INV.

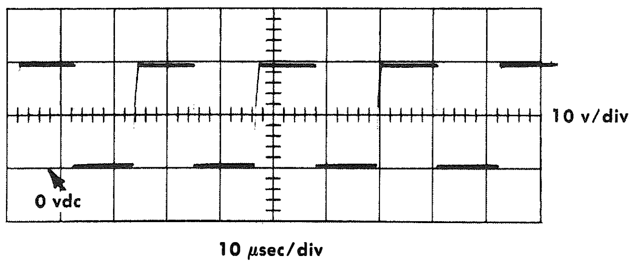


Fig. 6-1. Signal at collector of Q2245 or Q2255.

MOMORY GATE LENGTH Preliminary Adjustment

1. Connect the 10X probe to the test oscilloscope to test point (6).

2. Set the test oscilloscope for a sweep rate of 0.1 μsec/cm and a deflection factor (including probe) of 10 volts/cm.

3. Set the test oscilloscope triggering controls for a stable display, triggered on the negative slope of the waveform.

4. Adjust the MEMORY GATE LENGTH control so that the most negative (flat) portion of the display is 0.3 μsec (3 cm) long.

Blanking Amplifier Check

1. Connect the 10X probe of the test oscilloscope to test point (14).

2. Set the sweep rate of the test oscilloscope to 5 μsec/cm and the deflection factor at 20 volts/cm (including probe).

3. Set the test oscilloscope triggering controls for a stable display, triggered on the positive slope of the waveform. The positive pulses displayed at test point (14) should be between 40 and 50 volts in amplitude, to blank the CRT between dots.

4. Set the Vertical Mode switch of the Type S-311 to A ONLY and to B ONLY while observing the display on the test oscilloscope. The waveform should not change. Return the Vertical Mode switch to DUAL-TRACE.

5. Turn the sweep unit TRIGGER SENSITIVITY control fully counterclockwise. The test oscilloscope display should disappear. Return the TRIGGER SENSITIVITY control fully clockwise and the display should reappear.

Miller and Error Amplifier Check

1. With the A and B POSITION controls, move both traces onto the graticule.

2. Rotate the A and B DC OFFSET controls to insure that both traces move vertically. Return both DC OFFSET controls to midrange.

NOTE

In some cases, it may be possible to obtain a trace on one or both channels because one or both MILLER LEVEL adjustments are not set closely enough to their calibrated setting. In such a case, perform the following procedure and then repeat the Miller and Error Amplifier Check:

1. Place a shorting lead between the upper end of R1148 and ground.

2. Place the 10-megohm resistor (item 15 in Equipment Required) across C1132.

3. Connect the dc voltmeter to test point (10A) and adjust the A MILLER LEVEL for zero volts.

4. For channel B, the shorting lead goes between the upper end of R2148 and ground, the 10-megohm resistor goes across C2132, and the voltage is measured at test point (10B) as the B MILLER LEVEL is set.

A and B MILLER LEVEL Adjustment

1. Alternately switch the Type S-311 SMOOTH-NORMAL switch from one position to the other and adjust the A MILLER LEVEL for no vertical shift of the channel A trace.

2. Repeat step 1, except this time adjust the B MILLER LEVEL for no vertical shift of the channel B trace. Return the SMOOTH-NORMAL switch to NORMAL.

A NORM. GAIN Adjustment

1. Assembly the system shown in Fig. 6-2. Adjust the 500-ohm variable resistor so exactly 0.5 volt appears at the Type S-311 channel A INPUT connector.

2. Make sure the channel A MV/DIV. switch is set to 100, and the NORM.-INV. switches are set to INV.

3. Connect the precision, non-loading voltmeter to the emitter of Q1183, and alternately remove and connect the dc

voltage at the channel A INPUT connector. Adjust the A NORM. GAIN for an exact 5-volt change as the voltage is removed and then connected.

Leave the system of Fig. 6-2 connected to the Type S-311.

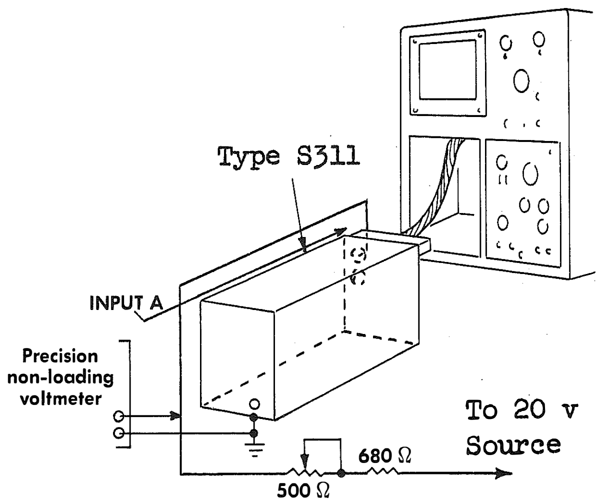


Fig. 6-2. Circuit used to set Type S-311 gain.

Front-Panel GAIN ADJ.

Set the front-panel GAIN ADJ. of the Type S-311 for a change of exactly 5 divisions of the channel A trace on the crt of the oscilloscope (to which the Type S-311 is connected) as the dc voltage at the INPUT A connector is alternately removed and connected. Maintain all conditions for the next adjustment.

A INV. GAIN Adjustment

Set the channel A NORM.-INV. switch to NORM. Recheck the amount of vertical deflection on the oscilloscope; it should change exactly 5 major graticule divisions as described in the previous gain adjustments. If not, set the A INV. GAIN adjustment. Remove the voltage from the INPUT A connector of the Type S-311.

B NORM. GAIN Adjustment

1. Apply the 0.5-volt dc voltage to the INPUT B connector of the Type S-311. Make sure the channel B NORM.-INV. switch is set to INV., and the B MV/DIV. switch is set to 100.

2. With the precision voltmeter, measure the voltage change at the emitter of Q2183 as the dc voltage is alternately removed and connected. Voltage change should be exactly 5 volts. If not, set the B NORM GAIN control. Maintain all conditions for the next adjustment.

B INV. GAIN

1. Set the channel B NORM.-INV. switch to NORM.

2. On the crt of the oscilloscope, check for a trace shift of exactly 5 major divisions as the dc voltage is alternately removed and connected at the INPUT B connector. If the trace does not shift exactly 5 major divisions, set the B INV. GAIN control. Disconnect the dc voltage from the INPUT B connector.

A BRIDGE VOLTS and Preliminary A BRIDGE BAL. Adjustment

1. Connect the 10X probe of the test oscilloscope (dc-coupled) to test point (3A) and adjust the A BRIDGE VOLTS control for a dc voltage on the test oscilloscope of +2.5 volts.

2. Connect the 10X probe of the test oscilloscope to test point (2A) and adjust the A BRIDGE BAL. control for a dc voltage of -2.5 volts.

3. Due to interaction between the two adjustments, steps 1 and 2 will have to be repeated several times.

Preliminary B BRIDGE VOLTS and B BRIDGE BAL. Adjustment

1. Connect the 10X probe of the test oscilloscope (dc-coupled) to test point (3B) and adjust the B BRIDGE VOLTS control for a dc voltage on the test oscilloscope of +2.5 volts.

2. Connect the 10X probe of the test oscilloscope to test point (2B) and adjust the B BRIDGE BAL. for a dc voltage of -2.5 volts.

3. Due to interaction between the two adjustments, steps 1 and 2 will have to be repeated several times.

SNAP-OFF CURRENT (Channel A Risetime Adjustment)

1. Connect a 65-nanosecond charge line between the Charge-Line connectors on the Type 109 Pulse Generator.

2. Connect the output of the pulse generator in series with the Type 113 Delay Cable to the Type S-311 INPUT A connector, and connect the Ext. Trigger Out to the Sampling Sweep Ext. Trigger Input connector.

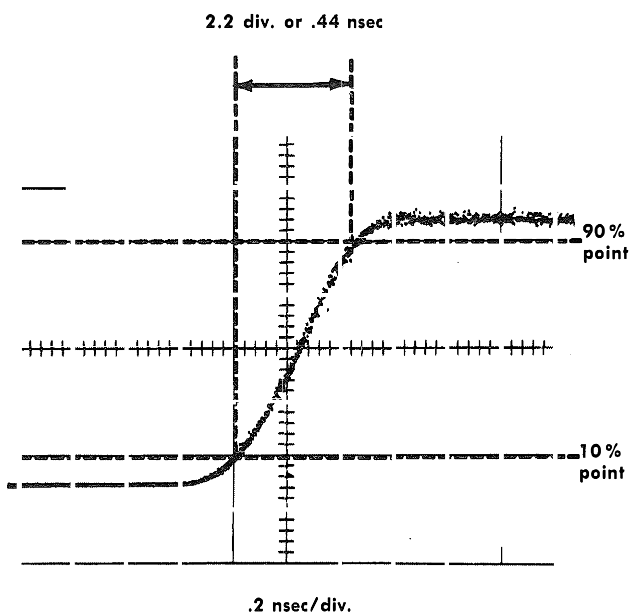


Fig. 6-3. Rising portion of a pulse with the risetime set for 0.44 nanosecond between 10% and 90% amplitude points.

3. Set the Amplitude control of the Type 109 Pulse Generator for a display of exactly 5 major divisions (0.5 volt, peak-to-peak). It may be necessary to readjust the sampling sweep TRIGGER SENSITIVITY control for a stable display.

4. Set the TIME/DIV. switch of the Sampling Sweep to 2 nSEC and the sweep magnifier to X10.

5. Set the SWEEP DELAY control to display the rising portion of the pulse-generator signal.

6. Adjust the SNAP-OFF CURRENT adjustment for a risetime of 0.41 to 0.44 nsec, measured between the 10% and 90% amplitude points of the signal (see Fig. 6-3).

7. On the Type S-311, remove the signal from INPUT A and connect it to the INPUT B.

B BRIDGE VOLTS (Channel B Risetime) Adjustment

1. Set the Sampling Sweep TRIGGER SENSITIVITY and DELAY controls for the same display as in the previous adjustment.

2. Adjust the B BRIDGE VOLTS for a risetime of 0.41 to 0.44 nsec between the 10% and 90% amplitude points of the signal (see Fig. 6-3).

3. Remove the signal from INPUT B for the next adjustment.

A BRIDGE BAL. Adjustment

1. Set the Sampling Sweep TRIGGER SENSITIVITY control fully clockwise.

2. Connect the 10X probe of the test oscilloscope to the channel A X100 OFFSET MONITOR jack. Dc couple the test oscilloscope and adjust the A DC OFFSET control for exactly zero volts on the test oscilloscope.

3. Turn the Type S-311 channel A MV/DIV. switch back and forth between 100 and 10 while adjusting the A BRIDGE BAL. control for no vertical trace shift.

4. Return the CHANNEL A MV/DIV. switch to 100.

B BRIDGE BAL. Adjustment

1. Connect the 10X probe of the oscilloscope to the

channel B X100 OFFSET MONITOR jack. Dc couple the test oscilloscope and adjust the B DC OFFSET control for exactly zero volts on the test oscilloscope.

2. Turn the Type S-311 channel B MV/DIV. switch back and forth between 100 and 10 while adjusting the B BRIDGE BAL. control for no vertical trace shift.

3. Turn the channel B MV/DIV. switch to 100.

A and B Bridge Voltage Check

1. Dc couple the test oscilloscope and, with the 10X probe, measure the dc voltage at test points (2A) and (3A). The voltage should be negative at test point (2A) and positive at test point (3A). Minimum voltage at either test point is 1.6 volts; the maximum difference (neglecting polarity) between the two voltages is 0.2 volt.

2. Repeat step 1 at the corresponding test points (2B) and (3B).

A PREAM SENS. and MEMORY GATE LENGTH Adjustment

NOTE

Adjustment of the A and B Preamp Sensitivity and Memory Gate Length may affect previous adjustments. Thus any adjustment in this step should be followed with a recheck of: A and B Normal Gain, and (front panel) Gain Adj. If Preamp Sens. is found to be badly out of adjustment it may also be necessary to recheck Snap-off Current (A risetime), B Bridge Volts, and A and B Bridge Balance.

1. Setup the Type 109 Pulse Generator as follows:

CHG. LINE 1 connector	No connection.
CHG. LINE 2 connector	Connect about 65-nsec charge line.

50 Ω OUTPUT connector	Connect to the INPUT A of the Type S-311 with the Type 113 Delay Cable.
AMPLITUDE and VOLTAGE RANGE	Set for 0.75 volts.
PULSE POLARITY	+

2. Set the Vertical Mode switch of the Type S-311 to A ONLY.

3. Set th e Sampling Sweep DOTS PER DIV. switch to 10 and the TIME/DIV. to 20 nSEC. Set the TRIGGER SENSITIVITY control for stable triggering on both the short and long pulse of the Type 109 (this will be evidenced by the presence of a baseline under the pulse; see Fig. 6-4).

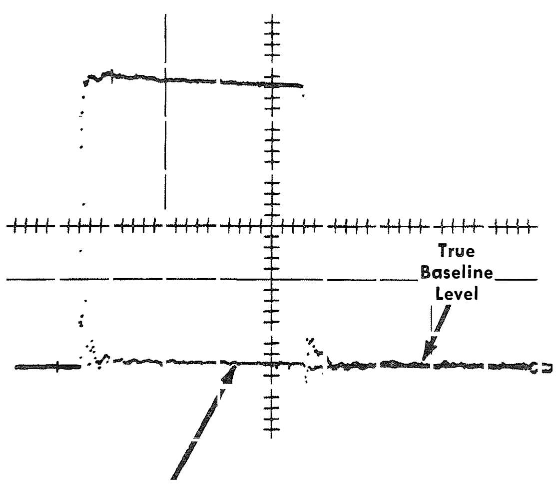


Fig. 6-4. Displayed pulse of Type 110 Pulse Generator with one charge line connected and the PREAMP SENS. control properly adjusted.

4. Adjust the MEMORY GATE LENGTH for the maximum distance between the baseline and the top of the pulse.

5. Adjust the A PREAMP SENS. to align the baseline (point "A" level in Fig. 6-4) under the pulse with the true baseline that precedes and follows the pulse.

6. Set the Type 109 Pulse Generator for a negative pulse output of the same amplitude.

7. Set the Sweep INT.-EXT. TRIGGER switch to -EXT., and the TRIGGER SENSITIVITY for a stable display triggering on both the long and short output pulse of the Type 109 Pulse Generator.

8. Check the level of the baseline under the pulse. This level should not deviate from the true baseline by more than 10% of the pulse amplitude. If the deviation is more than 10%, readjust the A PREAMP SENS. for the best compromise between steps 5 and 8.

B PREAMP SENS. Adjustment

1. Set the Vertical Mode switch of the Type S-311 to B ONLY.

2. Use the same setup of the Type 109 Pulse Generator as in step 1 of the previous adjustment except apply the pulse out to the INPUT B connector of the Type S-311.

3. Set the Sampling Sweep TRIGGER SENSITIVITY and INT.-EXT. controls for stable triggering on a positive pulse. Be sure to trigger on both the long and short output pulse of the Type 109 Pulse Generator as described in the previous adjustment.

4. Adjust the B PREAMP SENS. to align the baseline under the pulse with the true baseline (Fig. 6-4).

5. Reverse the polarity of the output pulse from the Type 109 and set the INT.-EXT. TRIGGER switch of the Sweep to -EXT. Readjust the Sweep TRIGGER SENSITIVITY to trigger on both the long and short pulses.

6. Check the level of the baseline under the pulse. This level should not deviate from the true baseline by more than

10% of the pulse amplitude. If the deviation is more than 10%, readjust the B PREAMP SENS. for the best compromise between steps 4 and 6. Return the Vertical Mode switch to A ONLY.

Pulse Aberration Check

1. Set up the Type 109 Pulse Generator as follows:

CHG. LINE 1 connector	Short center conductor to outer conductor with a single alligator clip.
CHG. LINE 2 connector	Connect about 65-nsec charge line.
OUTPUT connector	Connect to INPUT A of the Type S-311 with the Type 113 Delay Cable.
AMPLITUDE and VOLTAGE RANGE	Set for approximately 0.75 volts.
PULSE POLARITY	+

2. Display the output pulse of the Type 109 at a sweep rate of 5 nsec/div.

3. Adjust the output amplitude of the pulse generator for exactly 8 divisions, as measured after the first 20 nsec of the displayed pulse (with the Type S-311 A MV/DIV. switch at 100). Observe the first 10 nsec at the top, leading corner of the displayed pulse. Maximum aberration is ±3% (±0.24 division with 8 divisions of deflection) of the pulse amplitude.

4. Repeat steps 1 through 3 for channel B. Maximum aberrations for channel B are the same.

5. Remove all signal connections. Return the Vertical Mode switch to A ONLY.

DC OFFSET Range Check

1. Turn the Sampling Sweep TRIGGER SENSITIVITY control fully clockwise.

2. Set both Type S-311 NORM.-INV. switches to INV.

3. With the channel A POSITION control, move the trace to the centerline of the graticule.

4. Set the channel A MV/DIV. switch to 10 and use the channel A DC OFFSET control to return the trace to the centerline of the graticule.

5. Set the channel A MV/DIV. switch to 100 and repeat steps 3, 4, and 5 until no further adjustment is required.

6. With the 10X probe of the test oscilloscope (dc coupled) measure the dc voltage at the channel A X100 OFFSET MONITOR. Voltage must be zero, ±5 volts. Remove 10X probe from the channel A X100 OFFSET MONITOR.

Memory Drift Check

1. Connect the output of the Type 105 Square-Wave Generator to the INPUT A connector through a 10X attenuator (item 14 of "Equipment Required").

2. Set the Type S-311 Vertical Mode switch to A ONLY.

3. Set the Sampling Sweep TIME/DIV. switch to 10 μSEC and the DOTS PER DIV. switch to 10.

4. Set the output frequency of the Type 105 Square-Wave Generator to 30 cycles and adjust the output amplitude for about 6 divisions of deflection.

5. Connect the Sync Output of the Type 105 to the Ext. Trig. Input of the Sweep unit and set the triggering controls of the Sweep for a stable display.

6. Check the display for the amount of vertical elongation of the dots (memory drift). Maximum elongation at 30 cycles is 1 minor division (2 millimeters) on the graticule.

7. Repeat the steps for channel B.

Signal Rejection Ratio Check

1. Set the Type S-311 Vertical Mode switch to DUAL-TRACE, and the NORM.-INV. switches to opposite positions (one to NORM., one to INV.).

2. Set the sampling sweep plug-in unit for 10 dots/div and a sweep rate of 5 nsec/div.

3. Apply a signal from the Type 105 Square-Wave Generator to the Type S-311 INPUT A and INPUT B through a 10X attenuator and a GR "T" connector.

4. Set the output amplitude of the Type 105 for 8 divisions of deflection in both channels with the MV/DIV. switches set at 100.

5. Set the Vertical Mode switch to A+B and position the trace onto the crt.

6. Check the amount of vertical deflection. Maximum deflection is 0.16 division (neglecting spikes) for a minimum rejection ratio of 50:1.

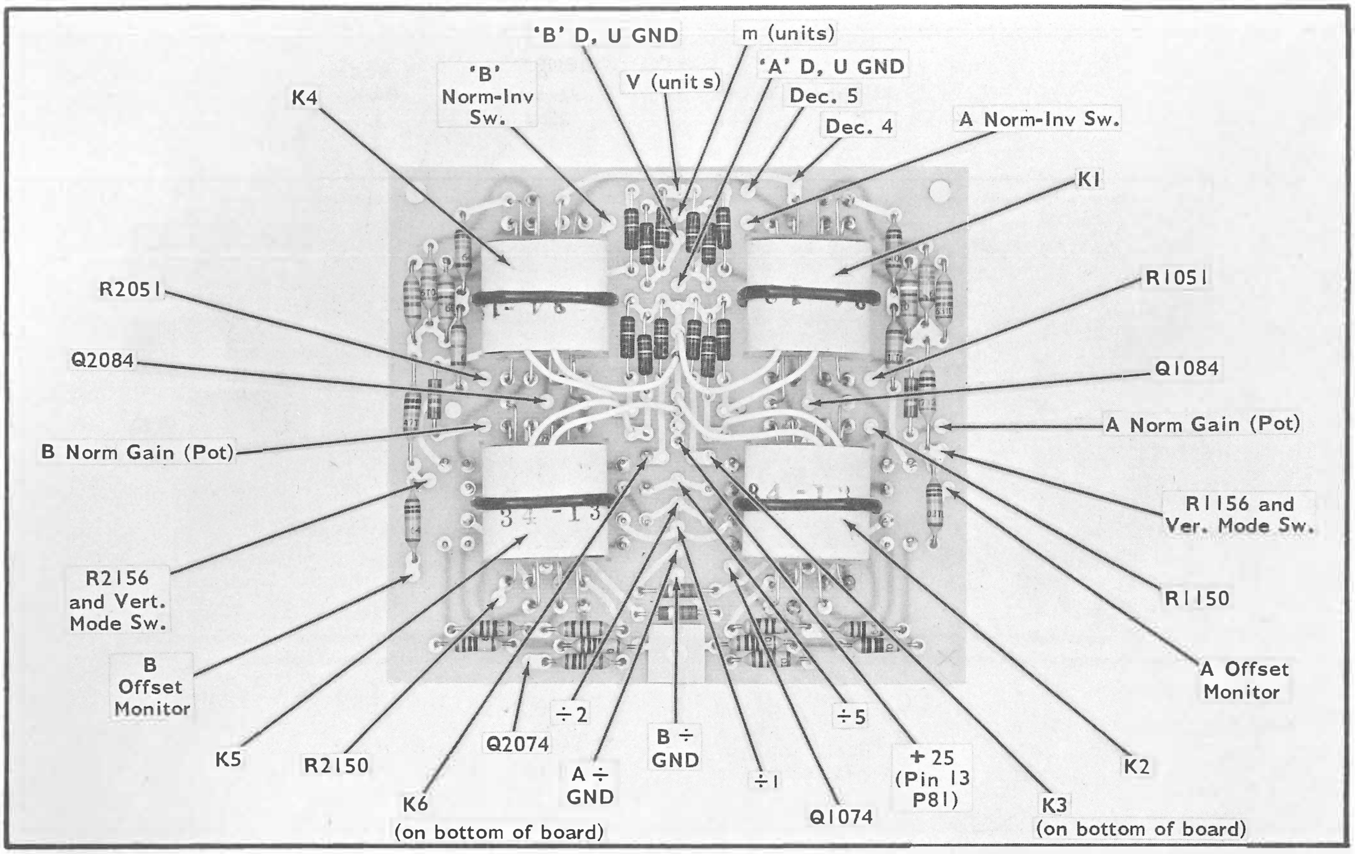
7. Set the Vertical Mode switch to DUAL-TRACE and decrease the amount of deflection to 4 divisions by decreasing the output amplitude of the Type 105 Square-Wave Generator.

8. Set the Vertical Mode switch to A+B and set both NORM.-INV. switches in the same position.

9. Check the amount of vertical deflection; it must be 8 division, ±0.16 division.

NOTE

The foregoing calibration does not check the External Program operation. This may be done by continuity checks from the 36-pin rear panel connector to appropriate circuit points per the Vertical Mode Switch and MV/DIV Circuit Board schematic diagrams, or by connection to a Type 262 Programmer system. Operation of the digital readout portion may be checked by use of a Type 6R1 (or 6R1A) Digital Readout Unit mounted in the Type 567 Oscilloscope.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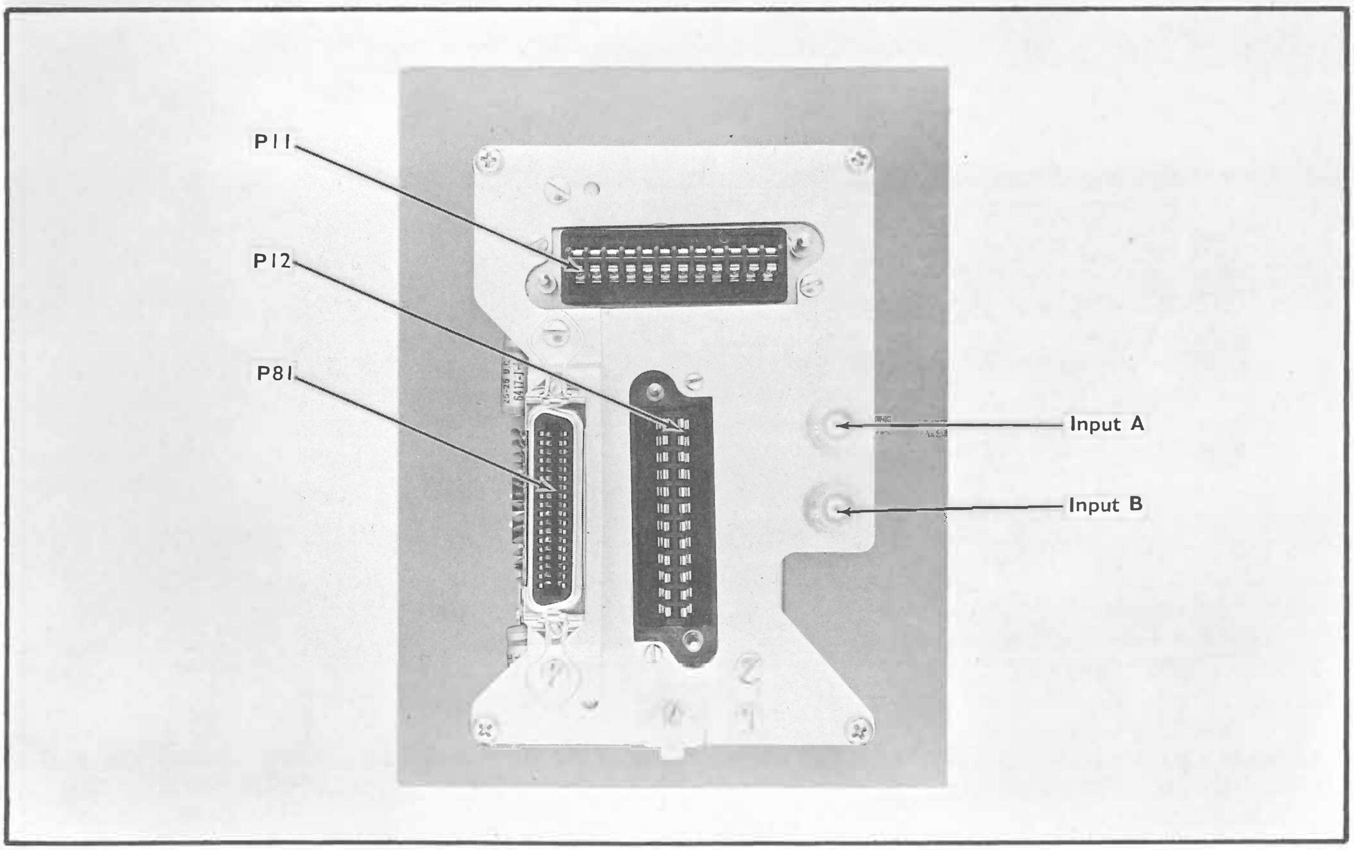
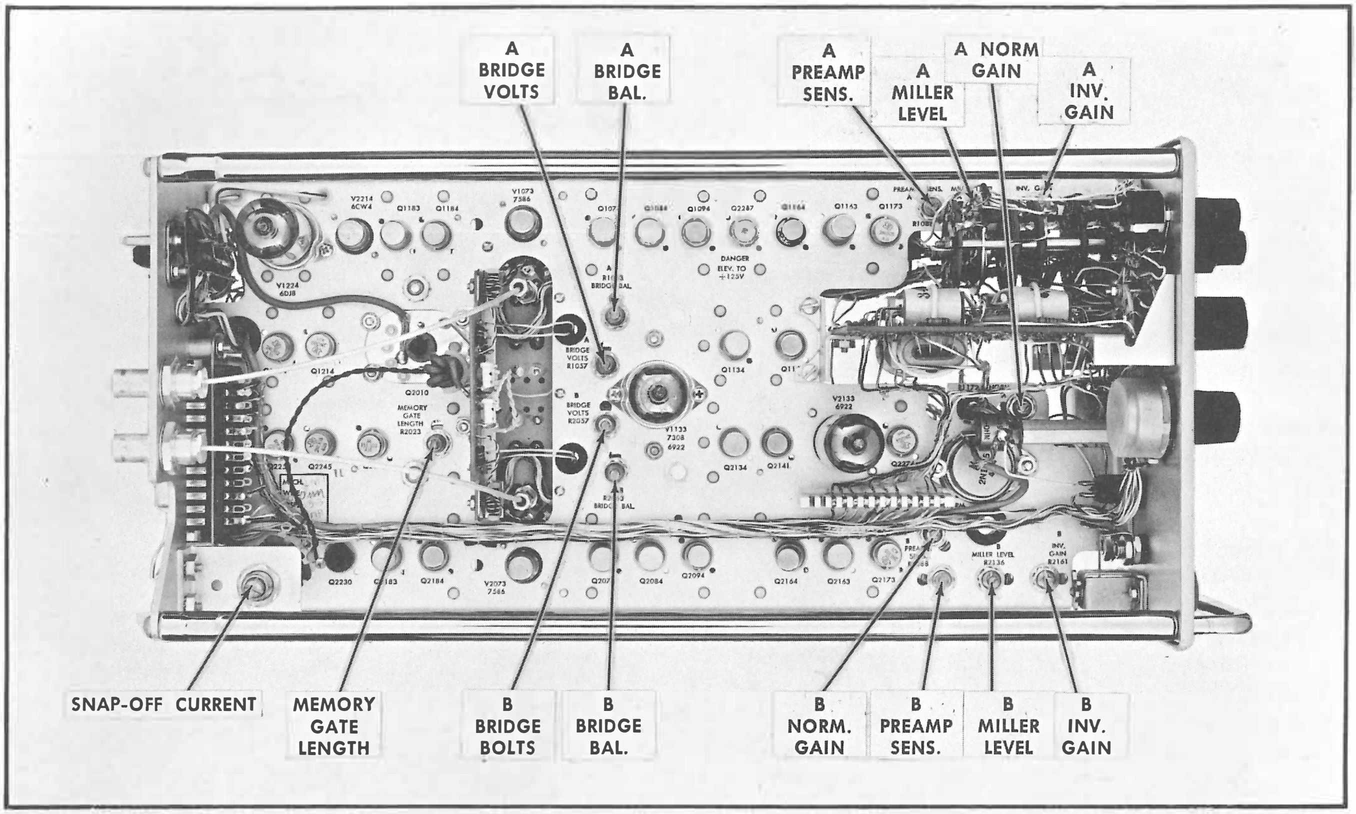
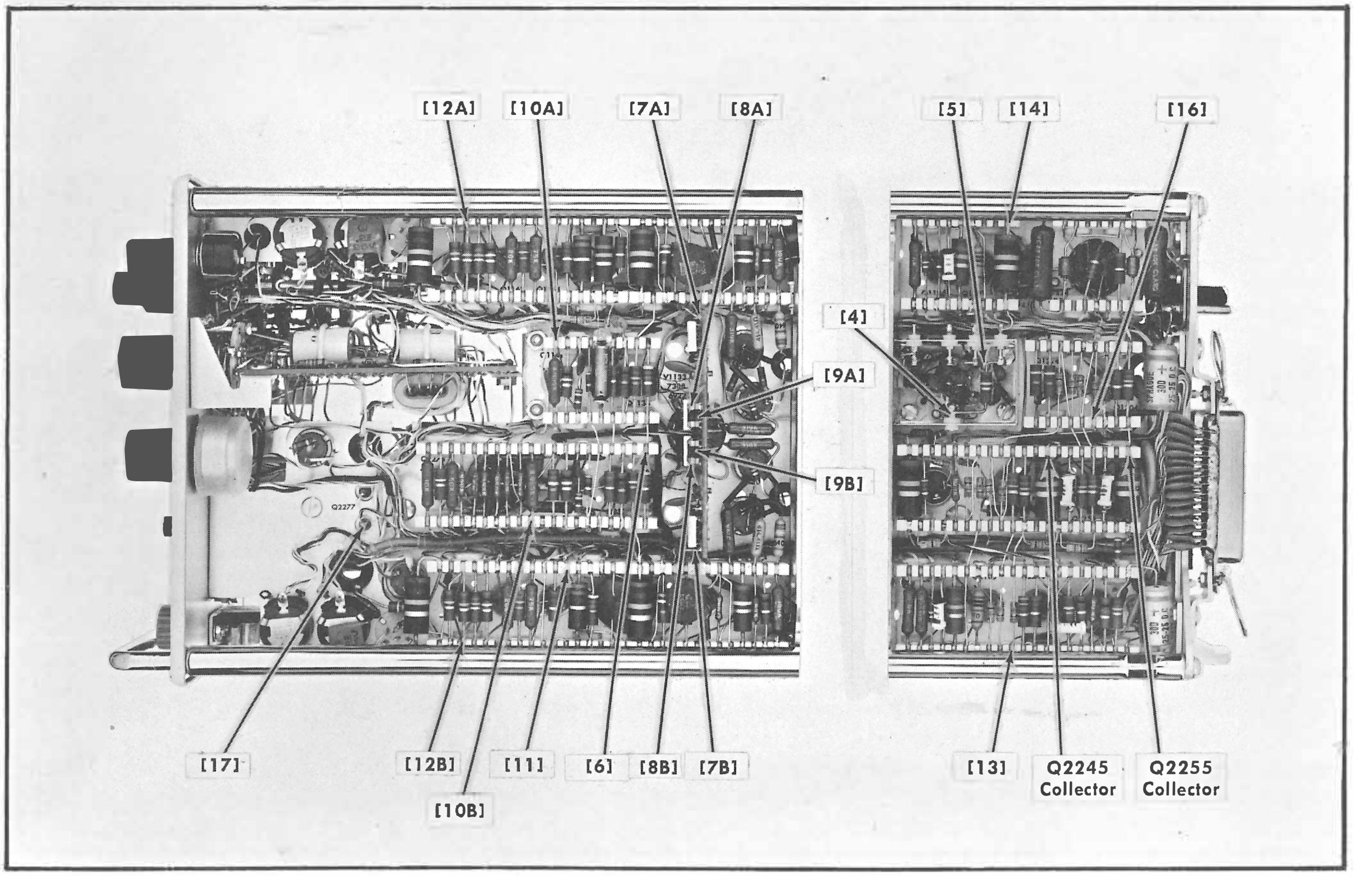
m (units)
'A' D, U GND
'B' Norm-Inv Sw.
V (units)
Dec. 5
Dec. 4
K4
A Norm-Inv Sw.
K1
R2051
R1051
Q2084
Q1084
A Norm Gain (Pot)
B Norm Gain (Pot)
R1156 and Ver. Mode Sw.
R2156 and Vert. Mode Sw.
R1150
B Offset Monitor
A Offset Monitor
÷2
÷5
K5
R2150
Q2074
B ÷ GND
+25 (Pin 13 P81)
K2
A ÷ GND
÷1
K6 (on bottom of board)
Q1074
K3 (on bottom of board)


P11
P12
P81
Input A
Input B


A BRIDGE VOLTS
A BRIDGE BAL.
A PREAMP SENS.
A MILLER LEVEL
A NORM GAIN
A INV. GAIN
SNAP-OFF CURRENT
MEMORY GATE LENGTH
B BRIDGE BOLTS
B BRIDGE BAL.
B NORM. GAIN
B PREAMP SENS.
B MILLER LEVEL
B INV. GAIN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Q2245 Collector
Q2255 Collector

ELECTRICAL PARTS

Values are fixed unless marked Variable.

*Indicates component manufactured by or for Tektronix, reworked and/or checked.

Ckt. No.	Tektronix Part No.	Description				S/N Range
		Bulb				
B2000	039-0420-00	28 v	White Lens			
		Capacitors				

Tolerance ±20% unless otherwise indicated.

C1042	281-0537-00	0.68 pf	Cer	500 v		
C1043	281-0537-00	0.68 pf	Cer	500 v		
C1046	283-0572-00	50 pf	Mica	500 v	5%	
C1047	283-0572-00	50 pf	Mica	500 v	5%	
C1049	281-0519-00	47 pf	Cer	500 v	10%	
C1055	281-0516-00	39 pf	Cer	500 v	10%	
C1056	281-0516-00	39 pf	Cer	500 v	10%	
C1073	283-0006-00	0.02 μf	Cer	500 v	10%	
C1077	283-0051-00	0.0033 μf	Cer	100 v	5%	
C1080	283-0000-00	0.001 μf	Cer	500 v		
C1088	283-0026-00	0.2 μf	Cer	25 v		
C1121	283-0023-00	0.1 μf	Cer	10 v		
C1124	281-0594-00	150 pf	Cer	100 v	5%	
C1128	283-0023-00	1 μf	Cer	10 v		
C1132	281-0594-00	150 pf	Cer	100 v	5%	
C1134	283-0028-00	0.0022 μf	Cer	50 v		
C1139	283-0000-00	0.001 μf	Cer	500 v		
C1140	283-0026-00	0.2 μf	Cer	25 v		
C1182	281-0500-00	2.2 pf	Cer	500 v	±0.5 pf	
C1219	283-0003-00	0.01 μf	Cer	150 v		

Ckt. No.	Tektronix Part No.	Description				S/N Range
		Capacitors (Cont'd)				
C2001	281-0517-00	39 pf	Cer	500 v	10%	
C2002	281-0541-00	6.8 pf	Cer	500 v	10%	
C2010	283-0000-00	0.001 μf	Cer	500 v		
C2012	283-0026-00	0.2 μf	Cer	25 v		
C2013	283-0001-00	0.005 μf	Cer	500 v		
C2015	283-0026-00	0.2 μf	Cer	25 v		
C2016	283-0000-00	0.001 μf	Cer	500 v		
C2018	283-0032-00	470 pf	Cer	500 v	5%	
C2019	283-0032-00	470 pf	Cer	500 v	5%	
C2026	283-0026-00	0.2 μf	Cer	25 v		
C2042	281-0537-00	0.68 pf	Cer	500 v		
C2043	281-0537-00	0.68 pf	Cer	500 v		
C2046	283-0572-00	50 pf	Mica	500 v	5%	
C2047	283-0572-00	50 pf	Mica	500 v	5%	
C2049	281-0519-00	47 pf	Cer	500 v	10%	
C2055	281-0516-00	39 pf	Cer	500 v	10%	
C2056	281-0516-00	39 pf	Cer	500 v	10%	
C2073	283-0006-00	0.02 μf	Cer	500 v		
C2077	283-0051-00	0.0033 μf	Cer	100 v	5%	
C2080	283-0000-00	0.001 μf	Cer	500 v		
C2088	283-0026-00	0.2 μf	Cer	25 v		
C2121	283-0023-00	0.1 μf	Cer	10 v		
C2124	281-0594-00	150 pf	Cer	100 v	5%	
C2128	283-0023-00	0.1 μf	Cer	10 v		
C2132	281-0594-00	150 pf	Cer	100 v	5%	
C2134	283-0028-00	0.0022 μf	Cer	50 v		
C2139	283-0000-00	0.001 μf	Cer	500 v		
C2140	283-0026-00	0.2 μf	Cer	25 v		
C2182	281-0500-00	2.2 pf	Cer	500 v	±0.5 pf	
C2226	281-0580-00	470 pf	Cer	500 v	10%	

Ckt. No.	Tektronix Part No.	Description				S/N Range
		Capacitors (Cont'd)				
C2229	283-0026-00	0.2 µf	Cer	25 v		
C2230	283-0000-00	0.001 µf	Cer	500 v		
C2231	283-0026-00	0.2 µf	Cer	25 v		
C2243	281-0543-00	270 µf	Cer	500 v	10%	
C2246	281-0528-00	82 pf	Cer	500 v	10%	
C2247	283-0026-00	0.2 µf	Cer	25 v		
C2253	281-0543-00	270 pf	Cer	500 v	10%	
C2263	283-0026-00	0.2 µf	Cer	25 v		
C2264	290-0107-00	25 µf	EMT	25 v	-10%, +75%	
C2271	290-0107-00	25 µf	EMT	25 v	-10%, +75%	
C2275	283-0006-00	0.02 µf	Cer	500 v		
C2277	283-0067-00	0.001 µf	Cer	200 v	10%	
C2279	283-0067-00	0.001 µf	Cer	200 v	10%	
C2283	283-0057-00	0.1 µf	Cer	200 v		
C2301	283-0003-00	0.01 µf	Cer	150 v		
C2302	283-0003-00	0.01 µf	Cer	150 v		
C2303	283-0003-00	0.01 µf	Cer	150 v		
C2304	283-0003-00	0.01 µf	Cer	150 v		
C2305	283-0003-00	0.01 µf	Cer	150 v		
C2306	283-0003-00	0.01 µf	Cer	150 v		
C2307	283-0003-00	0.01 µf	Cer	150 v		
C2308	283-0003-00	0.01 µf	Cer	150 v		
C2309	283-0003-00	0.01 µf	Cer	150 v		
C2310	283-0003-00	0.01 µf	Cer	150 v		
C2311	283-0003-00	0.01 µf	Cer	150 v		
C2312	283-0003-00	0.01 µf	Cer	150 v		
C2313	283-0003-00	0.01 µf	Cer	150 v		
C2314	283-0003-00	0.01 µf	Cer	150 v		
C2315	283-0003-00	0.01 µf	Cer	150 v		
C2316	283-0003-00	0.01 µf	Cer	150 v		

Ckt. No.	Tektronix Part No.	Description		S/N Range
		Diodes		
D1	*152-0185-00	Signal	Replaceable by 1N3605	
D2	*152-0185-00	Signal	Replaceable by 1N3605	
D3	*152-0185-00	Signal	Replaceable by 1N3605	
D4	*152-0185-00	Signal	Replaceable by 1N3605	
D5	*152-0185-00	Signal	Replaceable by 1N3605	
D6	*152-0185-00	Signal	Replaceable by 1N3065	
D1044 D1045 D1046 D1047	*152-0014-00	Checked	GaAs, 2 matched pairs	
D1122	*152-0075-00	Germanium	Tek Spec	
D1124	152-0034-00	Zener 1N753	6.2 v, 0.4 w, 10%	
D1129	*152-0075-00	Germanium	Tek Spec	
D1130 D1132	*153-0083-00	(1 Pair)	Capacitance 0.6 pf - up	
D1186	*152-0075-00	Germanium	Tek Spec	
D1191	*152-0075-00	Germanium	Tek Spec	
D1192	*152-0075-00	Germanium	Tek Spec	
D1193	*152-0075-00	Germanium	Tek Spec	
D1194	*152-0075-00	Germanium	Tek Spec	
D1292	*152-0185-00	Signal	Replaceable by 1N3605	
D1293	*152-0185-00	Signal	Replaceable by 1N3605	
D1294	*152-0185-00	Signal	Replaceable by 1N3605	
D2002	*152-0115-00	Snap-off, pre-tested		
D2018	152-0071-00	Germanium	ED2007	
D2021	*152-0075-00	Germanium	Tek Spec	
D2023	152-0034-00	Zener 1N753	6.2 v, 0.4 w, 10%	
D2024	*152-0075-00	Germanium	Tek Spec	
D2044 D2045 D2046 D2047	*153-0014-00	Checked	GaAs, 2 matched pairs	

Ckt. No.	Tektronix Part No.	Description		S/N Range

Diodes (Cont'd)

D2122	*152-0075-00	Germanium	Tek Spec
D2124	152-0034-00	Zener 1N753	6.2 v, 0.4 w, 10%
D2129	*152-0075-00	Germanium	Tek Spec
D2130 } D2132 }	*152-0083-00	(1 pair)	Capacitance 0.6 pf - up
D2186	*152-0075-00	Germanium	Tek Spec
D2191	*152-0075-00	Germanium	Tek Spec
D2192	*152-0075-00	Germanium	Tek Spec
D2193	*152-0075-00	Germanium	Tek Spec
D2194	*152-0075-00	Germanium	Tek Spec
D2202	*152-0075-00	Germanium	Tek Spec
D2203	*152-0075-00	Germanium	Tek Spec
D2230	*152-0075-00	Germanium	Tek Spec
D2238	*152-0075-00	Germanium	Tek Spec
D2239	*152-0075-00	Germanium	Tek Spec
D2244	*152-0075-00	Germanium	Tek Spec
D2254	*152-0075-00	Germanium	Tek Spec
D2287	*152-0075-0[illegible]	Germanium	Tek Spec
D2292	*152-0185-00	Signal	Replaceable by 1N3605
D2293	*152-0185-00	Signal	Replaceable by 1N3605
D2294	*152-0185-00	Signal	Replaceable by 1N3605

Relays

K1	039-0402-00	Coil, drive, 4-reed switch
K2	039-0402-00	Coil, drive, 4-reed switch
K3	039-0402-00	Coil, drive, 4-reed switch
K4	039-0402-00	Coil, drive, 4-reed switch
K5	039-0402-00	Coil, drive, 4-reed switch
K6	039-0402-00	Coil, drive, 4-reed switch

Inductors

Ckt. No.	Tektronix Part No.	Description	S/N Range
L1070	276-0507-00	Core, Ferramic Suppressor	
L1073	*120-0285-00	Toroid 4T	
L1225	108-0240-00	820 µh	
L1227	108-0240-00	820 µh	
L2023	*108-0215-00	1.1 µh	
L2070	276-0507-00	Core, Ferramic Suppressor	
L2073	*120-0285-00	Toroid 4T	

Transistors

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q1074	151-0015-00	2N1516	
Q1084	151-0015-00	2N1516	
Q1094	151-0058-00	RT5204	
Q1134	151-0015-00	2N1516	
Q1141	151-0058-00	RT5204	
Q1163	151-0015-00	2N1516	
Q1164	151-0058-00	RT5204	
Q1173	151-0071-00	2N1305	
Q1183	151-0063-00	2N2207	
Q1184	151-0058-00	RT5204	
Q1204	151-0040-00	2N1302	
Q1214	151-0040-00	2N1302	
Q1223	151-0042-00	2N1378	
Q2010	*151-0083-00	Selected from 2N964	
Q2024	*151-0103-00	Replaceable by 2N2219	
Q2074	151-0015-00	2N1516	
Q2084	151-0015-00	2N1516	
Q2094	151-0058-00	RT5204	
Q2134	151-0015-00	2N1516	
Q2141	151-0058-00	RT5204	

Ckt. No.	Tektronix Part No.	Description				S/N Range

Transistors (Cont'd)

Q2163	151-0015-00	2N1516
Q2164	151-0058-00	RT5204
Q2173	151-0071-00	2N1305
Q2183	151-0063-00	2N2207
Q2184	151-0058-00	RT5204
Q2230	151-0076-00	2N2048
Q2245	151-0072-00	2N1308
Q2255	151-0072-00	2N1308
Q2274	151-0069-00	2N1304
Q2277	151-0060-00	2N1545
Q2287	151-0058-00	RT5204
Q2297	151-0058-00	RT5204

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1035	321-0636-00	100 Ω	1/8 w		Prec	1/2%
R1038	321-0636-00	100 Ω	1/8 w		Prec	1/2%
R1042	315-0470-00	47 Ω	1/4 w			5%
R1043	315-0470-00	47 Ω	1/4 w			5%
R1044	315-0362-00	3.6 k	1/4 w			5%
R1046	315-0101-00	100 Ω	1/4 w			5%
R1047	315-0101-00	100 Ω	1/4 w			5%
R1049	316-0274-00	270 k	1/4 w			
R1050	309-0279-00	180 k	1/2 w		Prec	1%
R1051	318-0086-00	53 k	1/8 w		Prec	1%
R1053	316-0103-00	10 k	1/4 w			
R1054	316-0103-00	10 k	1/4 w			
R1056	316-0183-00	18 k	1/4 w			
R1057	311-0110-00	100 k		Var		A BRIDGE VOLTS
R1060	309-0330-00	319 k	1/2 w		Prec	1%
R1062	315-0752-00	7.5 k	1/4 w			5%

Ckt. No.	Tektronix Part No.	Description					S/N Range
		Resistors (cont'd)					
R1063	311-0310-00	5 k		Var		A BRIDGE BAL	
R1064	315-0752-00	7.5 k	1/4 w			5%	
R1065	309-0330-00	319 k	1/2 w		Prec	1%	
R1073	302-0102-00	1 k	1/2 w				
R1074	302-0393-00	39 k	1/2 w				
R1077	304-0154-00	150 k	1 w				
R1078	318-0064-00	250 Ω	1/8 w		Prec	1%	
R1079	301-0303-00	30 k	1/2 w			5%	
R1080	315-0751-00	750 Ω	1/4 w			5%	
R1081A	318-0049-00	1 k	1/8 w		Prec	1%	
R1081B	318-0037-00	500 Ω	1/8 w		Prec	1%	
R1081C	318-0098-00	300 Ω	1/8 w		Prec	1%	
R1081D	318-0040-00	100 Ω	1/8 w		Prec	1%	
R1081E	318-0066-00	50 Ω	1/8 w		Prec	1%	
R1081F	318-0066-00	50 Ω	1/8 w		Prec	1%	
R1086	302-0104-00	100 k	1/2 w				
R1087	302-0823-00	82 k	1/2 w				
R1088	311-0258-00	100 Ω		Var		A PREAMP SENS	
R1090	301-0392-00	3.9 k	1/2 w			5%	
R1091	306-0153-00	15 k	2 w				
R1093	315-0131-00	130 Ω	1/4 w			5%	
R1120	301-0124-00	120 k	1/2 w			5%	
R1121	301-0102-00	1 k	1/2 w			5%	
R1124	309-0356-00	103 k	1/2 w		Prec	1%	
R1125	309-0445-00	82 k	1/2 w		Prec	1%	
R1126	315-0153-00	15 k	1/4 w			5%	
R1127	315-0153-00	15 k	1/4 w			5%	
R1133	302-0682-00	6.8 k	1/2 w				
R1135	301-0184-00	180 k	1/2 w			5%	
R1136	311-0172-00	2.5 k		Var		A MILLER LEVEL	

Ckt. No.	Tektronix Part No.	Description				S/N Range

Resistors (cont'd)

R1137	315-0561-00	560 Ω	1/4 w		5%	
R1138	302-0104-00	100 k	1/2 w			
R1139	316-0390-00	39 Ω	1/4 w			
R1141	316-0470-00	47 Ω	1/4 w			
R1142	301-0564-00	560 k	1/2 w		5%	
R1144	306-0153-00	15 k	2 w			
R1146	309-0371-00	3.965 k	1/2 w	Prec	1%	
R1147A	321-0420-00	232 k	1/8 w	Prec	1%	
R1147B	321-0390-00	113 k	1/8 w	Prec	1%	
R1147C	321-0359-00	53.6 k	1/8 w	Prec	1%	
R1147D	321-0313-00	17.8 k	1/8 w	Prec	1%	
R1147E	321-0267-00	5.9 k	1/8 w	Prec	1%	
R1148	309-0398-00	414.41 Ω	1/2 w	Prec	1/4%	
R1149	309-0397-00	1.6402 k	1/2 w	Prec	1/4%	
R1150	318-0094-00	193 k	1/8 w	Prec	1%	
R1151	318-0001-00	100 k	1/8 w	Prec	1%	
R1153	309-0377-00	3 meg	1/2 w	Prec	1%	
R1154	318-0096-00	1.5 meg	1/8 w	Prec	1%	
R1156	318-0095-00	950 k	1/8 w	Prec	1%	
R1157	311-0271-00	200 k	Var		DC OFFSET	
R1158	309-0369-00	200 k	1/2 w	Prec	1/4%	
R1159	321-0385-00	100 k	1/8 w	Prec	1%	
R1161	311-0171-00	5 k	Var		A INV GAIN	
R1162	301-0183-00	18 k	1/2 w		5%	
R1164	309-0323-00	75 k	1/2 w	Prec	1%	
R1165	302-0104-00	100 k	1/2 w			
R1167	309-0392-00	20 k	1/2 w	Prec	1%	
R1168	302-0563-00	56 k	1/2 w			
R1170	316-0472-00	4.7 k	1/4 w			
R1171	315-0103-00	10 k	1/4 w		5%	

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description					S/N Range
R1172	311-0326-00	10 k		Var		A NORM GAIN	
R1173	302-0823-00	82 k	1/2 w				
R1174	316-0331-00	330 Ω	1/4 w				
R1175	309-0388-00	6 k	1/2 w		Prec	1%	
R1176	316-0105-00	1 meg	1/4 w				
R1177	315-0622-00	6.2 k	1/4 w			5%	
R1178	316-0271-00	270 Ω	1/4 w				
R1179	316-0154-00	150 k	1/4 w				
R1180	311-0347-00	100 k		Var		A POSITION	
R1181	316-0154-00	150 k	1/4 w				
R1182	318-0008-00	25.6 k	1/8 w		Prec	1%	
R1183	304-0273-00	27 k	1 w				
R1184	316-0104-00	100 k	1/4 w				
R1196	302-0183-00	18 k	1/2 w				
R1197	302-0183-00	18 k	1/2 w				
R1206	301-0242-00	2.4 k	1/2 w			5%	
R1208	316-0681-00	680 Ω	1/4 w			5%	
R1209	311-0091-00	1 k	1/2 w	Var		GAIN ADJ	
R1211	301-0242-00	2.4 k	1/2 w			5%	
R1214	302-0681-00	680 Ω	1/2 w				
R1217	318-0033-00	20.4 k	1/8 w		Prec	1%	
R1219	318-0033-00	20.4 k	1/8 w		Prec	1%	
R1222	302-0223-00	22 k	1/2 w				
R1224	316-0470-00	47 Ω	1/4 w				
R1225	308-0054-00	10 k	5 w		WW	5%	
R1226	316-0470-00	47 Ω	1/4 w				
R1227	308-0054-00	10 k	5 w		WW	5%	
R1229	302-0152-00	1.5 k	1/2 w				
R1299	316-0181-00	180 Ω	1/4 w				
R2001	316-0820-00	82 Ω	1/4 w				

Ckt. No.	Tektronix Part No.	Description					S/N Range
		Resistors (Cont'd)					
R2011	301-0361-00	360 Ω	1/2 w			5%	
R2012	311-0413-00	1 k	5 w	Var	WW	SNAP-OFF CURRENT	
R2013	301-0361-00	360 Ω	1/2 w			5%	
R2015	302-0102-00	1 k	1/2 w				
R2016	316-0102-00	1 k	1/4 w				
R2017	302-0824-00	820 k	1/2 w				
R2018	316-0222-00	2.2 k	1/4 w				
R2019	315-0510-00	51 Ω	1/4 w			5%	
R2020	315-0621-00	620 Ω	1/4 w			5%	
R2021	316-0471-00	470 Ω	1/4 w				
R2022	316-0270-00	27 Ω	1/4 w				
R2023	311-0392-00	10 k	2 w	Var	WW	MEMORY GATE LENGTH	
R2024	306-0103-00	10 k	2 w				
R2025	302-0102-00	1 k	1/2 w				
R2026	316-0100-00	10 Ω	1/4 w				
R2027	302-0471-00	470 Ω	1/2 w				
R2028	302-0471-00	470 Ω	1/2 w				
R2035	321-0636-00	100 Ω	1/8 w		Prec	1/2%	
R2038	321-0636-00	100 Ω	1/8 w		Prec	1/2%	
R2042	315-0470-00	47 Ω	1/4 w			5%	
R2043	315-0470-00	47 Ω	1/4 w			5%	
R2044	315-0362-00	3.6 k	1/4 w			5%	
R2046	315-0101-00	100 Ω	1/4 w			5%	
R2047	315-0101-00	100 Ω	1/4 w			5%	
R2049	316-0274-00	270 k	1/4 w				
R2050	309-0279-00	180 k	1/2 w		Prec	1%	
R2051	318-0086-00	53 k	1/8 w		Prec	1%	
R2053	316-0103-00	10 k	1/4 w				
R2054	316-0103-00	10 k	1/4 w				
R2056	316-0183-00	18 k	1/4 w				

Ckt. No.	Tektronix Part No.	Description				S/N Range
		Resistors (Cont'd)				
R2057	311-0110-00	100 k		Var		B BRIDGE VOLTS
R2060	309-0330-00	319 k	1/2 w		Prec	1%
R2062	315-0752-00	7.5 k	1/4 w			5%
R2063	311-0310-00	5 k		Var		B BRIDGE BAL
R2064	315-0752-00	7.5 k	1/4 w			5%
R2065	309-0330-00	319 k	1/2 w		Prec	1%
R2073	302-0102-00	1 k	1/2 w			
R2074	302-0393-00	39 k	1/2 w			
R2077	304-0154-00	150 k	1 w			
R2078	318-0064-00	250 Ω	1/8 w		Prec	1%
R2079	301-0303-00	30 k	1/2 w			5%
R2080	315-0751-00	750 Ω	1/4 w			5%
R2081A	318-0049-00	1 k	1/8 w		Prec	1%
R2081B	318-0037-00	500 Ω	1/8 w		Prec	1%
R2081C	318-0098-00	300 Ω	1/8 w		Prec	1%
R2081D	318-0040-00	100 Ω	1/8 w		Prec	1%
R2081E	318-0066-00	50 Ω	1/8 w		Prec	1%
R2081F	318-0066-00	50 Ω	1/8 w		Prec	1%
R2086	302-0104-00	100 k	1/2 w			
R2087	302-0823-00	82 k	1/2 w			
R2088	311-0258-00	100 Ω		Var		B PREAMP SENS
R2090	301-0392-00	3.9 k	1/2 w			5%
R2091	306-0153-00	15 k	2 w			
R2093	315-0131-00	130 Ω	1/4 w			5%
R2120	301-0113-00	11 k	1/2 w			5%
R2121	301-0102-00	1 k	1/2 w			5%
R2124	309-0356-00	103 k	1/2 w		Prec	1%
R2125	309-0445-00	82 k	1/2 w		Prec	1%
R2126	315-0153-00	15 k	1/4 w			5%
R2127	315-0153-00	15 k	1/4 w			5%

Ckt. No.	Tektronix Part No.	Description				S/N Range
		Resistors (Cont'd)				
R2133	302-0682-00	6.8 k	1/2 w			
R2135	301-0184-00	180 k	1/2 w		5%	
R2136	311-0172-00	2.5 k		Var	B MILLER LEVEL	
R2137	315-0561-00	560 Ω	1/4 w		5%	
R2138	302-0104-00	100 k	1/2 w			
R2139	316-0390-00	39 Ω	1/4 w			
R2141	316-0470-00	47 Ω	1/4 w			
R2142	301-0564-00	560 k	1/2 w		5%	
R2144	306-0153-00	15 k	2 w			
R2146	309-0371-00	3.965 k	1/2 w	Prec	1%	
R2147A	321-0420-00	232 k	1/8 w	Prec	1%	
R2147B	321-0390-00	113 k	1/8 w	Prec	1%	
R2147C	321-0359-00	53.6 k	1/8 w	Prec	1%	
R2147D	321-0313-00	17.8 k	1/8 w	Prec	1%	
R2147E	321-0267-00	5.9 k	1/8 w	Prec	1%	
R2148	309-0398-00	414.41 Ω	1/2 w	Prec	1/4%	
R2149	309-0397-00	1.6402 k	1/2 w	Prec	1/4%	
R2150	318-0094-00	193 k	1/8 w	Prec	1%	
R2151	318-0001-00	100 k	1/8 w	Prec	1%	
R2153	309-0377-00	3 meg	1/2 w	Prec	1%	
R2154	318-0096-00	1.5 meg	1/8 w	Prec	1%	
R2156	318-0095-00	950 k	1/8 w	Prec	1%	
R2157	311-0271-00	200 k		Var	DC OFFSET	
R2158	309-0369-00	200 k	1/2 w	Prec	1/4%	
R2159	321-0385-00	100 k	1/8 w	Prec	1%	
R2161	311-0171-00	5 k		Var	B INV GAIN	
R2162	301-0183-00	18 k	1/2 w		5%	
R2164	309-0323-00	75 k	1/2 w	Prec	1%	
R2165	302-0104-00	100 k	1/2 w			
R2167	309-0392-00	20 k	1/2 w	Prec	1%	

Ckt. No.	Tektronix Part No.		Description			S/N Range
			Resistors (Cont'd)			
R2168	302-0563-00	56 k	1/2 w			
R2170	316-0472-00	4.7 k	1/4 w			
R2171	315-0103-00	10 k	1/4 w			5%
R2172	311-0326-00	10 k		Var		B NORM GAIN
R2173	302-0823-00	82 k	1/2 w			
R2174	316-0331-00	330 Ω	1/4 w			
R2175	309-0388-00	6 k	1/2 w		Prec	1%
R2176	316-0105-00	1 meg	1/4 w			
R2177	309-0388-00	6 k	1/2 w		Prec	1%
R2178	316-0271-00	270 Ω	1/4 w			
R2179	316-0154-00	150 k	1/4 w			
R2180	311-0347-00	100 k	0.2 w	Var		B POSITION
R2181	316-0154-00	150 k	1/4 w			
R2182	318-0008-00	25.6 k	1/8 w		Prec	1%
R2183	304-0273-00	27 k	1 w			
R2184	316-0104-00	100 k	1/4 w			
R2187	318-0009-00	10.1 k	1/8 w		Prec	1%
R2189	302-0473-00	47 k	1/2 w			
R2196	302-0183-00	18 k	1/2 w			
R2197	302-0183-00	18 k	1/2 w			
R2212	302-0225-00	2.2 meg	1/2 w			
R2213	316-0101-00	100 Ω	1/4 w			
R2214	306-0103-00	10 k	2 w			
R2226	302-0102-00	1 k	1/2 w			
R2227	301-0124-00	120 k	1/2 w			5%
R2229	302-0331-00	330 Ω	1/2 w			
R2230	302-0182-00	1.8 k	1/2 w			
R2231	302-0101-00	100 Ω	1/2 w			
R2235	302-0183-00	18 k	1/2 w			
R2236	302-0273-00	27 k	1/2 w			

Ckt. No.	Tektronix Part No.	Description				S/N Range
		Resistors (Cont'd)				
R2237	302-0222-00	2.2 k	1/2 w			
R2243	302-0473-00	47 k	1/2 w			
R2244	306-0223-00	22 k	2 w			
R2245	316-0123-00	12 k	1/4 w			
R2246	302-0821-00	820 Ω	1/2 w			
R2247	316-0470-00	47 Ω	1/4 w			
R2253	302-0473-00	47 k	1/2 w			
R2254	306-0223-00	22 k	2 w			
R2255	316-0123-00	12 k	1/4 w			
R2272	309-0100-00	10 k	1/2 w	Prec	1%	
R2273	309-0389-00	50 k	1/2 w	Prec	1%	
R2274	302-0124-00	120 k	1/2 w			
R2276	304-0682-00	6.8 k	1 w			
R2277	302-0822-00	8.2 k	1/2 w			
R2278	304-0682-00	6.8 k	1 w			
R2279	302-0822-00	8.2 k	1/2 w			
R2283	302-0222-00	2.2 k	1/2 w			
R2287	316-0105-00	1 meg	1/4 w			
R2289	304-0104-00	100 k	1 w			
R2293	302-0471-00	470 Ω	1/2 w			
R2299	316-0181-00	180 Ω	1/4 w			

Switches

	Unwired	Wired		
SW1080[1]	260-0423-00	*262-0467-00	Rotary	SMOOTH-NORMAL
SW1101	039-0403-00		Rotary	A MV/DIV
SW1171	260-0145-00		Slide	A INV/NORM
SW2101	039-0403-00		Rotary	B MV/DIV
SW2171	260-0145-00		Slide	B INV/NORM

[1] SW1080 and SW2190 furnished as a unit.

Ckt. No.	Tektronix Part No.	Description		S/N Range
		Switches (Cont'd)		
SW2190[1]	039-0404-00	Rotary	Vertical Mode	
K1A	039-0401-00	Reed Type, SPDT		
K1B	039-0401-00	Reed Type, SPDT		
K1C	039-0401-00	Reed Type, SPDT		
K1D	039-0401-00	Reed Type, SPDT		
K2A	039-0401-00	Reed Type, SPDT		
K2B	039-0401-00	Reed Type, SPDT		
K2C	039-0401-00	Reed Type, SPDT		
K2D	039-0401-00	Reed Type, SPDT		
K3A	039-0401-00	Reed Type, SPDT		
K3B	039-0401-00	Reed Type, SPDT		
K3C	039-0401-00	Reed Type, SPDT		
K3D	039-0401-00	Reed Type, SPDT		
K4A	039-0401-00	Reed Type, SPDT		
K4B	039-0401-00	Reed Type, SPDT		
K4C	039-0401-00	Reed Type, SPDT		
K4D	039-0401-00	Reed Type, SPDT		
K5A	039-0401-00	Reed Type, SPDT		
K5B	039-0401-00	Reed Type, SPDT		
K5C	039-0401-00	Reed Type, SPDT		
K5D	039-0401-00	Reed Type, SPDT		
K6A	039-0401-00	Reed Type, SPDT		
K6B	039-0401-00	Reed Type, SPDT		
K6C	039-0401-00	Reed Type, SPDT		
K6D	039-0401-00	Reed Type, SPDT		
		Transformers		
T1052	*120-0243-00	Toroid, 8T		
T1130	*120-0245-00	Toroid, 3T		
T2001	*120-0242-00	Toroid, 4T		
T2010	*120-0241-00	Toroid, 3T		

[1] SW1080 and SW2190 furnished as a unit.

Ckt. No.	Tektronix Part No.	Description	S/N Range
		Transformers (Cont'd)	
T2052	*120-0243-00	Toroid, 8T	
T2130	*120-0245-00	Toroid, 3T	
T2230	*120-0244-00	Toroid, 4T	
T2261	*120-0286-00	Toroid, 2T	
T2262	*120-0286-00	Toroid, 2T	
		Electron Tubes	
V1073	154-0306-00	7586	
V1133	154-0371-00	7308	
V1224	154-0187-00	6DJ8	
V2073	154-0306-00	7586	
V2133	154-0195-00	6922	
V2214	154-0323-00	6CW4	
V2289	154-0370-00	ZZ1000	

MECHANICAL PARTS

Tektronix Part No.	Qty	Description	S/N Range
039-0123-00	1	BOARD, Vertical MV/DIV	
039-0124-00	1	BOARD, Diode Bridge	
670-0013-00	1	BOARD, Memory (wired)	
670-0015-00	1	BOARD, Snap-off (wired)	
039-0210-00	1	BRACKET, Program connector	
039-0211-00	1	BRACKETS, Mounting, PC board (set of 3)	
039-0213-00	2	BRACKET, Mounting, ferrite core	
406-0108-00	1	BRACKET, Mounting, pot	
406-0772-00	1	BRACKET, Etched circuit board	
358-0054-00	1	BUSHING, Banana jack, 1/4-32 X 13/32 inch	
358-0135-00	12	BUSHING, Teflon	
179-0614-00	1	CABLE HARNESS, Main	
179-0615-00	1	CABLE HARNESS, Right	
179-0616-00	1	CABLE HARNESS, Left	
179-0619-00	1	CABLE HARNESS	
441-0415-00	1	CHASSIS, Alum., 5 15/16 X 12 1/4 X 3/4 inch	
175-0284-00	1.5 ft	COAX, 50-ohm subminiature	
039-0206-00	2	CONNECTOR, 50-ohm, chassis mounted, male	
131-0149-00	2	CONNECTOR, Chassis mounted, 24 contact	
131-0180-00	7	CONNECTOR, Terminal stand-off (used with BUSHING, Teflon)	
131-0182-00	5	CONNECTOR, Terminal feed-thru (used with BUSHING, Teflon)	
131-0276-00	2	CONNECTOR, BNC, chassis mounted, female	
131-0294-00	1	CONNECTOR, 36 pin, chassis mounted, female	
131-0298-00	2	CONNECTOR, 50-ohm, cable end	
131-0375-00	2	CONNECTOR, 50-ohm, cable end, right angle	
131-0391-00	2	CONNECTOR, 50-ohm, PC board mounted	
200-0263-00	2	COVER, Dust, pot, polyethylene, 17/32 X 1 inch	
200-0385-00	1	COVER, Transistor, polyethylene	
200-0413-00	1	COVER, Shield, brass, 1 5/16 X 5 3/4 inches	
214-0052-00	1	FASTENER, Pawl right, with stop	
348-0002-00	1	GROMMET, Rubber, 1/4 inch	
348-0003-00	3	GROMMET, Rubber, 5/16 inch	

Tektronix Part No.	Qty	Description	S/N Range
348-0004-00	1	GROMMET, Rubber, 3/8 inch	
348-0005-00	1	GROMMET, Rubber, 1/2 inch	
351-0037-00	1	GUIDE, Plug-in, delrin, 5/8 X 13/16 X 3/16 inch track	
039-0212-00	1	HANDLE, Plug-in	
366-0061-00	1	KNOB, Gray, plug-in latch	
366-0140-00	1	KNOB, Red -- SMOOTH-NORMAL	
366-0148-00	2	KNOB, Charcoal -- DC OFFSET	
366-0153-00	2	KNOB, Charcoal -- POSITION	
366-0173-00	2	KNOB, Charcoal -- MV/DIV	
366-0175-00	1	KNOB, Charcoal -- Vertical Mode	
210-0004-00	13	LOCKWASHER, Internal No. 4	
210-0201-00	5	LUG, Solder, SE No. 4 with 2 wire holes	
210-0215-00	3	LUG, Solder, peewee	
210-0223-00	6	LUG, Solder, 1/4 inch hole, lock round perimeter	
210-0406-00	13	NUT, Hex., 4-40 X 3/16 inch	
210-0583-00	4	NUT, Hex., 1/4-32 X 5/16 inch double chamfered	
039-0207-00	1	PANEL, Front	
384-0566-00	4	ROD, Frame, spacing, 3/8 OD X 12 1/4 inches long	
384-0595-00	1	ROD, Spacer, alum., hex., 5/16 X 1 1/2 inches long	
211-0008-00	4	SCREW, 4-40 X 1/4 inch BHS	
211-0013-00	1	SCREW, 4-40 X 3/8 inch RHS	
211-0016-00	2	SCREW, 4-40 X 5/8 inch RHS	
211-0057-00	60	SCREW, 2-56 X 5/16 inch RHS	
211-0079-00	4	SCREW, 2-56 X 3/16 inch PHS	
211-0504-00	3	SCREW, 6-32 X 1/4 inch BHS	
211-0538-00	2	SCREW, 6-32 X 5/16 inch FHS, 100°, CSK	
212-0044-00	1	SCREW, 8-32 X 1/2 inch RHS	
213-0044-00	16	SCREW, Thread forming, 5-32 X 3/16 inch PHS	
213-0055-00	6	SCREW, Thread forming, 2-56 X 3/16 inch PHS	
337-0480-00	1	SHIELD, Blocking Oscillator	
337-0527-00	2	SHIELD, Etched circuit board	
337-0538-00	1	SHIELD, Electrostatic	
136-0014-00	2	SOCKET, STM9	
136-0015-00	1	SOCKET, STM9G	
136-0095-00	30	SOCKET, 4 pin transistor	

Tektronix Part No.	Qty	Description	S/N Range
136-0101-00	3	SOCKET, 5 pin, with mounting holes	
136-0129-00	2	SOCKET, Banana jack assembly	
136-0164-00	1	SOCKET, Light	
361-0009-00	46	SPACER, Nylon (for STRIP, Ceramic)	
346-0025-00	2	STRAP, Ground	
124-0126-00	4	STRIP, Ceramic, 16 notches, 2 7/16 X 7/16 inch	
124-0128-00	6	STRIP, Ceramic, 9 notches, 1 7/16 X 7/16 inch	
124-0145-00	6	STRIP, Ceramic, 20 notches, 3 X 7/16 inch	
124-0147-00	5	STRIP, Ceramic, 13 notches, 2 X 7/16 inch	
124-0149-00	2	STRIP, Ceramic, 7 notches, 1 5/32 X 7/16 inch	
214-0277-00	4	STUD, Spacer, 3/16 hex. X 7/8 inch long	
039-0208-00	1	SUB-PANEL, Front	
039-0209-00	1	SUB-PANEL, Rear	
039-0403-00	2	SWITCH, MV/DIV	
039-0404-00	1	SWITCH, Vertical Mode	
260-0145-00	2	SWITCH, NORM.-INV.	
166-0032-00	2	TUBE, Spacer, alum., 1/4 OD X 5/16 inch long	
210-0938-00	4	WASHER, Flat, No. 2	