INSTRUCTION MANUAL

TYPE 1A2 PLUG-IN

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070-0430-01

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WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

CONTENTS

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

Fig. 1-1. Type 1A2 Dual Trace Plug-In Unit.

SECTION 1
CHARACTERISTICS

Introduction

The Type 1A2 Dual-Trace Plug-In Unit contains two identical fast-rise calibrated preamplifier channels. Either channel can be used independently, or electronically switched to produce dual-trace displays. In addition, both channels can be combined at the output, adding or subtracting according to the settings of the polarity switches.

Each channel has its own input coupling, attenuator, gain, polarity and position controls which allows each display to be adjusted independently for optimum viewing.

There are two modes of dual-trace operation: Chopped or Alternate. In the chopped mode, an internal multivibrator switches the channels at a free-running rate of about 220 kHz. In the alternate mode, the oscilloscope time-base generator internally switches the channels at the end of each sweep during the retrace interval.

The Type 1A2 can be used with any of the Tektronix 530-, 540-, or 550-series Oscilloscopes. It can also be used with the 580-series Oscilloscopes in conjunction with the Type 81 or 81A Plug-In Adapter. The Type 1A2 can also be used with other oscilloscopes and devices through the use of the Type 127, 132, or 133 Plug-In Power Supplies.

CALIBRATED PREAMPLIFIER

Characteristic	Performance Requirement	Supplemental Information
Deflection Factor	.05 volts/cm to 20 volts/cm in 9 calibrated steps for each channel	Steps in 1-2-5 sequence
Deflection Accuracy	Within ±3% of indicated deflection with VARIABLE control fully clockwise	With gain correct at .05 V/cm
Variable Deflection Factor	Uncalibrated deflection factor at least 2.5 times the VOLTS/CM switch indication. This permits continuous (uncalibrated) adjustment from 0.05 volts/cm to at least 50 volts/cm.	
Frequency Response (not more than 3 dB down): Type 1A2 with Tektronix oscilloscope;		
544, 546, or 547	DC to 50 MHz	
581, 581A, 585, 585A	DC to 50 MHz with Type 81A Plug-In Adapter	DC to 33 MHz with Type 81 Plug-in Adapter
541, 541A, 543, 543A, 545, 545A, 545B, or 555	DC to 33 MHz	
551	DC to 27 MHz	
531, 531A, 533, 533A, 535, or 535A	DC to 15 MHz	
536	DC to 11 MHz	
Risetime: Type 1A2 with Tektronix oscilloscopes;		
544, 546, or 547	7 ns	
581, 581A, 585, 585A	7 ns with Type 81A Plug-In Adapter	11 ns with Type 81 Plug-In Adapter
541, 541A, 543, 543A, 545. 545A, 545B, or 555	11 ns	
551	13 ns	
531, 531A, 533, 533A, 535, or 535A	24 ns	
536	32 ns	
Input RC Characteristics		Typically 1 MΩ parallel with approximately 15 pF
Maximum Input Voltage		600 volts combined DC and peak AC; 600 volts peak-to-peak AC
Input Coupling Modes	AC or DC, selected by front-panel switch	GND, disconnects signal and grounds amplifier input

Characteristic	Performance Requirement	Supplemental Information
AC Low-Frequency Response		Typically 3 dB down at 2 Hz direct; 0.2 Hz with 10× probe
Display Modes	Channel 1 only Channel 2 only Dual-trace, alternate between channels. Dual-trace, chopped between channels. Added algebraically	
Chopped Repetition Rate	220 kHz ±20% rate to show successive 2 μs segments of each trace	
Common Mode Rejection Ratio	20:1 for common-mode signals up to 10 cm in amplitude	With optimum GAIN adjustment for both channels
Polarity Inversion	Signal on either Channel 1 or 2 can be inverted	
Output Trigger[1]		Measured at TRIG OUT connector
Output Trigger Voltage	Approximately 0.5 V/cm or gain of 10	VOLTS/CM at .05
Bandwidth	Low-Frequency 3 dB down is about 10 Hz when output of the amplifier is working into 1 MΩ; High-Frequency 3 dB down is amplitude dependent and shown in the graph of Fig. 1-2	
Output Coupling	AC	

[1]Applies only to instruments with a serial number of 716 or higher.

MECHANICAL CHARACTERISTICS

Characteristic	Information
Construction	Aluminum-alloy chassis
Finish	Anodized front panel

ACCESSORIES

Standard accessories supplied with this instrument will be found in the Mechanical Parts List. For optional accessories, see the current Tektronix, Inc. catalog.

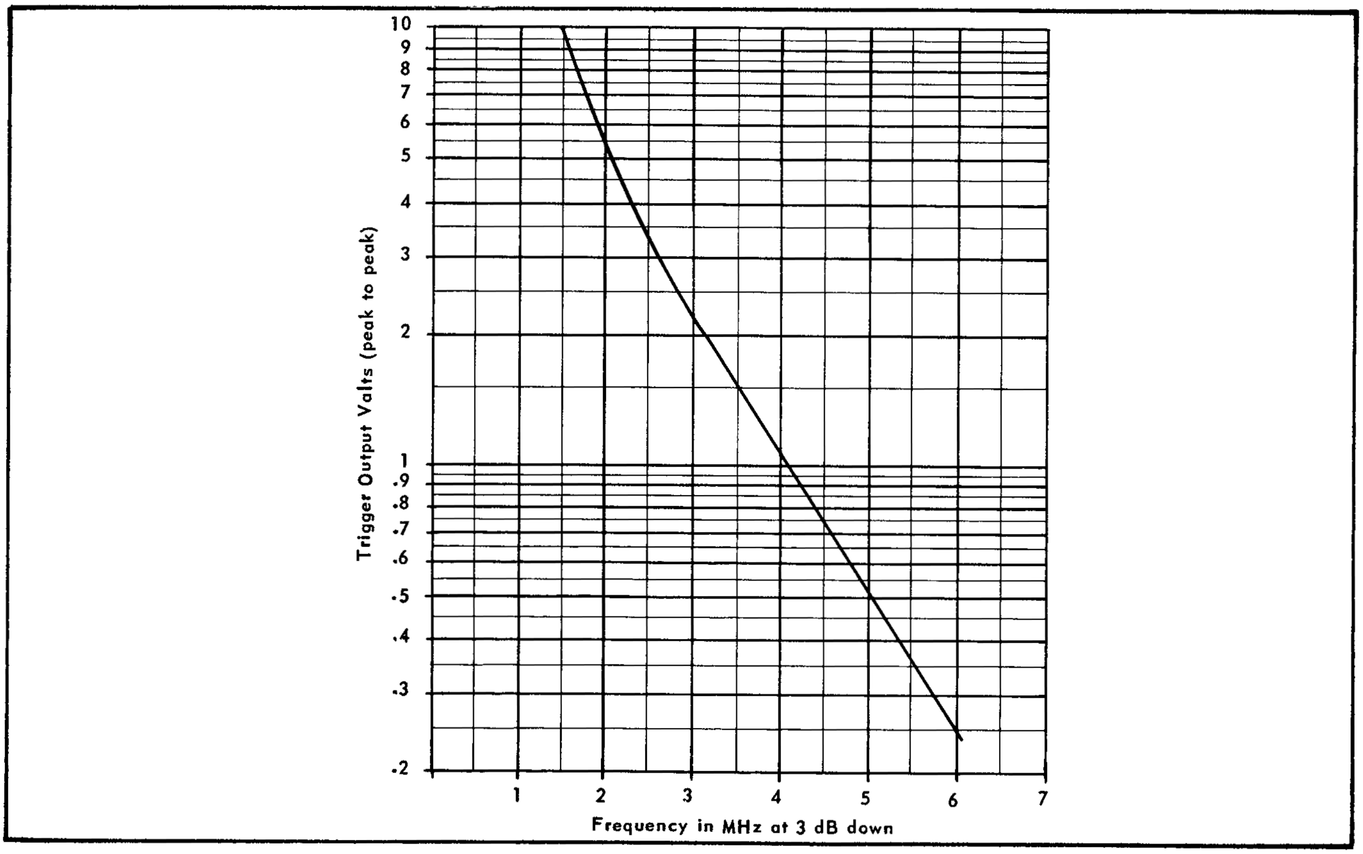

Fig. 1-2. Type 1A2 Trigger output amplitude and High-Frequency Response (3 dB down).

SECTION 2
OPERATING INSTRUCTIONS

FUNCTIONS OF FRONT-PANEL CONTROLS

The functions of all controls, adjustments and connectors except the MODE and TRIGGER SELECTOR switches are identical for both channels.

POSITION	Positions the trace vertically on the CRT. Only the Channel 1 POSITION controls position in the ADD mode.
PULL TO INVERT	A two-position switch that presents the display in a normal or inverted polarity with respect to the applied signal.
GAIN	A screwdriver adjustment that calibrates the basic deflection factor of the channel.
VAR ATTEN BAL	A screwdriver adjustment for setting the amplifier DC levels so the trace does not shift position under no-signal conditions as the VARIABLE VOLTS/CM control is turned.
MODE	A five-position switch that sets the mode of operation as follows: ALT—Dual-trace alternate mode of operation (triggered electronic switching between channels during the beam retrace interval). CH 1—Selects the use of Channel 1 only. ADD—Permits adding the outputs of the two channels algebraically. CH 2—Selects the use of Channel 2 only. CHOP—Dual-trace chopped mode of operation (free-running electronic switching of channels at about a 220-kHz rate).
VOLTS/CM	Nine-position switch to select the calibrated vertical-deflection factors.
VARIABLE	Provides overlapping variable uncalibrated attenuation between the calibrated deflection factors and extends the attenuation range to about 50 V/CM.
AC-DC-GND	Three-position switch to provide either AC- or DC-coupled input into the amplifier. A third position (GND) connects the amplifier input to ground without grounding the input signal.
TRIGGER SELECTOR[1]	Determines whether the Channel 1 or Channel 2 signal is applied to the Trigger Amplifier.
TRIG OUT[1]	Output signal of the Trigger Amplifier. Permits the use of Channel 1 or 2 as an external trigger source.

FIRST TIME OPERATION

The following procedure will help you become familiar with the Type 1A2 operation.

1. Insert the Type 1A2 into the oscilloscope, tighten the securing rod and turn on the oscilloscope power.

2. Allow about 2 to 3 minutes warm-up time and free run the oscilloscope sweep at 0.5 sec/cm.

3. Set the applicable Type 1A2 front-panel controls for both channels as follows:

AC-DC-GND	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED
PULL TO INVERT	Pushed in
POSITION	Centered
MODE	CH 1
TRIGGER SELECTOR[1]	CH 1

4. Position the trace about one centimeter above the graticule centerline with the Channel 1 POSITION control.

5. Place the MODE switch to CH 2 and position the trace one centimeter below the graticule center line with the Channel 2 POSITION control.

6. Place the MODE switch to ALT. Both Channel 1 and 2 traces should be displayed.

7. Set the oscilloscope Time/Cm switch to 50 msec. Note that for each sweep cycle one channel is displayed and the other is shut off. Electronic switching from one channel to the other occurs during the retrace interval.

8. Set the MODE switch to CHOP. Notice that both traces seem to start simultaneously and continue across the CRT.

9. Set the oscilloscope Time/Cm switch to 5 μsec and adjust the oscilloscope trigger controls to obtain a stable display. Notice that each trace is composed of many short-duration bits or segments with visible switching transients existing between channels (see Fig. 2-1A).

10. To see the chopped-mode switching action clearly, increase the sweep rate to 1 μsec/cm. Notice that Channels 1 and 2 are alternately on and off at about 2 μs intervals. (See Fig. 2-1B.) Chopping rate is determined by the free-running multivibrator switching rate and is about 220 kHz.

11. Blank out the switching transients between channels by setting the CRT Cathode Selector switch (located on the rear panel of most Tektronix oscilloscopes) to the Dual-Trace Chopped Blanking position (see Fig. 2-1C).

12. Set the oscilloscope Time/Cm switch to 0.5 msec. Using coaxial cables, a T connector connected to Channel 1 and a connector adapter (if needed), apply 0.1 volt from the oscilloscope Amplitude Calibrator to the Channel 1 and 2 input connectors.

13. Set the trigger controls for +internal (plug-in) triggering or connect a jumper coaxial cable from the TRIG OUT connector[1] to the oscilloscope Trigger Input connector and

[1]Applies only to instruments with a serial number of 716 or higher.

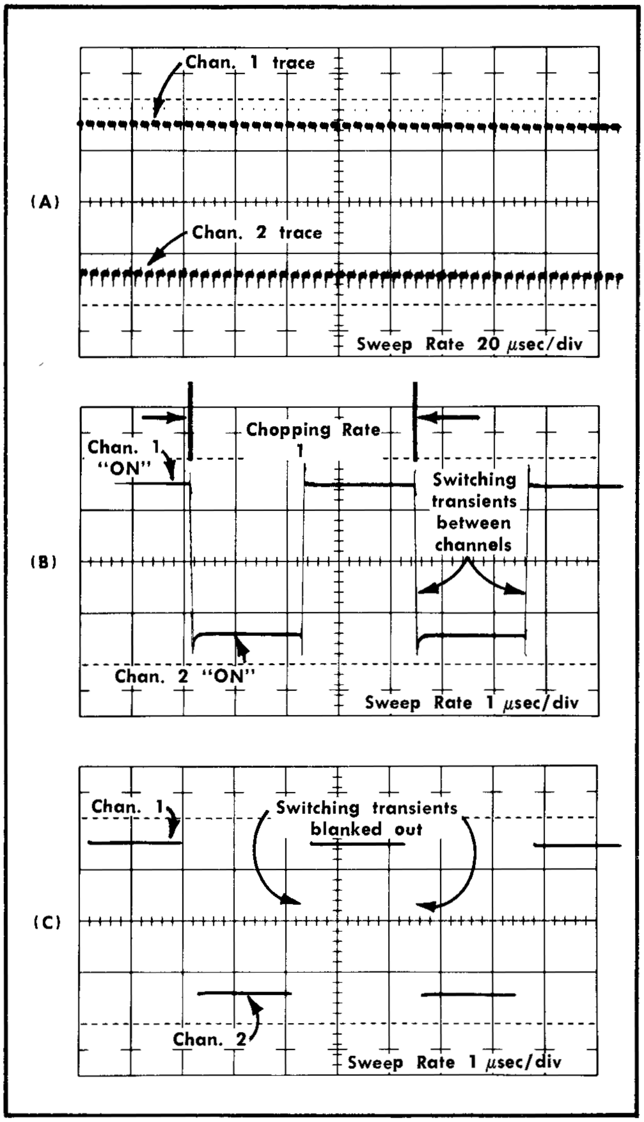

Fig. 2-1. Chopped-mode waveforms: (A) trace broken up into segments, (B) chopped-mode switching action from channel to channel, and (C) switching transients blanked out.

set the trigger controls for + external triggering. Both Channel 1 and 2 should display the calibrator waveform. Each waveform should be 2 cm in amplitude.

NOTE

If the waveforms are not exactly 2 cm in amplitude, overlook the inaccuracy until completing this operating procedure. Subsequent paragraphs describe how to properly set the gain of the unit.

14. Set the MODE switch to ADD. There should be one waveform display 4 cm in amplitude. This is the addition of the Channel 1 and 2 signals (2 cm each). Notice that only the Channel 1 POSITION control will move the display vertically.

15. Pull out the Channel 1 PULL TO INVERT switch and free run the time base. The display should be a straight line, indicating the algebraic difference between the two signals. Since both signals have equal amplitudes and waveshape, the difference is zero.

NOTE

If the display is not a straight line, this indicates that the gains of the channels are not matched. This may be overlooked until this operating procedure is completed. Subsequent paragraphs describe how to properly set the gain of each channel.

Before the Type 1A2 is used for accurate measurements, the GAIN and VAR ATTEN BAL for each channel should be adjusted. These adjustments are described in the following paragraphs.

Gain Adjustments

The gain adjustments should be checked periodically to assure correct vertical deflection factors, particularly when the Type 1A2 is used for the first time or is moved from one oscilloscope to another. Use the following procedure to check the gain of each channel:

1. Set the applicable Type 1A2 front-panel controls for both channels as follows:

AC-DC-GND	DC
VOLTS/CM	.05
PULL TO INVERT	Pushed in
POSITION	Centered
VARIABLE	CALIBRATED
MODE	CH 1
TRIGGER SELECTOR	CH 1

2. Set the oscilloscope sweep rate and triggering controls for a 0.1 msec/cm free-running sweep.

3. Apply a 0.2-volt peak-to-peak signal from the oscilloscope calibrator through a coaxial cable to the Channel 1 Input connector.

NOTE

For maximum accuracy use a calibrator signal source which has an amplitude accuracy of better than 3%.

4. The resulting display should be exactly 4 cm in amplitude. If not, set the Channel 1 GAIN for the correct waveform amplitude. (Use the Channel 1 POSITION control to align the display with the graticule markings.)

5. Set the MODE switch to CH 2 and apply the calibrator signal to the Channel 2 input connector.

6. The display should be exactly 4 cm in amplitude. If not, adjust the Channel 2 GAIN control for the proper display amplitude. Use the Channel 2 POSITION control to align the display with the graticule markings.

7. Disconnect the calibrator signal.

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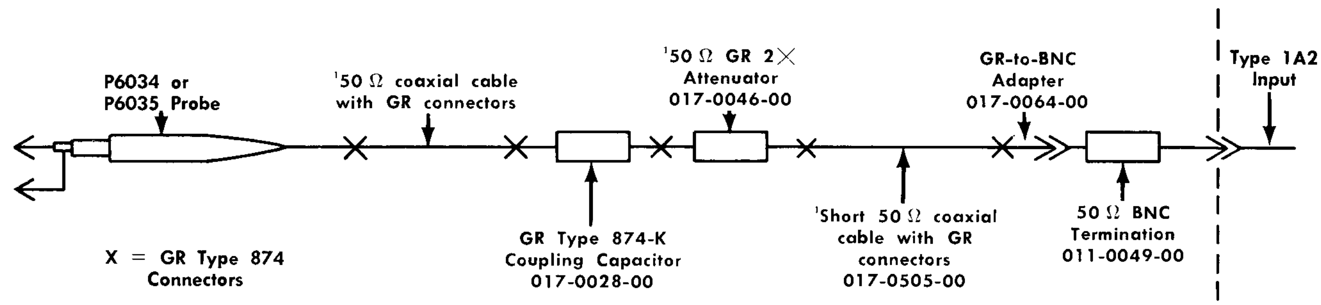

Fig. 2-2. Using the P6034 or P6035 Probe with the Type 1A2.

Variable Attenuator Balance Adjustments

If the VAR ATTEN BAL control of a channel is not properly set, the position of a no-signal free-running trace will shift vertically as the VARIABLE control is turned. If there is a trace shift, set the VAR ATTEN BAL adjustment for each channel as follows:

1. Set the Type 1A2 front-panel controls to the same positions as in the Gain Adjustments procedure except the AC-DC-GND switch must be set to GND and the MODE switch to ALT.

2. Carefully adjust the Channel 1 VAR ATTEN BAL control to a point where there is no trace shift as the Channel 1 VARIABLE control is turned back and forth through its full range.

3. Carefully adjust the Channel 2 VAR ATTEN BAL control to a point where there is no trace shift as the Channel 2 VARIABLE control is turned back and forth through its full range.

4. Due to interaction between channels, repeat steps 2 and 3 until there is no further interaction.

GENERAL OPERATION

Either of the two channels of the Type 1A2 can be used independently by setting the MODE switch to CH 1 or CH 2 and connecting the signal to be observed to the appropriate input. Table 2-1 lists several input systems compatible with the Type 1A2 input. Fig. 2-2 shows a block diagram of the input when using the system outlined in Method 7 of Table 2-1. Figure 2-3 shows the X_c and R curves for the Type 1A2.

Use of Probes

A conventional passive attenuator probe with a standard 42-inch cable lessens both capacitive and resistive loading, but at the same time reduces sensitivity. The attenuation introduced by the probe permits measurement of signal voltages that would overscan the CRT if applied directly to the Type 1A2. However, in applying high-amplitude signal voltages to either the probe or Type 1A2, do not exceed their maximum voltage ratings. When making amplitude measurements with an attenuator probe, be sure to multiply the observed amplitude by the probe attenuation factor.

To assure the accuracy of pulse or high-frequency measurements, check the probe compensation. To make the adjustment, proceed as follows:

1. Set the oscilloscope Amplitude Calibrator for a calibrator output signal of suitable amplitude (at least 2 cm).

2. Place the MODE switch to the appropriate channel setting (CH 1 or CH 2) to be used with the probe.

3. Touch the probe tip to the calibrator output connector and adjust the oscilloscope controls to display several cycles of the waveform.

4. Adjust the probe compensation for best square-wave response as shown in the right-hand picture of Fig. 2-4.

NOTE

If a square-wave source other than the oscilloscope calibrator is used for compensating the probe, do not use a repetition rate higher than 5 kHz. At higher repetition rates, the waveform amplitude appears to change as the probe is compensated. Thus, proper compensation is difficult. If the probe remains improperly compensated, measurements will be inaccurate.

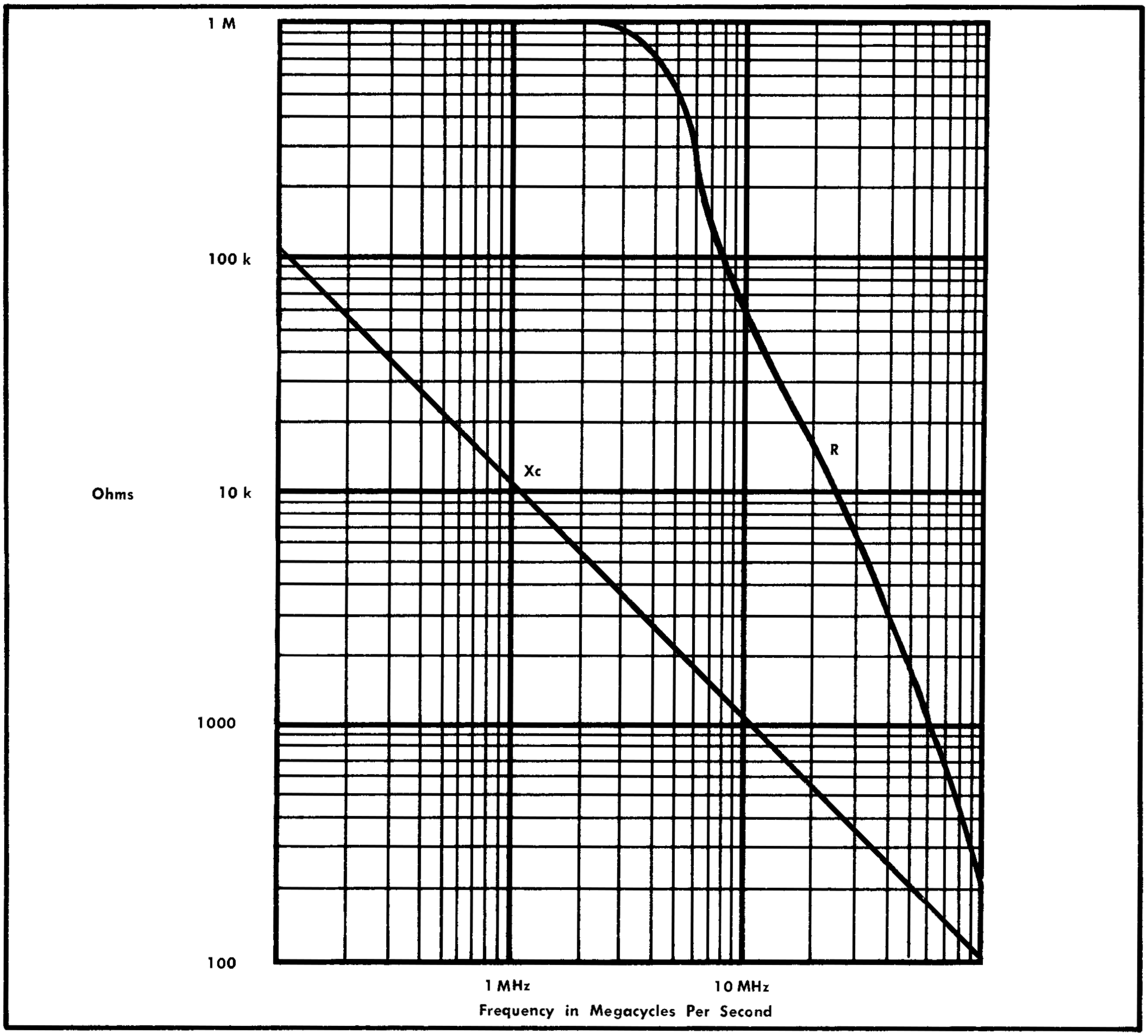

Fig. 2-3. Type 1A2 nominal input resistance and capacitive reactance vs frequency at any position of the VOLTS/CM switch.

AC-DC-GND Switch

To display both the DC and AC components of an applied signal, set the AC-DC-GND switch to DC; to display only the AC component of a signal, set the AC-DC-GND switch to AC.

In the AC position of the switch, the DC component of the signal is blocked by a capacitor in the input circuit. The input time constant of the input circuit is about 0.1 second and the low-frequency response of the unit is down 3 dB at about 2 Hz. If a 10× attenuator probe is used with the Type 1A2, the low-frequency response will be extended to about 0.2 Hz with a 100× probe, low-frequency response is about 2 Hz.

Placing the AC-DC-GND switch to the GND position grounds the input circuit of the Type 1A2 to provide a DC zero reference. When the AC-DC-GND switch is set to GND, the switch internally disconnects but does not ground the applied signal at the input connector. The GND position of the switch eliminates the need for externally grounding the input of the unit or probe tip to establish the ground reference.

VOLTS/CM Switch and VARIABLE Control

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of the probe, the setting of the VOLTS/CM switch and the setting of the VARIABLE control. Calibrated deflection factors indicated by the settings of the VOLTS/CM switch apply only when the VARIABLE control is set to the CALIBRATED position. Errors in display measurements may result

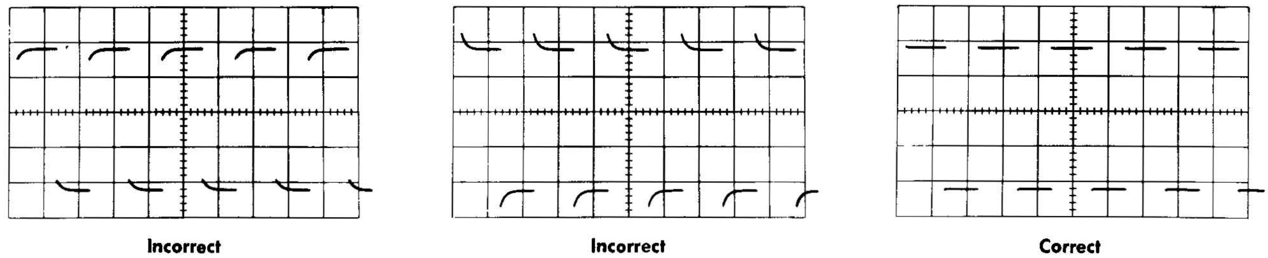

Fig. 2-4. Probe compensation waveforms using 1-kHz calibrator signals.

if the setting of this control is moved away from the CALIBRATED position.

The range of the VARIABLE control is at least 2.5 to 1 to provide continuously variable (uncalibrated) vertical deflection factors between all calibrated settings of the VOLTS/CM switch. When the control is turned to its maximum-counterclockwise position and the VOLTS/CM switch is set to 20, the VARIABLE control extends the vertical deflection factor to about 50 volts/cm. By applying the oscilloscope calibrator voltage or any other calibrated voltage source to the Type 1A2, any specific deflection factor can be set within the range of the VARIABLE control.

PULL TO INVERT Switch

The PULL TO INVERT switch may be used to invert the displayed waveform, particularly when using the dual-trace feature of the Type 1A2. The PULL TO INVERT switch has two positions. With the knob pushed in, the displayed waveform will have the same polarity as the applied signal; that is, a positive-going pulse applied to the Type 1A2 will be displayed as a positive-going waveform on the CRT. If a positive voltage is DC coupled to the Type 1A2, the beam will move up.

With the switch pulled the displayed waveform will be inverted; that is, a positive-going pulse applied to the Type 1A2 will be inverted or displayed as a negative-going waveform on the CRT. If a positive voltage is DC coupled to the Type 1A2, the beam will move down.

MODE Switch

The MODE switch has five positions: ALT, CH 1, ADD, CH 2, and CHOP. These positions and their purposes are described in subsequent paragraphs. Useful triggering information is included in the description of the ALT and CHOP switch positions.

CH 1, CH 2—Single Channel Operation

To display a single signal (single-channel operation), apply the signal either to the Channel 1 or Channel 2 Input connector and set the MODE switch to the corresponding position: CH 1 (Channel 1) or CH 2 (Channel 2).

To display a signal in one channel independently when the same signal or a different signal is applied to the other channel, simply select the signal in the channel to be displayed by setting the MODE switch to the appropriate CH 1 or CH 2 position.

ALT, CHOP—Dual Trace Operation

To display two signals together (dual-trace operation), apply one signal to the INPUT 1 connector and apply the other signal to the INPUT 2 connector.

In general, use the CHOP position (chopped-mode operation) with sweep rates of 50 μsec/cm or slower for displaying two non-repetitive signals occurring within the sweep-time interval set by the oscilloscope Time/Cm switch. Non-repetitive signals are those signals which are transient or random. The CHOP position is also useful for displaying low-frequency synchronous signals. Synchronous signals are those which have the same repetition rate or are frequency-related by whole number multiple.

NOTE

When using chopped-mode operation, be sure to set the oscilloscope CRT Cathode Selector switch to the Dual-Trace Chopped Blanking position to blank out the undesirable chopped-mode switching transients.

Use the ALT position (alternate-mode operation) when using sweep rates at about 0.5 ms/cm or faster to display high-frequency synchronous and asynchronous signals. Asynchronous signals are those which do not have the same repetition rate or are not frequency related to each other by a whole number multiple. Table 2-2 summarizes the following discussion for dual-trace operation.

Displaying Two Non-repetitive or Low-Frequency (Below 2 kHz) Synchronous Signals. To show true time and phase relationship between two non-repetitive or low-frequency synchronous signals, use chopped-mode operation. Transients as short as 0.5 ms can be well delineated or resolved. At 50 μs/cm a 0.5 ms duration transient, for example, will contain about 200 on segments in the trace. If a higher sweep rate is used, the number of segments that make up each of the traces will be less and therefore resolution will be poorer.

To make the low frequency or non-repetitive display stable, use either internal triggering on Channel 1 or 2 (from pin 5 of interconnecting plug—see Block Diagram in Section 10) or use the TRIG OUT connector as the external trigger source. If there is no Plug-In position on the oscilloscope Trigger Source switch, use the signal available at the TRIG OUT connector of the Type 1A2 by connecting a jumper coaxial cable from the TRIG OUT connector to the oscilloscope Trigger Input connector and setting the Triggering Source switch to Ext.

Type 1A2's below SN716 do not have the Plug-In triggering capability.

NOTE

Use the oscilloscope Plug-In position of the Triggering Source switch in preference to external patching to obtain optimum bandwidth capabilities from the Trigger Output Amplifier.

Do not set the oscilloscope Triggering Source switch to Norm Int or Int (oscilloscope vertical amplifier trigger take-off signal) because a stable display is difficult and sometimes impossible to obtain. During dual-trace chopped-mode operation the Norm Int or Int trigger source is a composite signal consisting of the signals applied to both channels superimposed on, but not synchronized with, the free-running rate of the chopped-mode switching signal. The switching signal has a square waveshape the same as the one shown in Fig. 2-1B. Its amplitude is dependent on the distance that the traces are positioned apart and the amount of DC component contained in the applied signals; its rate is the chopping rate (about 220 kHz).

Since the internal trigger from the oscilloscope vertical amplifier is a composite trigger during chopped mode of operation, and the trigger contains a nonsynchronized chopped-mode switching signal, internal triggering may occur first on one of the applied signals and then on the chopped-mode switching signal, or vice versa, resulting in an unstable display.

TABLE 2-1

Signal Coupling Methods

Method	Advantages	Limitations	Accessories Required	Source Loading See Fig. 2-3 Input R and X_c Curves	Precautions
1. Open test unshielded) leads	Simplicity	Limited frequency response, subject to stray pickup	BNC to Banana Jack adapter (103-0003-00). Two test leads.	1 Meg Ω and 15 pF at input, plus test leads	Stray pickup and spurious oscillations
2. Unterminated coaxial cable	Full Sensitivity	Limited frequency response. High capacitance of cable.	Coaxial cable with BNC connector(s)	1 Meg Ω and 15 pF plus cable capacitance	High capacitive loading
3. Terminated coaxial cable. Termination at Type 1A2 input.	Full sensitivity. Full Type 1A2/Oscilloscope bandwidth. Relatively flat resistive loading. Long cable with uniform response.	Presents R_o (typically 50 Ω) loading at end of coaxial. May need blocking capacitor to prevent DC loading or damage to termination.	Coaxial cable with BNC connectors R_o termination at Type 1A2 input. (BNC 50 Ω Termination, 011-0049-00.	R_o plus 15 pF at Type 1A2 end of coaxial can cause reflections	Reflection from 15 pF at input. DC and AC loading on test point. Power limit of termination.
4. Same as 3, with coaxial attenuator at termination	Less reflection from 15 pF at termination	Sensitivity is reduced (increased Deflection Factor)	BNC Coaxial attenuators	R_o only	DC and AC loading on test point. Power limit of attenuator.
5. Tap into terminated coaxial system. (BNC Tee: UG-274/U at Type 1A2 input).	Permits signal to go to normal load. DC or AC coupling without coaxial attenuators.	15 pF load at tap point	BNC Tee and BNC connectors on signal cables	1 Meg Ω and 15 pF at tap point.	Reflections from 15 pF input
6. 10×, 10 MΩ Probe 10×, 10 MΩ Probe 1000×, 100 MΩ Probe	Reduce resistive and capacitive loading, nearly full Type 1A2/Oscilloscope bandwidth.	×0.1 sensitivity ×0.01 sensitivity ×0.001 sensitivity	P6006, P6008 are 10×; P6007, P6009 are 100×; P6015 is 1000×	P6006[2]: ≈7 pF, 10 MΩ P6007: Less than 2 pF, 10 MΩ P6008: ≈7.5 pF, 10 MΩ P6009: ≈2.5 pF, 10 MΩ P6015: ≈ 2.7 pF, 100 MΩ.	Check probe frequency compensation. Use square-wave frequency less than 5 kHz, preferably 1 kHz.

[2]**P6006 Probe has less input capacitance than P6008, but P6008 has wider bandwidth.**

TABLE 2-1 *(cont)*

Method	Advantages	Limitations	Accessories Required	Source Loading See Fig. 2-3 Input R and X_c Curves	Precautions
7. 500 Ω and 5 kΩ Probes. (Must be terminated in 50 Ω at Type 1A2 input.)	Reduced capacitive loading to about 0.7 pF. Bandwidth that of Type 1A2/Oscilloscope. Probe compensation need not be adjusted, since effect is not apparent when used with the Type 1A2/Oscilloscope.	Resistive loading. ×0.1 or ×0.01 sensitivity. May need blocking capacitor to prevent DC loading or damage to termination. Limited low frequency response when AC coupled: 70 kHz for P6034: 7 kHz for P6035.	P6034—10× P6035—100× Items in Fig. 2-2	P6034: 500 Ω, 0.7 pF P6035: 5 kΩ, 0.6 pF	DC and AC loading. Voltage rating of probe.
8. Current transformer. Terminated in 50 Ω at Type 1A2. Upper Bandwidth that of Type 1A2/Oscilloscope.	Current xfmr can be permanent part of test circuit. Less than 2.2 pF to test circuit chassis. Measures signal current in transistor circuits: CT-1: 20 amps peak. CT-2 100 amps peak.	RMS current rating: CT-1: 0.5 amps CT-2: 2.5 amps Sensitivity: CT-1: 5 mV/mA. CT-2: 1 mV/mA.	CT-1: Coaxial adapter and BNC termination. CT-2: Nothing extra. (Perhaps additional coaxial cable for either transformer.)	CT:1 Insertion; 1 Ω paralleled by about 5 μH. Up to 1.5 pF. CT-2: Insertion; 0.04 Ω paralleled by about 5 μH. Up to 2.2 pF.	Not a quick-connect device. CT-1: low frequency limit about 75 kHz. CT-2: low frequency limit about 1.2 kHz, and is 1/5th as sensitive as the CT-1.

TABLE 2-2

Dual-Trace Operation

Applied Signals (One to Channel 1 and other to Channel 2)	Type 1A2 MODE Switch Setting	Oscilloscope Triggering Source Switch Setting	Oscilloscope Trigger Coupling Switch Setting	Displays show true time relationship between signals Other remarks
(a) Two non-repetitive signals or two low-frequency synchronous signals (below 2 kHz). Set the TRIGGER SELECTOR switch to the Channel with the reference signal applied.	CHOP	Plug-In[3] or Ext (connect jumper coaxial cable from TRIG OUT connector to Trigger Input connector on the oscilloscope).	AC or AC Slow or AC Fast or AC LF Reject	Yes Use sweep rates up to 50 μsec/cm. Higher sweep rates reduce resolution.
(b) Two asynchronous Signals, any frequency within full bandwidth of the system.	ALT	Norm Int or Int[4]	AC or AC Slow for frequencies below 1 kHz. AC Fast or AC LF Reject for frequencies above 1 kHz.	No
(c) Two synchronous signals. 60 Hz and above.	ALT	Plug-In[3] or Ext (connect jumper coaxial cable from TRIG OUT connector to Trigger Input connector on the oscilloscope).	AC or AC Slow or AC Fast or AC LF Reject	Yes Set the TRIGGER SELECTOR switch to the Channel with the reference signal applied.
		Norm Int or Int[4]	AC Fast or AC LF Reject	No

[3]Plug-In position is the Trigger Output Amplifier signal available at pin 5 of the Type 1A2 interconnecting plug to the oscilloscope. If your oscilloscope is not wired to permit use of this trigger source, use the Ext position and the TRIG OUT signal.

[4]Norm Int or Int switch position is the internal trigger takeoff signal from the oscilloscope vertical amplifier. In dual-trace operation this trigger is a composite of the applied signal superimposed on the DC positioning levels of the channels as they are switched.

Displaying Two Asynchronous Signals. To obtain a stable display of two asynchronous signals which do not exceed the system bandwidth, use alternate-mode operation and set the oscilloscope Trigger Source switch to Norm Int or Int. Set the oscilloscope Trigger Coupling switch to AC for stable triggering on signals below 1 kHz, set the Trigger

Coupling switch to AC LF Reject or AC Fast for stable triggering and a bright display of signals above 1 kHz. Since the oscilloscope vertical amplifier internal trigger is the trigger source, the applied signals will not be displayed in their true time relationship because triggering occurs on the applied signal in each channel as it switches on.

To obtain a stable display in this mode of operation, it is very important to set the oscilloscope Triggering Level control to a point where the time base can trigger on the signal in one channel as it turns on, and on the signal in the other channel when it turns on. In addition, both applied signals must be of sufficient amplitude to meet the internal trigger signal amplitude requirements of the oscilloscope.

If one displayed signal has a smaller amplitude than the other but is of adequate amplitude for internal triggering, then set the Triggering Level control to a point that will assure triggering on the smaller amplitude signal. To do this, set the Triggering Level control near the zero position.

Though it may seem easy to obtain stable triggering on asynchronous signals, there are certain conditions that may promote jitter. When using the AC Fast or AC LF Reject triggering mode, jitter most likely occurs when attempting to trigger on high-frequency asynchronous signals that are vertically positioned apart on the CRT with POSITION controls. If jitter occurs, it can be reduced and sometimes eliminated by positioning the displays close together or superimposing them. This not only reduces jitter but may also increase the display brightness.

If you use the AC or AC Slow triggering mode, stable internal triggering on asynchronous signals above 1 kHz is more difficult to obtain and the jitter will be greater. If you are using sweep rates faster than 0.5 ms/cm, the dual-trace display becomes noticeably brighter as the waveforms are vertically positioned together and dimmer when they are positioned apart. These effects are normal and are caused by the problem of triggering on the alternate-mode composite trigger waveform. The waveform is very similar to the one described for chopped-mode operation.

The alternate-mode composite trigger consists of the asynchronous signals applied to the Type 1A2 superimposed on the DC positioning and signal levels of the alternate-mode switching waveform. The switching waveform portion of the composite trigger is a low-frequency square wave whose amplitude is governed by the setting of the POSITION controls and DC components (if any) of the applied signals. By itself, the switching waveform viewed on a test oscilloscope resembles the waveshape shown in Fig. 2-1B when the traces are positioned two centimeters apart. Repetition rate of the switching waveform is one-half the sweep repetition rate.

When the alternate-mode composite trigger is internally AC coupled to the oscilloscope trigger input circuit, the trigger circuit may not respond instantly to the signals superimposed on the alternate-mode switching signal. The delay is caused by the recovery time of the trigger input circuit as each cycle of the low-frequency switching waveform couples into the input stage of the trigger circuits. Since AC coupling is used in all the Trigger Coupling switch positions (AC, AC Slow, AC Fast, AC LF Reject) recovery time is dependent on the RC time constant of the trigger input circuit.

In conclusion, trigger circuit recovery time is shorter, hence the sweep repetition rate can be higher and the display brighter, if AC Fast or AC LF Reject triggering mode is used. In either of these triggering modes, a smaller value coupling capacitor is used in the oscilloscope trigger input circuit as compared to the value used in the AC or AC Slow triggering mode. Trigger recovery time can be shortened and triggering will be more stable if high-frequency waveform displays are vertically positioned closer together or superimposed rather than positioned further apart.

Displaying Two Synchronous Signals, 60 Hz and Above. To show true time and phase relationship between two synchronous signals, 60 Hz and above, use alternate mode operation and trigger externally from one of the signals. In practice, for displaying signals between 60 Hz and 2 kHz you can choose either alternate- or chopped-mode operation since this is an overlapping area. Set the Trigger Coupling switch to the desired AC position (AC, AC Slow, AC Fast or AC LF Reject). Apply the reference signal to the external trigger input and set the oscilloscope Trigger Source switch to the Ext position in high-frequency applications. Set the TRIGGER SELECTOR switch to the channel with the reference signal and set the oscilloscope Triggering Source to the Plug-In position. If your oscilloscope does not have the Plug-In switch position, apply the signal from the TRIG OUT connector to the oscilloscope Trigger Input connector and set the Triggering Source switch to Ext.

When externally triggering the oscilloscope, if one of the signals changes frequency, one of the signals will remain stationary while the other signal will appear to free run. This phenomenon is useful for determining zero-beat points between the two signals.

ADD—Algebraic Addition of Two Signals

In many applications, the desired signal is superimposed on an undersired signal such as line frequency hum, etc. Algebraic addition makes it possible in many cases to improve the ratio of desired to undersired signal. To do this, connect one input to a source containing both the desired and undersired signal. Connect the other input to a source containing only the undersired signal. Place the MODE switch to the ADD position. Set the PULL TO INVERT switches to opposite settings (depending upon the polarity of the desired signal). By carefully adjusting (especially at low frequencies) the VARIABLE control of one of the channels, the undersired displayed signal can be reduced by a factor of at least 20 compared to the amplitude of the desired signal. In general the input coupling should be the same on both channels.

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SECTION 3
APPLICATIONS

Introduction

This section of the manual describes procedures and techniques for making basic measurements with the Type 1A2 and the associated Tektronix oscilloscope.

No attempt has been made to describe specific applications, since familarity with the unit enables the operator to apply these techniques to a wide variety of applications.

AC Component Voltage Measurements

To measure the AC component of a waveform, the AC-DC-GND switch of the channel you intend to use should be set to the AC position. In this position, only the AC components of the input signal are displayed on the CRT. (However, when the AC component of the input signal is very low in frequency, use the DC position of the switch.)

To make a peak-to-peak voltage measurement of the AC component of a waveform, perform the following steps (Channel 1 is used as the example):

1. Set the Channel 1 VOLTS/CM switch so that the voltage to be applied to the input connector is no more than about four to six times the setting.

2. Apply the signal to the INPUT 1 connector, preferably through a coaxial cable or an attenuator probe.

3. Set the MODE switch to CH 1.

4. Set the triggering controls to obtain a stable display and set the sweep rate to display several cycles of the waveform.

5. Use the Channel 1 POSITION control to vertically position the waveform to a point on the CRT where the waveform amplitude can be easily determined. For example, position the waveform so that the negative peaks coincide with one of the lower graticule lines and one of the positive peaks lies near the graticule vertical centerline (see Fig 3-1).

6. Measure the vertical deflection in centimeters from peak to peak on the waveform. Make sure the VARIABLE control is set to the CALIBRATED position.

NOTE

In measuring signal amplitudes, the width of the trace may be an appreciable part of the overall measurement. To make the measurement as accurate as possible, measure from one side of the trace (particularly when measuring low-amplitude signals). Notice in Fig. 3-1 that both points (a) and (b) correspond to the bottom side of the trace. The measurement would be just as accurate if points (a) and (b) corresponded to the top side or center of the trace.

7. Multiply the peak-to-peak distance measured in step 6 by the setting of the Channel 1 VOLTS/CM switch and the attenuation factor, if any, of the probe.

As an example of this method, assume that the peak-to-peak vertical deflection is 4.6 cm using 10× probe with the VOLTS/CM switch set to 0.5. Substituting these values in the following formula:

$$\text{Volts Peak to peak} = \text{Vertical deflection in cm} \times \text{VOLTS/CM switch setting} \times \text{Probe atten factor}$$

Then:

$$\text{Volts peak to peak} = 4.6 \times 0.5 \times 10 = 23 \text{ volts}$$

Instantaneous Voltage Measurements

To measure the DC level at a given point on a waveform proceed as follows:

1. Set the Channel 1 VOLTS/CM switch so that the voltage to be applied to the input connector is not more than about six times the switch setting.

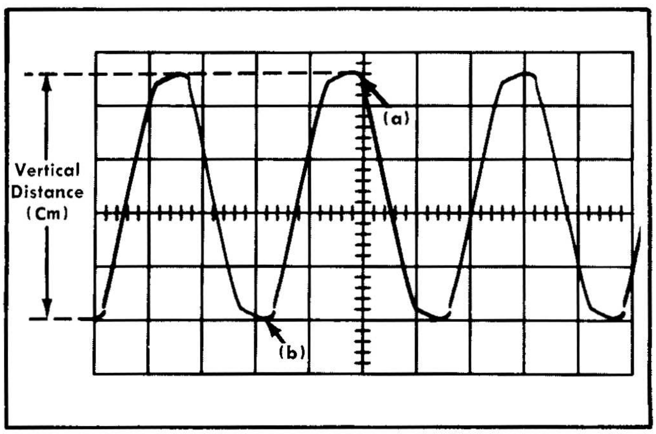


Fig. 3-1. Measuring the peak-to-peak voltage of a waveform.

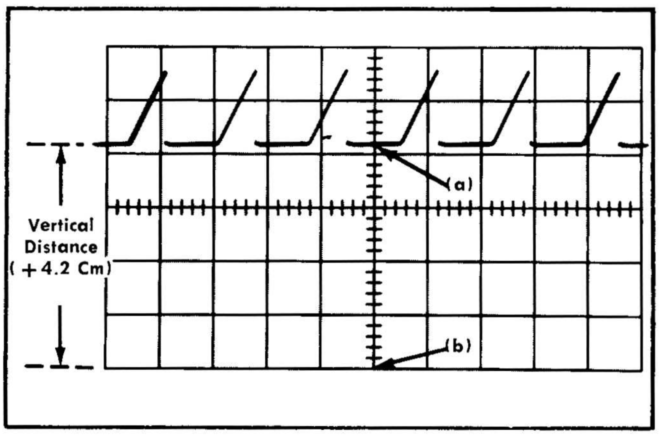


Fig. 3-2. Measuring instantaneous voltage with respect to some reference.

2. Set the oscilloscope triggering and time-base controls so that the time base free runs at the desired rate.

3. Set the Channel 1 AC-DC-GND switch to GND and position the trace (with the Channel 1 POSITION control) to one of the horizontal graticule lines such as point (b) in Fig. 3-2. This line will be used as a ground (or zero) reference line. In any case, the reference line chosen will depend upon the polarity and DC level of the signal to be measured. Do not move the Channel 1 POSITION control after the reference line has been established.

4. Set the Channel 1 AC-DC-GND switch to DC.

NOTE

Any shift in the position of the trace when the AC-DC-GND switch is moved from GND to DC, or vice versa, indicates grid current in the appropriate input Nuvistor (V133 or V233). Maximum trace shift due to grid current is ±2 mm. If the trace shifts more than this amount, replace the faulty Nuvistor.

5. Apply the signal, preferably through a coaxial cable or an attenuator probe, to the Channel 1 Input connector.

6. Set the triggering controls of the time base for a stable display.

7. Measure the vertical distance in centimeters from the ground (zero) reference line established in step 3 to the point on the waveform that you wish to measure, such as between (a) and (b) in Fig. 3-2. If the PULL TO INVERT switch is pushed in and the point on the waveform is above the reference line, the polarity is indicated to be positive (+). If the point is below the line, the polarity is negative (—). If the PULL TO INVERT switch is pulled out, the indicated polarities will be reversed.

8. Multiply the measured distance by the setting of the VOLTS/CM switch and the attenuator factor, if any, of the probe. This is the instantaneous DC level of the point measured. For example, assume the vertical deflection is 4.2 cm above the reference line (see Fig. 3-2) using a 10× attenuator probe with the PULL TO INVERT switch pushed in and the VOLTS/CM switch set to 2. Substitute these values in the following formula:

$$\text{Instantaneous Voltage (with respect to a ground reference)} = \text{Vertical Deflection in cm and polarity} \times \text{VOLTS/CM switch setting} \times \text{Probe atten factor}$$

Then:

$$\text{Instantaneous Voltage (with respect to a ground reference)} = +4.2 \times 2 \times 10 = +84 \text{ volts}$$

9. To re-establish the (zero) reference line without disconnecting the applied signal, set the AC-DC-GND switch to GND. To establish a reference other than zero, set the AC-DC-GND switch to DC, touch the signal probe to the desired reference voltage and position the free-running sweep along one of the horizontal graticule lines.

Voltage Comparison Measurements

In some applications you may want to establish a set of deflection factors other than those indicated by the VOLTS/CM switch. This is useful for comparing signals which are exact multiples of a given voltage amplitude. The following procedure describes how to determine deflection factors for Channel 1. The same basic procedure can be used for Channel 2. To establish a set of deflection factors based upon some specific reference amplitudes, proceed as follows:

1. Apply a known-amplitude reference signal to the Channel 1 Input connector and, with the Channel 1 VOLTS/CM switch and VARIABLE control, adjust the amplitude of the display for an exact number of graticule divisions. Do not move the VARIABLE control after obtaining the desired deflection.

2. Divide the amplitude of the reference signal (in volts by the product of the deflection in centimeters (established in step 1) and the VOLTS/CM switch setting. The result is the Deflection Conversion Factor:

$$\text{Deflection Conversion Factor} = \frac{\text{Reference signal amplitude in volts}}{(\text{Deflection in cm}) \times (\text{VOLTS/CM switch setting})}$$

3. To calculate the True Deflection Factor at any setting of the Channel 1 VOLTS/CM switch, multiply the VOLTS/CM switch setting by the Deflection Conversion Factor obtained in step 2:

$$\text{True Deflection Factor} = (\text{VOLTS/CM switch setting}) \times (\text{Deflection Conversion Factor})$$

The True Deflection Factor obtained for any setting of the Channel 1 VOLTS/CM switch applies to Channel 1 only, and only if the VARIABLE control is not moved from the position to which it was set in step 1.

For example, assume the amplitude of the reference signal applied to Channel 1 is 30 volts, the VOLTS/CM switch is set to 5 and the VARIABLE control is adjusted to decrease the amplitude of the display to exactly 4 cm. Then substitute the preceding values in the Deflection Conversion Factor and True Deflection Factor formulas:

$$\text{Deflection Conversion Factor} = \frac{30}{(4) \times (5)} = 1.5$$

$$\text{True Deflection Factor} = (5) \times (1.5) = 7.5 \text{ volts/cm}$$

4. To determine the peak-to-peak amplitude of a signal to be compared, disconnect the reference signal and apply the signal to Channel 1.

5. Set the Channel 1 VOLTS/CM switch to a setting that will provide enough deflection so that a measurement can be made.

6. Measure the vertical distance in centimeters and determine the amplitude by using the following formula:

$$\text{Signal Amplitude} = \text{Deflection Conversion Factor} \times \text{Deflection in cm} \times \text{VOLTS/CM switch setting}$$

For example, assume the signal to be compared caused a vertical deflection of 4.5 cm at a VOLTS/CM switch setting of 10 and the VARIABLE VOLTS/CM control was not moved from the setting used in the previous example. Then, substitute these values and a Deflection Conversion Factor of 1.5 in the Signal Amplitude formula:

Signal Amplitude (in volts) $= (1.5) \times (4.5) \times (10) = 67.5$ volts

Time-Difference Measurements

The calibrated sweep rate of the oscilloscope and the dual-trace feature of the Type 1A2 allows measurement of the time difference between events. Measure time difference as follows:

1. Set the AC-DC-GND switches to identical settings; either AC or DC depending on the type of coupling desired.

2. Push in the PULL TO INVERT switches.

3. Place the MODE switch to either CHOP or ALT, as desired. In general, the CHOP position is more suitable for low-frequency signals and the ALT position is more suitable for high-frequency signals.

4. Connect a trigger signal to the oscilloscope Trigger Input connector. This trigger signal must bear a fixed time relationship to the signals to be displayed.

5. Set the VOLTS/CM switches so that the expected voltages applied to the input connectors will provide suitable vertical deflection on the CRT.

6. Apply the signals to the input connectors. Use coaxial cables or probes having equal delay.

7. Set the oscilloscope Trigger Source switch to externally trigger on the signal.

8. Set the oscilloscope time-base controls for a calibrated sweep rate which will allow accurate measurement of the distance between the two waveforms.

9. Measure the horizontal distance between the points on the two waveforms.

10. Multiply the distance measured for each channel by the setting of the oscilloscope Time/Cm switch to obtain the apparent time interval.

11. To obtain the actual time interval, divide the apparent time interval by the amount of sweep magnification, if any, or by 1 if no sweep magnification is used. The formula is as follows:

$$\text{Time Delay} = \frac{(\text{Time/Cm switch setting}) \times (\text{Distance in cm})}{\text{Sweep Magnification}}$$

For example, assume that the Time/Cm switch setting is 2 μsec, the Magnifier is set for 5$\times$ magnification, and there is a horizontal distance of 3 cm (as shown in Fig. 3-3) between the leading edge of the reference waveform and the leading edge of the waveform displayed by Channel 2. Then substitute these values in the preceding formula:

$$\text{Time Delay} = \frac{(2\ \mu\text{sec}) \times (3\ \text{cm})}{5} = 1.2\ \mu\text{sec}$$

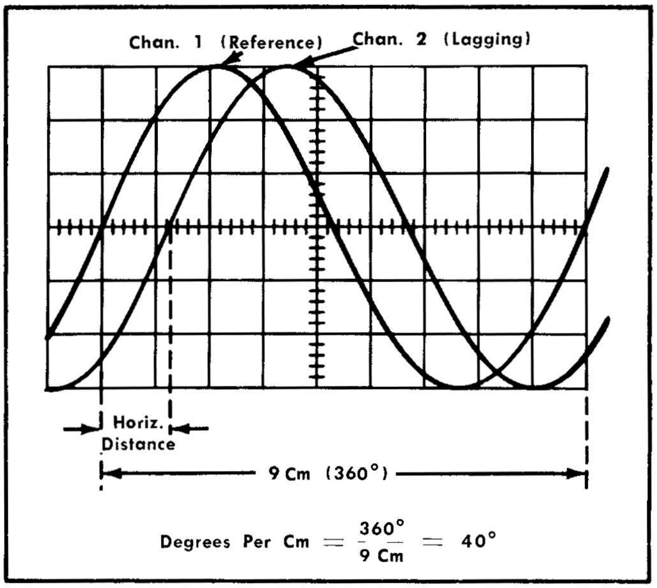


Fig. 3-3. Measuring phase shift between two sine waves.

Phase Measurements

Phase comparison of two signals of the same frequency can be made using the dual-trace feature of the Type 1A2. To make the comparison, proceed as follows:

1. Follow the procedure outlined in the first seven steps under Time-Difference Measurements.

2. Set the oscilloscope sweep rate to obtain a display of less than 1 cycle of the waveform.

3. Adjust the VARIABLE control for each channel so the waveform amplitudes are equal and fill the graticule area vertically. Reset the VOLTS/CM switches, if necessary, to

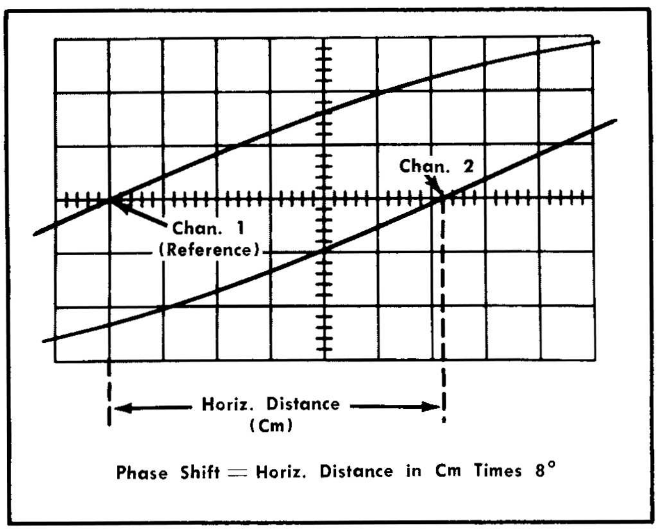


Fig. 3-4. Computing the phase shift when the oscilloscope sweep rate is increased 5$\times$.

obtain equal-amplitude waveform displays. (Equal amplitudes are used to make comparisons easier.)

4. Use the POSITION controls to center the waveforms vertically; that is, an equal distance each side of the graticule centerline.

5. Turn the oscilloscope Variable Time/Cm control counterclockwise until 1 cycle of the reference signal occupies 9 cm horizontally. Use the Trigger Slope and Triggering Level controls to trigger on the reference waveform at any point you desire. Each cm on the graticule now represents 40° of 1 cycle (see Fig. 3-3).

6. Measure the horizontal distance, in cm, between corresponding points on the waveforms. Note the distance and whether the Channel 2 waveform is leading or lagging (see Fig. 3-3).

7. Multiply the distance by 40°/cm to obtain the amount of phase difference.

For more precise measurements, increase the previous sweep rate but do not change the setting of the oscilloscope Variable Time/Cm control. However, you must consider this increase in your calculations.

For example, if you increase the sweep rate by a factor of 5, and then measure the distance between waveforms, each cm will represent 8° (40° ÷ 5) of a cycle. Thus, phase difference up to 80° can be measured more accurately. When preparing to make the measurement, horizontally position the waveforms to points where the graticule markings aid in determining the exact distance. Fig. 3-4 for example, shows how the phase difference of the Channel 2 waveform can be computed using this method.

SECTION 4
CIRCUIT DESCRIPTION

Introduction

The Type 1A2 contains two channel input amplifiers, a common output amplifier, a switching circuit for dual-trace operation and a trigger output amplifier. (Instruments with serial number below 715 do not have a trigger output amplifier.)

Channel Input Amplifiers

The applied signal from the INPUT connector passes through the AC-DC-GND switch to the attenuation network. The AC position of the AC-DC-GND switch AC couples the signal to the amplifier; the DC position directly couples the signal to the amplifier and the GND position opens the circuit to the input signal and grounds the input of the amplifier.

The deflection factor of the plug-in unit is changed with attenuators (VOLTS/CM switch) connected in the input circuit. Each attenuator is frequency compensated for equal attenuation of low and high frequencies. The input capacitance of each attenuator is standardized so that input capacitance is the same regardless of the settings of the VOLTS/CM switch.

From the attenuator network, the incoming signal passes to the grid of the input Nuvistor V133 (or V233 in Channel 2). The Nuvistor is connected as a cathode follower and has a voltage gain of about 0.9. The neon bulb B118, between the grid and cathode of the Nuvistor, keeps the grid-to-cathode voltage within safe limits while the tube is warming up. D134 (D234 in Channel 2) protects against excessive plate current in the event of a large positive voltage swing on the grid of the tube. D397 prevents current varitions in the supply due to positioning controls in common mode operation. C397 prevents the plate voltage following the grid signal at frequencies above 50 kHz. Diodes D137 and D138 protect the transistor stage by limiting the output voltage swing of the Nuvistor. In instruments with serial numbers below 715, D397 and C397 are not present; D134 is connected to the +100-V supply.

The remaining stage of the Channel Input Amplifier is an emitter coupled paraphase amplifier. This stage converts the single-ended input signal to push-pull. Gain of the stage is controlled by R142 and R161 in the common emitter circuit. These variable resistors vary emitter degeneration. Maximum gain occurs with minimum resistance between the two emitters. The VAR ATTEN BAL control sets the level on the base of the undriven transistor so that no current flows between emitters under no-signal conditions. This insures that there is no ground reference shift of the trace when the VARIABLE control is turned.

Resistors R140 and R160, in the collector circuits of Q143 and Q163, provide thermal stability by forcing the transistors to operate in a balanced power mode. This means that dissipation of the transistors remains balanced with varying signals.

The PULL TO INVERT switches reverse the displayed polarity of the signal. With the switches pushed in, a positive voltage change at the INPUT connector deflects the electron beam of the oscilloscope upward. With the switches pulled out, a positive voltage change at the INPUT connector deflects the electron beam downward.

The POSITION controls vary the current on each side of the push-pull circuit for positioning control. In the ADD position of the MODE switch, note that the Channel 2 POSITION control is out of the circuit and only the Channel 1 POSITION control can position the display.

Fig. 4-1 shows a simplified schematic diagram of the relationship of the last stage of each Channel Amplifier to the diode gates and the first stage of the Output Amplifier.

Diode Gates

The state of the diode gates determine which Channel Input Amplifier signal passes through to the Output Amplifier. The diode gates are controlled by the switching circuit. In the ADD position of the MODE switch, both diode gates allow both Channel Input Amplifier signals to pass on to the Output Amplifier. In all other positions of the MODE switch, the diode gates are never on at the same time.

The diode gates permit the signal current to pass when D301-D304 (D306-D309 in Channel 2) are forward biased and D302-D303 (D307-D308 in Channel 2) are back biased. The diode gates block the signal when the diodes are in the opposite state. For simplicity, the schematic of Fig. 4-1 represents the diode gates as switches.

Output Amplifier

The first stage of the Output Amplifier is a hybrid push-pull cascode amplifier. The Channel Input Amplifiers current-drive the emitters of Q354 and Q364. Toroids, T301 and T310, are parasitic oscillation suppressors. The voltage swing on the emitters is relatively small, due to the low input impedance.

The cathodes of V364 are current-driven by Q354 and Q364. V364 elevates the DC level of the stage to the correct voltage necessary for the vertical amplifier of the oscilloscope. The OUTPUT DC LEVEL adjustment is provided so that this voltage level can be accurately set.

The final stage of the Output Amplifier is an emitter follower circuit. The emitter follower stage isolates the preceding stage from the vertical amplifier of the oscilloscope. The high-frequency compensation network consisting of C377-R377 and C379-R379 standardizes the response of the instrument.

Switching Circuit

The switching circuit consists of a bistable multivibrator (Q315-Q325) and a trigger circuit (Q340). Both circuits are arranged in various configurations by the MODE switch SW350A. The operation of the switching circuit and its

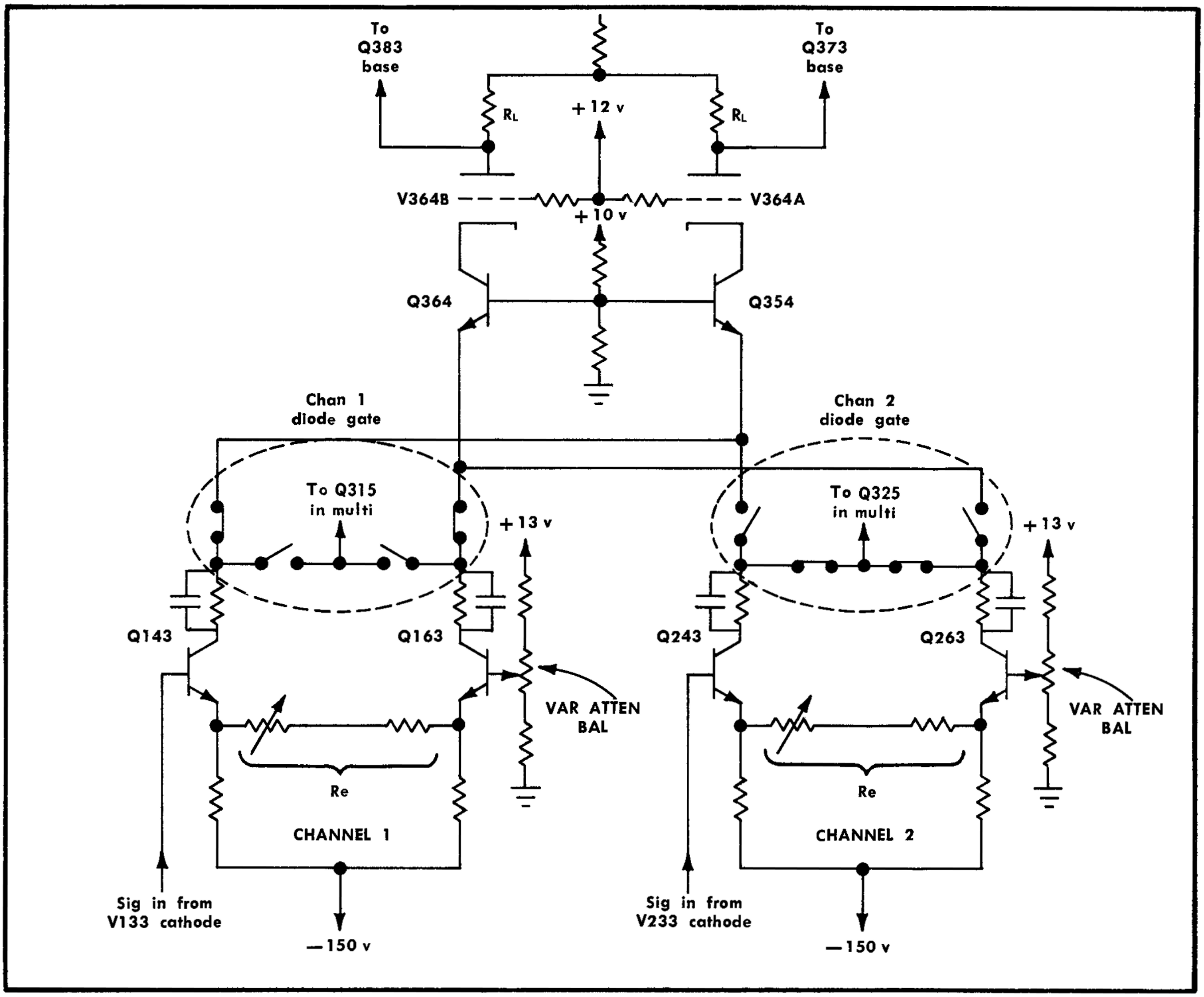


Fig. 4-1. Simplified schematic to illustrate the relationship of the Channel Input Amplifiers to the diode gates and the Output Amplifier. Resistances of R_e and R_L determine overall gain of the plug-in unit.

effect on the diode gates at the different settings of the MODE switch is described in the following paragraphs. See the schematic diagrams at the rear of this manual for the appropriate waveforms and voltages.

ALT. In the ALT position of the MODE switch, the switching circuit must switch to the opposite channel at the end of each sweep of a time-base circuit. The command pulse (called the Alt Trace Sync Pulse) for this purpose arrives at the base of Q340 from pin 8 of the interconnecting plug through diode D332. In this mode, Q340 is connected as a triggered Blocking-Oscillator. The output trigger pulse is transformer-coupled to the steering diodes D317-D327 of the bistable multivibrator (Q315-Q325). Depending on the state of the multivibrator, one of the steering diodes is forward biased by the trigger pulse. This steering diode passes the trigger signal to the appropriate side of the multivibrator and causes it to switch to the opposite state. The change of state of the multivibrator reverses the condition of both diode gates. Note that when Q325 conducts, diodes D307-D308 are forward biased, D306-D309 are back biased, and the Channel 2 diode gate does not permit the signal to pass to the Output Amplifier. When Q315 conducts, diodes D302-D303 are forward biased, D301-D304 are back biased, and the Channel 1 signal is then blocked from the Output Amplifier.

When the plug-in unit is used with an oscilloscope that has alternate sweep switching, an Alternate Sweep Slave Pulse is coupled into pin 7 of the interconnecting plug. The slave pulse insures that the multivibrator (Q315-Q325) turns on Channel 1 during the Time Base A sweep of the oscilloscope. This, in turn, allows the Channel 1 signal to be displayed on the Time Base A sweep of the oscilloscope and the Channel 2 signal to be displayed on the Main Time Base (B) sweep. See Fig. 4-2 for the relationship of the slaving pulse to the oscilloscope sweep voltages. Note that this capability occurs only in the ALT setting of the MODE switch.

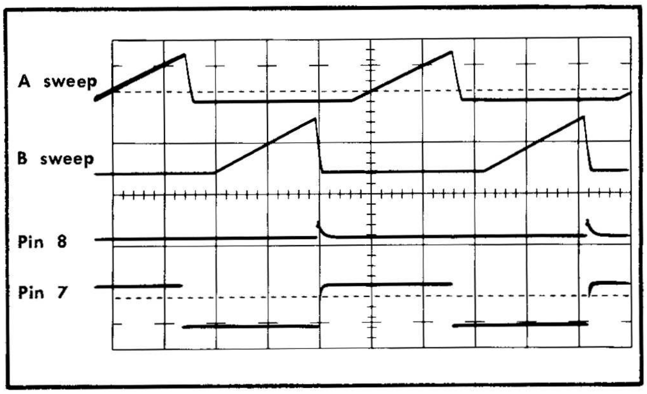


Fig. 4-2. The time relationship between the alternate-sweep slave pulse, alternate-trace sync pulse and the alternate sweeps of a Type 547 Oscilloscope.

CH 1. This position of the MODE switch allows only the Channel 1 signal to pass to the output amplifier. This is accomplished by reverse biasing the base of Q315 from the +225-volt supply through R311 and R314. The base of Q325 is forward biased by connecting it to ground through R324.

With Q325 conducting, a more positive voltage is developed at the junction of R327-R328 than at the emitters of Q354 and Q364. This positive voltage forces D307-D308 into conduction and back biases D306-D309. With D306-D309 back biased, the Channel 2 signal is blocked from the Output Amplifier.

With Q315 turned off, the junction of R317-R318 is sufficiently more negative than the emitters of Q354-Q364 to reverse bias D302-D303. Therefore, with D302-D303 not conducting, D301-D304 are forward biased and allow the Channel 1 signal to pass to the Output Amplifier. Fig. 4-1 shows the condition of the diode gates, in simplified form, when the MODE switch is set to CH 1.

ADD. This position of the MODE switch permits the output of both channels to pass to the Output Amplifier at the same time. The resultant display is an algebraic addition of the two inputs. To allow both diode gates to pass the signal at the same time, both Q315 and Q325 must be turned off. To do this, the MODE switch removes the voltages from the emitters and bases of Q315 and Q325. This places the junctions of D302-D303 and D307-D308 sufficiently below Q354-Q364 emitters so the diodes are back biased.

NOTE

R323 is switched in as a dummy load resistor that maintains the proper current drain on the +10-volt source.

With the two channels working into the Output Amplifier simultaneously, twice the amount of current is passed through the diode gates. Thus, additional current is supplied through R352 by the MODE switch to maintain the same output DC level.

CH 2. In this position of the MODE switch, only the Channel 2 signal passes to the Output Amplifier. This is done by reversing the state of the switching multivibrator from the condition of the CH 1 position. That is, Q325 is turned off and Q315 is turned on. This blocks the Channel 1 signal and permits the Channel 2 diode gate to pass the signal to the Output Amplifier.

CHOP. In this position of the MODE switch, the triggering circuit (Q340) is arranged as an astable (free running) blocking oscillator. Frequency of the blocking oscillator is about 220 kHz. The output pulse of the blocking oscillator is coupled to the switching multivibrator through C340 to the steering diodes. The only difference in the operation of the circuits from the ALT mode of operation is that the blocking oscillator (Q340) free runs and doesn't rely on a triggering signal from the time base circuitry of the oscilloscope. The result is that the switching multivibrator rapidly switches back and forth between channels during the sweep of the time base. A blanking signal is coupled from the collector of Q340 to pin 16 of the interconnecting plug. This blanking signal blanks the electron beam of the oscilloscope while the switching multivibrator switches between channels.

Filament Supplies

Filament current for V364 is supplied from pins 13 and 14 of the interconnecting plug. This voltage is approximately 6.3 volts at line frequency. Filament voltage for the input Nuvistors is regulated by the supply in the oscilloscope. The DC filament voltage eliminates any line frequency ripple that might otherwise be introduced into the cathodes of V133 and V233. Also, the constant filament voltage eliminates bias shift when there is any change in line voltage.

Trigger Output Amplifier

Q414 and Q424 with the associated circuitry are feedback amplifiers for the signal arriving from R136 or R236 in the cathode of the input Nuvistor. Variable resistor R415 simulates the input base impedence of Q414 so the input cathode follower of the channel not selected for trigger amplification has the same loading to ground as when it is selected for trigger amplification. Voltage gain for the stage is about 2 to 2.5 for Q414 and about 5 for Q424. The signal is AC coupled from the collector of Q414 to the base of Q424 to minimize the effect of DC drift, and from the collector of Q424 to both the TRIG OUT connector and pin 5 of the interconnecting plug to the oscilloscope.

The trigger at pin 5 is available for use as an internal trigger source. However, to make use of this trigger the associated oscilloscope must be capable of selecting it with a Triggering Source switch. If the trigger cannot be selected internally, external triggering must be used. The trigger has the same polarity as the signal applied at the Input connector. Output DC level is approximately zero volts.

SECTION 5
MAINTENANCE

PREVENTIVE MAINTENANCE

Cleaning the Interior

To clean the interior of the Type 1A2, blow off the accumulated dust using low-velocity compressed (10 psi) air. High-velocity air stream could damage components.

Visual Inspection

Many potential or existing troubles can be detected by a visual inspection of the unit. For this reason, a complete visual check should be performed periodically or every time the unit is inoperative, needs repair or needs recalibration. Visible defects may include loose or broken connections, frayed coax-shield (that could cause a short), damaged connectors, improperly seated tubes or semiconductors and scorched or burned parts.

The remedy for these troubles is readily apparent except in the case of heat-damaged parts. Damage to parts due to heat is often the result of other less apparent troubles in the unit. It is essential that the cause of overheating be determined and corrected before replacing the damaged parts.

Checking Tubes and Semiconductors

Periodic tester checks on the tubes and semiconductors used in the Type 1A2 are not recommended. Static tube and semiconductor testers in many cases indicate a defect when a component is operating satisfactorily in a circuit, or fail to indicate defects which affect circuit performance.

The true test of tube or semiconductor usability is whether or not the component works properly in the circuit. If it is working correctly, it should not be replaced.

Calibration

The Type 1A2 should provide many hours of trouble-free operation. However, to insure the reliability of measurements, check the calibration of the unit after each 500 hours of operation (or every six months if the unit is used intermittently). A complete step-by-step procedure for calibrating the unit and checking its operation is given in the Calibration section of this manual.

CORRECTIVE MAINTENANCE

Soldering Precautions

A. Soldering to Ceramic Terminal Strips

Solder used on the ceramic terminal strips should contain about 3% silver. Ordinary tin lead solder can be used but not repeatedly. If ordinary tin lead solder is used repeatedly or, if excessive heat is applied, the ceramic-to-solder bond can be broken. For this reason, we recommend solder with about a 3% silver content and a 40- to 75-watt soldering iron with a 1/8 inch wide chisel tip for installing or removing connections on the strips.

Silver-bearing solder is usually available locally but if it is not it can be purchased from Tektronix in one pound rolls: order by Tektronix part number 251-0514-00.

B. Soldering to metal terminals.

In soldering to metal terminals (such as interconnecting plug pins, switch terminals, potentiometers, etc.), ordinary 60/40 solder and a 40- to 75-watt soldering iron with 1/8 inch wide chisel tip can be used. The chisel tip must be properly tinned.

The procedure for soldering is as follows:

1. Apply only enough heat to melt the solder and remove the connection.

2. When resoldering the lead, apply enough heat to make the solder flow freely.

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

Replacing Tubes and Transistors

Do not replace tubes and transistors unless they actually cause trouble. During routine maintenance, it may be necessary to remove tubes or transistors from their sockets. It is important that these components be returned to the same sockets.

Unnecessary replacement or switching of tubes or transistors will often necessitate recalibration of the instrument. If any components do require replacement, it is recommended that they be replaced by previously checked, high quality components. The best check of tubes and transistors is to place them in the circuit and then check for proper operation.

CAUTION

Turn off the oscilloscope power when replacing tubes or transistors to prevent them from being damaged. Be sure the voltages and loads on the transistors are normal before making the substitution.

After completing the check, if you have replaced any tubes or transistors in the amplifier stages, check the gain and transient response of the Type 1A2 before using the unit for waveform measurements.

Removing and Replacing Switches

Single wafers or mechanical parts on rotary switches are not normally replaced. If the switch is defective, the entire switch should be replaced. The VOLTS/CM and MODE switches can be ordered through your Tektronix Field Engineering Office either unwired or wired, as desired. Refer to the Parts List to find the unwired and wired switch part numbers.

CAUTION

When disconnecting or connecting leads to a wafer-type switch, do not let solder flow around and beyond the rivet on the switch terminal. Excessive solder can destroy the spring tension of the contact.

OBTAINING REPLACEMENT PARTS

Standard Parts

Replacements for all electrical and mechanical parts used in the Type 1A2 can be purchased through your local Tektronix Field Engineer or Field Office. However, since many of the electrical components are standard parts, they can generally be obtained locally in less time than is required to obtain them from the factory. Before ordering or purchasing electrical components, be sure to consult the Electrical Parts List to determine the values, tolerances and ratings required.

Special Parts

In addition to the standard electrical components mentioned in the previous paragraph, special parts are also used in the assembly of the Type 1A2. These parts are manufactured or selected by Tektronix to satisfy particular reguirements or are manufactured specially for Tektronix by other companies in accordance with Tektronix specifications. These parts and most mechanical parts should be ordered from your Tektronix Field Engineer or Field Office as they are normally difficult or impossible to obtain from other sources.

TROUBLESHOOTING

Front-Panel Controls

Before troubleshooting, double check the front-panel controls of the plug-in unit and oscilloscope for proper settings. In addition, check the front-panel screwdriver-adjustable controls to determine if their settings are proper. This is important since symptoms caused by incorrect control settings are not described in this section of the manual. Next, determine whether the trouble is in the oscilloscope or the Type 1A2.

Type 1A2 or Oscilloscope

When following a troubleshooting procedure, it is assumed that the oscilloscope used with the Type 1A2 is operating normally. Since this is not always the case, check the operation of the oscilloscope before attempting to troubleshoot the Type 1A2.

Troubles occurring in the oscilloscope can usually be detected by substituting another plug-in unit for the Type 1A2—preferably another Type 1A2 which is working normally. Then, such troubles as loss of alternate sync pulses or improper chopped blanking can be readily isolated to either the Type 1A2 or the oscilloscope. If a substitute unit is not available, multi-trace troubles will have to be isolated by using signal tracing methods.

NOTE

Be sure proper line voltage is applied to the oscilloscope used with the Type 1A2. For proper oscilloscope low-voltage power supply regulation, the AC line voltage should contain no more than 3% to 5% sine-wave distortion.

If the Type 1A2 is definitely at fault and not the associated oscilloscope, make a careful operational check of the Type 1A2. Carefully note the effect that each front-panel control has on the symptom. By analyzing such effects, you can sometimes isolate a trouble to either a defective control or circuits containing the trouble. In addition, the normal or abnormal operation of each control should indicate checks to make.

The remainder of this section deals with detailed troubleshooting. Table 5-1 gives the interconnecting plug to ground resistances. A step-by-step method of checking and adjusting the Type 1A2 is given in the Calibration section. The calibration procedure can be used to check the operational standards of the Type 1A2. Any deficiency that shows up while performing the steps can lead you to the area at fault and the possible causes.

CIRCUIT TROUBLESHOOTING

Diagrams

Block and circuit diagrams are contained in the pullout pages of section 10. The circuit diagrams contain component circuit numbers, voltages and waveforms. Conditions under which the voltages and waveforms were taken are also indicated on the diagrams.

Coding of Switch Wafers

Switch wafers shown on the circuit diagrams are coded to indicate the physical location of the wafer on the actual switch. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the first wafer located behind the detent section of the switch to the last wafer. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. For example, 2R of a VOLTS/CM switch is the second wafer when counting back from the detent section, and R is the rear side of the wafer.

TABLE 5-1

Approximate Resistance Between the Interconnecting Plug Pins and Ground[3]

Pin. No.	Type of Meter: VOM[1]			Type of Meter: Manufacturer: Model No: Type 1A2 Ser. No.:	
	MODE Switch Setting	RESISTANCE Readings[2]	Ohms Range Used	Resistance Readings[2]	Ohms Range Used
1	Any	6 kΩ, 9 kΩ	R×1K		
2	Any	0 (gnd)			
3	Any	6 kΩ, 9 kΩ	R×1K		
4	Any	infinite (no connection)			
5	Any	infinite (no connection)			
6	Any	infinite (no connection)			
7	Any	infinite			
8	Any	3.3 kΩ	R×1K		
9	Any	6 kΩ, 10.1 kΩ	R×1K		
10	Any except ADD ADD	5 kΩ, 6 kΩ 7 kΩ, 11 kΩ	R×1K R×1K		
11	CH 1, CH 2 ALT, CHOP ADD	10 kΩ, 180 kΩ 9 kΩ, 82 kΩ infinite, 10 kΩ	R×10K R×10K R×10K		
12	Any	infinite (no connection)			
13	Any	infinite			
14	Any	infinite			
15	Any	400 Ω	R×100		
16	Any except ALT ALT	infinite 15 kΩ	 R×10K		

[1]VOM used to obtain these measurements is a 20,000 ohms per volt DC meter with a center-scale reading of 4.5 kΩ on the RX1K range.

[2]Ohmmeter leads are first connected one way and then the other to get both readings.

[3]With the unit unplugged from the oscilloscope.

Cable Color Coding

All wiring in the Type 1A2 is color coded to facilitate circuit tracing. The power-supply wires originating at the oscilloscope interconnecting plug are identified by the following code; the widest stripe identifies the first color in the code.

Supply Voltage	Cable Color Code
+225 V	Red/red/dark-brown on white
+100 V	Dark-brown/black/dark-brown on white
+75 V	Purple/green/black on white
+150 V	Dark-brown/green/dark-brown on tan
+13 V	Green on white
+12 V	Black/orange on white
+10 V	Black/blue on white

Test Equipment

Following is a list of suggested equipment useful in troubleshooting the Type 1A2:

1. Transistor tester to dynamically test transistors and diodes used in the Type 1A2. Tektronix Type 575 Transistor-Curve Tracer recommended.

2. VOM or VTVM for precision and general purpose use. Can also be used to check transistors and diodes if used with care. Not recommended as a substitute for a good transistor

and diode tester. The VOM DC sensitivity should be at least 20,000 ohms per volt; DC voltage accuracy for either the VOM or VTVM should be within 3%.

CAUTION

Be sure the test prods are well insulated (except for the very tip) to prevent accidental shorts when reaching a test point. If you use the VOM or VTVM as an ohmmeter to measure resistances when semiconductors are in the circuit, know and use ranges (usually R×1K and higher) that deliver a current of less than 2 mA at full deflection.

3. Milliammeter to determine full-scale current delivered by the VOM or VTVM on ohmmeter ranges used for semiconductor testing; range 0 to 2 mA.

4. Test oscilloscope to signal trace the switching circuits, a wide-bandwidth oscilloscope (DC to 10 MHz or better) with calibrated vertical deflection factors down to 0.1 V/cm without a 10× probe (1 V/cm with a 10× probe). To low-frequency signal trace and check DC levels in each amplifier stage, a low-bandwidth oscilloscope (DC to about 300 kHz or better) with calibrated vertical deflection factors down to 50 mV/cm without a 10× probe (500 mV/cm with a 10× probe). An Ext Trig Input connector on the test oscilloscope is desirable. The wide-bandwidth oscilloscope can be used if the vertical deflection factor is 50 mV/cm without a 10× probe; the low-bandwidth oscilloscope can be used to signal trace the switching circuits if the bandwidth limitation is considered.

5. Flexible cable plug-in extension to permit operation of the Type 1A2 out of the plug-in compartment so that all sides of the unit are accessible for servicing.

NOTE

The plug-in extension must be used with care since, under certain conditions, it can cause the instrument to oscillate and/or have poor high-frequency response.

6. Adapter for use, if the test oscilloscope Ext Trig (item 4) connector is a UHF type of connector, in a low-frequency signal-tracing setup to check phase relationship of the calibrator signal at output of each amplifier stage in the Type 1A2. (Signal tracing setup includes items 4 through 8.) Tektronix Part No. 103-0015-00 recommended.

7. BNC T connector to use in a low-frequency signal-tracing setup for connecting to the two BNC coaxial cables (item 8) and to the Cal Out connector on the oscilloscope used with the Type 1A2. Tektronix Part No. 103-0030-00 recommended.

8. Coaxial Cables (two required) for use in low-frequency signal-tracing setup to apply the calibrator signal to the Type 1A2 and to the test oscilloscope Ext Trig Input connector; equipped with BNC plug connectors on each end. Tektronix Part No. 012-0057-00 recommended.

9. Miscellaneous: Replacement tubes, transistors and diodes.

In-Circuit Diode Checks

In-circuit checks of diodes can be made quite easily by using a voltmeter to find out if the diode is functioning properly in the circuit. Measure the voltage on each side of the diode during its quiescent state as given on the schematics, then determine whether the difference between voltages is normal or not.

If you are in doubt whether a diode is defective, unsolder one end and check the forward-to-back resistance ratio. If the ohmmeter check proves unsatisfactory, replace the diode.

NOTE

As a general rule, do not use the R × 1 and R × 10 ohmmeter ranges. Use the higher ranges where the current is limited to less than 2 mA. You can quickly check the current by inserting a milliammeter between the ohmmeter leads, and then noting the current for each range you intend to use. Internal voltage of the ohmmeter should not exceed 22 V.

Interconnecting-Plug Resistance Checks

Table 5-1 lists the approximate resistances measured between the interconnecting-plug pins and ground of the 16-pin plug located on the rear panel of the Type 1A2. These measurements were taken with the Type 1A2 disconnected from the associated oscilloscope. The measurements are particularly useful for locating a possible short circuit or low-resistance path in the unit, if such trouble should occur.

The resistance measurements vary considerably due to the semiconductors in the circuitry. In addition, the readings can vary as much as 50% due to the type of ohmmeter in use, even when using the same ranges. Therefore, blank columns are provided in the table for logging your own measurements, and the type of meter used, for future reference.

Significant differences between ohmmeter types are: (1) the amount of internal voltage used, (2) the currents delivered for full-scale deflection in each range, and (3) the scale readings on the meter itself.

Isolating DC Imbalance

For free-running traces to appear within the usable viewing area of the CRT screen, the DC voltage as measured between pins 1 and 3 of the interconnecting plug to the oscilloscope must be less than ±0.3 volt. A voltage difference which exceeds ±0.3 volt between these two points may position the trace more than ±3 cm from the oscilloscope vertical-amplifier electrical center, thus positioning the trace above or below the range of visibility.

To find the oscilloscope vertical-amplifier electrical center, short pins 1 and 3 together momentarily and note the position of the trace. The position of the trace is the electrical center. When shorting the pins, use care to avoid shorting to other pins or to ground.

The DC voltages at pins 1 and 3 of the interconnecting plug depend on the DC balance of all amplifier stages in both channels. Since all the amplifier stages are DC coupled, any excessive imbalance between input and output can unbalance the output and cause the trace to deflect out of the viewing area.

TABLE 5-2

Trouble Isolation Procedure

Symptoms	Checks to Make	
	Some Possible Causes	Probable Circuit Area At Fault
1. No trace or waveform display, either channel. Trace deflected off the CRT.	Defective output amplifier tube or transistor (V364, Q354, Q364). Open filament in one of the tubes. Defective interconnecting plug. Check these nominal voltages in the Type 1A2: +225 V, +100 V, +75 V, +13 V, +12 V, +10 V, and —150 V. If any of these voltages are incorrect, find the trouble before going to the third column.	Check for DC imbalance in the Output Amplifier second stage.
2. Trace but no waveform display, either channel.	Open filament in V364.	Check Output Amplifier.
3. No Channel 1 trace or waveform display.	Open series diode D301 or D304; V133 defective. Check that the Switching Multivibrator stage is working properly. Q315 should be cut off and Q325 should be conducting. D302 or D303 shorted. Q143 or Q163 defective. SW160 defective. +13-volt source low.	Check for DC imbalance in Channel 1.
4. No Channel 2 trace or waveform display.	Open series diode D306 or D309; V233 defective. Check that the Switching Multivibrator stage is working properly. Q325 should be cut off and Q315 should be conducting. D307 or D308 shorted. Q243 or Q263 defective. SW260 defective. +13-volt source low.	Check for DC imbalance in Channel 2.
5. Channel 1 trace but no waveform display.	Short or open circuit between Channel 1 input connector and grid of V133.	Signal trace Channel 1 to locate faulty circuit.
6. Channel 2 trace but no waveform display.	Short or open circuit between Channel 2 input connector and grid of V233.	Signal trace Channel 2 to locate faulty circuit.
7. No chopped or alternate mode of operation. One channel is on all the time.	Q325 defective. Q315 defective.	Troubleshoot Switching Multivibrator stage Q325/Q315.
8. No alternate mode of operation. Chopped mode is normal.	D332 defective. Defective SW350.	Check Blocking Oscillator Q340 stage.
9. No chopped mode of operation. Alternate mode is normal.	Defective contact on the MODE switch in the CHOP position. Q340 defective (open).	Troubleshoot Q340 stage.
10. No signal or insufficient amplitude signal at TRIG OUT connector.	Q414 or Q424 defective.	Check Trigger Output Amplifier stage.

If the voltage limits are exceeded in one stage, the limits will be exceeded in the following stages (looking toward the output) and the trace will deflect off the screen. For example, if the voltage difference between the emitters of Q354 and Q364 in the Output Amplifier stage reads $\pm$0.04 volt, the voltage between the emitters of Q373 and Q383 in the Output Amplifier stage will read more than $\pm$0.3 volt, and cause the trace to be deflected off the CRT.

One quick method for isolating DC imbalance either to one of the channels or to the Output Amplifier stage is to turn one channel on at a time to see if the trace for the channel can be normally positioned on the CRT. If the trace for one channel cannot be positioned onto the CRT, then the DC imbalance originates in that channel.

If none of the traces appear on the CRT, then the trouble is probably in the Output Amplifier stage. Also, consider the possibility that the trouble might be one of the diode switches (D301, D302, D303, or D304 in Channel 1; D306, D307, D308, or D309 in Channel 2) or in the Switching Multivibrator stage Q315/Q325.

Troubleshooting Table

Table 5-2 is a list of typical symptoms, their possible causes and the probable circuit at fault. The list is based on deliberate troubles placed in various areas of the Type 1A2. Since it is impossible to list every kind of symptom that might happen, those that are included here may give you a clue to the most likely area to check.

To locate the exact cause of a trouble when it is not listed in the table, use the conventional method of trouble-shooting; i.e. signal tracing, voltage and resistance checks, and parts substitution. To reduce the parts substitution method of troubleshooting to a minimum, however, use the other methods of troubleshooting first. In addition, use the information provided on the schematics and in other portions of this manual as an aid to isolating the trouble.

SECTION 6
PERFORMANCE CHECK

Introduction

This performance check procedure is provided to check the operation of the Type 1A2 without removing the instrument from the oscilloscope plug-in compartment. This procedure may be used for incoming inspection, instrument familiarization, reliability testing, calibration verification, etc.

Recommended Equipment

The following equipment is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment is assumed to be calibrated and operating within the orginal specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the most accurate and convenient performance check, special calibration fixtures are used in this procedure. These calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Test oscilloscope. Bandwidth DC to 50 MHz. Tektronix Type 544, 546, or 547 recommended.

2. Standard amplitude calibrator. Amplitude accuracy, within 0.25%; signal amplitude, 20 millivolts to 100 volts; output signal, 1 kHz. Tektronix calibration fixture 067-0502-00 recommended.

NOTE

The Standard Amplitude Calibrator must be used to check and/or set the deflection factor of the Type 1A2 to an accuracy of ±3%. If an accuracy of ±6% is sufficient, use the calibrator of the oscilloscope instead of item 2.

3. Square-wave generator. Frequency, 1 kHz and 120 kHz; risetime, 13 ns and 1 ns maximum; output amplitude, about 8 volts into 50 ohms. Tektronix Type 106 Square-Wave Generator recommended.

4. Termination. Impedance, 50 ohms; accuracy, ±3%; connectors, BNC. Tektronix Part No. 011-0049-00.

5. Constant amplitude signal generator. Frequency, 50 kHz to at least 50 MHz. Tektronix Constant Amplitude Signal Generator Type 191 recommended.

6. Input RC standardizer. Time constant, 1 megohm × 15 pF; attenuation, 2×, connectors, BNC. Tektronix Part No. 011-0073-00.

7. Cable (two). Impedance, 50 ohm; length, 18 inch; connectors, BNC. Tektronix Part No. 012-0076-00.

8. Dual input coupler. Matched signal transfer to each input. Tektronix Part No. 067-0525-00.

9. Patch cord. BNC to banana plug, length 18 inches.

10. Adapter. Connectors, GR to BNC jack. Tektronix Part No. 017-0063-00.

PERFORMANCE CHECK PROCEDURE

General

In the following procedure, test equipment connections or control settings should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information.

The following procedure uses the equipment listed under Recommended Equipment. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

Names of front and rear-panel controls on the Type 1A2 are written in all upper-case letters.

Preliminary Procedure

Insert the Type 1A2 into the Test oscilloscope. Connect the power cord of the oscilloscope to the proper operating voltage and turn on the power switch. Allow a 15-minute warm-up time before preceeding with the performance check to allow the unit to stablize. Preset the front panel controls as follows:

Test Oscilloscope

Horizontal Display	B (546, 547) Normal (×1) (544)
Sweep Magnifier	×1 off (546, 547)
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/CM	20 μs
Variable (Time/CM)	Calibrated
Horizontal Position	Trace starts at left graticule line
Amplitude Calibrator	Off

Type 1A2

MODE	CH 1
TRIGGER SELECTOR	CH 1
Both channels	
POSITION	At or near midrange
VOLTS/CM	.05
VARIABLE	CALIBRATED
AC-DC-GND	GND
PULL TO INVERT	Pushed in

1. Check Variable Attenuator Balance

a. Requirement—Minimum vertical trace movement as the VARIABLE control is rotated.

b. Rotate the Channel 1 VARIABLE control in both directions.

c. If vertical trace movement occurs, adjust the Channel 1 VAR ATTEN BAL for minimum vertical trace movement.

d. Check—Minimum vertical trace movement as the VARIABLE control is rotated.

e. Change the MODE switch to CH 2.

f. Rotate the Channel 2 VARIABLE control in both directions.

g. If vertical trace movement occurs, adjust the Channel 2 VAR ATTEN BAL for minimum vertical trace movement.

h. Check—Minimum vertical trace movement as the VARIABLE control is rotated.

i. Set both VARIABLE controls in the CALIBRATED position.

2. Check Position Control Range

a. Requirement—POSITION control moves trace off the graticule area in both directions; clockwise rotation moves the trace upward and counterclockwise rotation moves the trace downard.

b. Rotate the Channel 2 POSITION control fully clockwise and counterclockwise.

c. Check—Rotation moves trace off the graticule area; upward with clockwise rotation and downward with counterclockwise rotation.

d. Position the trace at the graticule centerline.

e. Change the MODE switch to CH 1.

f. Rotate the Channel 1 POSITION control fully clockwise and counterclockwise.

g. Check—Rotation moves trace off the graticule area; upward with clockwise rotation and downward with counterclockwise rotation.

h. Position the trace at the center graticule line.

3. Check Normal to Invert Trace Shift

a. Requirement—Maximum trace shift ±1 cm.

b. Pull out the Channel 1 PULL TO INVERT switch.

c. Check—Trace shift is no more than ±1 cm.

d. Change the MODE switch to CH 2.

e. Pull out the Channel 2 PULL TO INVERT switch.

f. Check—Trace shift is no more than ±1 cm.

g. Push in both PULL TO INVERT switches.

4. Check CH 1 to ADD Trace Shift

a. Requirement—Maximum trace shift ±2 cm; Channel 1 POSITION controls trace movement.

b. Set the MODE switch to CH 1 and center the trace vertically, then change the MODE switch to ADD.

c. Check—Trace shift is no more than ±2 cm.

d. Rotate the Channel 2 POSITION control.

e. Check—Trace does not move.

f. Rotate the Channel 1 POSITION control.

g. Check—Trace is moved by the Channel 1 POSITION control.

h. Set the MODE switch to CH 2 and center the trace with the Channel 2 POSITION control.

i. Set the MODE switch to CH 1 and center the trace with the CH 1 POSITION control.

5. Check Grid Current and Microphonics

a. Requirement—Maximum shift (grid current) from AC to GND is 4 mm; microphonics should not exceed 1 cm peak to peak.

b. Change the Channel 1 AC-DC-GND switch to AC and back to GND.

c. Check—Maximum trace shift due to grid current is 4 mm.

d. Tap the left side of the oscilloscope lightly near the Type 1A2 front panel and watch for excessive microphonics.

e. Check—Microphonics should not exceed 1 cm peak to peak.

f. Set the MODE switch to CH 2.

g. Change the Channel 2 AC-DC-GND switch to AC and back to GND.

h. Check—Maximum trace shift due to grid current is 4 mm.

i. Tap the left side of the oscilloscope lightly near the Type 1A2 front panel and watch for excessive microphonics.

j. Check—Microphonics should not exceed 1 cm peak to peak.

6. Check Alternate Mode Operation and Slave Pulse

a. Requirement—Alternate operation at all sweep rates; Channel 1 must run with the A Sweep, when the Test oscilloscope has provision for alternate slave operation.

b. Set the MODE switch to ALT.

c. Position the Channel 1 trace 1 cm above the graticule center line and the Channel 2 trace 1 cm below the graticule center line.

d. Set the oscilloscope Time/CM switch to various sweep rates.

e. Check—Alternate traces at all sweep rates.

f. Set the oscilloscope Horizontal Display switch to A Alt B, and A Time/CM switch to 20 mSEC and the B Time/CM switch to .5 mSEC.

g. Operate the Channel 1 position control, and by noting which channel moves vertically, differentiate between the traces of Channel 1 and Channel 2.

h. Check—Channel 1 trace is 20 mSEC/CM, Channel 2 trace at .5 mSEC/CM.

7. Check Chopped Mode Operation

a. Requirement—Chopped waveform must be 220 kHz ±20%; flat top distortion must be no more than 2 mm; chopped transients (rising and falling portions) must be blanked in Chopped Blanking.

b. Set the Horizontal Display switch to B and the B Time/CM switch to 1 μSEC.

c. Set the MODE switch to CHOP and adjust the B Triggering Level control for a stable display. Position the Channel 1 trace 1 cm above the graticule center line.

d. Measure the time of one cycle.

e. Check—Time duration of one cycle is approximately 4.5 μs ±0.9 μs for a frequency of 220 kHz ±20%. See Fig. 6-1A.

f. Set the CRT Cathode Selector (located at the rear of the oscilloscope) to Chopped Blanking.

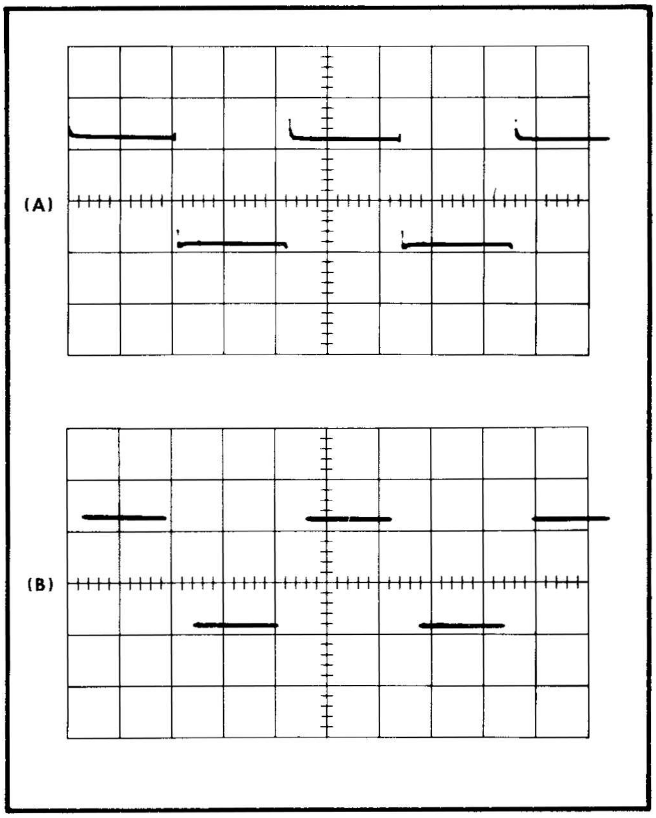


Fig. 6-1. (A) Unblanked chopped-mode waveform, and (B) blanked waveform. Sweep rate is 1 μsec/div.

g. Check—Horizontal flat top distortion must be no more than 2 mm, vertical switching transients must be blanked. See Fig. 6-1B.

h. Return the CRT Cathode Selector switch to External CRT Cathode and set the B Time/CM switch to .05 mSEC/CM

8. Check Gain

a. Requirement—Gain adjusted to the deflection sensitivity of the oscilloscope at the .05 VOLTS/CM position; adjustable without being at the extreme ends of its range.

b. Connect the Dual Input Coupler to both INPUT connectors and apply a 0.2 volt signal from the Standard Amplitude Calibrator to the Dual Input Coupler through a 50 ohm coaxial cable.

c. Set the MODE switch to CH 1 and both AC-DC-GND switches to DC. Center the display.

d. Rotate the Channel 1 GAIN control fully clockwise, then fully counterclockwise, and note the amplitude range. The control must vary the amplitude of the display through the calibrated 4 cm amplitude. (4.2 to 3.8 cm.)

e. Set the GAIN adjustment for exactly 4 cm of display amplitude.

f. Set the MODE switch to CH 2.

g. Repeat the above procedure for Channel 2.

9. Check Input Switch DC to AC Shift

a. Requirement—Waveform shifts downward so center graticule line is approximately through the center of the waveform.

b. Position the bottom of the waveform to the center graticule line.

c. Set the Channel 2 AC-DC-GND to AC and check the amount of waveform shift.

d. Check—Waveform shift is approximately 2 cm downward. Amount of shift depends on symmetry of calibration signal and amount of grid current.

e. Set the MODE switch to CH 1 and repeat the above procedure for Channel 1.

10. Check Added Algebraic and Common Mode Rejection

a. Requirement—Added accuracy must be within ±3%; common mode rejection must be 20 to 1 or greater.

b. Set the Standard Amplitude Calibrator output to .1 volt.

c. Set the MODE switch to ADD.

d. Check—Display amplitude is 4 cm ±3% (±1.2 mm).

e. Pull the Channel 1 PULL TO INVERT switch and change the Standard Amplitude Calibrator output to .5 volt.

f. Check—Amplitude of the display must not be more than 5 mm, a common mode rejection ratio of 20 to 1.

g. Push in the Channel 1 PULL TO INVERT switch and pull the Channel 2 PULL TO INVERT switch.

h. Check—Display amplitude not more than 5 mm, the common mode rejection ratio is 20 to 1 or greater.

i. Set the Standard Amplitude Calibrator output to .2 volt, the MODE switch to CH 1, the Channel 2 AC-DC-GND switch to GND. Push in the Channel 2 PULL TO INVERT switch.

11. Check Volts/CM Accuracy and Variable Ratio

a. Requirement—Volts/CM accuracy is ±3% at all settings; Variable control ratio must be 2.5 to 1 or greater.

b. Check—Amount of vertical deflection and the % error with the instrument controls set according to Table 6-1.

TABLE 6-1

Attenuator Accuracy Check

Type 1A2 VOLTS/CM	Standard Amplitude Calibrator In Volts	Display Amplitude In Centimeters	Allowable Error In Millimeters
.05	.2	4	0.0[1]
.1	.5	5	1.5
.2	1	5	1.5
.5	2	4	1.2
1	5	5	1.5
2	10	5	1.5
5	20	4	1.2
10	50	5	1.5
20	100	5	1.5

[1]**Adjusted during step 8.**

NOTE

The bottom of the output square-wave signal from the Standard Amplitude Calibrator is at ground potential. Since the AC-DC-GND switch is set to DC, the bottom of the square-wave signal will remain fixed. Therefore, it is possible to set the bottom of the square-wave signal one centimeter below the bottom graticule line and still make accurate measurements. It is necessary to do this so a signal five centimeters high may be measured on instruments having only four centimeter high graticules. To establish the new base line for the calibrator signal, display a four centimeter square-wave signal. With the Type 1A2 POSITION control align the top of the square-wave with the third graticule line up from the bottom of the graticule.

c. Rotate the VARIABLE control fully counterclockwise and check the amount of vertical deflection.

d. Check—Amplitude of vertical deflection must be 2 cm or less with a 5 cm amplitude signal for a VARIABLE ratio of 2.5 to 1 or greater.

e. Return the Standard Amplitude Calibrator output signal to .2 volts.

f. Set the MODE switch to CH 2, the Channel 2 AC-DC-GND switch to DC, and the Channel 1 AC-DC-GND switch to GND.

g. Repeat the above check procedures for the Channel 2 VOLTS/CM attenuator and VARIABLE control.

h. Remove the Standard Amplitude Calibrator signal and the Dual Input Connector.

i. Return both VARIABLE controls to the CALIBRATED position, both VOLTS/CM switches to .05 and the Channel 1 AC-DC-GND switch to DC.

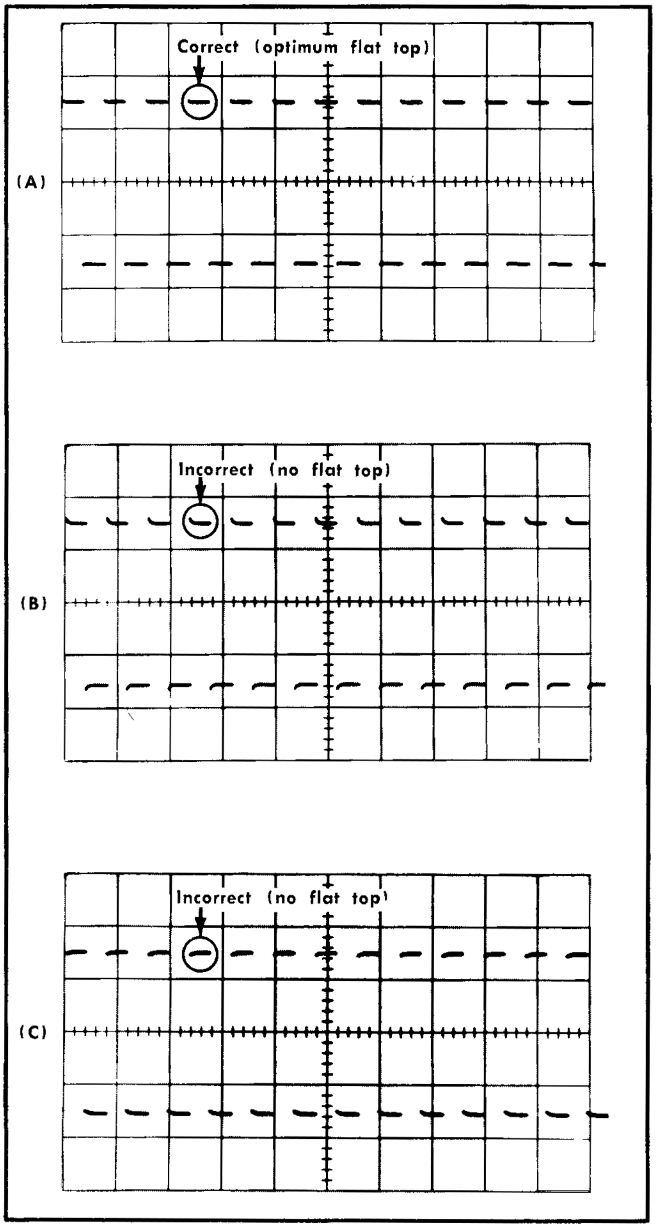


Fig. 6-2. (A) Typical CRT display showing correct VOLTS/CM switch compensation; (B) and (C) incorrect compensation.

12. Check Input and Attenuator Compensation

a. Requirement—Top of waveform deviation must be less than ±3%.

b. Set the oscilloscope Time/CM switch to .5 mSEC.

c. Apply a 1 kHz signal from the Type 106 Square-Wave Generator through a GR to BNC adapter, a 50 ohm coaxial cable, a 50 ohm termination and a 15 pF Input RC Standardizer to the INPUT 2 connector.

d. Adjust the output of the Square-Wave Generator for an approximate 4 cm amplitude, center the display and adjust the oscilloscope Triggering Level control for a stable display.

e. Check—Compensation of the waveform for level flat top, overshoot and undershoot at all VOLTS/CM switch settings, for deviation less than ±3% (1.2 mm), see Fig. 6-2. Adjust the output of the generator to maintain about 4 cm of display amplitude. It will be necessary to remove the 50 ohm termination at VOLTS/CM settings higher than 1 volt.

WARNING

To avoid a signal shock hazard, reduce the generator output to minimum when changing signal connections.

f. Set the MODE switch to CH 1.

g. Remove the Input RC Standardizer from the INPUT 2 connector and connect it to the INPUT 1 connector. (Replace the 50 ohm termination.)

h. Repeat the above proocedure to check the Channel 1 attenuator compensation.

i. Remove the Square-Wave Generator signal and the 15 pF Input RC Standardizer.

j. Set both VOLTS/CM switches to .05 and AC-DC-GND switches to AC.

13. Check High Frequency Compensation

a. Requirement—Waveform must be flat topped with no more than 3% peak-to-peak rolloff, spiking and/or ringing; no more than 6% peak-to-peak aberration in ADD. The risetime is dependent on the oscilloscope/Type 1A2 combination. See the Characteristics section.

b. Connect the fast rise + output of the Square-Wave Generator through a GR to BNC adapter, a 50 ohm coaxial cable, a 50 ohm termination to the INPUT 1 connector.

c. Set the frequency to approximately 120 kHz and adjust the amplitude for a 4 cm display.

d. Set the Time/CM switch to .1 μSEC and adjust the Triggering Level control for a stable display.

e. Check—Waveform is flat topped with no more than 3% (1.2 mm) peak-to-peak rolloff, spiking and/or ringing. (See Fig. 6-3A.)

f. Set the MODE switch to ADD.

g. Check—Wavefrom is flat topped with no more than 6% (2.4 mm) peak-to-peak aberration.

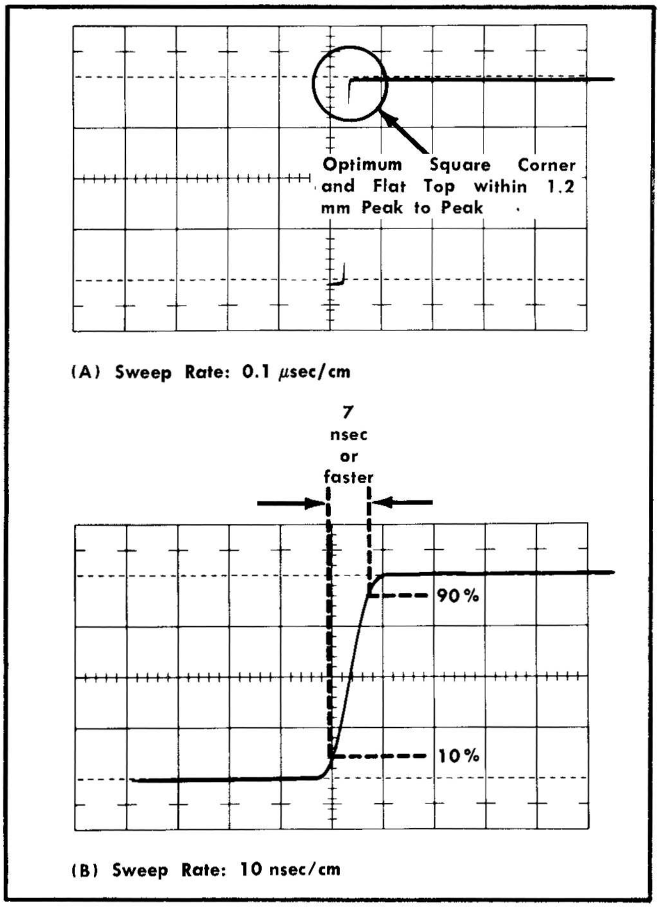


Fig. 6-3. High-Frequency waveform displays at different sweep rates.

h. Check risetime by setting the Magnifier to ×10 and measuring the rising portion of waveform between the 10% and 90% points. Risetime should be 7 ns or less with Types 544, 546 or 547 oscilloscopes (see Fig. 6-3B).

i. Remove the 50 ohm termination from the INPUT 1 connector and reconnect it to the INPUT 2 connector.

j. Turn the Maginifier to ×1 and repeat the above check procedure to check the flat top of the Channel 2 waveform.

k. Remove the signal and turn the Triggering Level control fully clockwise; set the MODE switch to CH 1.

14. Check Frequency Response

a. Requirement—Frequency response is dependent on the oscilloscope/Type 1A2 combination. See the Characteristics section.

b. Connect the Constant Amplitude Signal Generator to the INPUT 1 connector through a GR to BNC adapter, 50 ohm coaxial cable and a 50 ohm termination.

c. Adjust the output of the Constant Amplitude Signal Generator for 4 cm of 50 kHz signal.

d. Increase the frequency until there is exactly 2.8 cm of deflection. See Fig. 6-4.

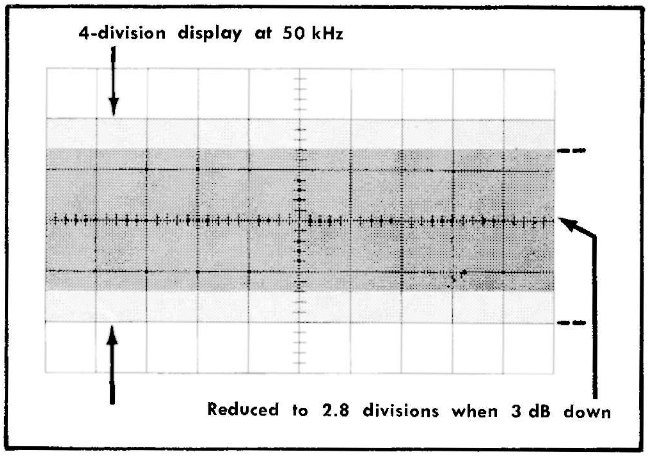


Fig. 6-4. Typical CRT display when checking frequency response.

e. Check—This is the 3 dB down point and should be no lower in frequency than the Characteristics section shows (50 MHz or higher with Types 544, 546 or 547 Oscilloscopes).

f. Change the MODE switch to ADD and repeat the above check procedure.

g. Remove the signal from the INPUT 1 connector and apply it to the INPUT 2 connector; set the MODE switch to CH 2 and repeat the check procedure to determine the frequency response of Channel 2.

h. Remove the signal and set the MODE switch to CH 1.

i. Set the Time/CM switch to .1 mSEC.

15. Check High Frequency Common Mode Rejection

a. Requirement—Common mode rejection must be 20 to 1 or greater.

b. Set both VOLTS/CM switches to .2 volts.

c. Connect the Constant Amplitude Signal Generator to both INPUT connectors through a GR to BNC adapter, a 50 ohm coaxial cable, a 50 ohm termination and a Dual Input Coupler.

d. Adjust the output amplitude of the Constant Amplitude Signal Generator for 2.5 cm of 50 kHz signal.

e. Change the frequency to 50 MHz (with Types 544, 546 or 547 Oscilloscope).

f. Set both VOLTS/CM switches to .05, the MODE switch to ADD and pull the Channel 2 PULL TO INVERT switch.

g. Check—Displayed amplitude must be .5 cm or less, a 20 to 1 rejection ratio. If displayed amplitude is greater, pull the Channel 1 PULL TO INVERT switch and push in the Channel 2 PULL TO INVERT switch. One of the combinations must result in a displayed amplitude of .5 cm or less.

h. Remove the Dual Input Coupler, push in both PULL TO INVERT switches and set the MODE switch to CH 1.

16. Check AC Coupled Low Frequency Response

a. Requirement—Response 3 dB down at 2 Hz or less.

b. Set both AC-DC-GND switches to AC, both VOLTS/CM switches to 2 volts and the Time/CM switch to .1 SEC, reducing the Intensity to normal brilliance to avoid burning the CRT.

c. Connect a patch cord from the + Gate B connector to the INPUT 1 connector. The display obtained should be a falling RC curve.

d. Adjust the Channel 1 VARIABLE control for a display amplitude of 4 cm.

e. Position the display to the center of the graticule area and measure the time it takes the waveform to fall from 4 cm to 1.5 cm. See Fig. 6-5.

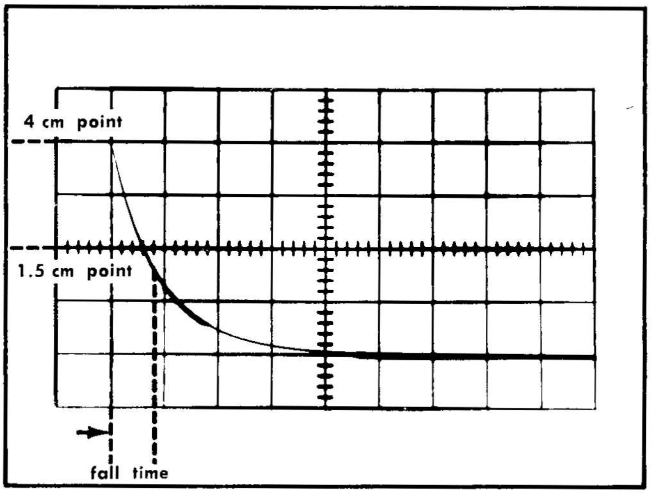


Fig. 6-5. Measuring AC coupled low-frequency response using an RC curve.

f. Check—Time should be more than 0.08 s (8 mm) which indicates a frequency of less than 2 Hz.

g. Change the patch cord to the INPUT 2 connector and set the MODE switch to CH 2.

h. Repeat the check procedure to check the Channel 2 low frequency response.

i. Remove the patch cord and set the Time/CM switch to .1 mSEC.

TRIGGER OUTPUT CHECKS[2]

17. Check Trigger Balance

a. Requirement—Trace must shift no more than ± 2 mm when the TRIGGER SELECTOR is switched from CH 1 to CH 2.

b. Set the MODE switch to ALT and readjust the VAR ATTEN BAL if necessary (step 1).

[2]Applies only to instruments with a serial number of 716 or higher.

Ⓑ

c. Position both traces to the center of the graticule area, 4 mm apart.

d. Change the TRIGGER SELECTOR switch between CH 1 and CH 2.

e. Check—Trace must shift no more than ± 2 mm.

18. Check Trigger Out Gain

a. Requirement—Trigger gain must be at least 10.

b. Set the TRIGGER SELECTOR switch to CH 1.

c. Connect a 50 ohm coaxial cable from the TRIG OUT connector to the INPUT 2 connector.

d. Connect a 50 ohm coaxial cable from the Calibrator to the INPUT 1 connector and set the Calibrator for a 50 mV signal.

e. Set the Channel 2 VOLTS/CM switch to .5 and compare the Channel 2 display amplitude against the Channel 1 display amplitude.

f. Check—Channel 2 amplitude must be at least equal to or greater than the Channel 1 amplitude (10×).

g. Disconnect the Calibrator signal.

19. Check Trigger Bandwidth

a. Requirement—Must be no more than 3 dB down at 5 MHz with a .5 V peak-to-peak reference signal amplitude.

b. Set the MODE switch to CH 2 and the TRIGGER SELECTOR switch to CH 1.

c. Set the Channel 2 VOLTS/CM switch to .1 volt.

d. Apply a 50 kHz reference signal from the Constant Amplitude Signal Generator to the INPUT 1 connector through a 50 ohm coaxial cable and 50 ohm termination.

e. Set the Constant Amplitude Signal Generator output control for a signal amplitude of 5 cm.

f. Change the Constant Amplitude Signal Generator frequency to 5 MHz.

g. Check—Signal amplitude must be at least 3.5 cm or greater.

h. Disconnect the Constant Amplitude Signal Generator coaxial cable and the coaxial cable from the TRIG OUT connector to the INPUT 2 connector.

This completes the performance check procedure for the Type 1A2 Dual-Trace Plug-In Unit. If the instrument has met all performance requirements given in this procedure, it is correctly calibrated and within the specified tolerances.

SECTION 7
CALIBRATION

Introduction

The Type 1A2 should be calibrated after each 500 hours of operation or every six months if used intermittently. Also, if tubes, transistors, or other electrical components are changed, calibration of the instrument should be checked.

The instructions that follow are arranged in a specific sequence for a complete calibration. Any of the steps may be performed out of sequence except the adjustment of the OUTPUT DC LEVEL, the +10 VOLTS and the high-frequency compensation steps. That is, the OUTPUT DC LEVEL and +10 VOLTS should be set prior to the high-frequency compensation. Also, neither of these steps should be performed alone without at least a check of the other.

EQUIPMENT REQUIRED

(see Fig. 7-1)

General

The following equipment, or its equivalent, is required for complete calibration of the Type 1A2. Specifications given are the minimum necessary for accurate calibration of this instrument. All test equipment is assumed to be correctly calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

Special Test Equipment

For the quickest and most accurate calibration, special calibration fixtures are used where necessary. All calibration fixtures listed under Equipment Required can be obtained from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Equipment Required

1. Test oscilloscope for use with the Type 1A2. Type 544, 546 or 547 recommended.

2. Standard amplitude calibrator. Amplitude accuracy, within 0.25%; signal amplitude, 20 millivolts to 100 volts; output signal, 1 kHz. Tektronix calibration fixture 067-0502-00 recommended.

NOTE

The standard amplitude calibrator must be used to check and/or set the deflection factor of the Type 1A2 to an accuracy of ±3%. If an accuracy of ±6% is sufficient, use the calibrator of the oscilloscope instead of item 2.

3. Square-wave generator. Frequency 1, 10 and 120 kHz risetime, 13 ns and 1 ns maximum; output amplitude, about 8 volts into 50 ohms. Tektronix Type 106 Square-Wave Generator recommended.

4. Constant amplitude signal generator. Frequency, 50 kHz to at least 50 MHz. Tektronix Constant Amplitude Signal Generator Type 191 recommended.

5. Termination. Impedance, 50 ohms; accuracy, ±3%; connectors, BNC. Tektronix Part No. 011-0049-00.

6. Input RC standardizer. Time constant, 1 megohm × 15 pF; attenuation, 2×; connectors, BNC. Tektronix Part No. 011-0073-00.

7. Cable (two). Impedance, 50 ohm; length, 18 inch; connectors, BNC. Tektronix Part No. 012-0076-00.

8. Dual input coupler. Matched signal transfer to each input. Tektronix Part No. 067-0525-00.

9. Adapter. Connectors, GR to BNC jack. Tektronix Part No. 017-0063-00.

10. Precision DC voltmeter. Accuracy, within ±0.05%; meter resolution, 50 μV; range, 10 to 100 volts. A John Fluke Differential Voltmeter, Model 801B recommended.

11. Adjustment tools. (See Fig. 7-2).

Description	Tektronix Part No.
a. Screwdriver, 3" shaft, 1/8" wide tip.	003-0192-00
b. Insulated screwdriver, 1½" shaft, non-metallic.	003-0000-00
c. Tuning tool	
Handle	003-0307-00
Insert with a wire pin	003-0308-00
Calibration tool tip	003-0334-00

CALIBRATION RECORD AND INDEX

This Abridged Calibration Procedure is provided to aid in checking the operation of the Type 1A2. It may be used as a calibrating guide by the experienced calibrator, or it may be used as a calibration record. Since the step numbers and titles used here correspond to those used in the complete Calibration Procedure, the following procedure serves as an index to locate a step in the complete Calibration Procedure. Characteristics are those listed in the Characteristics section of the Instruction Manual.

Type 1A2 Serial No.________________

Calibration Date________________

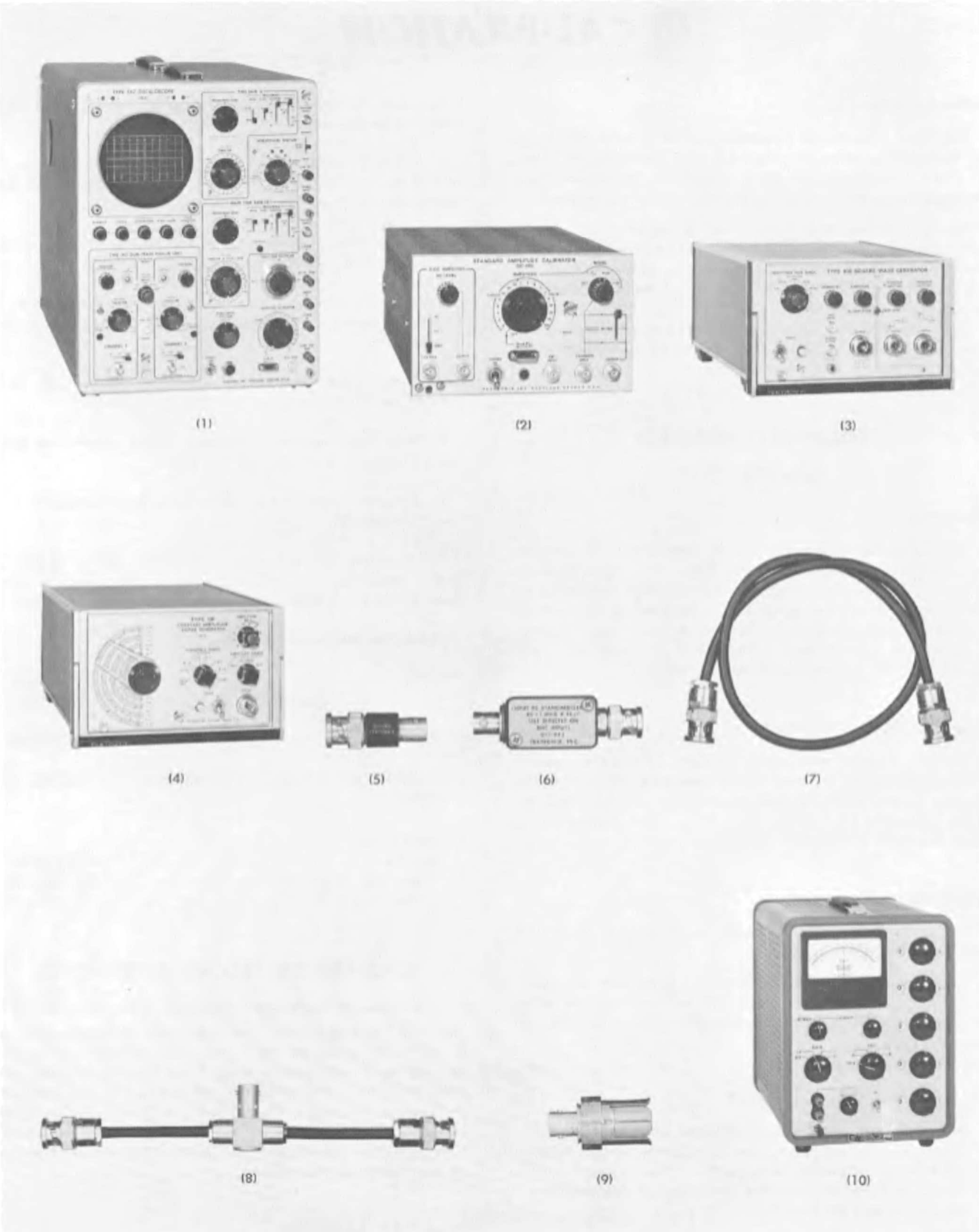


Fig. 7-1. Equipment required for calibrating.

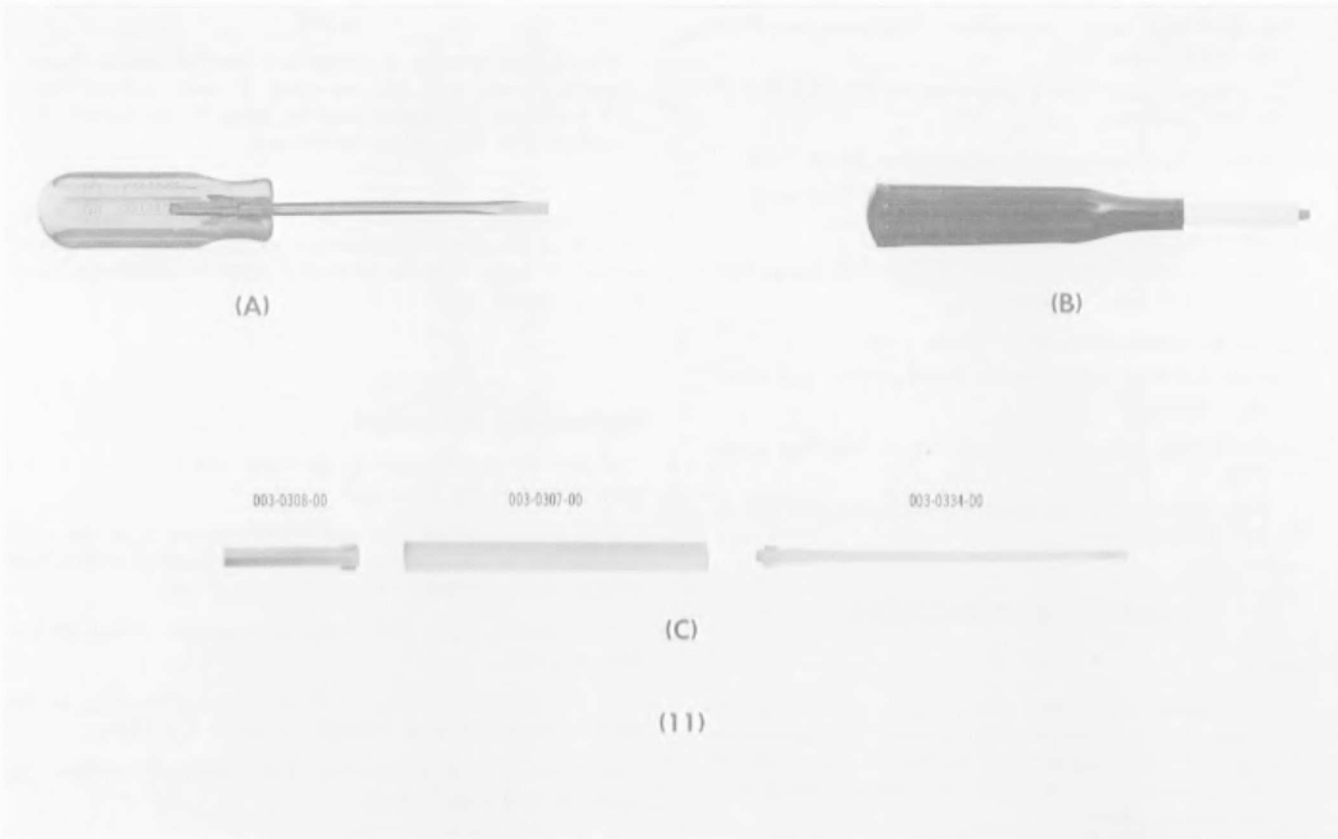


Fig. 7-2. Adjusting tools required for calibrating the Type 1A2.

☐ 1. Adjust Variable Attenuator Balance (page 7-5)
Traces should not shift as either VARIABLE control is rotated.

☐ 2. Adjust R415[1] (page 7-6)
Maximum trace shift of ±2 mm as TRIGGER SELECTOR switch is changed from CH 1 to CH 2.

☐ 3. Adjust Output DC Level (page 7-6)
Meter reading 67.5% of the measured +100-volt supply.

☐ 4. Adjust +10 Volts (page 7-6)
Meter reading of +10 volts.

☐ 5. Adjust Channel 2 Gain (page 7-7)
Correct vertical deflection indicated by VOLTS/CM switch.

☐ 6. Check Channel 2 Variable Control (page 7-7)
VARIABLE control range at least 2.5 to 1.

☐ 7. Adjust Channel 1 Gain (page 7-8)
Correct vertical deflection indicated by VOLTS/CM switch.

☐ 8. Check Channel 1 Variable control (page 7-8)
VARIABLE control range at least 2.5 to 1.

☐ 9. Check for Microphonics (Both Channels) (page 7-8)
Microphonics should not exceed 1 cm peak to peak.

[1]Applies only to instruments with serial numbers of 716 or higher.

☐ 10. Check Channel 1 Grid Current (page 7-8)
Maximum trace shift is ±4 mm.

☐ 11. Check Channel 2 Grid Current (page 7-8)
Maximum trace shift is ±4 mm.

☐ 12. Check Channel 2 Normal-Invert Balance (page 7-8)
Maximum trace shift is ±1 cm.

☐ 13. Check Channel 1 Normal-Invert Balance (page 7-8)
Maximum trace shift is ±1 cm.

☐ 14. Check Chopped-Mode Operation (page 7-9)
Repetition rate is 220 kHz ±20%.

☐ 15. Check Alternate-Mode Operation (page 7-9)
Two traces on the CRT. Trace alternation at all sweep rates.

☐ 16. Check Add Mode Operation (page 7-9)
Correct addition and subtraction of signals.

☐ 17. Check Volts/CM Attenuation Ratios (Both Channels) (page 7-10)
Vertical deflection within ±3% of VOLTS/CM switch indication.

☐ 18. Check Trigger Out Gain[1] (page 7-11)
Gain at least 10.

☐ 19. Adjust Input and Attenuator Compensation (Both Channels (page 7-12)

Optimum square-wave response in all VOLTS/CM switch positions.

☐ 20. Adjust High-Frequency Compensation (page 7-15)

Optimum square-wave response at high frequency.

☐ 21. Check Frequency Response (page 7-17)

No more than 3 dB down at 50 MHz with Types 544, 546 or 547 Oscilloscopes.

☐ 22. Check Trigger Bandwidth[2] (page 7-18)

No more than 3 dB down at 5 MHz with .5 volt reference signal.

☐ 23. Check High-Frequency Common Mode Rejection (page 7-18)

Ratio at least 20:1 at 50 MHz with Types 544, 546 or 547 Oscilloscopes.

CALIBRATION PROCEDURE

General

In the following calibration procedure, a test equipment setup is shown for each major setup change. Complete control settings are listed beneath the picture. If only a partial calibration is preformed, start with the nearest setup preceding the desired portion.

[2]Applies only to instruments with serial numbers of 716 or higher.

NOTE

When performing a complete recalibration, best performance will be provided if each adjustment is made to the exact setting, even if the Check is within the allowable tolerance.

The following procedure uses the equipment listed under Equipment Required. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

Preliminary Procedure

a. Lay the oscilloscope on its right side for access to the bottom side of the Type 1A2.

b. Remove the left side and bottom panels from the oscilloscope to expose the left and bottom sides of the vertical plug-in compartment.

c. Install the Type 1A2 in the oscilloscope vertical plug-in compartment.

d. Connect the power cord of the oscilloscope to the design-center operating voltage for which it is wired.

e. Turn on the oscilloscope and allow 15 minutes for warm up and stabilization.

f. Turn on all test equipment.

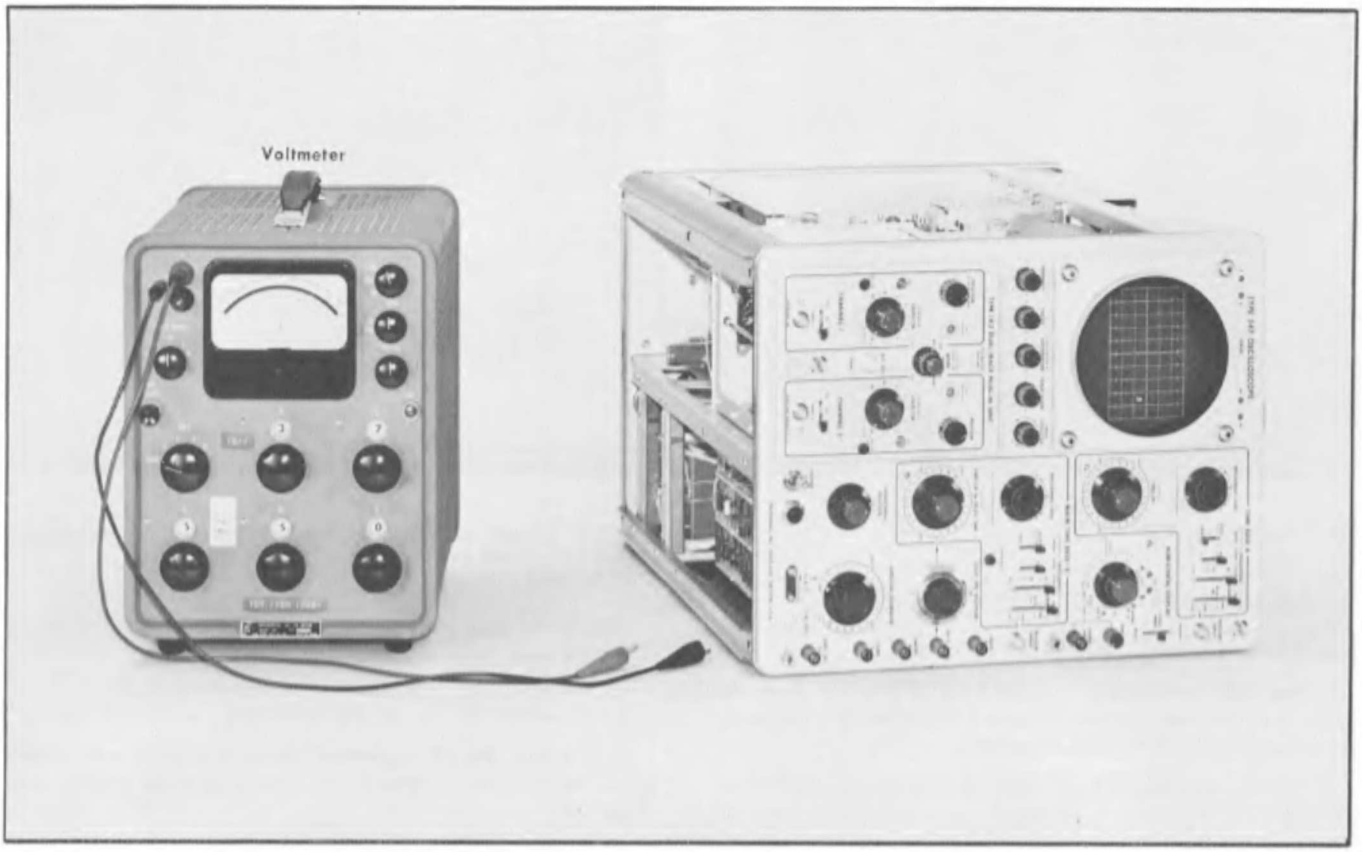


Fig. 7-3. Initial equipment setup for steps 1 through 4.

Control Settings

Test Oscilloscope

Horizontal Display	B (546, 547) Normal (×1) (544)
Sweep Magnifier	×1 off (546, 547)
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto
Time/CM	.5 mSEC
Variable (Time/CM)	Calibrated
Horizontal Position	Centered
Vernier (Horizontal Position)	Centered
CRT Cathode Selector	CRT Cathode
Amplitude Calibrator	Off

Type 1A2

MODE	ALT
TRIGGER SELECTOR[3]	CH 1

[3]Applies only to instruments with serial numbers of 716 or higher.

Both Channels

POSITION	Centered
VOLTS/CM	.05
VARIABLE	CALIBRATED
PULL TO INVERT	Pushed in
AC-DC-GND	GND

1. Adjust Variable Attenuator Balance

a. Equipment setup is shown in Fig. 7-3.

b. Position traces near center of CRT.

c. Check—Traces should not shift as either VARIABLE control is rotated.

d. Adjust—Channel 1 VAR ATTEN BAL adjustment for no trace shift as the Channel 1 VARIABLE control is rotated and the Channel 2 VAR ATTEN BAL adjustment for no trace shift as the Channel 2 VARIABLE control is rotated.

e. Interaction of the VAR ATTEN BAL adjustments makes it necessary to repeat the adjustments until there is no further interaction.

f. Set both VARIABLE controls in the CALIBRATED position.

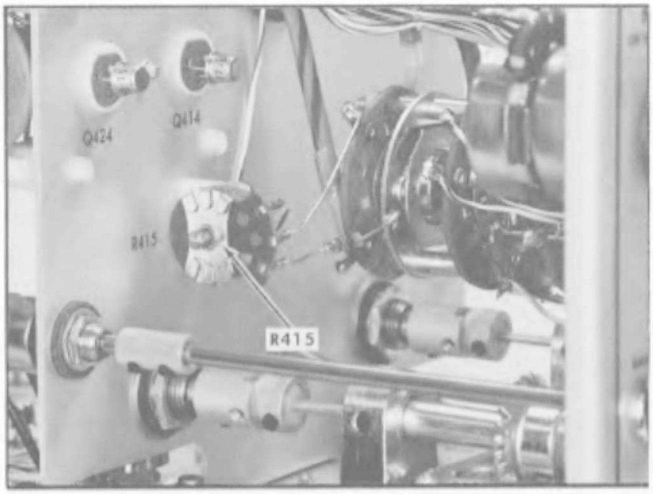


Fig. 7-4. Location of R415.

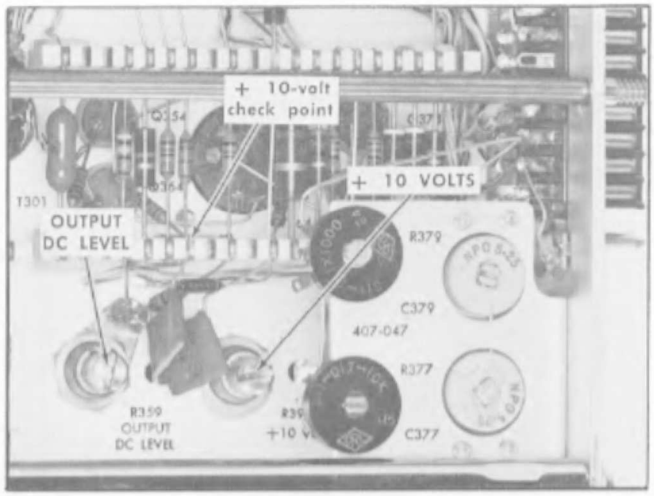


Fig. 7-5. Location of Output DC Level and +10 Volts adjustments and +10 volt test point.

2. Adjust R415[4]

a. Equipment setup remains as in step 1.

b. Position the Channel 1 trace 1 cm above the graticule center line and the Channel 2 trace 1 cm below the graticule center line with the POSITION controls.

c. Check—Maximum trace shift of ±2 mm as the TRIGGER SELECTOR switch is changed back and forth between CH 1 and CH 2.

d. Adjust—R415 for minimum trace shift as the TRIGGER SELECTOR switch is changed back and forth between CH 1 and CH 2. See Fig. 7-4 for location.

3. Adjust Output DC Level

a. Equipment setup is shown in Fig. 7-3.

b. Measure the +100-volt supply of the oscilloscope with the DC voltmeter.

NOTE

Do not connect the voltmeter to the +100 volts available at pin 10 of the interconnecting plug. This voltage is on the output side of a decoupling network and will typically be a few volts less than the required +100 volts. The +100-volt supply leads in the oscilloscope are color coded with black and brown stripes on a white wire.

c. Calculate 67.5% of the measured +100-volt supply.

d. Connect the DC voltmeter between ground and either pin 1 or 3 (+67.5 volts) of the interconnecting plug in the Type 1A2.

e. Check—Meter reading 67.5% of the measured +100-volt supply.

f. Adjust—OUTPUT DC LEVEL of the Type 1A2 for a meter reading of exactly 67.5% of the measured +100-volt supply. See Fig. 7-5 for location.

g. Remove the voltmeter connections.

4. Adjust +10 Volts

a. Equipment setup is shown in Fig. 7-3.

b. Connect the DC voltmeter between the +10-volt test point and ground. See Fig. 7-5 for location.

c. Check—Meter reading of +10 volts.

d. Adjust—+10 VOLTS for a meter reading of exactly 10 volts.

e. Remove the voltmeter connections.

[4]Applies only to instruments with serial number 716 or higher.

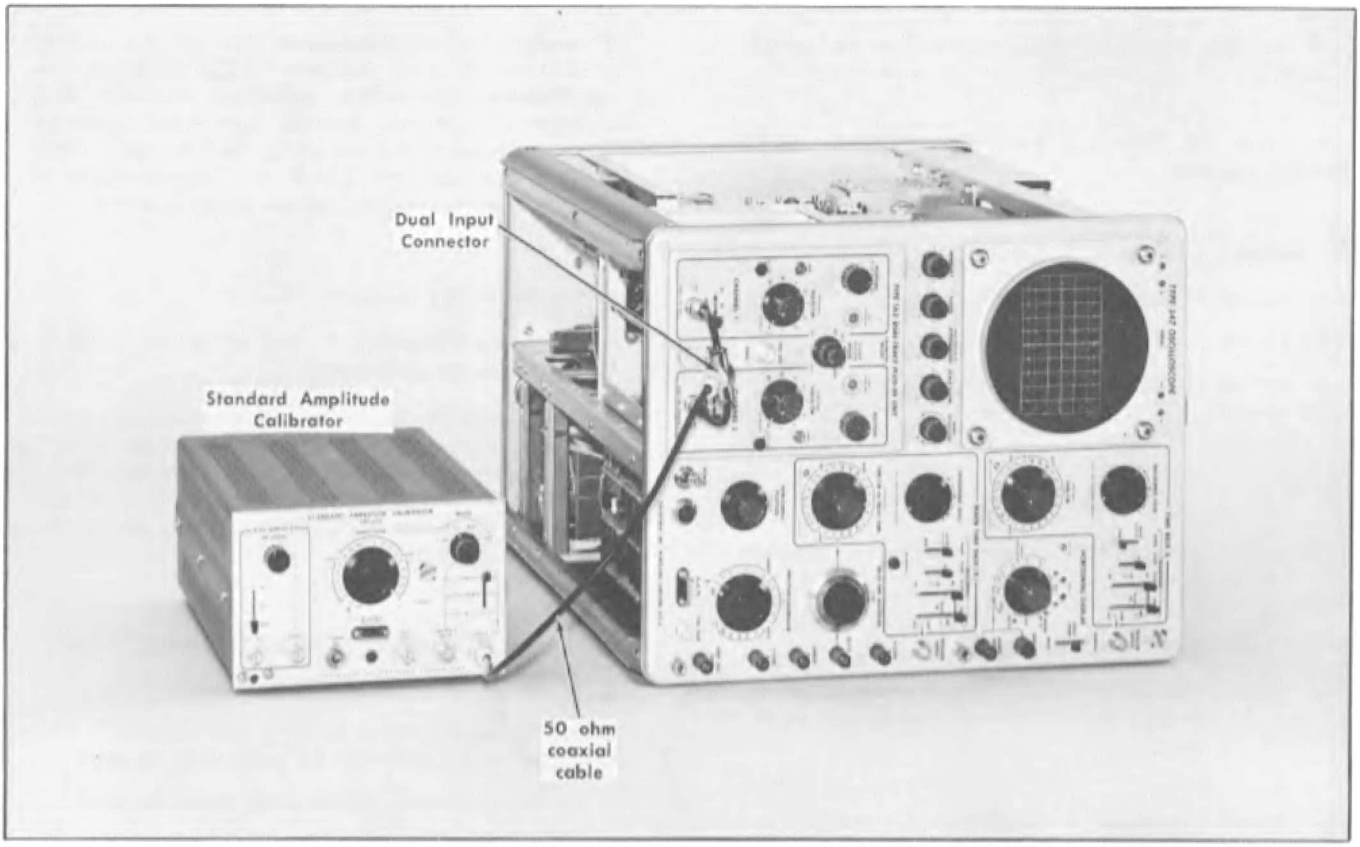


Fig. 7-6. Initial equipment setup for steps 5 through 16.

Control Settings

Test Oscilloscope

Horizontal Display	B (546, 547) Normal (×1) (544)
Sweep Magnifier	×1 off (546, 547)
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto
Time/CM	.5 mSEC
Variable (Time/CM)	Calibrated
Horizontal Position	Centered
Vernier (Horizontal Position)	Centered
CRT Cathode Selector	CRT Cathode
Amplitude Calibrator	Off

Type 1A2

MODE	CH 2
TRIGGER SELECTOR	CH 2
Both Channels	
POSITION	Centered
VOLTS/CM	.05
VARIABLE	CALIBRATED
PULL TO INVERT	Pushed in
AC-DC-GND	GND

5. Adjust Channel 2 Gain

a. Equipment setup is shown in Fig. 7-6.

b. Apply a 0.2 volt calibrator signal from the Standard Amplitude Calibrator to both INPUT 1 and INPUT 2 connectors through a 50 ohm coaxial cable and the Dual Input Coupler. (See the note after item 2 in Equipment Required.)

c. Set the Channel 2 AC-DC-GND switch to AC.

d. Check—Display amplitude should be 4 cm.

e. Adjust—Channel 2 GAIN adjustment for a display amplitude of 4 cm.

NOTE

Use the Channel 2 POSITION control to position the display for convenient measuring.

6. Check Channel 2 Variable Control

a. Equipment setup is as given in step 5.

b. Set the Channel 2 VOLTS/CM switch to the .2 position and change the input signal to 1 volt.

c. Turn the Channel 2 VARIABLE control fully counterclockwise.

d. Check—Displayed amplitude should be 2 cm or less.

NOTE

If turning the VARIABLE control causes erratic jumping of the trace, the control is defective.

e. Return the Channel 2 VARIABLE control to the CALIBRATED position.

7. Adjust Channel 1 Gain

a. Equipment setup is as given in step 6.

b. Set the input signal to .2 volt.

c. Set the MODE switch to ADD, the Channel 1 AC-DC-GND switch to AC and the Channel 2 VOLTS/CM switch to .05. Pull out the Channel 2 PULL TO INVERT switch.

NOTE

Use the Channel 1 POSITION control to position the trace to a convenient point on the screen.

d. Check—Signal canceled on the CRT.

e. Adjust—Channel 1 GAIN adjustment to cancel signal on the CRT. Be sure both VARIABLE controls are set to the CALIBRATED position.

8. Check Channel 1 Variable Control

a. Equipment setup is as given in step 7.

b. Set the MODE switch to CH 1, the Channel 1 VOLTS/CM switch to .2 and the Channel 2 AC-DC-GND switch to GND.

c. Set the input signal to 1 volt.

d. Turn the Channel 1 VARIABLE control fully counterclockwise.

e. Check—Displayed amplitude should be 2 cm or less.

NOTE

If turning the VARIABLE control causes erratic jumping of the trace, the control is defective.

f. Disconnect the Dual Input Coupler, return the Channel 1 VARIABLE control to the CALIBRATED position and set the Channel 1 VOLTS/CM switch to .05.

9. Check for Microphonics (Both Channels)

a. Equipment setup remains as in step 8.

b. Set both AC-DC-GND switches to GND and adjust the Channel 1 POSITION control so the trace is positioned to the graticule center.

c. Tap the left side of the oscilloscope lightly near the Type 1A2 front panel and watch for excessive microphonics

d. Check—Amplitude of microphonics should not exceed 1 cm peak to peak.

NOTE

If microphonics are excessive, turn off the oscilloscope power and replace V133. Turn on the oscilloscope and allow sufficient warm-up time (about 15 minutes) for the new tube. Get the trace on the CRT by adjusting the Channel 1 VAR ATTEN BAL control. Check for microphonics. If they are not excessive, repeat steps 1 and 7.

e. Set the MODE switch to CH 2.

f. Adjust the Channel 2 POSITION control so the trace is positioned to graticule center.

g. Repeat step 9b. In this case, if microphonics are excessive, turn off the oscilloscope power and replace V233. Turn on the power and allow about 15 minutes warm-up time. Get the trace on the CRT by adjusting the Channel 2 VAR ATTEN BAL control. Check for microphonics. If they are not excessive, repeat steps 1 and 5.

10. Check Channel 1 Grid Current

a. Equipment setup remains as in step 9.

b. Set the MODE switch to CH 1, the Channel 1 AC-DC-GND switch to DC and note the position of the trace.

c. Set the Channel 1 AC-DC-GND switch to GND.

d. Check—Maximum trace shift is ±4 mm.

11. Check Channel 2 Grid Current

a. Equipment setup is the same as in step 10.

b. Set the MODE switch to CH 2, the Channel 2 AC-DC-GND switch to DC and note the position of the trace.

c. Set the Channel 2 AC-DC-GND switch to GND.

d. Check—Maximum trace shift is ±4 mm.

12. Check Channel 2 Normal-Invert Balance

a. Equipment setup is unchanged from step 11.

b. Note position of the trace.

c. Pull out the Channel 2 PULL TO INVERT switch and note trace shift.

d. Check—Maximum trace shift is ±1 cm.

e. Push in the Channel 2 PULL TO INVERT switch.

13. Check Channel 1 Normal-Invert Balance

a. Equipment setup remains unchanged.

b. Set the MODE switch to CH 1.

c. Note position of the trace.

d. Pull out the Channel 1 PULL TO INVERT switch and note trace shift.

e. Check—Maximum trace shift is ± 1 cm.

f. Push in the Channel 1 PULL TO INVERT switch.

14. Check Chopped-Mode Operation

a. Equipment setup remains as in step 13.

b. Set the MODE switch to CHOP. Two free-running traces should be displayed.

c. Using both POSITION controls, position the Channel 1 trace 1 cm above the center graticule line and the Channel 2 trace 1 cm below the center graticule line.

d. Set the oscilloscope Time/CM switch to 0.5 μSEC and adjust the Triggering Level control to obtain a stable display.

e. Horizontally position the display so the display starts at the left side of the graticule.

f. Check—Repetition rate of the displayed waveform should be approximately 220 kHz, within a tolerance of $\pm$ 20%. This is equal to a time duration of 4.5 μs per cycle with a tolerance of ± 0.9 μs. See Fig. 7-7A.

g. Set the oscilloscope CRT Cathode Selector switch to the Chopped Blanking position. Note that the switching portion (vertical lines) of the trace from one channel to the other blanks out (becomes dim). This indicates that the Type 1A2 blanking pulses are blanking the beam during the switching time interval between channels. See Fig. 7-7B.

h. Set the oscilloscope Time/CM switch to .1 mSEC and turn the Triggering Level control fully clockwise.

i. At normal intensity and with the FOCUS and Astigmatism controls properly set, check the width (thickness) of the traces. Normal trace width is about 1 mm or less.

j. Return the oscilloscope CRT Cathode Selector switch to CRT Cathode position.

15. Check Alternate-Mode Operation

a. The equipment setup remains unchanged.

b. Set the MODE switch to the ALT position.

c. Check—Two traces on the CRT.

d. Set the oscilloscope Time/CM switch to various sweep rates and check that the traces run alternately across the face of the CRT.

e. Set the Time/CM switch to .5 mSEC.

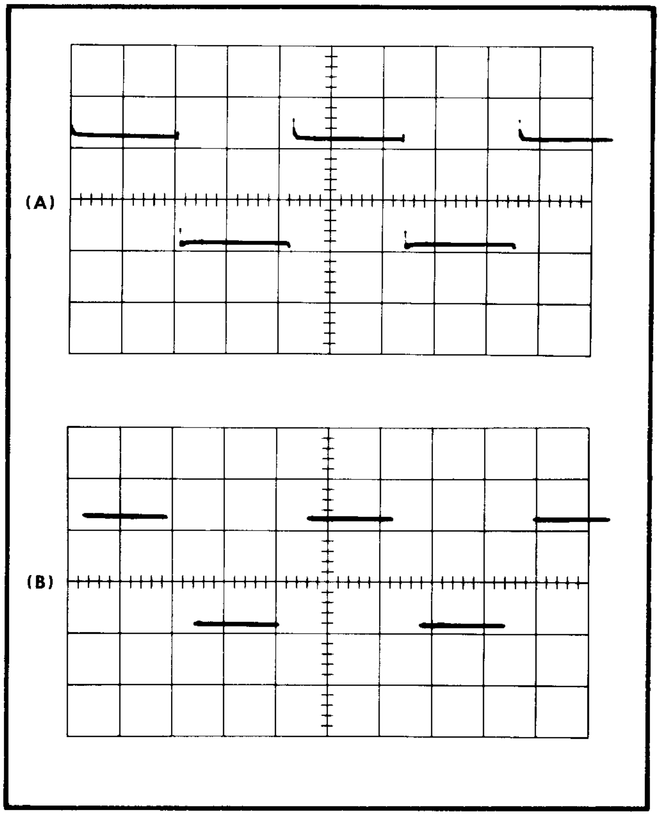


Fig. 7-7. (A) Unblanking chopped-mode waveform, and (B) blanked waveform. Sweep rate is 1 μsec/div.

16. Check Add Mode Operation

a. Equipment setup remains as in step 15.

b. Apply a 0.1 volt peak-to-peak signal from the Standard Amplitude Calibrator to both INPUT 1 and INPUT 2 connectors through a 50 ohm coaxial cable and the Dual Input Connector.

c. Set the MODE switch to ADD, both AC-DC-GND switches to AC and adjust the Triggering Level control for a stable display.

d. Check—Display waveform is 4 cm in amplitude.

e. Pull out the Channel 1 PULL TO INVERT switch.

f. Set the input signal to 1 volt.

g. Check—The two signals should cancel each other out within 1 cm.

h. Disconnect the Dual Input Connector and push in the Channel 1 PULL TO INVERT switch.

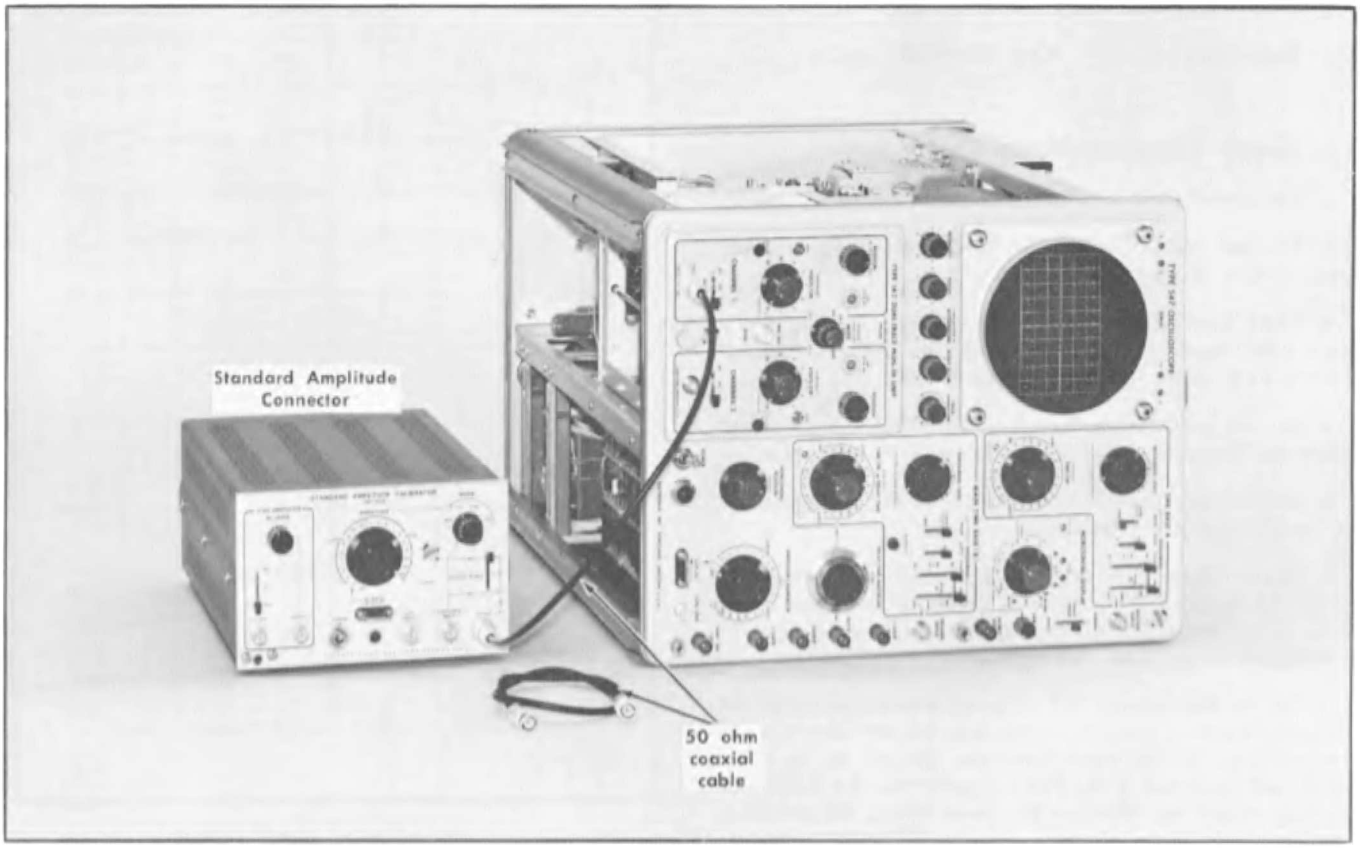


Fig. 7-8. Initial equipment setup for steps 17 and 18.

Control Settings

Test Oscilloscope

Horizontal Display	B (546, 547) Normal (×1) (544)
Sweep Magnifier	×1 off (546, 547)
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto
Time/CM	.5 mSEC
Variable (Time/CM)	Calibrated
Horizontal Position	Centered
Vernier (Horizontal Position)	Centered
CRT Cathode Selector	CRT Cathode
Amplitude Calibrator	Off

Type 1A2

MODE	CH 1
TRIGGER SELECTOR	CH 1
Both Channels	
POSITION	Centered
VOLTS/CM	.05
VARIABLE	CALIBRATED
PULL TO INVERT	Pushed in
AC-DC-GND	GND

17. Check Volts/CM Attenuation Ratios (Both Channels)

a. Equipment setup is shown in Fig. 7-8

b. Apply a .2 volt signal from the Standard Amplitude Calibrator to the INPUT 1 connector through a 50 ohm coaxial cable.

c. Set the Channel 1 AC-DC-GND switch to DC and the MODE switch to CH 1.

d. Adjust the oscilloscope Triggering Level control to obtain a stable display.

e. Check—Proper deflection at each Channel 1 VOLTS/CM switch position using Table 7-1 as a guide; the allowable error is ±3%.

f. Set the input signal to .2 volt and apply the signal to to the INPUT 2 connector.

g. Set the Channel 2 AC-DC-GND switch to DC and the MODE switch to CH 2.

TABLE 7-1

Attenuator Accuracy Check

Type 1A2 VOLTS/CM	Standard Amplitude Calibrator In Volts	Display Amplitude In Centimeters	Allowable Error In Millimeters
.05	.2	4	0.0[5]
.1	.5	5	1.5
.2	1	5	1.5
.5	2	4	1.2
1	5	5	1.5
2	10	5	1.5
5	20	4	1.2
10	50	5	1.5
20	100	5	1.5

[5]**Was adjusted during step 5 and 7.**

h. Check—Proper deflection at each Channel 2 VOLTS/CM switch position using Table 7-1 as a guide; allowable error is $\pm 3\%$.

18. Check Trigger Out Gain[6]

a. Equipment setup is given in step 17.

[6]**Applies only to instruments with serial number 716 or higher.**

b. Apply a .02 volt signal from the Standard Amplitude Calibrator to the INPUT 1 connector through a 50 ohm coaxial cable and connect another 50 ohm coaxial cable from the TRIG OUT connector to the INPUT 2 connector.

c. Set both VOLTS/CM switches to .05, the MODE switch to CH 2, the TRIGGER SELECTOR to CH 1 and both AC-DC-GND switches to AC.

d. Center the display with the Channel 2 POSITION control.

e. Check—Display amplitude is at least 4 cm.

f. Connect the input signal to the INPUT 2 connector and the TRIG OUT signal to the INPUT 1 connector.

g. Set the MODE switch to CH 1 and the TRIGGER SELECTOR switch to CH 2.

h. Center the display with the Channel 1 POSITION control.

i. Check—Display amplitude is at least 4 cm.

j. Disconnect the coaxial cable from the TRIG OUT connector to the INPUT 2 connector and disconnect the input signal.

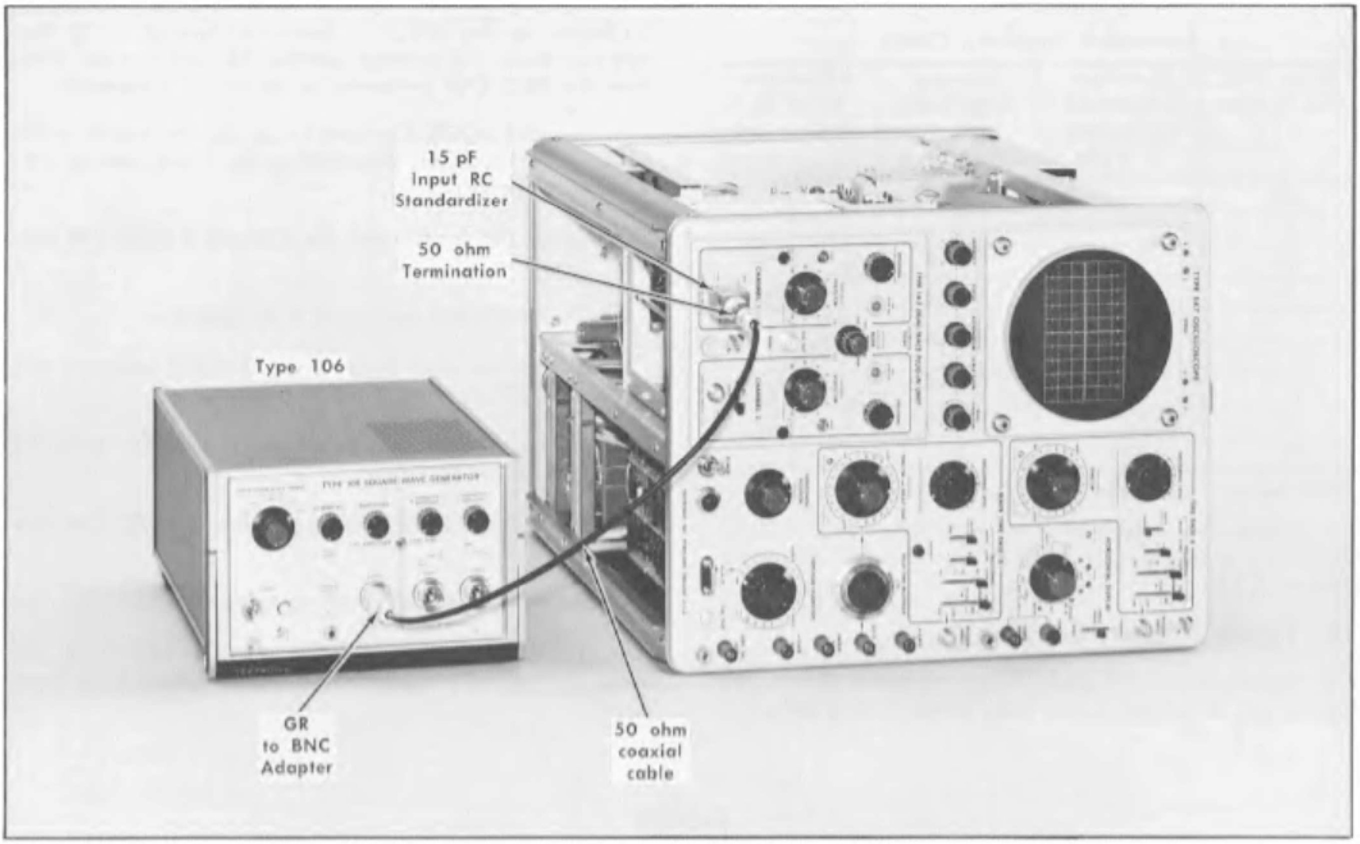


Fig. 7-9. Initial equipment setup for step 19.

Control Settings

Test Oscilloscope

Horizontal Display	B (546, 547) Normal (×1) (544)
Sweep Magnifier	×1 off (546, 547)
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto
Time/CM	.5 mSEC
Variable (Time/CM)	Calibrated
Horizontal Position	Centered
Vernier (Horizontal Position)	Centered
CRT Cathode Selector	CRT Cathode
Amplitude Calibrator	Off

Type 1A2

MODE	CH 1
TRIGGER SELECTOR	CH 1
Both Channels	
POSITION	Centered
VOLTS/CM	.05
VARIABLE	CALIBRATED
PULL TO INVERT	Pushed in
AC-DC-GND	GND

19. Adjust Input and Attenuator Compensations (Both Channels)

This step describes how to properly adjust the input shunt capacitance of each channel so the input time constant is the same for each position of the VOLTS/CM switch. Thus, an attenuator probe, when compensated to match one setting of the VOLTS/CM switch, will work into the same time constant when using the other VOLTS/CM switch positions. Standardizing the input capacitance virtually eliminates the need for recompensating the probe each time a different switch position is used.

This procedure also describes a method for compensating the input attenuators so AC attenuation is equal to DC attenuation. Since there is some interaction between both sets of adjustments (input capacitance and attenuator compensation) faster, more accurate results are obtained by combining both sets of adjustments in this one procedure.

a. Equipment setup is shown in Fig. 7-9.

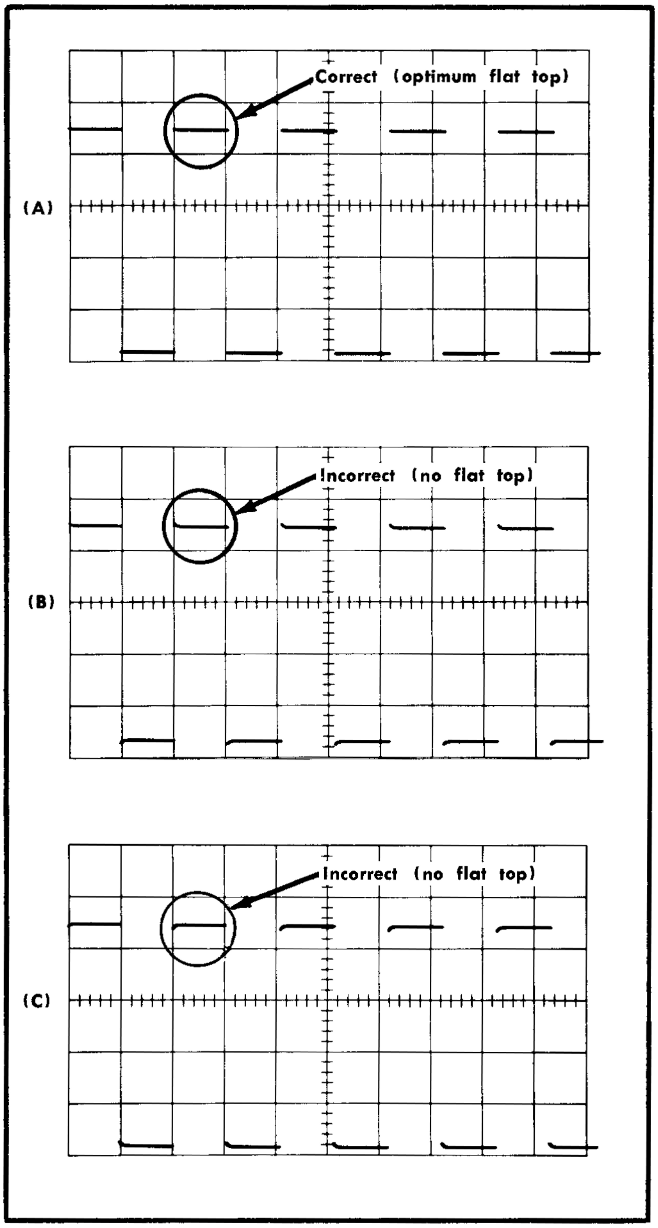


Fig. 7-10. Standardizing the input time constant and shunt compensation attenuator adjustments of the Type 1A2. Square-wave repetition rate is 1 kHz and sweep rate is 0.5 mSEC/CM.

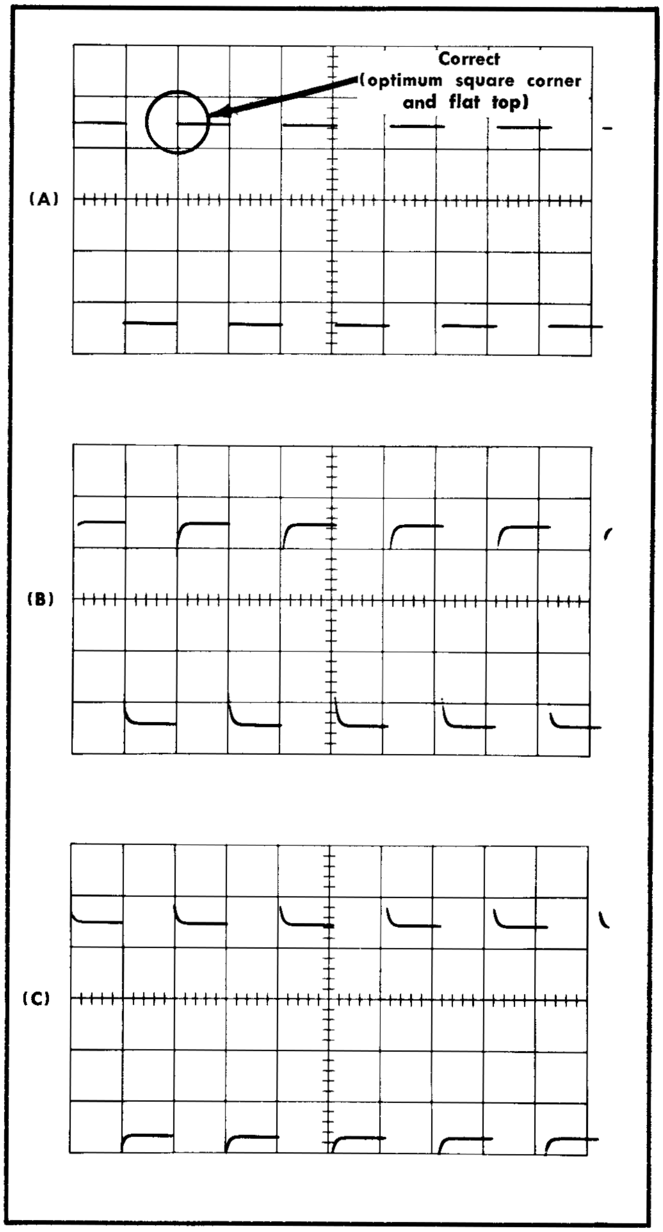


Fig. 7-11. Waveform (A) shows desired result obtained when the series frequency compensating adjustment is correct. Waveforms (B) and (C) show misadjustment. Incorrect adjustment of the shunt compensations will not be seen. Square-wave repetition rate is 10 kHz and sweep rate is 50 μSEC.

b. Apply a 1 kHz signal from the Type 106 Square-Wave Generator high amplitude output through a GR to BNC adapter, a 50 ohm coaxial cable, 50 ohm termination and a 15 pF Input RC Standardizer to the INPUT 1 connector.

c. Adjust the output of the Square-Wave Generator for an approximate 4 cm amplitude display. Center the display with the Channel 1 POSITION control and adjust the oscilloscope Triggering Level control for a stable display.

d. Check—Waveform display should be flat topped as shown in Fig. 7-10.

e. Adjust—C104 for best square-wave response as shown in Fig. 7-10A if the waveform is not optimum and looks something like that of Fig. 7-10B or Fig. 7-10C.

f. Check—Waveform for optimum flat top at each VOLTS/CM switch setting. Adjust the output of the generator to maintain about 4 cm of display amplitude. It will be necessary to remove the 50 ohm termination at VOLTS/CM switch settings higher than 1 volt.

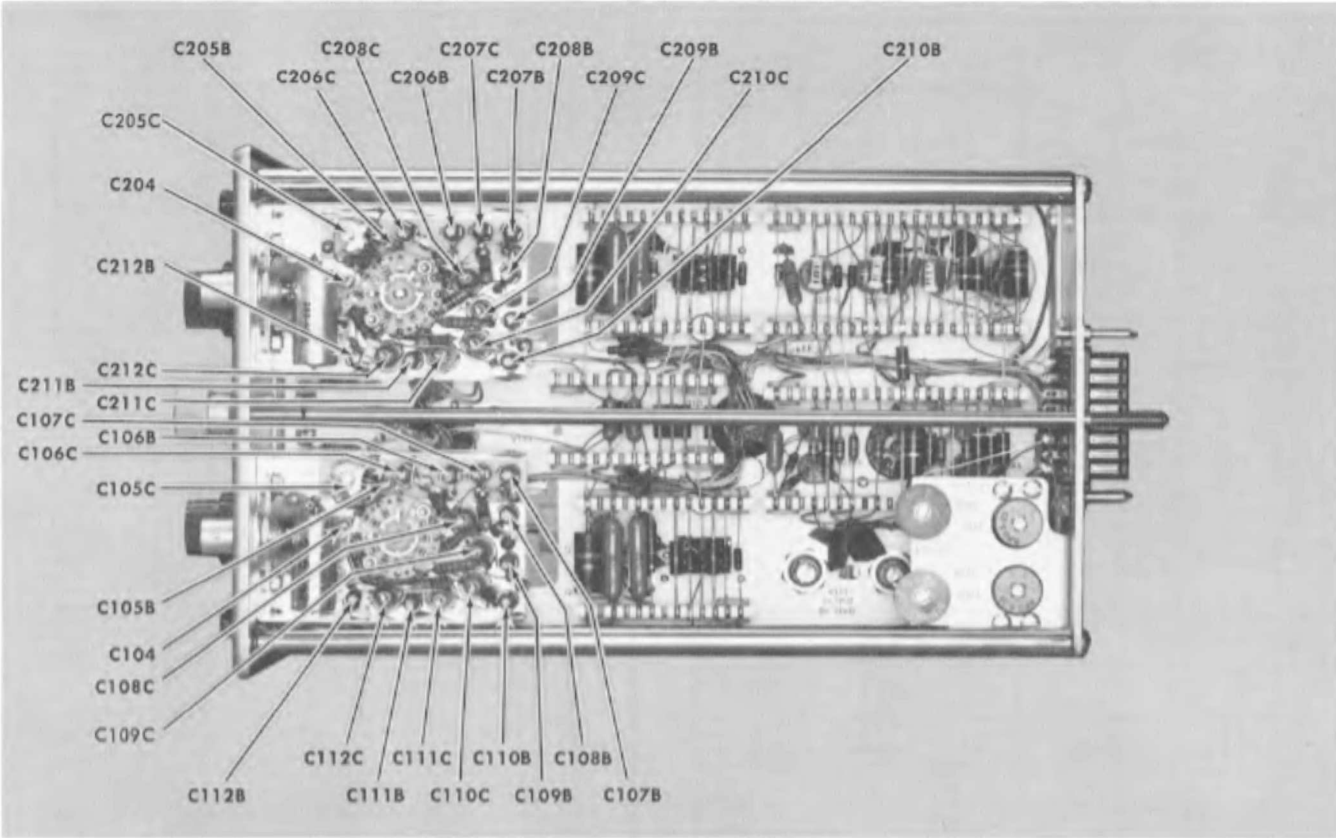


Fig. 7-12. Location of input and attenuator compensation adjustments.

WARNING

To avoid a signal shock hazard, reduce the generator output to minimum when changing signal connections.

g. Adjust—Input Shunt Capacitor for optimum flat top at each VOLTS/CM switch setting using Table 7-2. See Fig. 7-12 for the location of adjustments.

h. Remove the 15 pF Input RC Standardizer and replace the 50 ohm termination.

i. Change the Square-Wave Generator frequency to 10 kHz, the Time/Cm switch to 50 μSEC, the VOLTS/CM switch to .1 and adjust the output for a display amplitude of 4 cm.

j. Adjust—Frequency Compensating Capacitor for optimum square corner and flat top at each VOLTS/CM switch setting using Table 7-2. See Fig. 7-11A for waveform and Fig. 7-12 for location of adjustments. (It will not be possible to maintain the 4 cm amplitude at the 5, 10 and 20 VOLTS/CM switch positions.)

k. Replace the 15 pF Input RC Standardizer and repeat step 19f.

l. Change the MODE and TRIGGER SELECTOR switches to CH 2 and apply the Square-Wave Generator signal to the INPUT 2 connector.

m. Perform steps 19d through k, adjusting the Channel 2 capacitors using Table 7-2. Location of adjustments is shown in Fig. 7-12.

n. Disconnect the Input RC Standardizer and coaxial cable.

TABLE 7-2

Input Time-Constant Standardization and Frequency Compensation

VOLTS/CM Switch Setting	Channel 1		Channel 2	
	Input Shunt Capacitor	Frequency Compensating Capacitor	Input Shunt Capacitor	Frequency Compensating Capacitor
.05	C104	None	C204	None
.1	C105B	C105C	C205B	C205C
.2	C106B	C106C	C206B	C206C
.5	C107B	C107C	C207B	C207C
1	C108B	C108C	C208B	C208C
2	C109B	C109C	C209B	C209C
5	C110B	C110C	C210B	C210C
10	C111B	C111C	C211B	C211C
20	C112B	C112C	C212B	C212C

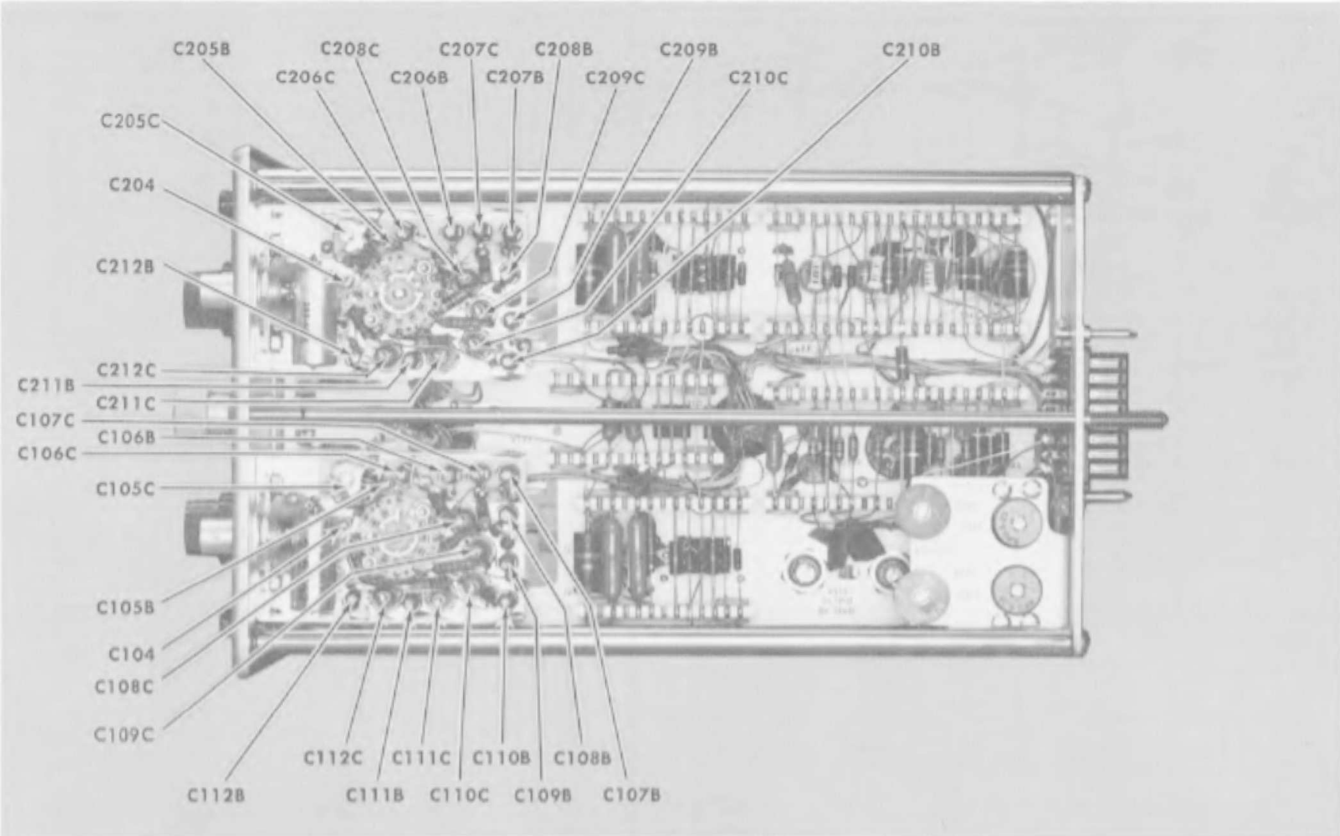


Fig. 7-12. Location of input and attenuator compensation adjustments.

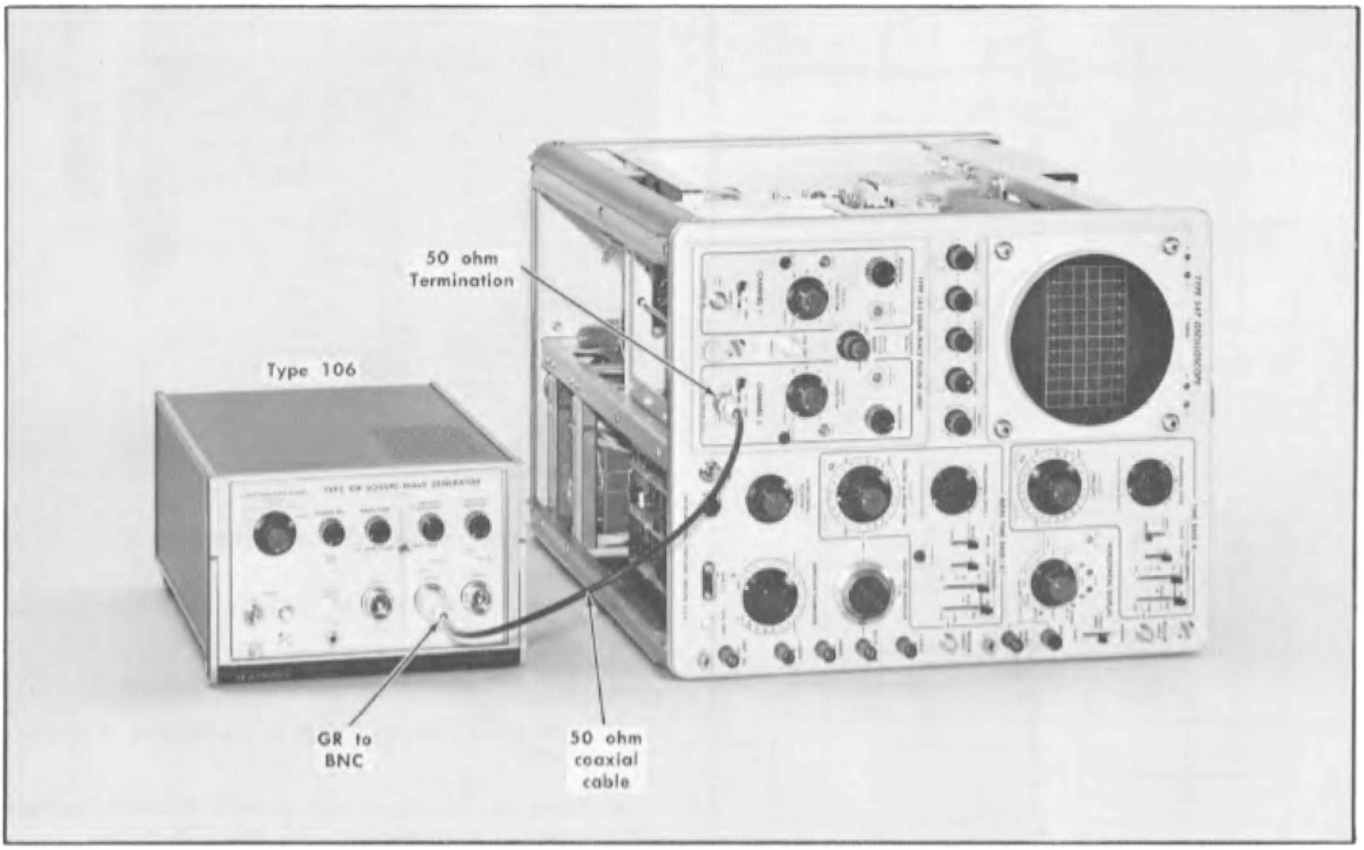


Fig. 7-13. Initial equipment setup for step 20.

Control Settings

Test Oscilloscope

Horizontal Display	B (546, 547) Normal (×1) (544)
Sweep Magnifier	×1 off (546, 547)
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto
Time/CM	.1 μSEC
Variable (Time/CM)	Calibrated
Horizontal Position	Centered
Vernier (Horizontal Position)	Centered
CRT Cathode Selector	CRT Cathode
Amplitude Calibrator	Off

Type 1A2

MODE	CH 2
TRIGGER SELECTOR	CH 2

Both Channels

POSITION	Centered
VOLTS/CM	.05
VARIABLE	CALIBRATED
PULL TO INVERT	Pushed in
AC-DC-GND	AC

20. Adjust High-Frequency Compensation

a. Equipment setup is shown in Fig. 7-13.

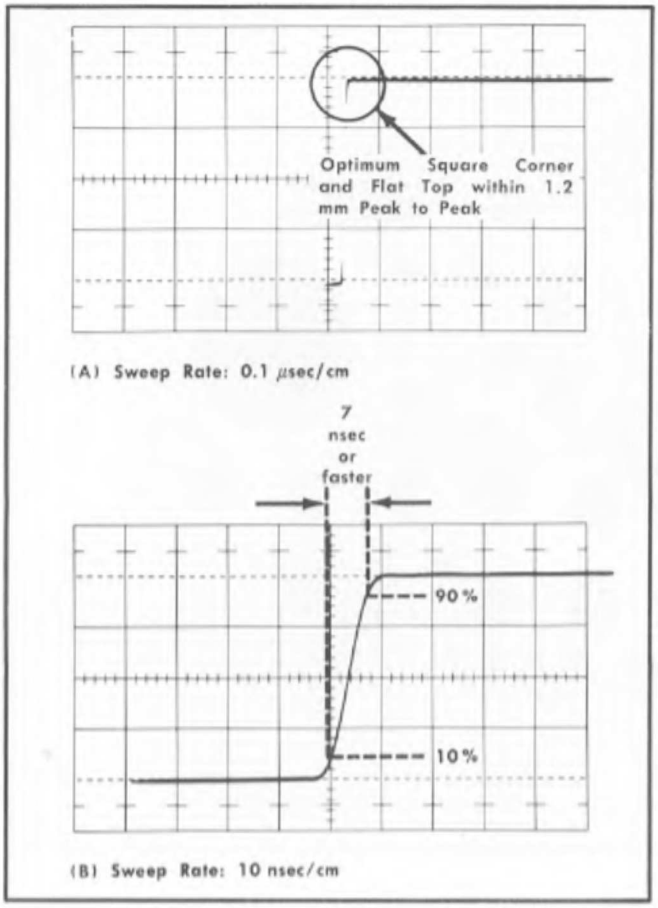
b. Apply an approximate 120 kHz signal from the Fast-Rise + output of the Type 106 Square-Wave Generator to the INPUT 2 connector through a GR to BNC adapter, 50 ohm coaxial cable and a 50 ohm termination.

c. Set both AC-DC-GND switches to AC and the Time/CM switch to 0.1 μSEC.

d. Adjust the amplitude control for a display amplitude of 4 cm and the Triggering Level control for a stable display.

e. Position the rising portion of the display near the graticule center.

f. Check—Waveform is flat topped with no more than 3% (1.2 mm) peak-to-peak rolloff, spiking and/or ringing.



(A) Sweep Rate: 0.1 μsec/cm

(B) Sweep Rate: 10 nsec/cm

Fig. 7-14. Typical CRT display showing (A) high-frequency adjustment and (B) measuring risetime.

g. Adjust—R379, C379, R377 and C377 for the sharpest leading corner and a level top. See Fig. 7-14A and Fig. 7-15 for location.

h. Change the Time/CM switch to 2 μsec/cm and again check the waveform, readjusting R377 and C377 if necessary.

i. Disconnect the 50 ohm termination from the INPUT 2 connector and connect it to the INPUT 1 connector.

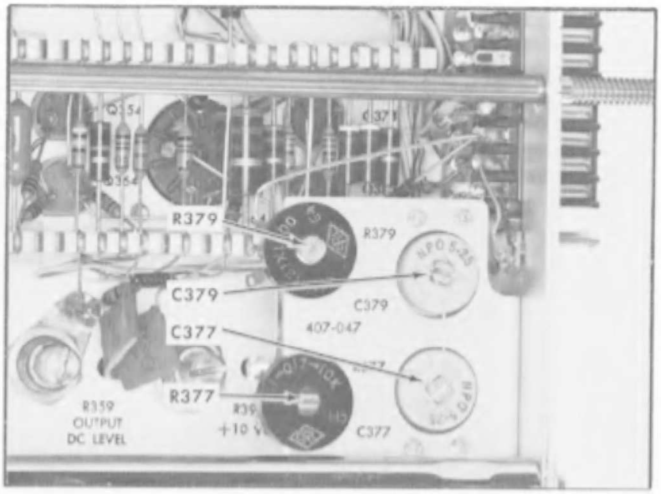


Fig. 7-15. Location of high-frequency compensations.

j. Change the MODE and TRIGGER SELECTOR switches to CH 1.

k. Check—Waveform for optimum front corner.

l. Change the Time/CM switch to .1 μSEC and the Magnifier to ×10.

m. Center the waveform and measure the rising portion of the waveform between the 10% and 90% points.

n. Check—Risetime should be 7 ns or less, using a Type 544, 546 or 547 Oscilloscope. See Fig. 7-14B.

o. Change the MODE switch to ADD, center the waveform and measure the risetime.

p. Check—Risetime should be 7 ns or less using a Type 544, 546 or 547 Oscilloscope.

q. Turn the Magnifier to ×1 (Off).

r. Check—Waveform is flat topped with no more than 6% (2.4 mm) peak-to-peak aberrations.

s. Disconnect the input signal.

Ⓑ

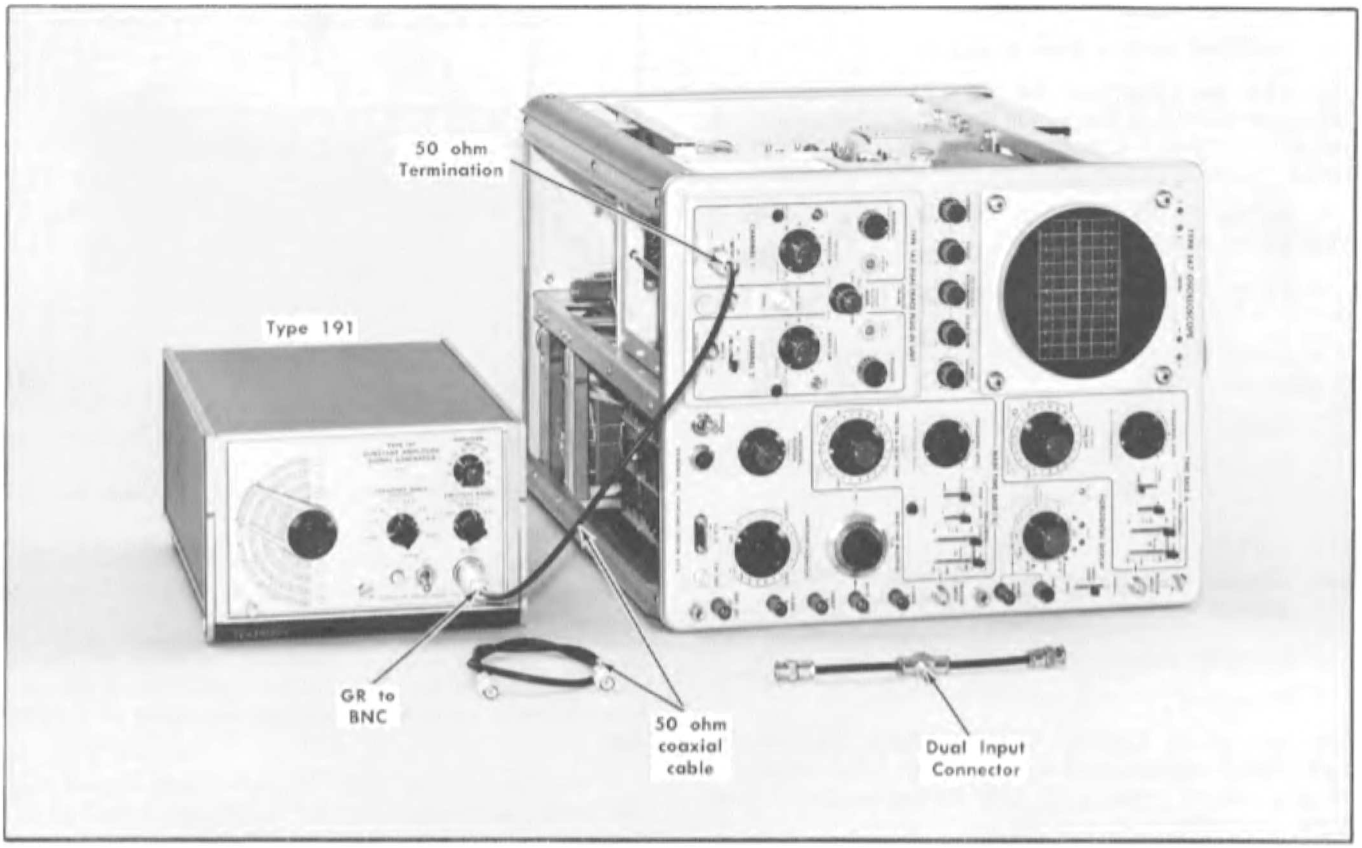


Fig. 7-16. Initial equipment setup for steps 21 through 23.

Control Settings

Test Oscilloscope

Horizontal Display	B (546, 547) Normal (×1) (544)
Sweep Magnifier	×1 off (546, 547)
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto
Time/CM	.1 μSEC
Variable (Time/CM)	Calibrated
Horizontal Position	Centered
Vernier (Horizontal Position)	Centered
CRT Cathode Selector	CRT Cathode
Amplitude Calibrator	Off

Type 1A2

MODE	CH 1
TRIGGER SELECTOR	CH 1

Both Channels

POSITION	Centered
VOLTS/CM	.05
VARIABLE	CALIBRATED
PULL TO INVERT	Pushed in
AC-DC-GND	GND

21. Check Frequency Response

a. Equipment setup is shown in Fig. 7-16.

b. Connect the Constant Amplitude Signal Generator to the INPUT 1 connector through a GR to BNC adapter, and 50 ohm coaxial cable and a 50 ohm termination.

c. Adjust the output of the Constant Amplitude Signal Generator for 4 cm of 50 kHz signal amplitude.

d. Increase the frequency until there is exactly 2.8 cm of deflection. See Fig. 7-17.

e. Check—This is the 3 dB down point and should be no lower in frequency than the Characteristics section of the manual shows (50 MHz or higher with Types 544, 546 or 547 Oscilloscopes).

f. Change the MODE switch to ADD and repeat the above check procedure.

g. Remove the signal from the INPUT 1 connector and apply it to the INPUT 2 connector.

h. Set the MODE switch to CH 2 and repeat the check procedure to determine the frequency response of Channel 2.

22. Check Trigger Bandwidth[7]

a. Equipment setup is given in step 21.

b. With the signal from the Constant Amplitude Signal Generator applied to Channel 2, set the TRIGGER SELECTOR switch to CH 2 and connect the TRIG OUT connector to the INPUT 1 connector through a 50 ohm coaxial cable.

c. Set the MODE switch to CH 1 and the Channel 1 VOLTS/CM switch to .1.

d. Adjust the Constant Amplitude Signal Generator output for a 5 cm display amplitude at 50 kHz.

e. Increase the frequency until 3.5 cm of display amplitude is obtained.

f. Check—Frequency should be 5 MHz or greater.

g. Remove the input signal and the coaxial cable between the TRIG OUT connector and the INPUT 1 connector.

23. Check High-Frequency Common Mode Rejection

a. Equipment setup is given in step 22.

b. Set both VOLTS/CM switches to .2 volts.

c. Connect the Constant Amplitude Signal Generator to both INPUT connectors through a GR to BNC adapter, a 50 ohm coaxial cable, a 50 ohm termination and a Dual Input Connector.

d. Adjust the output amplitude of the Constant Amplitude Signal Generator for 2.5 cm of 50 kHz signal.

e. Change the frequency to 50 MHz (with Types 544, 546 or 547 Oscilloscopes).

[7]Applies only to instruments with serial numbers 716 or higher.

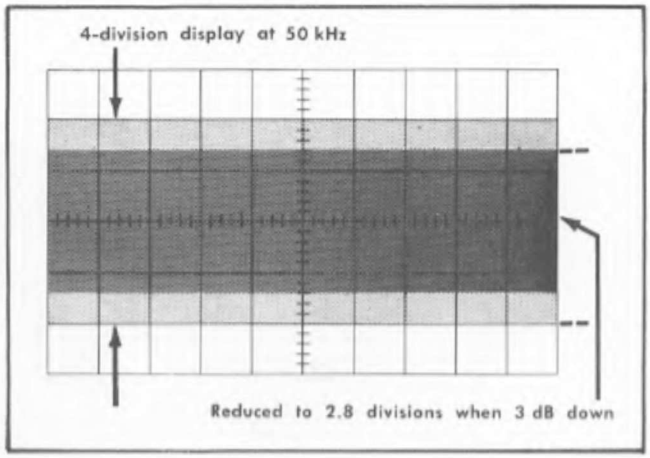


Fig. 7-17. Typical CRT display when checking frequency response.

f. Set the MODE switch to ADD, both VOLTS/CM switches to .05 and pull the Channel 2 PULL TO INVERT Switch.

g. Check—Displayed amplitude must be .5 cm or less, a 20 to 1 rejection ratio. If displayed amplitude is greater, pull the Channel 1 PULL TO INVERT switch. One of the combinations must result in a displayed amplitude of .5 cm or less.

h. Remove the Dual Input Connector, push in both PULL TO INVERT switches and set the MODE switch to CH 1.

This completes the calibration of the Type 1A2. Disconnect all test equipment and replace the side and bottom covers of the oscilloscope. If the instrument has been completely calibrated to the tolerances given in this procedure, it will perform to the limits given in the Characteristics section of the Instruction Manual.

ABBREVIATIONS AND SYMBOLS

A or amp	amperes
AC or ac	alternating current
AF	audio frequency
α	alpha—common-base current amplification factor
AM	amplitude modulation
$\approx$	approximately equal to
β	beta—common-emitter current amplification factor
BHB	binding head brass
BHS	binding head steel
BNC	baby series "N" connector
$\times$	by or times
C	carbon
C	capacitance
cap.	capacitor
cer	ceramic
cm	centimeter
comp	composition
conn	connector
$\sim$	cycle
c/s or cps	cycles per second
CRT	cathode-ray tube
csk	countersunk
Δ	increment
dB	decibel
dBm	decibel referred to one milliwatt
DC or dc	direct current
DE	double end
°	degrees
°C	degrees Celsius (degrees centigrade)
°F	degrees Fahrenheit
°K	degrees Kelvin
dia	diameter
$\div$	divide by
div	division
EHF	extremely high frequency
elect.	electrolytic
EMC	electrolytic, metal cased
EMI	electromagnetic interference (see RFI)
EMT	electrolytic, metal tubular
ε	epsilon—2.71828 or % of error
$\geq$	equal to or greater than
$\leq$	equal to or less than
ext	external
F or f	farad
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
FM	frequency modulation
ft	feet or foot
G	giga or 10^9
g	acceleration due to gravity
Ge	germanium
GHz	gigahertz
GMV	guaranteed minimum value
GR	General Radio
$>$	greater than
H or h	henry
h	height or high
hex.	hexagonal
HF	high frequency
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
HV	high voltage
Hz	hertz (cycles per second)
ID	inside diameter
IF	intermediate frequency
in.	inch or inches
incd	incandescent
∞	infinity
int	internal
$\int$	integral
k	kilohms or kilo (10^3)
k Ω	kilohm
kc	kilocycle
kHz	kilohertz
L	inductance
λ	lambda—wavelength
$\gg$	large compared with
$<$	less than
LF	low frequency
lg	length or long
LV	low voltage
M	mega or 10^6
m	milli or 10^{-3}
MΩ or meg	megohm
μ	micro or 10^{-6}
mc	megacycle
met.	metal
MHz	megahertz
mm	millimeter
ms	millisecond
—	minus
mtg hdw	mounting hardware
n	nano or 10^{-9}
no. or #	number
ns	nanosecond
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
Ω	omega—ohms
ω	omega—angular frequency
p	pico or 10^{-12}
/	per
%	percent
PHB	pan head brass
ϕ	phi—phase angle
π	pi—3.1416
PHS	pan head steel
$+$	plus
$\pm$	plus or minus
PIV	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
pwr	power
Q	figure of merit
RC	resistance capacitance
RF	radio frequency
RFI	radio frequency interference (see EMI)
RHB	round head brass
ρ	rho—resistivity
RHS	round head steel
r/min or rpm	revolutions per minute
RMS	root mean square
s or sec.	second
SE	single end
Si	silicon
SN or S/N	serial number
$\ll$	small compared with
T	tera or 10^{12}
TC	temperature compensated
TD	tunnel diode
THB	truss head brass
θ	theta—angular phase displacement
thk	thick
THS	truss head steel
tub.	tubular
UHF	ultra high frequency
V	volt
VAC	volts, alternating current
var	variable
VDC	volts, direct current
VHF	very high frequency
VSWR	voltage standing wave ratio
W	watt
w	wide or width
w/	with
w/o	without
WW	wire-wound
xmfr	transformer

PARTS ORDERING INFORMATION

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

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

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

SPECIAL NOTES AND SYMBOLS

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

SECTION 8

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description					S/N Range
		Bulbs					
B118	150-0035-00	Neon, A1D					
B218	150-0035-00	Neon, A1D					

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description					S/N Range
C101	*285-0662-00	0.1 μF	PTM		600 V	+5%—15%	100-1299
C101	*285-0697-00	0.1 μF	PTM		600 V		1300-up
C103	281-0613-00	10 pF	Cer		200 V	10%	
C104	281-0064-00	0.2-1.5 pF	Tub.	Var			
C105A	281-0538-00	1 pF	Cer		500 V		100-921
C105A	281-0537-00	0.68 pF	Selected	(nominal value)			922-1299
C105A	Use 281-0537-00	0.68 pF	Selected	(nominal value)			1300-up
C105B	281-0064-00	0.2-1.5 pF	Tub.	Var			
C105C	281-0081-00	1.8-13 pF	Air	Var			
C106B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C106C	281-0027-00	0.7-3 pF	Tub.	Var			
C106D	281-0538-00	1 pF	Selected	(nominal value)			X1300-up
C107A	281-0529-00	1.5 pF	Selected	(nominal value)			100-1299
C107A	281-0547-00	2.7 pF	Selected	(nominal value)			1300-up
C107B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C107C	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C108A	281-0547-00	2.7 pF	Cer		500 V	10%	100-921
C108A	281-0529-00	1.5 pF	Selected	(nominal value)			922-1299
C108A	281-0534-00	3.3 pF	Selected	(nominal value)			1300-up
C108B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C108C }	281-0082-00	0.2-1.5 pF	Tub.	Var			
C108E }		15 pF	Mica			10%	
C109A	281-0547-00	2.7 pF	Cer		500 V	10%	100-921
C109A	281-0529-00	1.5 pF	Selected	(nominal value)			922-1299
C109A	281-0547-00	2.7 pF	Selected	(nominal value)			1300-up
C109B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C109C }	281-0083-00	0.2-1.5 pF	Tub.	Var			
C109E }		50 pF	Mica			10%	
C110A	281-0529-00	1.5 pF	Selected	(nominal value)			100-1299
C110A	281-0547-00	2.7 pF	Selected	(nominal value)			1300-up

Capacitors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C110B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C110C	281-0084-00	0.2-1.5 pF	Tub.	Var			
C110E		100 pF	Mica			10%	
C111A	281-0547-00	2.7 pF	Cer		500 V	10%	
C111B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C111C	281-0085-00	0.2-1.5 pF	Tub.	Var			
C111E		200 pF	Mica			10%	
C112A	281-0547-00	2.7 pF	Selected (nominal value)				100-1299
C112A	281-0534-00	3.3 pF	Selected (nominal value)				1300-up
C112B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C112C	281-0086-00	0.2-1.5 pF	Tub.	Var			
C112E		500 pF	Mica			10%	
C117	281-0591-00	0.0056 μF	Cer		200 V		100-1299
C117	281-0614-00	5600 pF	Cer		200 V		1300-up
C134	283-0000-00	0.001 μF	Cer		500 V		
C135	283-0068-00	0.01 μF	Cer		500 V		100-715X
C140	283-0000-00	0.001 μF	Cer		500 V		
C159	283-0000-00	0.001 μF	Cer		500 V		
C160	283-0000-00	0.001 μF	Cer		500 V		
C201	*285-0662-00	0.1 μF	PTM		600 V	+5%—15%	100-1299
C201	*285-0697-00	0.1 μF	PTM		600 V		1300-up
C203	281-0613-00	10 pF	Cer		200 V		
C204	281-0064-00	0.2-1.5 pF	Tub.	Var			
C205A	281-0538-00	1 pF	Cer		500 V		100-921
C205A	281-0537-00	0.68 pF	Selected (nominal value)				922-1299
C205A	Use 281-0537-00	0.68 pF	Selected (nominal value)				1300-up
C205B	281-0064-00	0.2-1.5 pF	Tub.	Var			
C205C	281-0081-00	1.8-13 pF	Air	Var			
C206B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C206C	281-0027-00	0.7-3 pF	Tub.	Var			
C206D	281-0538-00	1 pF	Selected (nominal value)				X1300-up
C207A	281-0529-00	1.5 pF	Selected (nominal value)				100-1299
C207A	281-0547-00	2.7 pF	Selected (nominal value)				1300-up
C207B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C207C	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C208A	281-0547-00	2.7 pF	Cer		500 V	10%	100-921
C208A	281-0529-00	1.5 pF	Selected (nominal value)				922-1299
C208A	281-0534-00	3.3 pF	Selected (nominal value)				1300-up
C208B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C208C	281-0082-00	0.2-1.5 pF	Tub.	Var			
C208E		15 pF	Mica			10%	
C209A	281-0547-00	2.7 pF	Cer		500 V	10%	100-921
C209A	281-0529-00	1.5 pF	Selected (nominal value)				922-1299
C209A	281-0547-00	2.7 pF	Selected (nominal value)				1300-up
C209B	Use 281-0037-00	0.7-3 pF	Tub.	Var			

Capacitors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C209C }	281-0083-00	0.2-1.5 pF	Tub.	Var			
C209E }		50 pF	Mica			10%	
C210A	281-0529-00	1.5 pF		Selected (nominal value)			100-1299
C210A	281-0547-00	2.7 pF		Selected (nominal value)			1300-up
C210B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C210C }	281-0084-00	0.2-1.5 pF	Tub.	Var			
C210E }		100 pF	Mica			10%	
C211A	281-0547-00	2.7 pF	Cer		500 V	10%	
C211B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C211C }	281-0085-00	0.2-1.5 pF	Tub.	Var			
C211E }		200 pF	Mica			10%	
C212A	281-0547-00	2.7 pF		Selected (nominal value)			100-1299
C212A	281-0534-00	3.3 pF		Selected (nominal value)			1300-up
C212B	Use 281-0037-00	0.7-3 pF	Tub.	Var			
C212C }	281-0086-00	0.2-1.5 pF	Tub.	Var			
C212E }		500 pF	Mica			10%	
C217	281-0591-00	0.0056 μF	Cer		200 V		100-1299
C217	281-0614-00	5600 pF	Cer		200 V		1300-up
C234	283-0000-00	0.001 μF	Cer		500 V		
C240	283-0000-00	0.001 μF	Cer		500 V		
C259	283-0000-00	0.001 μF	Cer		500 V		
C260	283-0000-00	0.001 μF	Cer		500 V		
C315	281-0524-00	150 pF	Cer		500 V		
C325	281-0524-00	150 pF	Cer		500 V		
C326	281-0518-00	47 pF	Cer		500 V		
C333	Use 283-0003-00	0.01 μF	Cer		150 V		
C334	283-0079-00	0.01 μF	Cer		250 V		
C335	283-0000-00	0.001 μF	Cer		500 V		
C340	281-0523-00	100 pF	Cer		350 V		
C343	283-0051-00	0.0033 μF	Cer		100 V	5%	100-715
C343	283-0079-00	0.01 μF	Cer		250 V		716-up
C344	283-0054-00	150 pF	Cer		200 V	5%	
C346	283-0026-00	0.2 μF	Cer		25 V		
C354	283-0057-00	0.1 μF	Cer		200 V		
C377	281-0011-00	5-25 pF	Cer	Var			
C379	281-0011-00	5-25 pF	Cer	Var			
C391	283-0000-00	0.001 μF	Cer		500 V		
C395	283-0026-00	0.2 μF	Cer		25 V		
C396	283-0026-00	0.2 μF	Cer		25 V		
C397	290-0149-00	5 μF	EMT		150 V		X716-up
C421	290-0107-00	25 μF	EMT		25 V		X716-up
C424	283-0057-00	0.1 μF	Cer		200 V	+80%—20%	X716-up

Diodes

Ckt. No.	Tektronix Part No.	Description		S/N Range
D134	*152-0107-00	Silicon	Replaceable by 1N647	
D137	152-0141-00	Silicon	1N3605	
D138	152-0141-00	Silicon	1N3605	
D234	*152-0107-00	Silicon	Replaceable by 1N647	
D237	152-0141-00	Silicon	1N3605	
D238	152-0141-00	Silicon	1N3605	
D301	152-0141-00	Silicon	1N3605	
D302	152-0141-00	Silicon	1N3605	
D303	152-0141-00	Silicon	1N3605	
D304	152-0141-00	Silicon	1N3605	
D306	152-0141-00	Silicon	1N3605	
D307	152-0141-00	Silicon	1N3605	
D308	152-0141-00	Silicon	1N3605	
D309	152-0141-00	Silicon	1N3605	
D317	152-0141-00	Silicon	1N3605	
D327	152-0141-00	Silicon	1N3605	
D332	152-0008-00	Germanium		
D340	152-0141-00	Silicon	1N3605	
D395	152-0168-00	Zener	1N963A 0.4 W, 12 V, 20%	
D397	152-0172-00	Zener	1N970A 0.4 W, 24 V, 10%	X716-up
D416	Use *152-0075-00	Germanium	Tek Spec	X716-up

Connectors

Ckt. No.	Tektronix Part No.	Description	S/N Range
J101	131-0342-00	BNC, female, 1 contact	100-3919
J101	*131-0342-01	BNC, female, 1 contact	3920-up
J201	131-0342-00	BNC, female, 1 contact	100-3919
J201	*131-0342-01	BNC, female, 1 contact	3920-up

Inductors

Ckt. No.	Tektronix Part No.	Description	S/N Range
LR105A	*108-0286-00	0.17 μH (wound on a 36 Ω resistor)	100-921
LR105A	*108-0268-00	0.1 μH (wound on a 36 Ω resistor)	922-up
LR106A	*108-0270-00	0.25 μH (wound on a 62 Ω resistor)	100-921
LR106A	*108-0268-00	0.1 μH (wound on a 36 Ω resistor)	922-up
LR107A	*108-0270-00	0.25 μH (wound on a 62 Ω resistor)	100-921
LR107A	*108-0286-00	0.17 μH (wound on a 36 Ω resistor)	922-up
LR108A	*108-0286-00	0.17 μH (wound on a 36 Ω resistor)	100-921X
LR109A	*108-0268-00	0.1 μH (wound on a 36 Ω resistor)	100-921X
LR205A	*108-0286-00	0.17 μH (wound on a 36 Ω resistor)	100-921
LR205A	*108-0268-00	0.1 μH (wound on a 36 Ω resistor)	922-up
LR206A	*108-0270-00	0.25 μH (wound on a 62 Ω resistor)	100-921
LR206A	*108-0268-00	0.1 μH (wound on a 36 Ω resistor)	922-up
LR207A	*108-0270-00	0.25 μH (wound on a 62 Ω resistor)	100-921
LR207A	*108-0286-00	0.17 μH (wound on a 36 Ω resistor)	922-up
LR208A	*108-0286-00	0.17 μH (wound on a 36 Ω resistor)	100-921X
LR209A	*108-0268-00	0.1 μH (wound on a 36 Ω resistor)	100-921X

Transistors

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q143	*151-0120-00	Selected from 2N2475	
Q163	*151-0120-00	Selected from 2N2475	
Q243	*151-0120-00	Selected from 2N2475	
Q263	*151-0120-00	Selected from 2N2475	
Q315	151-0107-00	2N967	
Q325	151-0107-00	2N967	
Q340	151-0080-00	2N706	
Q354	151-0080-00	2N706	100-929
Q354	*151-0108-00	Replaceable by 2N2501	930-up
Q364	151-0080-00	2N706	100-929
Q364	*151-0108-00	Replaceable by 2N2501	930-up
Q373	*151-0120-00	Selected from 2N2475	
Q383	*151-0120-00	Selected from 2N2475	
Q414	*151-0108-00	Replaceable by 2N2501	X716-up
Q424	*151-0108-00	Replaceable by 2N2501	X716-up

Resistors

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

R103	317-0560-00	56 Ω	1/8 W		5%	
R104	317-0560-00	56 Ω	1/8 W		5%	
R105C	322-0610-00	500 kΩ	1/4 W	Prec	1%	100-3629
R105C	322-0610-01	500 kΩ	1/4 W	Prec	1/2%	3630-up
R105E	322-0481-00	1 MΩ	1/4 W	Prec	1%	100-3629
R105E	322-0481-01	1 MΩ	1/4 W	Prec	1/2%	3630-up
R106C	322-0469-00	750 kΩ	1/4 W	Prec	1%	100-3629
R106C	322-0469-01	750 kΩ	1/4 W	Prec	1/2%	3630-up
R106E	321-0628-00	333 kΩ	1/8 W	Prec	1%	100-3629
R106E	321-0628-01	333 kΩ	1/8 W	Prec	1/2%	3630-up
R107C	322-0621-00	900 kΩ	1/4 W	Prec	1%	100-3629
R107C	322-0621-01	900 kΩ	1/4 W	Prec	1/2%	3630-up
R107E	321-0617-00	111 kΩ	1/8 W	Prec	1%	100-3629
R107E	321-0617-01	111 kΩ	1/8 W	Prec	1/2%	3630-up
R108C	322-0622-00	950 kΩ	1/4 W	Prec	1%	100-3629
R108C	322-0622-01	950 kΩ	1/4 W	Prec	1/2%	3630-up
R108E	321-0616-00	52.6 kΩ	1/8 W	Prec	1%	100-3629
R108E	321-0616-01	52.6 kΩ	1/8 W	Prec	1/2%	3630-up
R108G	317-0430-00	43 Ω	1/8 W		5%	100-921X
R109C	322-0623-00	975 kΩ	1/4 W	Prec	1%	100-3629
R109C	322-0623-01	975 kΩ	1/4 W	Prec	1/2%	3630-up
R109E	321-0627-00	25.6 kΩ	1/8 W	Prec	1%	100-3629
R109E	321-0627-01	25.6 kΩ	1/8 W	Prec	1/2%	3630-up
R109G	317-0820-00	82 Ω	1/8 W		5%	100-921
R109G	317-0560-00	56 Ω	1/8 W		5%	922-up

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R110C	322-0624-00	990 kΩ	¼ W		Prec	1%	100-3629
R110C	322-0624-01	990 kΩ	¼ W		Prec	½%	3630-up
R110E	321-0614-00	10.1 kΩ	⅛ W		Prec	1%	100-3629
R110E	321-0614-01	10.1 kΩ	⅛ W		Prec	½%	3630-up
R110G	317-0151-00	150 Ω	⅛ W			5%	
R111C	322-0625-00	995 kΩ	¼ W		Prec	1%	100-3629
R111C	322-0625-01	995 kΩ	¼ W		Prec	½%	3630-up
R111D	317-0430-00	43 Ω	⅛ W			5%	X922-up
R111E	321-0613-00	5.03 kΩ	⅛ W		Prec	1%	100-3629
R111E	321-0613-01	5.03 kΩ	⅛ W		Prec	½%	3630-up
R111G	317-0151-00	150 Ω	⅛ W			5%	100-921
R111G	317-0201-00	200 Ω	⅛ W			5%	922-up
R112A	317-0560-00	56 Ω	⅛ W			5%	X922-up
R112C	322-0626-00	997.5 kΩ	¼ W		Prec	1%	100-3629
R112C	322-0626-01	997.5 kΩ	¼ W		Prec	½%	3630-up
R112E	321-0626-00	2.51 kΩ	⅛ W		Prec	1%	100-3629
R112E	321-0626-01	2.51 kΩ	⅛ W		Prec	½%	3630-up
R112G	317-0101-00	100 Ω	⅛ W			5%	X922-up
R114	317-0270-00	27 Ω	⅛ W			5%	
R115	322-0481-00	1 MΩ	¼ W		Prec	1%	100-3629
R115	322-0481-01	1 MΩ	¼ W		Prec	½%	3630-up
R117	317-0474-00	470 kΩ	⅛ W			5%	
R133	305-0203-00	20 kΩ	2 W			5%	
R134	308-0212-00	10 kΩ	3 W		WW	5%	
R136	316-0272-00	2.7 kΩ	¼ W				
R140	315-0181-00	180 Ω	¼ W			5%	
R141	315-0620-00	62 Ω	¼ W			5%	
R142	311-0169-00	100 Ω		Var			
R143	308-0302-00	20 kΩ	5 W		WW	1%	
R144	315-0101-00	100 Ω	¼ W			5%	100-2699
R144	315-0151-00	150 Ω	¼ W			5%	2700-up
R150	311-0178-00	200 Ω		Var			
R151	301-0391-00	390 Ω	½ W			5%	
R152	302-0390-00	39 Ω	½ W				100-715
R152	301-0180-00	18 Ω	½ W			5%	716-up
R155	316-0680-00	68 Ω	¼ W				100-715
R155	315-0101-00	100 Ω	¼ W			5%	716-up
R156	316-0680-00	68 Ω	¼ W				100-715
R156	315-0101-00	100 Ω	¼ W			5%	716-up
R159	316-0470-00	47 Ω	¼ W				
R160	315-0271-00	270 Ω	¼ W			5%	
R161	Use 311-0592-00	250 Ω		Var			
R163	308-0302-00	20 kΩ	5 W		WW	1%	

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R165	301-0202-00	2 kΩ	½ W			5%	
R167	311-0471-00	2 x1 kΩ		Var			
R169	301-0202-00	2 kΩ	½ W			5%	
R203	317-0560-00	56 Ω	⅛ W			5%	
R204	317-0560-00	56 Ω	⅛ W			5%	
R205C	322-0610-00	500 kΩ	¼ W		Prec	1%	100-3629
R205C	322-0610-01	500 kΩ	¼ W		Prec	½%	3630-up
R205E	322-0481-00	1 MΩ	¼ W		Prec	1%	100-3629
R205E	322-0481-01	1 MΩ	¼ W		Prec	½%	3630-up
R206C	322-0469-00	750 kΩ	¼ W		Prec	1%	100-3629
R206C	322-0469-01	750 kΩ	¼ W		Prec	½%	3630-up
R206E	321-0628-00	333 kΩ	⅛ W		Prec	1%	100-3629
R206E	321-0628-01	333 kΩ	⅛ W		Prec	½%	3630-up
R207C	322-0621-00	900 kΩ	¼ W		Prec	1%	100-3629
R207C	322-0621-01	900 kΩ	¼ W		Prec	½%	3630-up
R207E	321-0617-00	111 kΩ	⅛ W		Prec	1%	100-3629
R207E	321-0617-01	111 kΩ	⅛ W		Prec	½%	3630-up
R208C	322-0622-00	950 kΩ	¼ W		Prec	1%	100-3629
R208C	322-0622-01	950 kΩ	¼ W		Prec	½%	3630-up
R208E	321-0616-00	52.6 kΩ	⅛ W		Prec	1%	100-3629
R208E	321-0616-01	52.6 kΩ	⅛ W		Prec	½%	3630-up
R208G	317-0430-00	43 Ω	⅛ W			5%	100-921X
R209C	322-0623-00	975 kΩ	¼ W		Prec	1%	100-3629
R209C	322-0623-01	975 kΩ	¼ W		Prec	½%	3630-up
R209E	321-0627-00	25.6 kΩ	⅛ W		Prec	1%	100-3629
R209E	321-0627-01	25.6 kΩ	⅛ W		Prec	½%	3630-up
R209G	317-0820-00	82 Ω	⅛ W			5%	100-921
R209G	317-0560-00	56 Ω	⅛ W			5%	922-up
R210C	322-0624-00	990 kΩ	¼ W		Prec	1%	100-3629
R210C	322-0624-01	990 kΩ	¼ W		Prec	½%	3630-up
R210E	321-0614-00	10.1 kΩ	⅛ W		Prec	1%	100-3629
R210E	321-0614-01	10.1 kΩ	⅛ W		Prec	½%	3630-up
R210G	317-0151-00	150 Ω	⅛ W			5%	
R211C	322-0625-00	995 kΩ	¼ W		Prec	1%	100-3629
R211C	322-0625-01	995 kΩ	¼ W		Prec	½%	3630-up
R211D	317-0430-00	43 Ω	⅛ W			5%	X922-up
R211E	321-0613-00	5.03 kΩ	⅛ W		Prec	1%	100-3629
R211E	321-0613-01	5.03 kΩ	⅛ W		Prec	½%	3630-up
R211G	317-0151-00	150 Ω	⅛ W			5%	100-921
R211G	317-0201-00	200 Ω	⅛ W			5%	922-up
R212A	317-0560-00	56 Ω	⅛ W			5%	X922-up
R212C	322-0626-00	997.5 kΩ	¼ W		Prec	1%	100-3629
R212C	322-0626-01	997.5 kΩ	¼ W		Prec	½%	3630-up
R212E	321-0626-00	2.51 kΩ	⅛ W		Prec	1%	100-3629
R212E	321-0626-01	2.51 kΩ	⅛ W		Prec	½%	3630-up
R212G	317-0101-00	100 Ω	⅛ W			5%	X922-up
R214	317-0270-00	27 Ω	⅛ W			5%	
R215	322-0481-00	1 MΩ	¼ W		Prec	1%	100-3629

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R215	322-0481-01	1 MΩ	¼ W		Prec	½%	3630-up
R217	317-0474-00	470 kΩ	⅛ W			5%	
R233	305-0203-00	20 kΩ	2 W			5%	
R234	308-0212-00	10 kΩ	3 W		WW	5%	
R236	316-0272-00	2.7 kΩ	¼ W				
R240	315-0181-00	180 Ω	¼ W			5%	
R241	315-0620-00	62 Ω	¼ W			5%	
R242	311-0169-00	100 Ω		Var			
R243	308-0302-00	20 kΩ	5 W		WW	1%	
R244	315-0101-00	100 Ω	¼ W			5%	100-2699
R244	315-0151-00	150 Ω	¼ W			5%	2700-up
R250	311-0178-00	200 Ω		Var			
R251	301-0391-00	390 Ω	½ W			5%	
R252	302-0390-00	39 Ω	½ W				100-715
R252	301-0180-00	18 Ω	½ W			5%	716-up
R255	316-0680-00	68 Ω	¼ W				100-715
R255	315-0101-00	100 Ω	¼ W			5%	716-up
R256	316-0680-00	68 Ω	¼ W				100-715
R256	315-0101-00	100 Ω	¼ W			5%	716-up
R259	316-0470-00	47 Ω	¼ W				
R260	315-0271-00	270 Ω	¼ W			5%	
R261	Use 311-0592-00	250 Ω		Var			
R263	308-0302-00	20 kΩ	5 W		WW	1%	
R265	301-0202-00	2 kΩ	½ W			5%	
R267	311-0471-00	2 x 1 kΩ		Var			
R269	301-0202-00	2 kΩ	½ W			5%	
R311	301-0154-00	150 kΩ	½ W			5%	
R314	302-0103-00	10 kΩ	½ W				
R315	321-0207-00	1.4 kΩ	⅛ W		Prec	1%	
R317	321-0079-00	64.9 Ω	⅛ W		Prec	1%	
R318	321-0143-00	301 Ω	⅛ W		Prec	1%	
R321	301-0154-00	150 kΩ	½ W			5%	
R323	323-0147-00	332 Ω	½ W		Prec	1%	
R324	302-0103-00	10 kΩ	½ W				
R325	321-0207-00	1.4 kΩ	⅛ W		Prec	1%	
R327	321-0079-00	64.9 Ω	⅛ W		Prec	1%	
R328	321-0143-00	301 Ω	⅛ W		Prec	1%	
R329	321-0133-00	237 Ω	⅛ W		Prec	1%	
R332	302-0332-00	3.3 kΩ	½ W				
R333	302-0154-00	150 kΩ	½ W				
R334	302-0103-00	10 kΩ	½ W				
R335	302-0272-00	2.7 kΩ	½ W				
R340	Use 302-0151-00	150 Ω	½ W				
R342	302-0470-00	47 Ω	½ W				X2050-up
R343	303-0473-00	47 kΩ	1 W			5%	100-715

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R343	305-0243-00	24 kΩ	2 W			5%	716-up
R344	301-0471-00	470 Ω	½ W			5%	100-1629
R344	301-0471-00	470 Ω	½ W	Selected (nominal value)		5%	1630-up
R346	302-0101-00	100 Ω	½ W				
R348	321-0227-00	2.26 kΩ	⅛ W		Prec	1%	
R349	321-0213-00	1.62 kΩ	⅛ W		Prec	1%	
R351	308-0235-00	6.5 kΩ	10 W		WW	5%	
R352	308-0307-00	5 kΩ	3 W		WW	1%	
R353	321-0222-00	2 kΩ	⅛ W		Prec	1%	
R354	321-0105-00	121 Ω	⅛ W		Prec	1%	
R355	316-0470-00	47 Ω	¼ W				
R356	302-0680-00	68 Ω	½ W				
R357	304-0681-00	680 Ω	1 W				
R359	311-0362-00	500 Ω		Var			
R361	321-0131-00	226 Ω	⅛ W		Prec	1%	
R362	321-0189-00	909 Ω	⅛ W		Prec	1%	
R363	321-0222-00	2 kΩ	⅛ W		Prec	1%	
R364	321-0105-00	121 Ω	⅛ W		Prec	1%	
R365	316-0470-00	47 Ω	¼ W				
R373	301-0912-00	9.1 kΩ	½ W			5%	
R375	315-0510-00	51 Ω	¼ W			5%	
R377	311-0017-00	10 kΩ		Var			
R379	Use 311-0131-00	1 kΩ		Var			
R383	301-0912-00	9.1 kΩ	½ W			5%	
R385	315-0510-00	51 Ω	¼ W			5%	
R391	Use 308-0252-00	390 Ω	3 W		WW	5%	
R393	308-0089-00	1 kΩ	10 W		WW	5%	
R395	308-0183-00	500 Ω	10 W		WW	5%	
R396	311-0178-00	200 Ω		Var			
R411	301-0823-00	82 kΩ	½ W			5%	X716-up
R412	315-0622-00	6.2 k	¼ W			5%	X716-up
R413	303-0273-00	27 kΩ	1 W			5%	X716-up
R414	303-0243-00	24 kΩ	1 W			5%	X716-up
R415	311-0539-00	150 Ω		Var			X716-up
R421	315-0511-00	510 Ω	¼ W			5%	X716-up
R422	315-0392-00	3.9 kΩ	¼ W			5%	X716-up
R423	303-0303-00	30 kΩ	1 W			5%	X716-up
R424	303-0562-00	5.6 kΩ	1 W			5%	X716-up
R425	301-0105-00	1 MΩ	½ W			5%	X716-up

Switches

Ckt. No.	Unwired	Wired	Description	S/N Range
SW101	260-0621-00	Use *050-0281-00	Lever Channel 1 AC-DC-GND	100-921
SW105	260-0620-00		Rotary Channel 1 VOLTS/CM	
SW101	260-0621-00	*262-0694-00	Lever Channel 1 AC-DC-GND	922-1299
SW105	260-0673-00		Rotary Channel 1 VOLTS/CM	

Switches *(Cont)*

Ckt. No.	Tektronix Part No.		Description		S/N Range
SW101	260-0621-00	*262-0694-01	Lever	Channel 1 AC-DC-GND	1300-4229
SW105	260-0673-01		Rotary	Channel 1 VOLTS/CM	
SW101	260-0621-00	*262-0694-02	Lever	Channel 1 AC-DC-GND	4230-up
SW105	260-0673-02		Rotary	Channel 1 VOLTS/CM	
SW160	260-0583-00		Slide	Channel 1 PULL TO INVERT	
SW201	260-0621-00	Use *050-0281-00	Lever	Channel 2 AC-DC-GND	100-921
SW205	260-0620-00		Rotary	Channel 2 VOLTS/CM	
SW201	260-0621-00	*262-0694-00	Lever	Channel 2 AC-DC-GND	922-1299
SW205	260-0673-00		Rotary	Channel 2 VOLTS/CM	
SW201	260-0621-00	*262-0694-01	Lever	Channel 2 AC-DC-GND	1300-4229
SW205	260-0673-01		Rotary	Channel 2 VOLTS/CM	
SW201	260-0621-00	*262-0694-02	Lever	Channel 2 AC-DC-GND	4230-up
SW205	260-0673-02		Rotary	Channel 2 VOLTS/CM	
SW260	260-0583-00		Slide	Channel 2 PULL TO INVERT	
SW350	260-0622-00		Rotary	MODE	100-715
SW350A,B	260-0691-00		Rotary	MODE	716-up

Transformers

T301	*120-0346-00	Toroid, 2 turns bifilar
T310	*120-0346-00	Toroid, 2 turns bifilar
T340	*120-0343-00	Toroid, 3 windings

Electron Tubes

V133	Use *154-0306-02	7586, aged
V233	Use *154-0306-02	7586, aged
V364	154-0187-00	6DJ8

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FIGURE AND INDEX NUMBERS

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

INDENTATION SYSTEM

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

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

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

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

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

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

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

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

ABBREVIATIONS AND SYMBOLS

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

SECTION 9

MECHANICAL PARTS LIST

FIG. 1 EXPLODED VIEW

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-1	333-0810-00	100	715	1	PANEL, front
	333-0906-00	716		1	PANEL, front
-2	387-0952-00			1	PLATE, sub-panel
-3	366-0113-00			1	KNOB, charcoal—POSITION (CHANNEL 1)
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
-4	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-5	210-0207-00			1	LUG, solder, $^3/_8$ ID x $^5/_8$ inch OD, SE
	210-0012-00			1	LOCKWASHER, internal, $^3/_8$ ID x $^1/_2$ inch OD
-6	210-0840-00			1	WASHER, flat, 0.390 ID x $^9/_{16}$ inch OD
	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
-7	366-0189-00	X716		1	KNOB, red—TRIGGER SELECTOR
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x $^1/_8$ inch, HSS
-8	366-0113-00	100	715	1	KNOB, charcoal—MODE
	366-0175-00	716		1	KNOB, charcoal—MODE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
-9	260-0622-00	100	715	1	SWITCH, unwired—MODE
	260-0691-00	716		1	SWITCH, unwired—MODE
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, $^3/_8$ ID x $^1/_2$ inch OD
-10	210-0840-00			1	WASHER, flat, 0.390 ID x $^9/_{16}$ inch OD
	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
-11	366-0113-00			1	KNOB, charcoal—POSITION (CHANNEL 2)
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
-12	366-0142-00			1	KNOB, charcoal—VOLTS/CM (CHANNEL 1)
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
-13	366-0031-00			1	KNOB, red—VARIABLE (CHANNEL 1)
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
-14	262-0666-00	100	921	2	SWITCH, wired—VOLTS/CM
	262-0694-00	922	1299	2	SWITCH, wired—VOLTS/CM
	262-0694-01	1300		2	SWITCH, wired—VOLTS/CM
	- - - - - -			-	each switch includes:
	260-0620-00	100	921	1	SWITCH, unwired—VOLTS/CM
	260-0673-00	922	1299	1	SWITCH, unwired—VOLTS/CM
	260-0673-01	1300		1	SWITCH, unwired—VOLTS/CM
-15	337-0673-00			1	SHIELD, attenuator
-16	211-0007-00			2	SCREW, 4-40 x $^3/_{16}$ inch, PHS

FIG. 1 EXPLODED VIEW *(Cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-17	260-0621-00			1	SWITCH, lever—AC-DC-GND
	- - - - - -			-	mounting hardware: (not included w/lever switch)
	211-0105-00			2	SCREW, 4-40 x $^3/_{16}$ inch, FHS
-18	210-0586-00			2	NUT, keps, 4 40 x $^1/_4$ inch
-19	426-0201-00			1	FRAME, attenuator
	- - - - - -			-	frame includes:
	213-0020-00			1	SCREW, set, 6-32 x $^1/_8$ inch, HSS
-20	214-0272-00			2	GEAR, miter
	- - - - - -			-	each gear includes:
-21	213-0020-00			2	SCREW, set, 6-32 x $^1/_8$ inch, HSS
-22	384-0311-00			1	ROD, shaft
-23	358-0242-00			1	BUSHING, rod
-24	354-0177-00			1	RING, retaining
	- - - - - -			-	mounting hardware for each: (not included w/switch)
-25	358-0029-00	100	619	1	BUSHING, rod, $^3/_8$-32 x $^1/_2$ x 0.257 inch ID
	358-0249-00	620		1	BUSHING, rod, $^3/_8$-32 x $^1/_2$ x 0.272 inch ID
-26	210-0840-00			1	WASHER, flat, 0.390 ID x $^9/_{16}$ inch OD
-27	366-0142-00			1	KNOB, charcoal—VOLTS/CM (CHANNEL 2)
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
-28	366-0031-00			1	KNOB, red—VARIABLE (CHANNEL 2)
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
-29	366-0125-00			1	KNOB, plug-in securing
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^3/_{16}$ inch, HSS
-30	210-0894-00			1	WASHER, plastic, 0.190 ID x $^7/_{16}$ inch OD
-31	384-0510-00			1	ROD, securing
	- - - - - -			-	rod includes:
-32	354-0025-00			1	RING, retaining
-33	366-0215-00	100	1219	1	KNOB, lever—AC-DC-GND
	366-0215-01	1220		1	KNOB, lever—AC-DC-GND
-34	131-0342-00			2	CONNECTOR, 1 contact, BNC (w/hardware)
-35	358-0054-00			2	BUSHING, banana jack
	- - - - - -			-	mounting hardware for each: (not included w/bushing)
	210-0465-00			1	NUT, hex., $^1/_4$-32 x $^3/_8$ inch
	348-0031-00	X1310		1	GROMMET, plastic, $^3/_{32}$ inch diameter
-36	384-0310-00			2	ROD, slide switch, w/knob
-37	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-38	210-0494-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ x $^{11}/_{16}$ inch
-39	210-0255-00			1	LUG, solder, 0.391 inch ID
-40	358-0010-00			1	BUSHING, $^3/_8$-32 x 0.562 inch
-41	384-0313-00			2	ROD, extension

FIG. 1 EXPLODED VIEW *(Cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-42	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-43	210-0904-00			2	WASHER, fiber, 1/4 ID x 1/2 inch OD
-44	210-0914-00			1	WASHER, wavy, 0.320 ID x 0.492 inch OD
	210-0046-00			1	LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
-45	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-46	376-0029-00			2	COUPLING, shaft
	- - - - - -			-	each coupling includes:
	213-0075-00			2	SCREW, set, 4-40 x 3/32 inch, HSS
-47	384-0312-00	100	1159	2	ROD, inner shaft
	384-0276-00	1160		2	ROD, inner shaft
-48	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-49	210-0865-00			2	WASHER, fiber, 3/8 ID x 5/8 inch OD
-50	210-0902-00			1	WASHER, flat, 0.470 ID x 21/32 inch OD
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-51	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-52	376-0038-00	100	111	2	COUPLING, shaft
	- - - - - -			-	each coupling includes:
	213-0022-00			2	SCREW, set, 4-40 x 3/16 inch, HSS
	376-0010-00	112	1159	2	COUPLING, plastic
	376-0014-00	X112	1159X	2	COUPLING, wire
	354-0163-00	X112	1159X	2	RING, retaining
	376-0054-00	1160		2	COUPLING, flexible
	- - - - - -			-	each coupling includes:
-53	354-0251-00	X1160		1	RING, coupling
-54	213-0022-00			2	SCREW, set, 4-40 x 3/16 inch, HSS
-55	376-0046-00	X1160		1	COUPLING, plastic
-56	354-0261-00	X1160		1	RING, coupling
-57	213-0115-00			1	SCREW, set, 4-40 x 5/16 inch, HSS
-58	213-0075-00			2	SCREW, set, 4-40 x 3/32 inch, HSS
-59	407-0033-00	100	867	1	BRACKET, mounting
-60	407-0155-00	X716	867	1	BRACKET, mounting
-61	407-0156-00	868		1	BRACKET, mounting
	- - - - - -			-	bracket includes:
-62	211-0094-00	X716		2	SCREW, 4-40 x 1/2 inch, THS
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-63	136-0181-00	X716		2	SOCKET, transistor, 3 pin
-64	354-0234-00	X716		2	RING, socket mounting
-65	210-0204-00	X716		1	LUG, solder, DE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-66	348-0065-00	100	867	1	GROMMET, plastic, 0.422 inch diameter
-67	358-0215-00	868		1	BUSHING, plastic
-68	348-0031-00	X868		1	GROMMET, plastic, 3/32 inch diameter

FIG. 1 EXPLODED VIEW *(Cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-69	- - - - - -	X716		1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0438-00			2	NUT, hex., 1-72 x 5/32 inch
-70	406-0635-00	X716		1	BRACKET, plastic
	- - - - - -			-	mounting hardware: (not included w/bracket)
-71	213-0088-00			2	SCREW, thread forming, 4-40 x 1/4 inch, PHS
-72	441-0567-00			1	CHASSIS
	- - - - - -			-	mounting hardware: (not included w/chassis)
-73	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
	210-0006-00			2	LOCKWASHER, internal, #6
	211-0538-00			4	SCREW, 6-32 x 5/16 inch, FHS
-74	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-75	136-0014-00			1	SOCKET, tube, 9 pin
	- - - - - -			-	mounting hardware: (not included w/socket)
-76	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-77	136-0181-00			11	SOCKET, transistor, 3 pin
-78	354-0234-00			11	RING, socket mounting
-79	260-0583-00			2	SWITCH, slide—PULL TO INVERT
	- - - - - -			-	mounting hardware for each: (not included w/switch)
	213-0055-00			2	SCREW, thread forming, 2-32 x 3/16 inch, PHS
-80	214-0274-00			2	BALL, stainless steel
-81	214-0483-00			2	SPRING, detent
	- - - - - -			-	mounting hardware for each: (not included w/spring)
-82	361-0080-00			1	SPACER, detent spring, plastic
-83	213-0113-00			2	SCREW, thread forming, 2-32 x 5/16 inch, RHS
-84	407-0046-00			1	BRACKET, switch actuator, right
	- - - - - -			-	mounting hardware: (not included w/bracket)
-85	211-0542-00			1	SCREW, 6-32 x 5/16 inch, THS
-86	210-0975-00			1	WASHER, plastic, 0.140 ID x 0.375 inch OD
-87	136-0101-00			2	SOCKET, nuvistor, 5 pin
	- - - - - -			-	mounting hardware for each: (not included w/socket)
-88	213-0055-00			2	SCREW, thread forming, 2-32 x 3/16 inch, PHS
-89	131-0157-00			3	CONNECTOR, terminal stand-off
-90	348-0012-00	100	867	1	GROMMET, rubber, 5/8 inch diameter
	348-0064-00	868		1	GROMMET, plastic, 5/8 inch diameter
-91	352-0065-00			1	HOLDER, toroid, plastic
-92	361-0007-00			1	SPACER, plastic, 0.188 inch long
-93	200-0536-00			1	CAP, toroid, plastic

FIG. 1 EXPLODED VIEW *(Cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-94	210-0201-00			3	LUG, solder, SE #4
	- - - - - -			-	mounting hardware for each: (not included w/lug)
	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-95	337-0674-00			1	SHIELD, front
	- - - - - -			-	mounting hardware: (not included w/shield)
-96	210-0586-00			1	NUT, keps, 4-40 x 1/4 inch
-97	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-98	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, RHS
	210-0601-00			1	EYELET, 0.190 ID x 0.323 inch OD
	210-0478-00			1	NUT, hex., resistor mounting
	210-0202-00			1	LUG, solder, SE #6
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-99	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
-100	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, RHS
-101	210-0601-00			1	EYELET, 0.190 ID x 0.323 inch OD
-102	210-0478-00			1	NUT, hex., resistor mounting
-103	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-104	407-0047-00			1	BRACKET, mounting
	- - - - - -			-	mounting hardware: (not included w/bracket)
-105	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-106	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-107	210-0438-00			2	NUT, hex., 1-72 x 5/32 inch
-108	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
	211-0008-00	100	129	2	SCREW, 4-40 x 1/4 inch, PHS
	210-0004-00	100	129	2	LOCKWASHER, internal, #4
	210-0406-00	100	129	2	NUT, hex., 4-40 x 3/16 inch
	213-0088-00	130		2	SCREW, thread forming, 4-40 x 1/4 inch, PHS
-109	387-0951-00			1	PLATE, frame
-110	131-0017-00			1	CONNECTOR, 16 contact
	- - - - - -			-	mounting hardware: (not included w/connector)
-111	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0201-00			1	LUG, solder, SE #4
-112	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch

FIG. 1 EXPLODED VIEW *(Cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-113	407-0032-00			1	BRACKET, switch actuator, left
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0542-00			1	SCREW, 6-32 x $^5/_{16}$ inch, THS
	210-0975-00			1	WASHER, plastic, 0.140 ID x 0.375 inch OD
-114	384-0508-00	100	619	4	ROD, spacer, plug-in
	384-0631-00	620		4	ROD, spacer, plug-in
	- - - - - -			-	mounting hardware for each: (not included w/rod)
-115	212-0044-00			1	SCREW, 8-32 x $^1/_2$ inch, RHS
-116	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware : (not included w/resistor)
	210-0840-00			1	WASHER, flat, 0.390 ID x $^9/_{16}$ inch OD
	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
-117	131-0276-00	X716		1	CONNECTOR, coaxial, 1 contact, BNC (w/hardware)
-118	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0255-00			1	LUG, solder, 0.391 inch ID
	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
-119	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
	211-0553-00			1	SCREW, 6-32 x 1$^1/_2$ inches, RHS
	210-0601-00			1	EYELET, 0.190 ID x 0.323 inch OD
	210-0478-00			1	NUT, hex., resistor mounting
	210-0203-00			1	LUG, solder, SE #6, long
	211-0507-00			1	SCREW, 6-32 x $^5/_{16}$ inch, PHS
-120	210-0204-00			2	LUG, solder, DE #6
	- - - - - -			-	mounting hardware for each: (not included w/lug)
	213-0044-00			1	SCREW, thread forming, 5-32 x $^3/_{16}$ inch, PHS
-121	124-0156-00	X716	867	2	STRIP, ceramic, $^7/_{16}$ inch h, w/13 notches
	124-0147-00	868		2	STRIP, ceramic, $^7/_{16}$ inch h, w/13 notches
	- - - - - -			-	each strip includes:
	355-0082-00	716	867	2	STUD, plastic
	355-0046-00	868		2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0008-00			2	SPACER, plastic, 0.281 inch long
-122	124-0147-00			6	STRIP, ceramic, $^7/_{16}$ inch h, w/13 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long

FIG. 1 EXPLODED VIEW *(Cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Q t y	Description 1 2 3 4 5
1-123	124-0145-00			4	STRIP, ceramic, $^{7}/_{16}$ inch h, w/20 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-124	179-0903-00	100	867	1	CABLE HARNESS, chassis
	179-0985-00	X716	867	1	CABLE HARNESS, chassis (partial)
	179-0986-00	868		1	CABLE HARNESS, chassis
-125	352-0017-00	X3120		2	HOLDER, plastic
	- - - - - -			-	mounting hardware for each: (not included w/holder)
	361-0007-00			1	SPACER, plastic, 0.188 inch long

STANDARD ACCESSORIES

	070-0430-01			2	MANUAL, instruction (not shown)

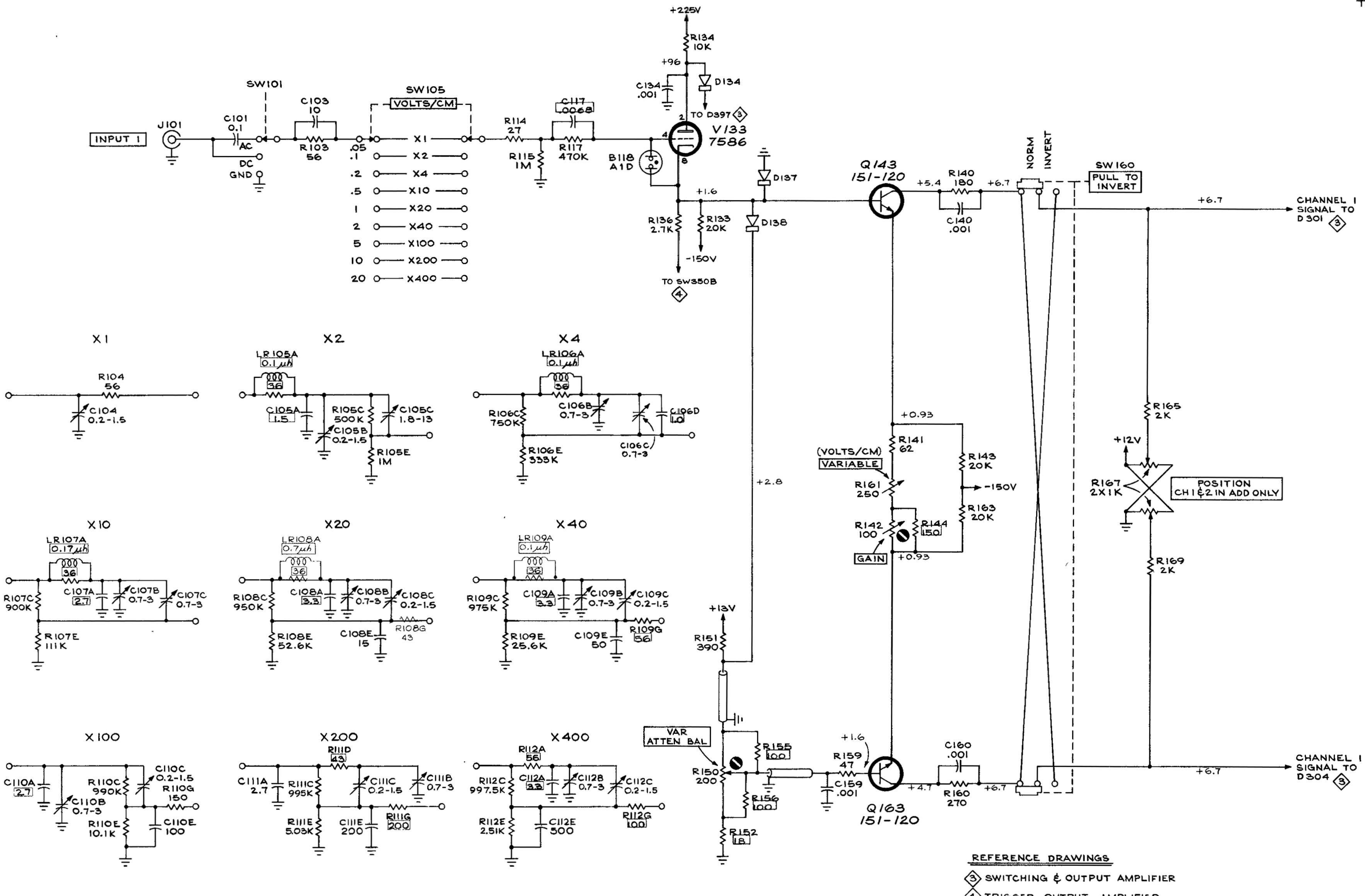
IMPORTANT

ALL WAVEFORMS were obtained with the Type 1A2 operating in Type 547 Oscilloscope with the control settings as follows:

Type 547	
TIME/CM (A and B)	10 μsec/cm
TRIGGERING LEVEL (A and B)	Top ALT position
MODE (A and B)	AUTO STABILITY
SINGLE SWEEP Switch	NORMAL
Other controls	Any position
Type 1A2	
POSITION (both)	Midrange
MODE	ALT
AC DC-GND (both)	GND
Other controls	Any position

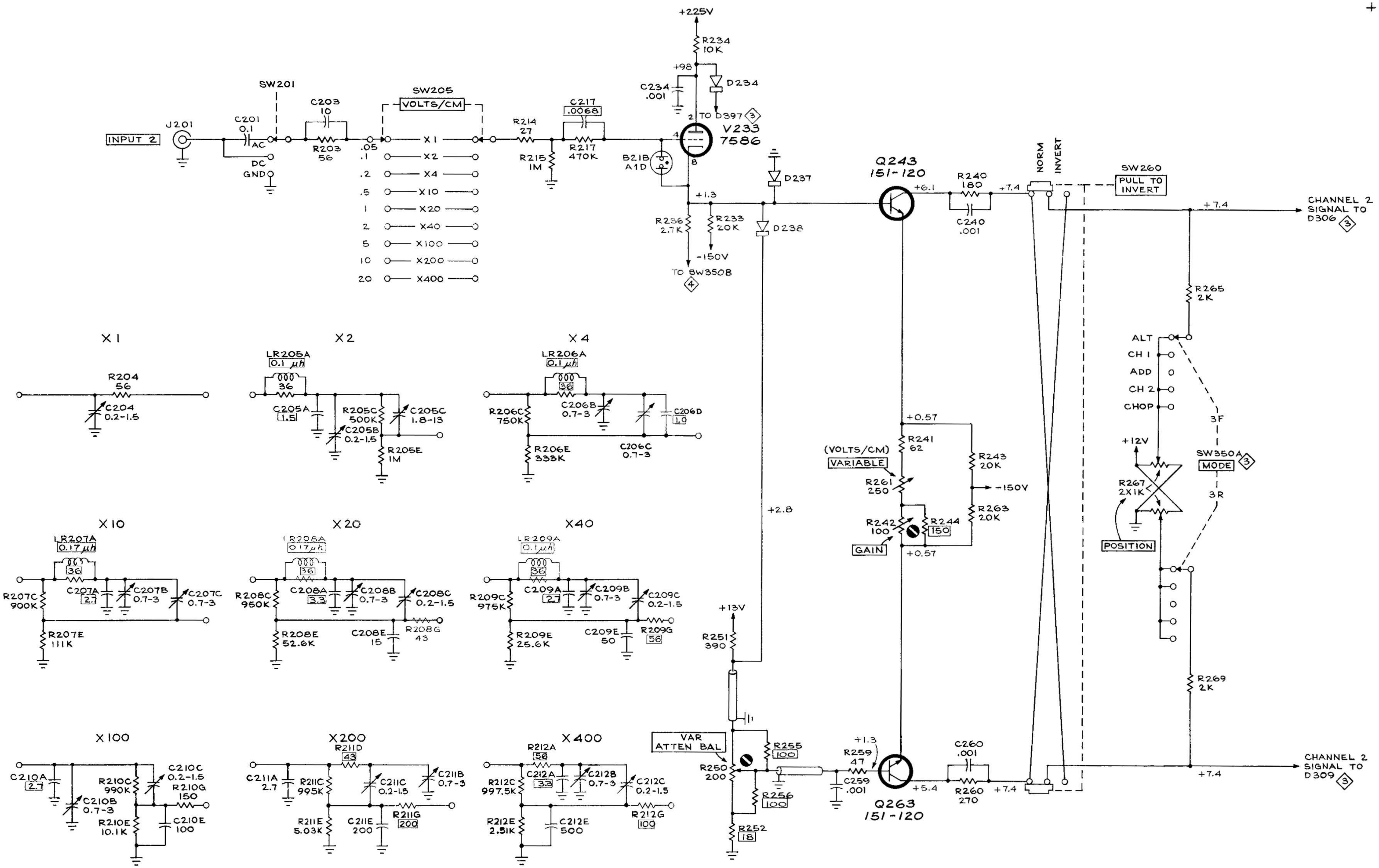
ALL VOLTAGES were obtained with a 20,000 ohm/volt meter with the Type 1A2 operating in a Type 547 Oscilloscope. Set the controls of the Type 1A2 as follows:

POSITION (both)	Midrange
MODE	CH 1
AC-DC-GND	GND
Other controls	Any position



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

DON 467



REFERENCE DRAWINGS

3 SWITCHING & OUTPUT AMPLIFIER

4 TRIGGER OUTPUT AMPLIFIER

SEE IMPORTANT NOTE ON CHANNEL 1 INPUT AMPLIFIER DIAG.

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

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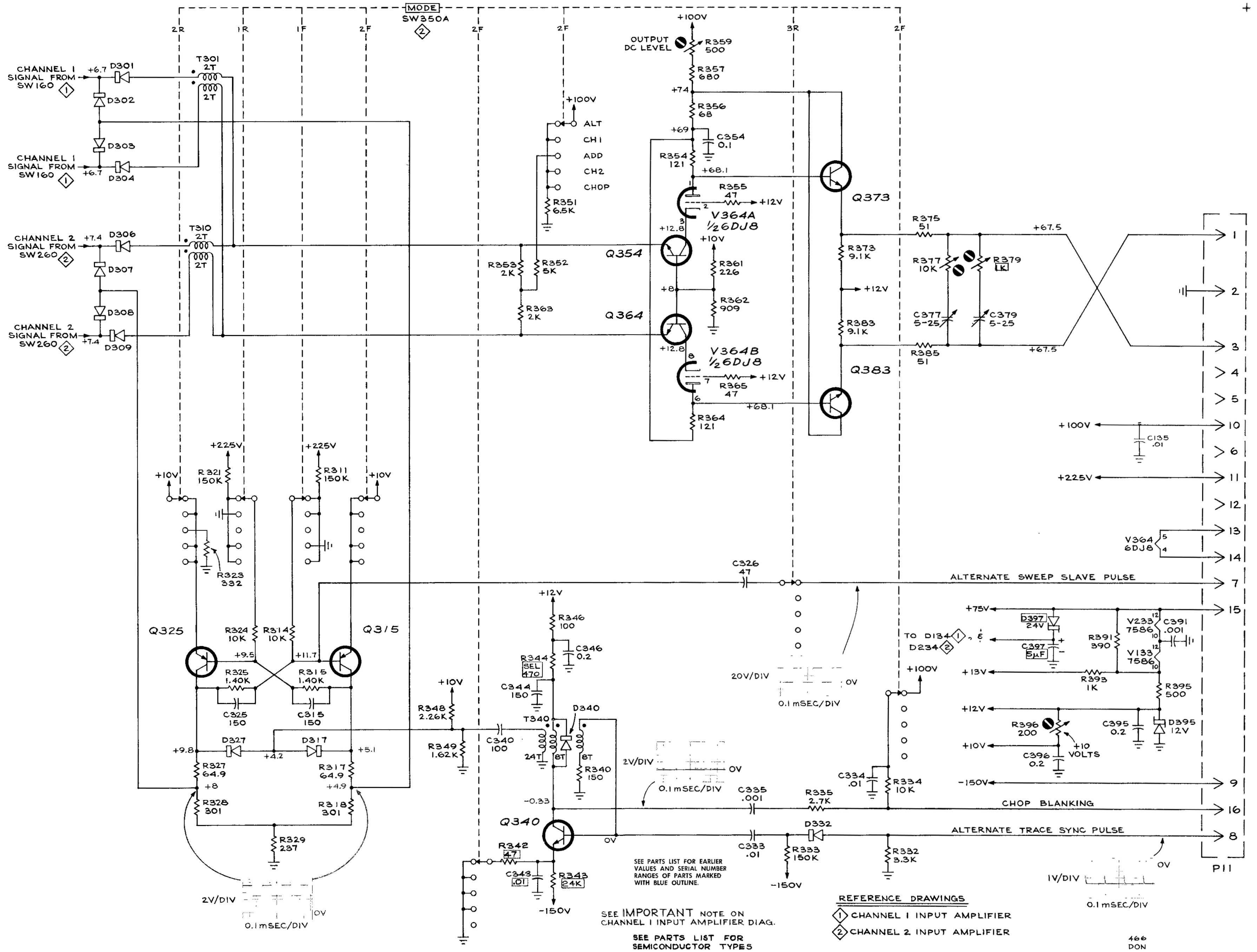
TYPE 1A2 PLUG-IN

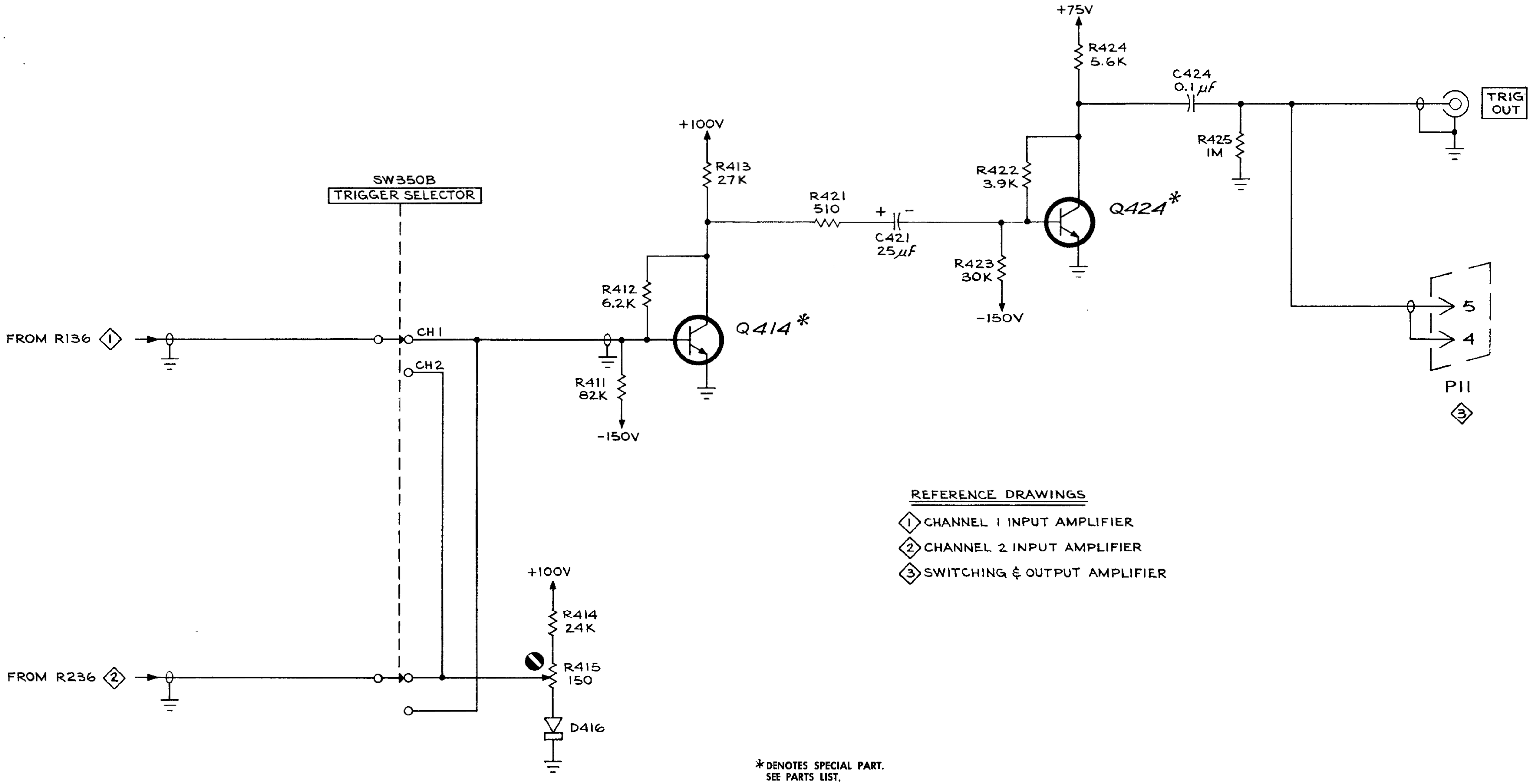
CHANNEL 2 INPUT AMPLIFIER 2



TYPE 1A2 PLUG-IN

E4

SWITCHING & OUTPUT AMPLIFIER 3



REFERENCE DRAWINGS

1 CHANNEL 1 INPUT AMPLIFIER

2 CHANNEL 2 INPUT AMPLIFIER

3 SWITCHING & OUTPUT AMPLIFIER

*DENOTES SPECIAL PART. SEE PARTS LIST.

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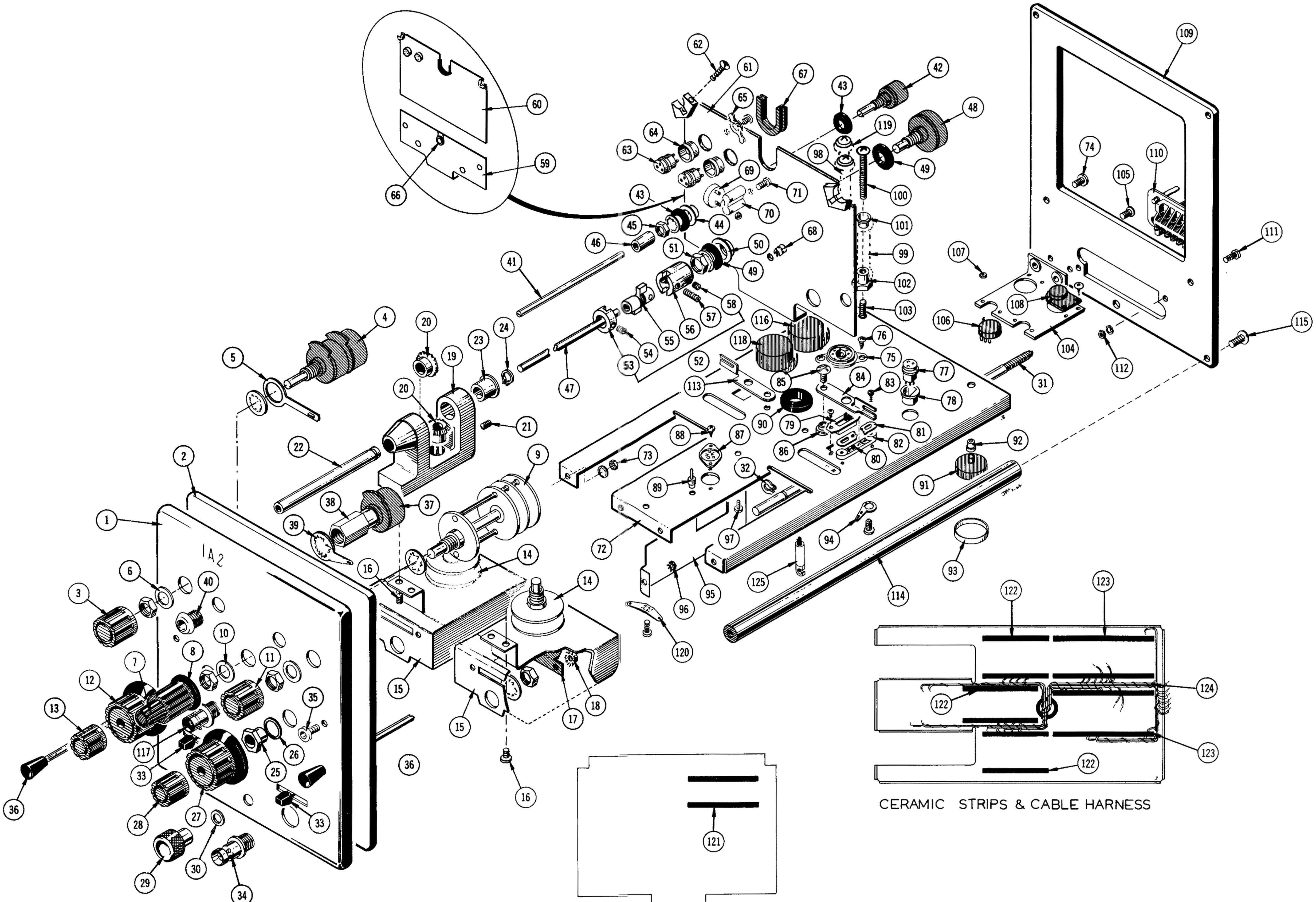
FIG. 1 EXPLODED VIEW



TYPE 1A2 DUAL TRACE PLUG-IN UNIT

MANUAL CHANGE INFORMATION

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

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

TEXT CORRECTION

Section 6 Performance Check

Page 6-3 Column 2, Step 9(d)

ADD: Amount of shift depends on symmetry of calibrator signal and amount of grid current.