INSTRUCTION MANUAL

Serial Number 338

TYPE 4S3

SAMPLING-PROBE DUAL-TRACE UNIT

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Specifications and price change privileges reserved.

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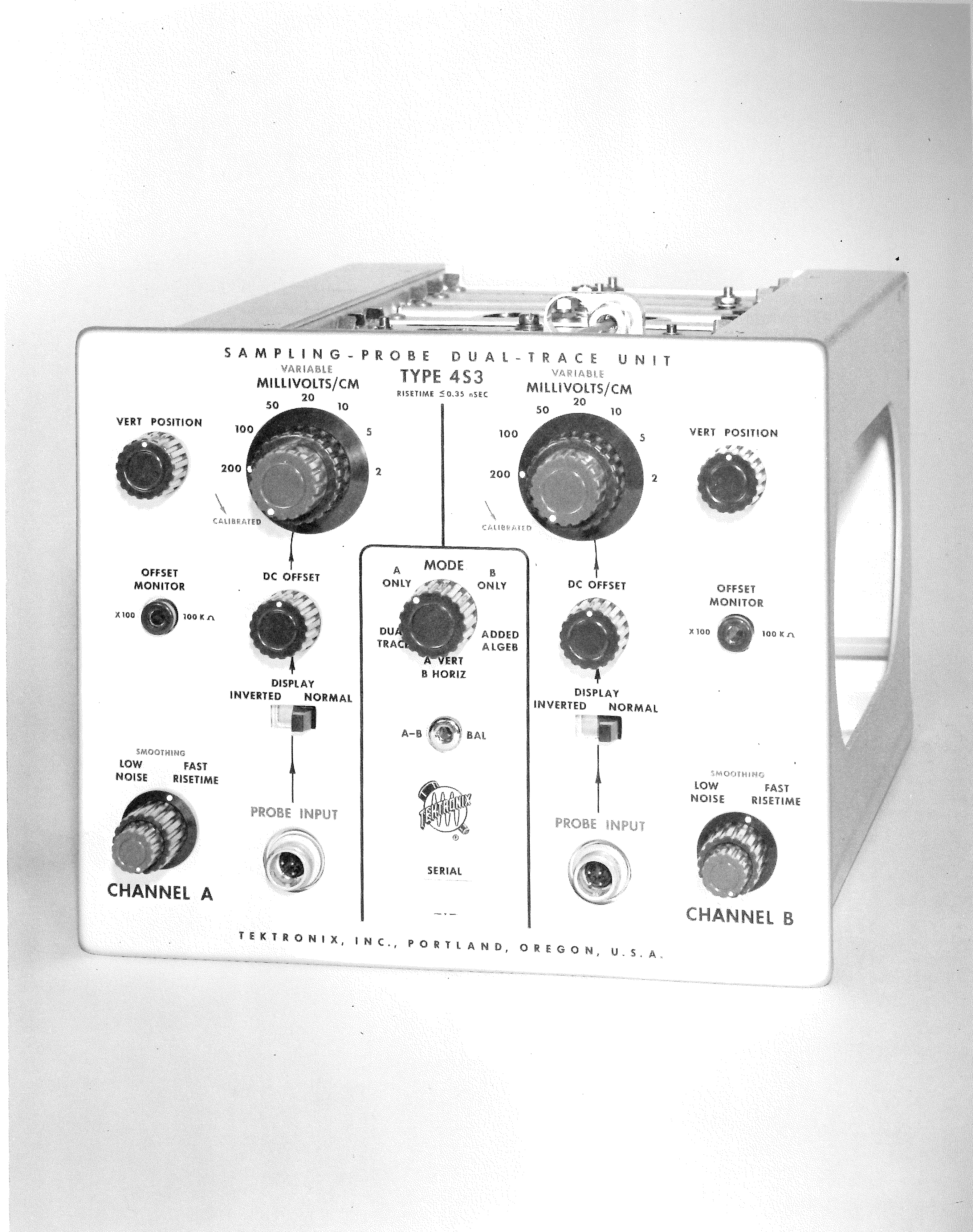
A list of abbreviations and symbols used in this manual will be found on page 6-1.



The Type 4S3 Sampling-Probe Dual-Trace Unit.

SECTION 1
CHARACTERISTICS

General Information

The Tektronix Type 4S3 Sampling-Probe Dual-Trace Unit is a vertical channel plug-in unit for the Type 661 Oscilloscope. The Type 4S3, operated with P6038 Probes, has a basic risetime of 0.35 nsec or less when the signal source impedance is 50 ohms and the Noise-Risetime switch is at FAST RISETIME. The LOW NOISE position provides a system risetime of approximately 0.5 nsec. The P6038 sampling probe has a low-frequency input resistance of 100 k paralleled by about 2 pf. The system is capable of presenting accurate single- or dual-trace displays of repetitive high-speed signals with fractional-nanosecond risetime. By taking successive samples of a repetitive signal, each sample at a slightly later time with respect to the previous sample, the system reconstructs the signal on an equivalent time base.

ELECTRICAL CHARACTERISTICS

Maximum Signal Input

	Linear Display	Momentary Dc or Ac Peak Overload
Probe Only	± 2 volts	10 volts
Probe and 10X Attenuator	±20 volts	100 volts
Probe and Response Normalizer	± 2 volts	10 volts
Probe and Ac Coupling Capacitor	±20 volts	100 volts

Input Capacitance

Probe Only	2 pf ±10%
Probe and 10X Attenuator	1.8 pf ±10%
Probe and Response Normalizer	4 pf ±10%

Input Resistance

Probe Only	100 k ±1%
Probe and 10X Attenuator	1 meg ±1.5%
Probe and Response Normalizer	100 k ±1.5%

Ac Coupling Capacitor

Capacitance 1000 pf min. 100 volts

Approximate Low-Frequency 3-db Point

Probe Only	1.5 kc
Probe and 10X Attenuator	150 cycles
Probe and Response Normalizer	1.5 kc

Signal Performance

Typical values of performance for signals from a 50- and a 300-ohm source (±1%) are listed in Table 1-1. Typical sine-wave response is shown in Fig. 1-1.

Deflection Factors

Calibrated steps of 2, 5, 10, 20, 50, 100 and 200 mv/cm. Accuracy: DISPLAY switch at NORMAL—10 through 200 mv/cm ±3%, 2 and 5 mv/cm ±4%; DISPLAY switch at INVERTED—10 through 200 mv/cm ±3.5%, 2 and 5 mv/cm ±4.5%. A VARIABLE control with a 3:1 range permits an uncalibrated sensitivity increase, thus decreasing the deflection factor of each setting of the MILLIVOLTS/CM switch. The 2 mv/cm factor can therefore be changed to be about 2/3 mv/cm.

Triggering

External to Timing Unit. Pretrigger must arrive at Timing Unit external trigger input connector about 50 nsec prior to

TABLE 1-1

Input	Source Impedance	Risetime in nsec	Overshoot in %	Noise in mv	Risetime in nsec	Overshoot in %	Noise in mv
		FAST RISETIME			LOW NOISE		
Probe Only	50 Ω	≤0.35	3	1	0.5	2	≤0.5
	300 Ω	1.5	0	1.5	1.5	0	1
Probe and Coupling Capacitor	50 Ω	0.37	5	1	0.5	4	0.5
	300 Ω	2.5	0	1.5	2.5	0	1
Probe and 10X Attenuator	50 Ω	0.38	4	1.2	0.5	3	0.5
	300 Ω	1.5	0	1.5	1.5	0	0.5
Probe and Response Normalizer	50 Ω	1.5	0	1.5	1.5	0	1
	300 Ω	5	0	1.5	5	0	1

Risetime is 10% to 90%.

Overshoot is peak aberration of first 1 nsec of square-pulse display.

Noise is for single-channel operation at unity loop gain; multiply figures by 1.5 for combined-trace operation.

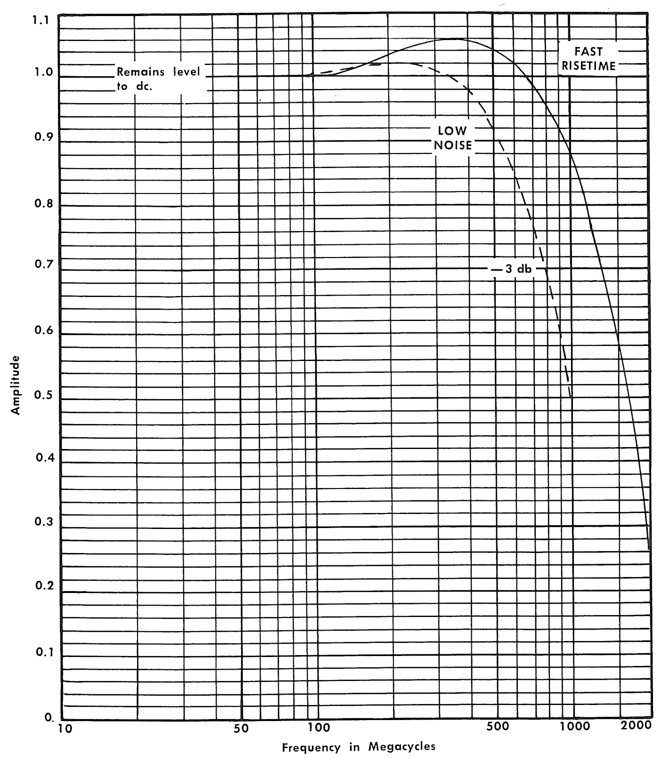


Fig. 1-1. Type 4S3-P6038 Probe typical sine-wave response from 50-ohm signal source. Graph is fraction of display amplitude vs frequency for both positions of the Noise-Risetime switch.

arrival of signal at input to P6038 Probe when sweep rate is 1 nsec/cm. Pretrigger can arrive at Timing Unit more than 50 nsec ahead of signal to probe at slower sweep rates.

Operating Modes

A Only, B Only, Dual Trace, Added Algebraic, and A Vertical—B Horizontal (X-Y operation). The dual-trace switching frequency is approximately 50 kc.

Rejection ratio for Added Algebraic mode is 40:1 or better when each channel is driven with a 1-volt flat-top pulse and the deflection factor is 50 mv/cm, each channel. At 200 mv/cm, added algebraically, a 4-cm identical signal in each channel will produce an 8-cm display, ±1.5 mm.

Display

Normal or Inverted, permitting the addition or subtraction of dual-trace displays. Valuable in X-Y displays for observation of hysterisis loops, or for inverting the phase of signals into or out of an amplifier for phase comparison. Inverted operation can add an additional error to the deflection factors. With the Type 661 vertical signal output at zero, and Type 4S3 at 200 mv/cm, the trace will not shift more than 0.5 cm when switching the DISPLAY switch.

Smoothing

Each channel SMOOTHING control permits adjustment of the dot transient response. The dot transient response can be made correct for source impedances from less than 50 ohms to at least 300 ohms when the Noise-Risetime switch is at LOW NOISE; from less than 50 ohms to some higher value (depending on source capacitance) when the switch is at FAST RISETIME.

Dc Offset

The dc component of a signal may be offset up to ±1 volt (with a five-turn control) to either bring a display back onto the crt, or to make an incremental measurement.

Signal Outputs to Type 661

(The Type 661 signal output terminals are connected directly to the plug-in unit circuits through the interconnecting socket.) The signal output voltages are within 3% of a 1-volt signal applied to the input connectors when the deflection factor is 200 mv/cm. (Does not include crt display accuracy.) Output impedance is 10 k.

Dot Slash

The sampling dot vertical stability is such that no dot slash is visible when triggering at a rate above about 150 cps. At a triggering rate of 50 cps, at 200 mv/cm, the dot slash will not exceed 2 mm.

Co-Channel Time Coincidence

Dual-trace display of a fast-rise pulse will produce no more than 60-psec time difference between channels.

Mechanical

Construction: Aluminum-alloy chassis with six plug-in subchassis.

Finish: Anodized panel.

Dimensions: Height 7 inches, width 8½ inches, depth 14 inches.

Accessories

Information on accessories for use with this instrument is included at the rear of the mechanical parts list.

SECTION 2

OPERATING INSTRUCTIONS

CAUTION

ALWAYS TURN OFF THE OSCILLOSCOPE POWER BEFORE INSERTING OR REMOVING PLUG-IN UNITS.

General Information

The Type 4S3 with P6038 Probes is part of a wide-band, high input impedance dual-channel servo-type, slide-back sampling system. Each channel employs a miniature probe that contains the sampling gate. The sampled signal drives a rachet memory that sets the vertical dot position after each sample is taken. The sampling principle is essentially that of an error signal device that corrects a memory output voltage each time a sample is taken. (See "Sampling Notes", Tektronix publication number 061-557.) An external trigger pickoff or other source of triggering signal is required by the associated timing unit.

A minimum deflection factor of about 2/3 mv/cm at the probe input may be employed to view low-level signals or portions of signals with a peak-to-peak value up to 1 volt. High-resolution amplitude measurements may be made on any waveform, or on any part of a waveform, through the use of the ±1-volt DC OFFSET control. A front-panel OFFSET MONITOR jack permits voltmeter measurements of the offset voltage at 100 times the internal ±1-volt maximum signal offset value.

At minimum deflection factors, random noise can be reduced by use of the SMOOTHING control. Smoothing will not significantly affect the display risetime, but will reduce noise if each sample taken represents only a small increment of the total signal amplitude.

FUNCTION OF FRONT-PANEL CONTROLS AND CONNECTORS

MODE Switch—Selects one of five operational modes.

A ONLY: Only Channel A is displayed.

B ONLY: Only Channel B is displayed.

DUAL TRACE: Each channel has its own display, switched between channels at about 50 kc.

ADDED ALGEB: Both channels are combined to display the algebraic sum or difference of two signals as a single trace.

A VERT-B HORIZ: With the Type 661 SWEEP MAGNIFIER at X1, Channel A controls the vertical deflection and Channel B controls the horizontal deflection. Permits X-Y operation at full bandwidth.

VERT POSITION Control (Both Channels)—Permits moving the trace about 10 cm vertically.

MILLIVOLTS/CM Switch (Both Channels)—Selects the desired vertical deflection factor. For example, with the MILLIVOLTS/CM switch at 100, each major division (cm) of vertical deflection corresponds to 100 millivolts of applied signal. 10X attenuator changes this to 1 volt/cm.

VARIABLE Control (Both Channels)—3:1-range uncalibrated control permits increased system gain at each position of the MILLIVOLTS/CM switch. Minimum deflection factor (maximum gain) is then about 2/3 millivolt/cm.

SMOOTHING Control (Both Channels)—A gain control in the Ac Amplifier that permits adjustment of the sampling system loop gain. With the Noise-Risetime switch at LOW NOISE, the loop gain can be set to unity for a source-impedance range from less than 50 ohms to at least 300 ohms. With the Noise-Risetime switch at FAST RISETIME, the loop gain can be set to unity for a source-impedance range from less than 50 ohms to some higher value depending upon the source capacitance at the tip of the P6038 Probe.

Time jitter and/or amplitude noise may be objectionable when operating at minimum deflection factors or maximum sweep rates. This is important when making documentation photographs. Turning the SMOOTHING control counterclockwise reduces the loop gain of the automatic slide-back feed-back system to allow random noise reduction. (See "Sampling Notes" publication, pages 5 and 6, for additional information about using the SMOOTHING control.) When measuring signals at unknown source impedances, always start with the SMOOTHING control fully counterclockwise.

To test for proper position of the SMOOTHING control, increase the Timing Unit samples/cm by a factor of 2 or more and observe the amount of display change. If the change is insignificant, the SMOOTHING control is not substantially affecting the dot transient response. The transient response will always be proper at 1000 samples/cm with the SMOOTHING control fully counterclockwise. See "Unity Loop Gain" near the end of this section.

NOISE-RISETIME Switch (Both Channels)—A switch that changes the conduction time of the probe sampling bridge at the time of each sample. The FAST RISETIME position sets the bridge conduction time for a risetime of 0.35 nsec or less. The LOW NOISE position sets the bridge conduction time to about 0.5 nsec and reduces the sampling system display noise.

DC OFFSET Control (Both Channels)—Applies an internal signal-offset voltage of −1 to +1 volt. May be used to effectively cancel a dc component in the presence of a small ac signal. Permits a chosen portion of the waveform to remain relatively fixed on the crt when the vertical deflection factor is changed. By monitoring the voltage at the OFFSET MONITOR jack, highly accurate display voltage-difference measurements can be made.

OFFSET MONITOR Jack (Both Channels)—The voltage at this jack is 100 times the offset voltage applied to the vertical signal. Useful for making voltage-difference measurements of all or part of the displayed signal. By positioning a display with the DC OFFSET control, the difference between two voltage levels can be accurately measured.

DISPLAY Switch (Both Channels)—In the NORMAL position, the crt display has the same polarity as the applied signal, + up and − down. Placing one DISPLAY switch at NORMAL, the other at INVERTED, and the MODE switch at ADDED ALGEB permits the difference of two signals to be presented as a single trace.

A-B BAL Control—Screwdriver adjustment of the Channel A gain. (Channel B gain adjustment is internal.) The A-B BAL control permits the gain of Channel A to be adjusted ±10% to equal the Channel B gain. Useful when making common-mode and/or differential measurements.

PROBE INPUT (P6038 Probe Connector)—Each channel has its own P6038 Probe. Probes may be disconnected and may be interchanged but recalibration will be necessary. If probes are interchanged, most internal adjustments require recalibration. Channel A probe is marked blue and Channel B probe is marked red for easy identification.

Signal Outputs to the Type 661 Oscilloscope

The Type 4S3 has two auxiliary output signals in addition to the regular vertical signals to the crt. The two outputs are connected internally to the Type 661 front panel and are available at the connectors labeled SIGNAL OUTPUTS, VERT A and VERT B, both at 200 mv/cm through 10 k. External loading of the signal output leads will not disturb normal sampling operations or the crt display. The two auxiliary outputs are for use by external analog paper recorders or oscilloscope monitors.

PRELIMINARY INSTRUCTIONS

CAUTION

TURN POWER OFF BEFORE INSERTING OR REMOVING PLUG-IN UNITS.

Since the Type 4S3 is part of a complete sampling system, we suggest that you read the Operating Instructions section of both the Type 661 Oscilloscope and the Timing Unit instruction manuals before proceeding.

Installing the Type 4S3 into the Type 661 Oscilloscope

With the Type 661 power off, place the gray locking latch perpendicular to the oscilloscope front panel, then push the Type 4S3 as far into the cell as possible. Lock the Type 4S3 in place by moving the locking latch flush with the front panel.

To remove the Type 4S3, first turn off the power, then move the gray locking latch perpendicular to the front panel and remove the unit.

FIRST-TIME OPERATION

The Type 4S3 is calibrated to operate in any Type 661 Oscilloscope. There are small differences in Type 661 power supplies that may be apparent when operating the Type 4S3 at 2 or 5 millivolts/cm. Thus, a small adjustment may be needed when the unit is first installed.

Connect the two P6038 Probes to the PROBE INPUT connectors. Mate the probe color to the panel color.

Balance Procedure

1. Turn on the Type 661 power and set the Timing Unit controls for a 10-nsec/cm free-running sweep and 100 samples/cm.

2. Set the Type 4S3 Controls as follows:

VERT POSITION	Midrange
MILLIVOLTS/CM	200
Noise-Risetime	LOW NOISE
DISPLAY	NORMAL
MODE	A ONLY
SMOOTHING	Fully counterclockwise
DC OFFSET	Zero volts at OFFSET MONITOR jack.

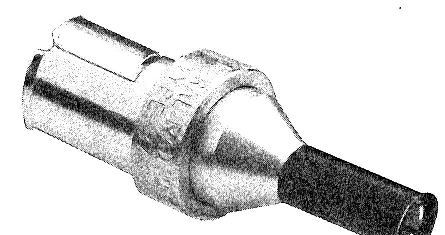


Fig. 2-1. Special GR-to-P6038 Adapter for connecting the P6038 Probe to a 50-ohm line.

3. Place the P6038 Probe tip into a 50-ohm environment, such as shown in Fig. 5-2. Use a 50-ohm cable and a GR-to-P6038 Adapter. The adapter is a special item, available from Tektronix (Part No. 017-076). See Fig. 2-1. The electrical length of the cable need be no longer than 2 nsec and its other end can be left open since its electrical length is much longer than the gate-generator pulse duration, and the probe sees the 50-ohm line only during the gate time.

4. Let the instrument warm up for 30 minutes. Center the trace with the VERT POSITION control.

5. Set the MILLIVOLTS/CM switch to 10. If the trace shifts more than 3 cm, check that the probe tip is secure in the 50-ohm environment. Recenter the trace with the DC OFFSET control.

6. Remove the Type 661 left side-panel.

7. Locate the A RISETIME BAL control. Switch to FAST RISETIME. Use an insulated screwdriver and recenter the trace with the A RISETIME BAL control.

8. Switch to LOW NOISE. Set the MILLIVOLTS/CM switch to 2. Recenter the trace with the DC OFFSET control.

9. Repeat step 7. The final adjustment of the A RISETIME BAL control should limit the trace shift to 2 cm or less when switching the Noise-Risetime switch between its two positions.

10. Repeat the procedure for Channel B using the B RISETIME BAL control.

The P6038 probe(s) will now operate in balance for either low-noise or fast-risetime operation for source impedances from 50 to at least 300 ohms. The DC OFFSET control must be adjusted (as in the balance procedure) for each different source impedance if it is desired that the trace shift be minor when switching the Noise-Risetime switch. This type of operation is not always necessary, but can be of value when signal tracing and then making a quick risetime measurement. See "Signal Searching—Signal Analyzing Suggestions" at the end of this section.

Using the P6038 Probe

The P6038 Probes can be used to signal trace directly within a test circuit, or can be inserted into special chassis or coaxial fittings. (The test point jack provided with the probe adds about 0.6 pf to the probe input.) The signal source impedance must be low when measuring pulses with risetimes near the system limit.

The P6038 Probe can be compared with any standard oscilloscope probe. The bandwidth (risetime) is limited by internal circuitry, and by the source resistance-input capacitance time constant. However, the P6038 input capacitance is quite low, nominally 2 pf, allowing a very fast response to low-impedance signals.

The major difference between the P6038 and a standard attenuator probe is the sampling circuit. A small signal is sent out the probe tip to the signal source at each sample. This can be reduced a factor of ten by using the 10X Attenuator. Normal sampling-pulse kickout (system at equilibrium) is less than 50 mv, and less than 5 mv with the 10X Attenuator. The kickout is not seen by the sampling system, and if more than about 1/3-nsec delay cable is used between the signal source and the probe tip, the kickout is lost before the next sample is taken.

Source Impedance Sensitivity

The probe input is sensititve to both source resistance and capacitance, and the system dot-transient response varies as the input-circuit impedance is varied. The no-signal trace level will shift vertically as the signal source impedance is changed. This is caused by the small amount of kickout from the probe tip. It is impossible to select perfectly equal input bridge diodes, and their minor differences cause the small kickout signal when the system is at equilibrium. (The kickout pulse is a bit larger during the time the sampling bridge is responding to a change in signal level.)

The probe tip is not critically damped when measuring very low impedance signal sources. The probe tip is a short length of wire between the very tip and the sampling bridge. The tip has about 2 nh of inductance. Combined with the input capacitance of about 2 pf, the input tip will ring when driven from an impedance less than about 33 ohms. The ringing is obvious when the Noise-Risetime switch is at FAST RISETIME and the probe sees an impedance less than 50 ohms. Ringing is less when the switch is at LOW NOISE. For this reason, the Characteristics section of this manual shows risetime figures for signal sources of no less than 50 ohms.

Response Normalizer

To make the probe input insensitive to source impedance, a special nonattenuating Response Normalizer is provided. Placing it on the tip of a probe lets the probe sampling gate look into a constant 300-ohm source impedance during the time each sample is taken. Thus, there will be essentially no base-line trace shift due to different source impedances.

The Response Normalizer, however, adds about 2 pf to the probe input capacitance. The system risetime is now limited because the sampling gate is fed through 300 ohms in series with the signal source impedance. Without the normalizer, the probe input is 100 k, paralleled by 2 pf and has a 0.35-nsec risetime. With the normalizer, the probe input is 100 k, paralleled by 4 pf and has a risetime of 1.5 nsec. The advantage of the Response Normalizer is that its use eliminates the display base-line shift as the signal source impedance is changed.

Using the Response Normalizer on a 1000-ohm source-impedance signal produces about a 10-nsec risetime display. This is due to the input time constant limiting the voltage rise rate to the probe input.

10X Attenuator

A second method for making the probe input insensitive to source impedance is to use the 10X Attenuator. This is particularly valuable when measuring signals greater than 2 volts peak-to-peak. Using the 10X Attenuator on a 1000-ohm source-impedance signal produces a 5- or 6-nsec risetime display. Thus, the attenuator has less input capacitance than the Response Normalizer.

The 10X Attenuator is correctly frequency compensated as it leaves the factory. Each attenuator is color coded to be used with one probe only. See the P6038 Probe instruction manual for compensation procedure.

Coax-To-Probe Adapters

The following three special adapters are available for mating the P6038 Probe to coaxial systems. Their use is described here.

GR-To-P6038 Adapter. The P6038 Probe can be used at the end of an unterminated 50-ohm system (System 5 of Table 2-1) with some precautions. Fig. 2-1 shows the GR-To-P6038 Adapter. (Tektronix Part No. 017-076.)

BNC-To-P6038 Adapter. Identical in function to the GR-To-P6038 Adapter, but for cables fitted with BNC connectors. (Tektronix Part No. 013-0084-00.)

Voltage Pickoff Adapter. The Tektronix Voltage-Pickoff Adapter VP-2 (System 8 of Table 2-1) permits using the P6038 Probe to look at signals within a closed 50-ohm system with negligible effect on the signal (see Fig. 2-2). The VP-2 makes it unnecessary to use a 25-ohm source for the P6038 Probe. (Tektronix Part. No. 017-077)

Terminated 50-ohm System. Fig. 2-3 shows a special adapter that can be constructed for use with the P6038 Probe to look at a terminated 50-ohm system. It should be used with the Noise-Risetime switch at LOW NOISE to keep the input circuit overshoot (ringing) to a minimum in the display. This special adapter is recommended over a BNC in-line 50-ohm termination with the BNC-to-P6038 Adapter which places extra capacitance at the probe tip. The VP-2, however, is superior to this special adapter.

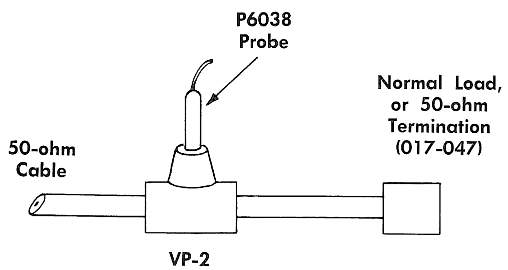


Fig. 2-2. Using the VP-2.

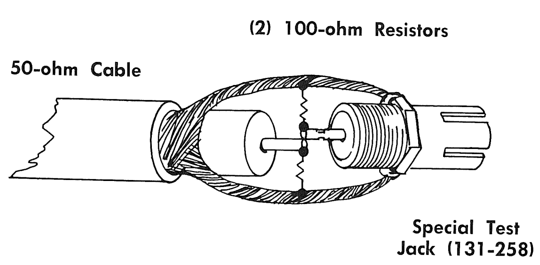


Fig. 2-3. Special 50-ohm Termination for P6038 Probe. Make leads as short as possible.

Checking Deflection Factor

The Type 661 Amplitude/Time Calibrator can be used to quickly check the Type 4S3-P6038 deflection factor. Use the VP-2 system shown in Fig. 2-2 (or equivalent) at the calibrator output connector. Operate the Timing Unit at 0.1 μsec/cm with internal triggering from the calibrator. Obtain a stable display with the THRESHOLD control in the minus region.

Operate the calibrator at 0.1 μsec/cycle (10 mc), and the output at 1000 mv (1 volt). Set the Type 4S3 MILLIVOLTS/CM switch to 200, CALIBRATED.

Channel B deflection factor is set by adjusting B CAL (R2182) located at the top center of the Dual Trace sub-chassis. Channel A deflection factor is set by adjusting the front-panel A-B BAL control. The A-B BAL control is not a differential control, but rather a Channel A gain control. However, it is used to balance the channels when making differential measurements.

Quick Risetime Check

The Type 661 Delayed Pulse generator can be used to quickly check the Type 4S3-P6038 risetime. See "Pulse Risetime Measurements" at the end of this section before proceeding.

Use the GR-to-P6038 Adapter shown in Fig. 2-1 with a 10-nsec signal-delay cable from the DELAYED PULSE connector. The system risetime, in either the LOW NOISE or FAST RISETIME position of the Noise-Risetime switch, can then be read directly from the crt display.

Set the Type 5T1 controls as follows:

SWEEP TIME/CM	1 nSEC, CALIBRATED
MAGNIFIER (Type 661)	X10 (equals 100 psec/cm)
SAMPLES/CM	100
SOURCE	FREE RUN
TIME DELAY	Center the display

Set the Type 5T1A controls as follows:

SWEEP TIME/CM	2 nSEC, CALIBRATED
MAGNIFIER (Type 661)	X1
TIME EXPANDER	X20 (equals 100 psec/cm)
SAMPLES/CM	100
SOURCE	FREE RUN
TIME POSITION	Near its clockwise end, to view the first step. See Fig. 5-5.

Set the Type 4S3 controls as follows:

MODE	A ONLY
MILLIVOLTS/CM	100
VARIABLE	About midrange for 8-cm display.
SMOOTHING	Adjust to unity loop gain.*
DISPLAY	INVERTED
Noise-Risetime	FAST RISETIME

*To set the system loop gain to unity, use the procedure for the SMOOTHING control under "Function of Front-Panel Controls and Connectors".

Dual-Trace Operation

The dual-trace feature of the Type 4S3 permits viewing signals into and out of an amplifier, or signals of differing amplitude and time delay, but not signals of differing repetition rate or frequency unless harmonically related or otherwise synchronously coupled. A suggested system is illustrated in Fig. 2-4.

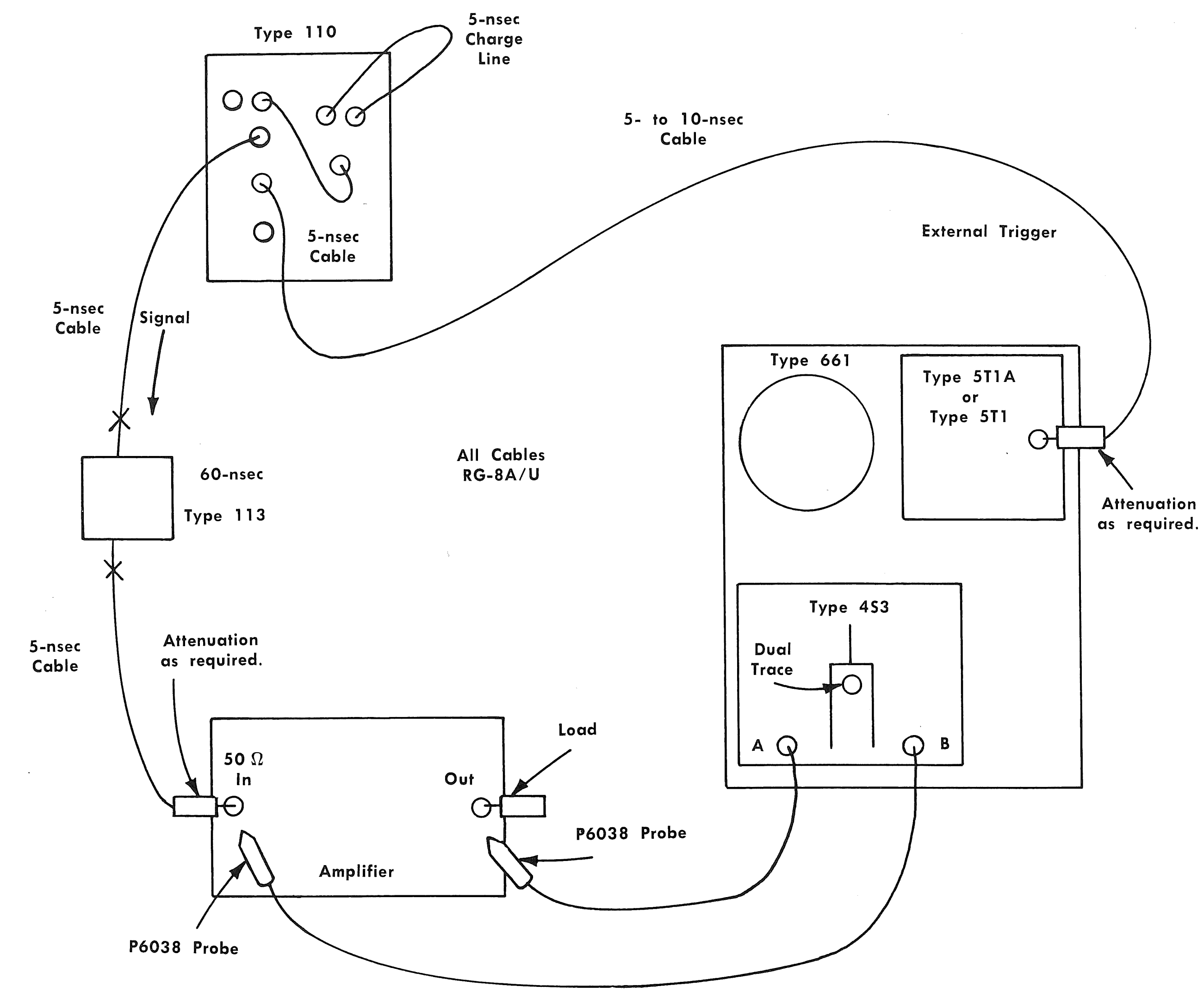


Fig. 2-4. Pulse testing an amplifier using Tektronix Types 4S3, 5T1A (or 5T1), 661, 110, 113, and P6038.

Use the following procedure for setting up the Type 4S3:

1. Set the MODE switch to DUAL TRACE.

2. Set the MILLIVOLTS/CM switches to the approximate values for 3 or 4 cm of display on each channel. If necessary, use the 10X Attenuator on the probe at the amplifier output.

3. Set the SMOOTHING controls fully counterclockwise.

4. Set the Noise-Risetime switches to FAST RISETIME.

5. If the amplifier inverts the signal, you may wish to place one DISPLAY switch to NORMAL and the other DISPLAY switch to INVERTED.

6. If a signal has a dc component over 1 volt, be sure to ac couple it at the input. The peak-to-peak input should not exceed 2 volts.

Triggering the Sampling System

The Type 4S3 has no internal trigger takeoff system. Therefore, an external trigger signal must be applied to the Timing Unit. Two convenient trigger-signal sources are an in-line trigger takeoff system, such as available in the Tektronix Type 110, or an external trigger-output signal from a pulse generator such as the Tektronix Type 105, 107, or 111.

To complete the dual-trace operation, set the Type 5T1A controls as follows (for Type 5T1, omit step 2):

1. Set the TRIGGERING SOURCE switch to EXT and the POLARITY switch to the polarity of the triggering signal.

2. Set the TIME EXPANDER switch to X1.

3. Select a sweep rate to display two or three cycles of the signal. If unknown, start at 10 nsec/cm.

4. Set the SAMPLES/CM switch to 50. This can be altered to suit your display as soon as step 7 is completed.

5. Set the TIME POSITION control to midrange. It can be set later to properly position the waveform on the crt.

6. Set the RECOVERY TIME control fully counterclockwise.

7. Set the THRESHOLD control to hold off the sweep (clockwise if the POLARITY switch is at +, and counterclockwise if the POLARITY switch is at —). Turn the control toward zero to obtain proper triggering.

8. The display should be a faithful reconstruction of the signal. If you have trouble obtaining a stable or properly triggered display, the problem may be trigger-signal amplitude too high or too low, trigger-signal frequency too high or too low, or internal interference due to recovery time.

To find the cause, first check the position of the THRESHOLD control and/or turn the RECOVERY TIME control. If the THRESHOLD control cannot stop the display (by turning away from zero), the trigger-signal amplitude is too high. Or if a stable display cannot be obtained before the THRESHOLD control passes zero and the Timing Unit free runs, the trigger-signal amplitude is too low.

If adjustment of the THRESHOLD and RECOVERY TIME controls produces triggering, but it is jittery or confused, the trigger-signal frequency may be too high or too low.

Set the TIME/CM switch to 1 nSEC, and if the display is other than the beginning of a waveform, the trigger-signal frequency is too high. In this case, a trigger-countdown device such as the Tektronix Type 280 is needed. External synchronizing operates to over 3000 mc.

Low-frequency sine-wave trigger-signal amplitude must be at least 10 mv peak-to-peak below about 250 mc. Additional amplitude is needed when the trigger signal is below about 200 kc.

If confused triggering occurs in the form of multiple traces, try turning the RECOVERY TIME control while changing the position of the TIME/CM switch.

A combination of recovery time and sweep rate can be found which will produce a stable display except at low frequencies. The object is to time the arrival of the trigger signal with respect to the recovery of the trigger circuits to prevent premature retriggering. This is accomplished by having the signal interval of opposite polarity to that selected on the trigger POLARITY switch to provide supplementary hold-off.

If making time or voltage measurements directly from the crt, it is usually best to align the display with the appropriate vertical or horizontal graticule markings. The graticule can then serve as a scale from which to make either time or amplitude measurements.

With the aid of the DC OFFSET control, any point on a waveform within ±1 volt of ground can be made to stay relatively fixed on the crt independent of vertical sensitivity. The VERT POSITION control will then place that portion of the waveform wherever desired within the control limits. Remember: The VERT POSITION control is a ±5-cm control. The DC OFFSET is an input ±1-volt control.

To check that the system dot-transient response is proper, set the SAMPLES/CM switch of the Type 5T1A to 100 and then 1000. If the risetime of the display, or the peak-to-peak amplitude, is not altered, the system is providing a valid display. If the risetime or signal amplitude changes from what it was at 50 samples/cm, slowly turn the SMOOTHING control until the display remains essentially constant regardless of the number of samples/cm. If the signal repetition rate is fast enough, there can be proper operation with the SMOOTHING control counterclockwise with 100 or more samples/cm.

Unity Loop Gain

To set the sampling-system loop gain to unity, set the Timing Unit SAMPLES/CM switch to 5, and the SWEEP TIME/CM switch so the display-pulse rise has only one or two dots. Turn the TIME POSITION control (Type 5T1: DELAY TIME control) slowly to "paint-in" the true pulse waveshape. Set the SAMPLES/CM switch to 100. If the peak of the pulse is different from the "painted-in" pulse peak at 5 samples/cm, adjust the Type 4S3 SMOOTHING control until the many-dot display and the "painted-in" 5-dot display appear equal. This is the point where the loop gain is unity.

If the loop gain is greater than unity, the display will be either excessively noisy, tearing at the display beginning, or spread all over the crt. This is particularly true when the Timing Unit is operating at 5 or 10 samples/cm.

If the loop gain is less than unity, the display amplitude will decrease for sine waves, and the amplitude of a fast-rise pulse will be low at the end of the rise. This is particularly true when the Timing Unit is operating at 5 or 10 samples/cm. The sampling system can always be operated at something less than unity loop gain if there are sufficient samples/cm to correct for these display limits just described. Fig. 2-5 shows three displays with different loop gain.

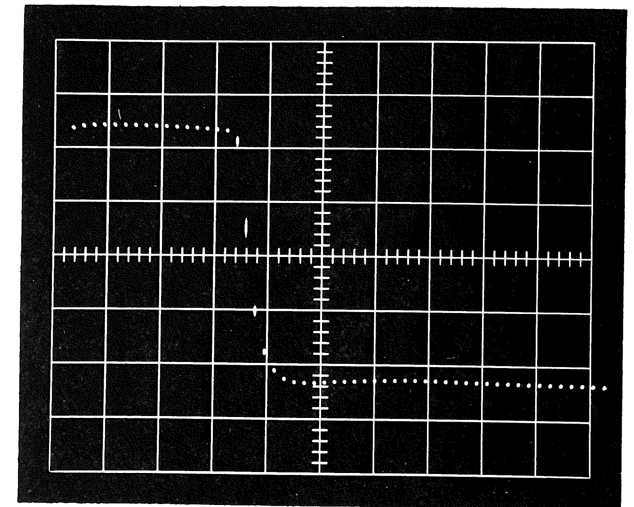
Voltage Measurements

Vertical displacement of the crt trace is directly proportional to the voltage at the input to the P6038 Probe. The amount of displacement for a given voltage can be selected with the MILLIVOLTS/CM switch. To provide sufficient deflection for best resolution, set the MILLIVOLTS/CM switch so the display spans a large portion of the graticule. Also, when measuring between points on a display, measure consistently from either the bottom or top of the trace so the width of the trace is not included in your measurements.

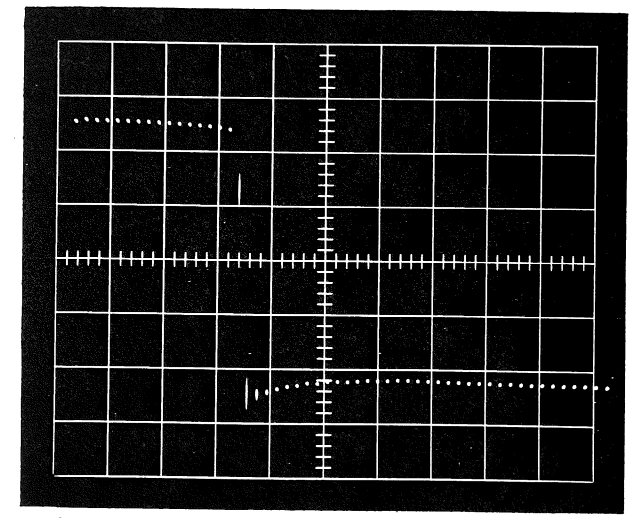
To make a voltage-difference measurement between two points on a display, proceed as follows:

1. Using the graticule as a scale, note the vertical deflection, in divisions, between the two points on the display. Make sure the VARIABLE control is in the CALIBRATED position.

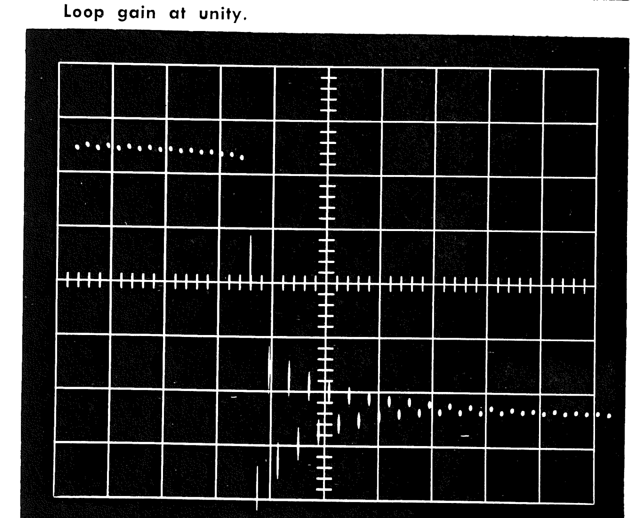
2. Multiply the divisions of vertical deflection by the numerical setting of the MILLIVOLTS/CM switch and the attenuation factor (if any) of an attenuator. The product is the voltage difference between the two points measured.



Loop gain less than unity.



Loop gain at unity.



Loop gain greater than unity.

Fig. 2-5. Type 661 Delayed Pulse displayed at 2 nsec/cm and 5 samples/cm.

If desired, you can measure the instantaneous (or dc) voltage-to-ground of a signal. This is accomplished in the same manner as described previously. However, with no signal applied, you must first establish a ground reference point on the crt. To do this, allow the Timing Unit to present a free-running sweep, and install either the Response Normalizer or the 10X Attenuator to the probe tip. Then, vertically position the trace so that it is exactly aligned with one of the horizontal graticule lines. (This assumes no vertical shift in the trace base-line due to unequal duty cycle of an ac-coupled pulse train.) The actual graticule line selected will be largely determined by the polarity and amplitude of the applied signal. After this point, make no further adjustments with the VERT POSITION or the DC OFFSET controls. Once the ground reference is established, apply the signal and measure the voltage in the same manner as described previously. Use the established ground reference as the point from which to make all measurements.

If the applied signal has a relatively high dc level, the ground-reference point and the actual signal may be so far apart that one or both will not be in the viewing area of the graticule. In this case, refer to the following discussion regarding dc offset voltage measurements.

Dc Offset Voltage Measurements

The DC OFFSET control allows you to cancel the effects of a relatively high (up to ±1 volt, or ±10 volts using the 10X Attenuator) dc voltage in the presence of a low ac-signal amplitude. Also, by measuring the offset voltage at the OFFSET MONITOR jack, you can determine the instantaneous voltage-to-ground at any point on a signal, or its peak-to-peak amplitude.

Voltage measurements made with the Type 4S3 and Type 661 system can be far more accurate than normal oscilloscope crt display resolution. The DC OFFSET control permits measuring any point on a waveform within ±1 volt of ground.

Operate the DC OFFSET control as follows:

1. Obtain the desired display through normal operating procedures.

2. Position the bottom of the waveform to the graticule centerline. Use either or both the VERT POSITION and DC OFFSET controls.

3. Measure and record the voltage at the OFFSET MONITOR jack with a high-impedance voltmeter.

4. With the DC OFFSET control, position the top of the waveform to the graticule centerline.

5. Measure and record the voltage at the OFFSET MONITOR jack with the voltmeter. The difference between the two offset voltages, divided by 100, is the display amplitude in volts at the probe tip. If the input includes the 10X Attenuator, the signal source voltage is then the final offset voltage times the attenuation. The accuracy of the measurement is that of the two offset voltage measurements, and is not affected by the Type 4S3/661 display linearity.

Pulse Risetime Measurements

To make accurate measurement of a fast pulse risetime, consider the following:

1. The Type 661 crt alignment must be correct so that a free-running sweep is parallel to a horizontal graticule line. See the note on alignment of the crt in Section 2 of the Type 661 instruction manual.

2. The Timing Unit must be correctly calibrated. This can be checked quickly by inserting a 30-cm air line (1-nsec delay) in series with the external triggering-signal cable and noting the trace shift. See the Timing Unit instruction manual for more details.

3. The signal source impedance must be low (50 ohms) to obtain the Type 4S3-P6038 0.35-nsec risetime performance.

4. If the signal repetition rate is low, and if you use a small number of samples/cm, the dot transient response must be checked and the SMOOTHING control correctly adjusted.

5. Calculate the signal true risetime from the following:

If the pulse signal is transported to the P6038 Probe through a short section of coaxial cable, and if the cable is a large as RG-8/AU exhibiting essentially no high-frequency attenuation in the form of "dribble-up", the pulse-display risetime T_r is:

$$T_r = \sqrt{(\text{Signal } T_r)^2 + \text{Scope } T_r)^2}$$

TABLE 2-1
Type 4S3-P6038 Input Systems

System	Advantages	Limitations	Accessories Required	Source Loading. See P6038 Instruction Manual, Input R_P and C_P Curves.	Precautions
1. Probe only.	Convenient for most uses.	Trace shift with source impedance changes. Dc and ac voltage. Ground clip will ring at high frequency.	Use ground clip provided or special adapter.	100 k + 2 pf plus C of adapter.	Dot transient response varies with signal source impedance. Less than 50 mv sampling - pulse kickout into test circuit.
2. Probe plus 10X Attenuator.	No trace shift with different source impedance. Can handle larger signals. Reduced sampling - pulse kickout.	Careful compensation required. Loss of sensitivity.	Use ground clip provided or special adapter.	1 meg + 1.8 pf plus C of adapter.	Compensate at beginning of each use.
3. Probe and Ac Coupling Capacitor.	Dc voltage isolation.	Adds some C and L to probe tip.	Use ground clip provided or special adapter.	100 k + 3.5 pf plus C of adapter.	Degraded risetime to charge 3.5 pf.
4. Probe and Response Normalizer.	Minimum trace shift with different source impedance. Full sensitivity.	Degraded risetime.	Use ground clip provided or special adapter.	100 k + 4 pf. 300 Ω for ≈ 1/3 nsec.	Input voltage limited to probe V Max.
5. Probe into unterminated coaxial cable.	R_O (of cable) as source Z to probe. Full bandwidth to 2T of cable, then reflections. Full sensitivity.	Input Z remains R_O for only 2T of cable. Ok for 50Ω systems only, and for pulses shorter than 2T of cable.	Adapter at cable end. Coaxial attenuator(s), such as 5X at source. Ac Coupler.	R_O + 2 pf for 2T of cable, then all of cable C on source.	100% reflection sent back to source.
6. Terminated coax; termination at probe tip.	$R_O/2$ at probe tip without cable 2T limit. Full bandwidth. 1/2 sensitivity of system 5.	2 pf of probe tip causes reflections. Probe tip rings.	Termination and adapter. Ac Coupler.	R_O + 2 pf. R_O + 3.5 pf if Ac Coupler used. Plus adapter C.	Reflection of input C. Dc and ac loading on test point. Power limit of termination.
7. Same as 6, with coaxial attenuator at termination.	Less reflection from 2-pf input.	Reduced signal. Probe tip rings.	Attenuators with correct fittings.	R_O only.	
8. Tap into terminated coaxial system.	Permits signal to go to normal load. Dc or ac coupling without coaxial attenuators.	2 pf load at tap point. 3.5 pf if Ac Coupler is used.	Special tap adapter such as Tektronix VP-2.	See probe or 10X Attenuator input curves, also P6038 Probe manual.	Reflection from probe 2 pf, or attenuator 1.8 pf. Use attenuator to stop probe kickout going to load.

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Transposing:

$$\text{Signal } T_r = \sqrt{T_r^2 - (\text{Scope } T_r)^2}.$$

Voltage Pickoff In Terminated Coaxial Line

The P6038 Probe can be used to look at the voltage signal in a terminated 50-ohm coaxial line by using the Tektronix VP-2. The VP-2 is a specially designed Tee adapter that causes very little reflection in a closed coaxial system. (An ordinary coaxial Tee causes much more reflection.) The VP-2 provides a 50-ohm source impedance to the P6038 Probe (there is 25 ohms in series with the tip inside the VP-2). Its use allows the probe to observe signals on the coaxial center conductor with essentially no effect upon the information on its way to its normal load. Use of the VP-2 will degrade the signal risetime slightly.

Signal Searching—Signal Analyzing Suggestions

When signal tracing through a circuit and the crt display does not need to show the waveshape in all its detail, the following suggestions may be of value:

1. Assemble the P6038 Probe 10X Attenuator and an Ac Coupler.

2. Set the Noise-Risetime switch to LOW NOISE and the SMOOTHING control fully counterclockwise.

3. Set the Timing Unit SAMPLES/CM switch to 5 or 10. Set other Timing Unit controls as required for proper triggering.

4. As signal tracing is done through the circuit, the Timing Unit TIME POSITION control may have to be adjusted to restore the display to mid-crt if significant signal delay exists between test points.

To view precise waveshapes at a test point, obtain a display and then set the system loop gain (dot transient response) to unity, or as close to unity as the input circuit impedance will allow. See the paragraph at the end of "Triggering the Sampling System," page 2-5. Use as many dots/cm as the signal repetition rate (display flicker) will allow.

P6038 Input Systems

Table 2-1 is a quick reference guide for using the P6038 Probe most effectively. Not every situation is included, but many forms of input systems commonly used with direct-sampling probes is included. The letter "C" means capacitance, "L" means inductance, and "T" means time.

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SECTION 3

CIRCUIT DESCRIPTION

General Information

Most circuits in the Type 4S3 are on plug-in subchassis. The main frame contains only the preamplifier circuits, controls, interconnections, and cables. You may wish to refer to the Tektronix publication "Sampling Notes", publication number 061-557, during the following discussion.

Block Diagram

The Type 4S3 simplified block diagram in Fig. 3-1 shows each circuit in block form, with all front-panel and internal controls identified. Since the two channels are identical, only the Channel A circuits and controls are labeled.

External trigger information to the Timing Unit starts the sampling cycle. The Timing Unit sends command pulses to the Type 4S3 Gate Generator. The Gate Generator sends very short duration push-pull pulses to both P6038 Probes, and longer duration pulses to both Memory circuits. The pulses from the Gate Generator connect the signal to the Preamplifiers, and then each Ac Amplifier to its Memory.

Input signals arrive at the P6038 Probe sampling gate. The sampling gate is biased to conduction by the Gate Generator as command pulses arrive from the Timing Unit. The sampling-gate output signal is a series of pulses, amplified by the Preamplifier, and coupled through the MILLIVOLTS/CM switch to the Ac Amplifier. The Ac Amplifier amplifies the signal and presents it to the Memory. The Gate Generator biases a two-diode gate at the Memory input to conduction as the signal arrives.

The Memory amplifies and stores the signal. The Memory output is used by the Type 661 to produce the crt display and to set the probe and input circuit to the voltage of the signal at the time the sample was taken. (The next sample only corrects for any signal changes since the last sample.) The Memory output signal can be inverted by a unity gain Inverter. The output of both channels then pass to the Dual Trace electronic switch where either or both are sent on to the Type 661.

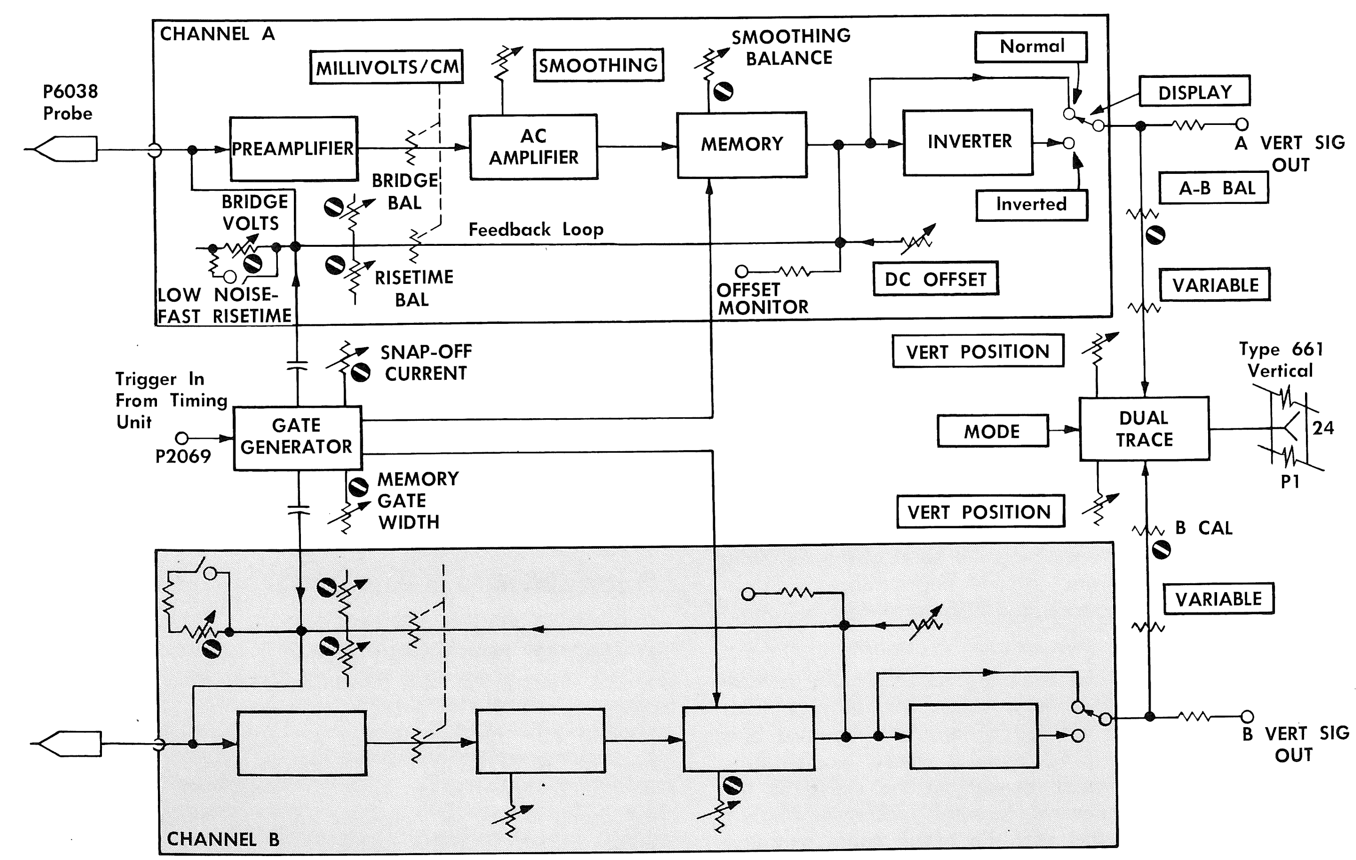


Fig. 3-1. Type 4S3 block diagram. Shaded area of Channel B is identical to corresponding area in Channel A.

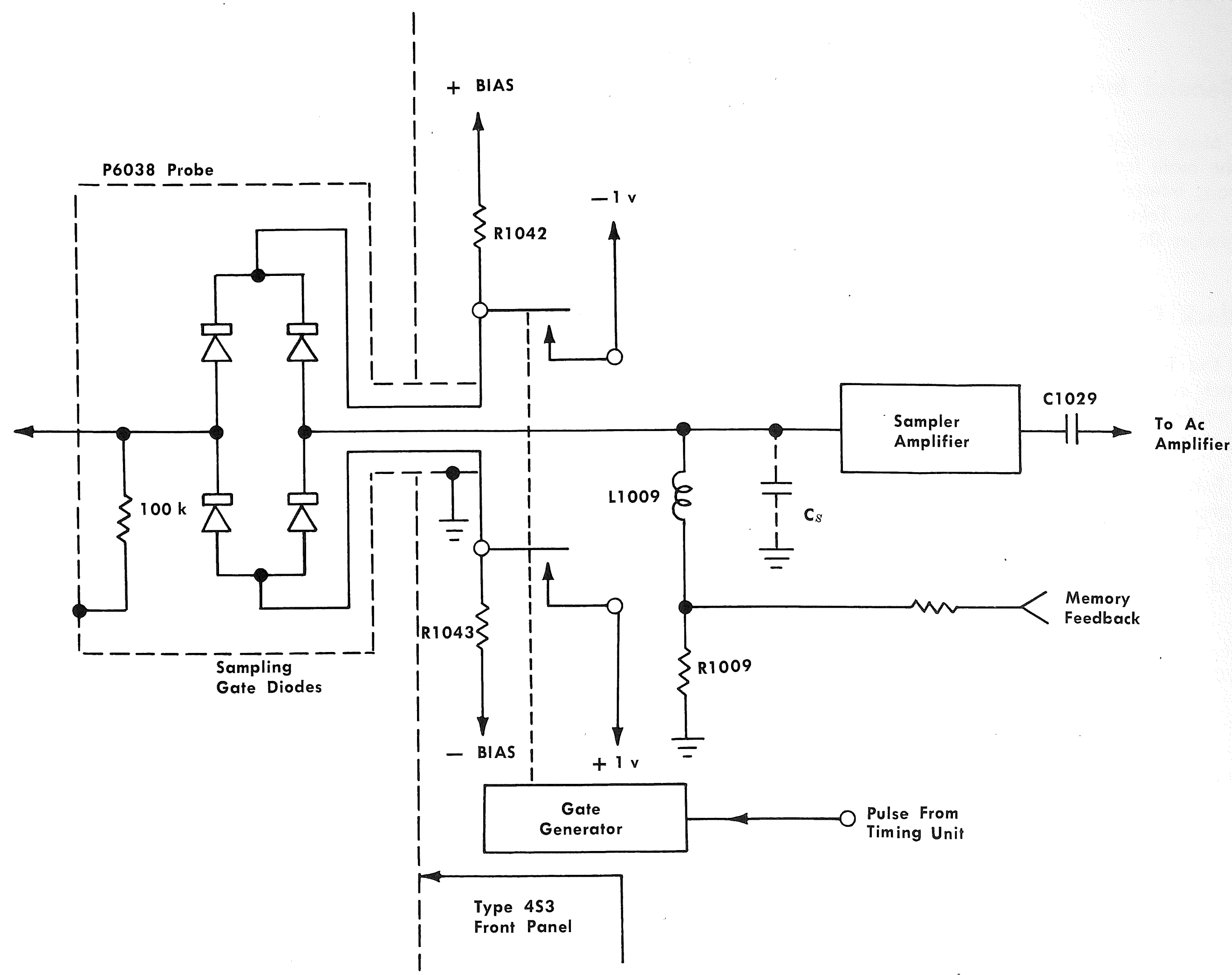


Fig. 3-2. Simplified Channel A input.

P6038 Probe

The Type 4S3 input is via the P6038 Probe shown in simplified form in Fig. 3-2. The probe is the heart of the sampling system where the 0.35-nsec risetime performance is established. The input impedance is 100 k paralleled by about 2 pf.

Fig. 3-2 shows the probe sampling gate normally reverse biased a total of about 4 to 5 volts. The relay contacts represent an equivalent method of applying forward bias to the sampling gate. If the relay is closed momentarily, the gate is forward biased, connecting the signal to the Preamplifier. The duration of forward biasing is slightly less than 0.35 nsec; so fast that the probe cable and Preamplifier shunt capacitance (C_s) limit the signal to the Preamplifier grid to about 2% of the input amplitude. C_s is stray input capacitance that increases the signal duration at the Preamplifier input. Because only about 2% of the signal gets to the Preamplifier, the sampling efficiency is about 2%.

Preamplifier

The Preamplifier has a high input impedance and a gain of about 50. Refer to the Preamplifier schematic at the back of this manual (Channel A) during the following discussion. Input tube V1014 is a low-noise cascode amplifier with a gain of 100. It amplifies and ac couples the signal to the base of Q1024. Q1024 is a feedback amplifier with a gain of 0.5. The gain is set by R1021 and R1022. Q1024 sends the signal to the Ac Amplifier subchassis through a section of the MILLIVOLTS/CM switch. The signal is amplified and stored, then a part of it is returned to the input grid of V1014A via a section of the MILLIVOLTS/CM switch and L1009. The Ac Amplifier, Memory, and feedback loop are discussed following the Gate Generator description.

Gate Generator (Model 1)

The pulses that gate the sampling diodes into conduction are formed by a snap-off diode and clipping line, driven by sampling pulse generator Q2060. The sampling pulse generator also drives the Memory circuit gates.

The sampling pulse generator quiescent state is as follows:

Q2060 is cut off with about +0.1 volt at its base. The 0.1 volt is the drop across D2063 caused by about 0.1 ma diode forward current. The collector of Q2060 rests at −19 volts. Current through SNAP-OFF CURRENT control R1067 and the rest of its circuit, including D1062, is between 20 and 40 ma. Q2074 is cut off with about +0.8 volt at its base. Its collector rests at −19 volts.

As the positive trigger pulse arrives from the Timing Unit, the following takes place:

The Timing Unit command pulse passes through coupling capacitor C2069 and diode D2068 into the collector circuit of Q2060. Q2060 is a common-emitter type blocking oscillator with reverse swing damping by D2060. When the positive trigger pulse is received, current passes through the collector winding of T2060. D2060 is back biased. The current in the collector winding induces a voltage in the base winding of T2060 which overcomes the back bias on the emitter of Q2060, and turns the transistor on for a blocking-oscillator cycle. The fast positive pulse which then occurs at the collector of Q2060 (about 14 volts rise) is coupled by C2066 to the snap-off circuit. During turn-on, Q2060 base-emitter junction is forward biased by the feedback winding of T2060, charging C2062. After the collector voltage of Q2060 rises to the saturation point, the normal blocking oscillator back-swing tries to occur. D2060 clamps the back-swing of the collector winding of T2060. At the same time, the charge on C2062 back biases the base of Q2060, allowing a quick return to equilibrium. The output pulse from Q2060 is ac coupled to the pulse-forming snap-off diode and clipping line.

The quiescent condition of snap-off diode D1062 is set by SNAP-OFF CURRENT control R1067. The circuit typically carries between 20 and 40 ma of forward current through D1062. This heavy forward current assures that D1062 has many carriers within its junction region. Should the forward current suddenly reverse by reversing the applied voltage, the many carriers in the diode junction will require a short time to clear out and open the diode in a normal reverse-bias condition. Snap-off diode D1062 is reverse biased by the 14-volt pulse from Q2060, but does not become a high impedance immediately.

As the pulse from Q2060 arrives at D1062, the following action takes place:

T1064 transforms the pulse into a heavy reverse-current drive to D1062. D1062 and the clipping line are a series low impedance so a large current builds up in the clipping line. The carriers in the junction of D1062 reverse direction of flow as a heavy reverse current. D1062 is specially constructed so that the heavy reverse current stops suddenly as all the carriers are cleared out of the junction. As the reverse current of D1062 suddenly stops, a fast-rise voltage pulse is sent into the 50-ohm clipping line and toward each sampling gate.

The clipping line acts as an inductance, thus the diode reverse current before snap-off establishes a flux in the line. When the diode snaps off, the flux collapses, and causes a sharp voltage step of the same polarity as the snap-off diode current. This step is transmitted through four blocking capacitors, C1042-C1043 and C2042-C2043, to the sampling gates, forward biasing the probe sampling diodes and allowing a sample to pass.

The sharp step which appears at the clipping-line input at snap-off is now propagated down the clipping line. The clipping line acts as a balanced transmission line, terminated in a short circuit. A finite period of time is needed for the step to travel to the short. When it reaches the short, the step is reflected equal in amplitude and opposite in polarity to the original step back to the snap-off diode and sampling gates. The reflection turns off the sampling diodes, ending the sample, and again turns on the snap-off diode in its normal forward-biased state. Thus, the sample time is established mainly by the time it takes the sampling pulse to travel down the clipping line and be reflected back. C1063 and R1063 limit reflections which would turn the sampling diodes back on after the sample is taken. T1042 and T2042 assist in balancing the gate pulses sent to the probes sampling diodes.

Low Noise—Fast Risetime

The system risetime is easily altered by changing the peak value of the gate generator pulse that causes the sampling gates to conduct. The Type 4S3 uses a switch that changes the value of the bridge volts (reverse bias) instead of changing the pulse amplitude. By this method, the peak value of gate pulse is effectively changed as shown in Fig. 3-3, thus changing the length of time the sampling gates conduct and the system risetime.

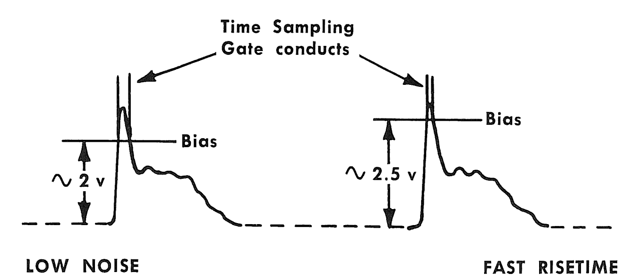


Fig. 3-3. Two conditions of Noise-Risetime switch (idealized waveforms).

When the Noise-Risetime switch is placed at LOW NOISE, R1054 is placed in parallel with the BRIDGE VOLTS control. This reduces the amount of sampling-bridge reverse bias. The sampling diodes' current-balance changes slightly with a change in bridge volts. The combination of the BRIDGE BALANCE and RISETIME BAL controls allows each probe gate to be balanced for both bias conditions of the Noise-Risetime switch.

Memory Gate Width

The Memory is allowed to receive signals only when a sample is taken. Because the feedback loop contains positive feedback, the output of the Preamplifier and Ac Amplifiers must be disconnected from the Memory input while the feedback loop is shifting the level at the input to the Preamplifier. The Gate Generator subchassis has a Memory gate driver that controls the Memory gates.

Memory gate amplifier Q2074 is normally biased to cutoff by reverse bias through MEMORY GATE WIDTH control R2073. Q2074 collector rests at —19 volts. The collector current path is through the two windings of the two Memory gates, not through D2074 and R2074. As Q2060 pulses, a third winding of T2060 sends a negative signal to Q2074, then D2072 conducts and forward biases Q2074 to saturation. Collector current flows through R2069 and R2077 and the two coils of the Memory gates. D2074 and R2074 reduce ringing when Q2074 again cuts off. Duration of the Memory gate pulse is controlled by the carrier clean out time of Q2074. Q2074 remains saturated over about a 2 to 1 time range, as adjusted by the MEMORY GATE WIDTH control (nominally 0.4 μsec).

Sampler Controls

The Gate Generator subchassis contains all sampler internal adjustments that control sampling efficiency and loop gain; they are the SNAP-OFF CURRENT, MEMORY GATE WIDTH, A and B BRIDGE VOLTS, A and B BRIDGE BALANCE, and A and B RISETIME BAL controls. See the Calibration section for the effect of each control upon the display.

Ac Amplifier

The Ac Amplifier receives its input signal from the sampler amplifier through a section of the front-panel MILLIVOLTS/CM switch, amplifies it a maximum of 200 times, inverts it, and feeds the Memory circuit. The input dc level is zero volts to ground, and the input resistance ranges from 10 ohms at 200 mv/cm to 1000 ohms at 2 mv/cm. The Ac Amplifier is made up of two dc-coupled feedback amplifiers with a third dc feedback path around the whole circuit. The "outside" feedback path includes the front-panel SMOOTHING control that allows a gain reduction of about 10 to 1. (When using SMOOTHING, the dot transient response must be considered and a sufficient number of samples/cm used to make the display response correct.) The outside feedback path is for dc stabilization and does not act upon the pulse signal.

The signal pulses handled by the Ac Amplifier are about ½ to 1 μsec in duration (see Fig. 4-4). The amplifier output voltage can change 1.6 volts in about 0.1 μsec. Normally, the system causes the output pulses to be less than 1 volt, but if the display moves 8 cm in one sample, the output pulse will be about 1.6 volts peak. The output impedance of the circuit is quite low, so it can drive the memory input.

The gain of the first amplifier (Q1084 and Q1094) is about 40 when the SMOOTHING control (R1081) is set to zero resistance. When the SMOOTHING control is fully clockwise, the gain is set by the ratio of R1089 to R1083. When using full smoothing, the gain is about 4.5, set by the ratio of R1089 to R1083 and R1081 (SMOOTHING) in series. The gain of the second amplifier (Q1104 and Q1113) remains fixed at about 5, set by the ratio of R1107 to R1096.

The frequency response of the first amplifier is fixed-compensated by C1089. The second-amplifier frequency response is adjusted during calibration by C1107.

Memory

A simplified schematic of the Memory circuit is shown in Fig. 3-4. The Gate Generator closes the Memory input gate (D1130 and D1131) at the correct time of each sampling cycle. The Memory circuit is a feedback amplifier; input and feedback elements are both capacitors. The input capacitor is C1121; the feedback capacitor is C1132. V1133A is an input cathode follower, Q1134 is the amplifier, and Q1141 is an output emitter follower.

The input impedance at the grid of V1133A acts as a virtual ground because, as the input signal changes the grid voltage, the signal is amplified and applied back to the input as negative feedback to cancel the original change.

The action of the Memory is to transfer a charge from C1121 to C1132. The circuit between the Ac Amplifier output and the grid of V1133A looks like 150 ohms and 510 pf in series (when the Memory gate is conducting). Thus, as a signal appears at the Ac Amplifier output, C1121 is charged. C1121 tries to couple the signal to the grid of V1133A, but feedback prevents the grid voltage from changing significantly; the result is for both C1121 and C1132 to receive a charge.

When the Memory gate is not conducting, the grid of V1133A has a very high impedance to ground, and at this time the only possible discharge path for C1132 is by V1133A grid current or stray leakage current. The grid current is very low. Total leakage current is so low that there is essentially no change in the output voltage between samples even when sampling at the low rate of 150 times a second.

The circuit elements between C1121 and the grid of V1133A serve several purposes:

1. D1125 and D1127 are amplitude-limiting diodes. They normally do not conduct.

2. D1122 is a 6-volt Zener diode to provide back bias for gating diodes D1130 and D1131.

3. The resistors all aid in setting the input quiescent voltage level.

4. T1130 is a pulse transformer that allows rapid turn-on of the gating diodes to connect the input circuit to V1133A.

5. C1122 assures that both sides of D1122 follow the signal equally.

Within the Memory amplifier:

1. C1138 corrects for transistor phase shift.

2. D1136 permits Q1134 to turn on hard for only a short time, long enough for the stored charge of D1136 to be removed, thus preventing damage to Q1134 in the event of negative-drive overload.

3. D1142 assures that fast positive pulses at the base of Q1141 are coupled to C1132 and the output, even if Q1141 is momentarily cut off.

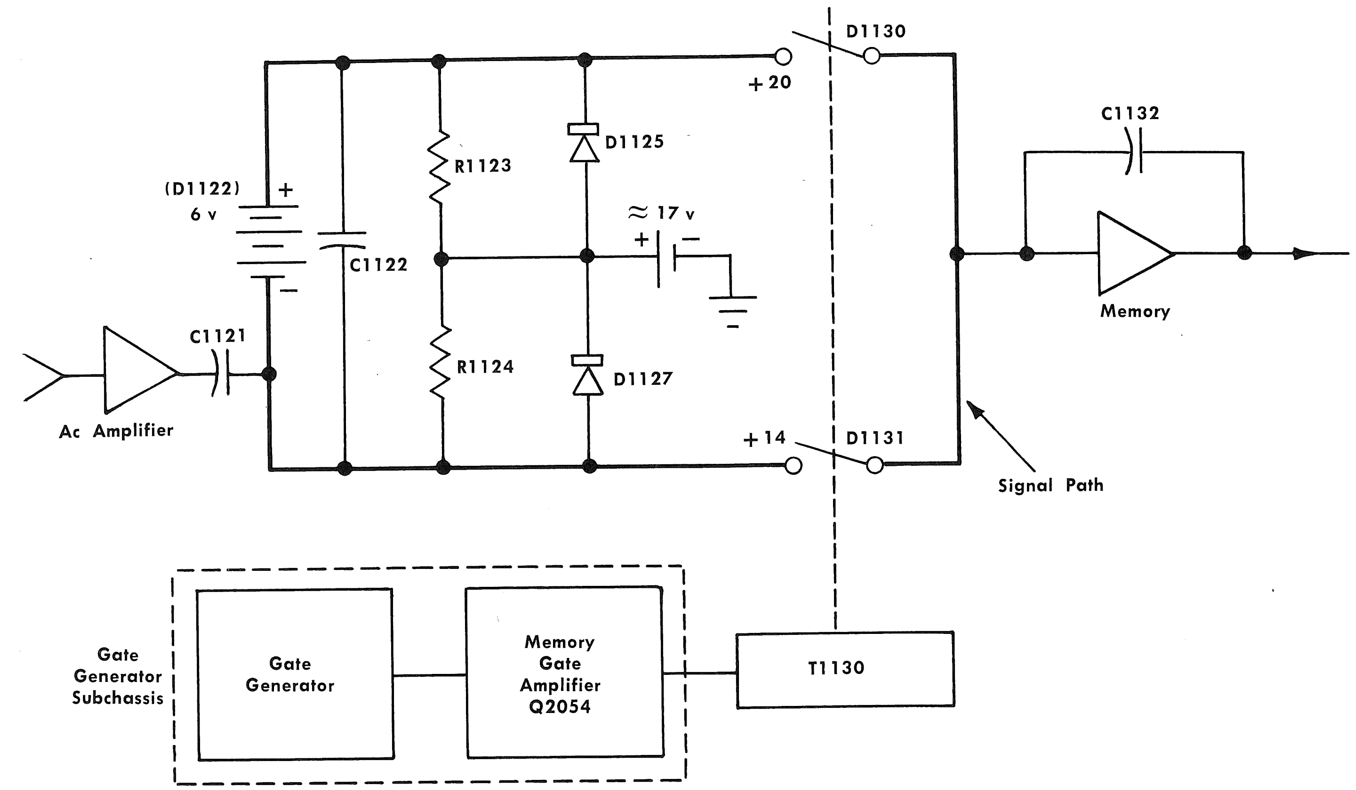


Fig. 3-4. Simplified Memory gate.

4. D1144 limits the positive swing of the output lead to about +10 volts and D1143 assures a high impedance when the output voltage tries to reverse bias D1144.

5. D1140 limits the collector voltage of Q1141 to —9 volts.

6. R1145 prevents reverse reflections in the output cable from disturbing the display.

Between samples, the Ac Amplifier output returns to its quiescent level, and any C1121 charge (that was gained at the last sample) is cancelled. At the next sample (if there is any change at the Preamplifier input), C1121 will receive a new charging signal and can add to or subtract from the residual charge of C1132. C1121 is charged by the Ac Amplifier only when the Memory gate is conducting.

System Operation With No Signal

Remember the following when examining signals at various points between the Preamplifier output and the Memory output:

1. It is impossible to install perfectly balanced sampling-gate diodes, so at each gate-generator pulse there will be some small error signal sent into the system.

2. The Memory circuit does not retain a perfectly stable output voltage because C1132 cannot hold a charge permanently.

3. The Memory output is coupled back to the Preamplifier input (with proper attenuation).

4. Theoretically, if there is no input at the sampling gate, there will be no Ac Amplifier signal, and the Memory output will be zero. The Memory output will be essentially zero, but there will always be a small pulse at the Ac Amplifier output.

5. The SMOOTHING BALANCE control (R1125) sets the quiescent dc level at the Memory input, and if incorrectly adjusted will cause an offset voltage that looks like a continuous signal. For example, assume the SMOOTHING BALANCE control is off by +1 mv. Also assume the Memory amplifier internal gain to be 500. The Memory output will now be —500 mv. The —500-mv feedback to the input bridge creates an error signal which will drive the Memory output nearly back to zero. After several dots, the Memory output will stabilize near but slightly off from zero to provide enough error signal to correct for the original +1-mv error. Thus, a continuous minor error signal is amplified to place the output level near zero. If the Ac Amplifier gain is reduced by the SMOOTHING control, the Memory output must now be larger so the error signal fed into the Ac Amplifier is larger, restoring again the —1-mv correction at the Memory input. (A trace shift seen when the SMOOTHING control is turned is the increased Memory output to make up for the reduced amplifier gain). Thus, the Memory input-balance control is called the SMOOTHING BALANCE because its effect is seen by turning the SMOOTHING control.

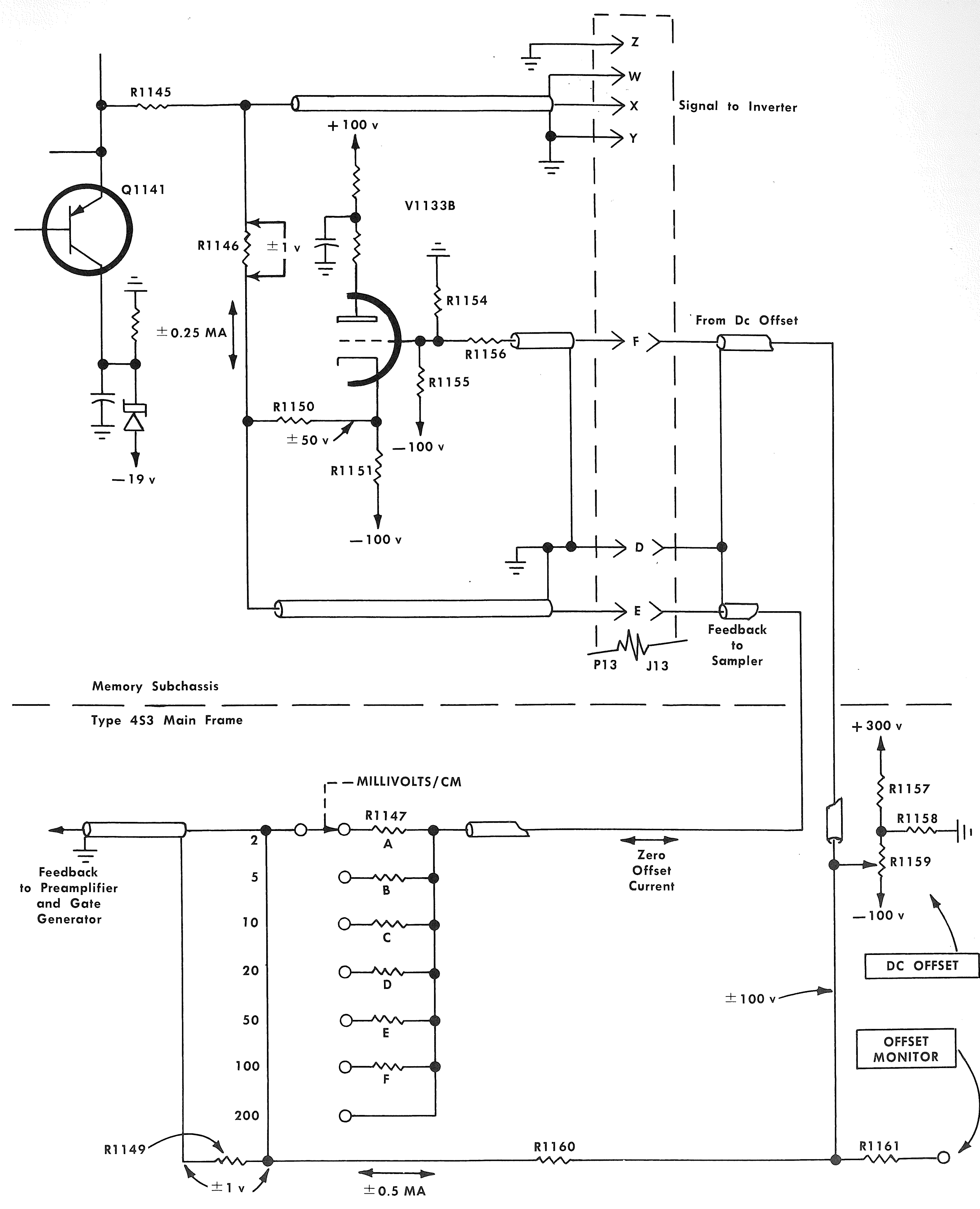


Fig. 3-5. Channel A Dc Offset and Memory feedback circuit.

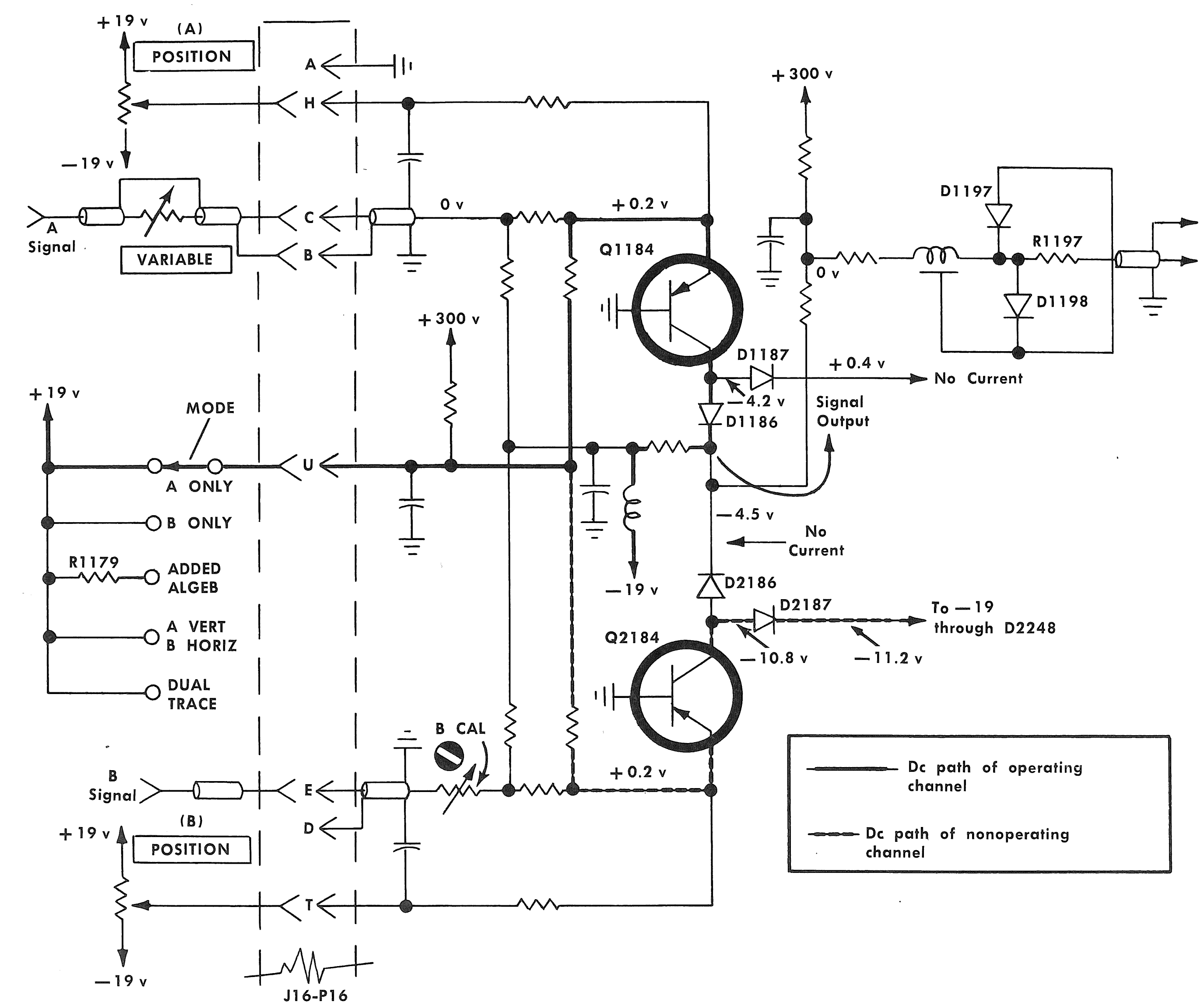


Fig. 3-6. Dual Trace circuit dc conditions. Mode-A ONLY: OFFSET-zero: trace centered: no signal: Timing Unit-FREE RUN.

Dc Offset

The Memory output of Q1141 is fed to the inverter or to the dual-trace circuit. It is also fed to a voltage divider that controls the feedback signal sent to the Preamplifier. Feedback attenuator resistors R1147 A through F (see the Interconnectors and Switching schematic, Channel A, at the rear of this manual) set the feedback amplitude to keep the basic Memory output at 600 mv/cm while the feedback voltage just matches the input signal.

The Dc Offset circuit adds a dc shift to the feedback loop. It includes a current-cancelling system that prevents offset current from flowing in R1147 (see Fig. 3-5). The grid voltage of V1133B is set by the DC OFFSET control through a 2-to-1 resistance divider. Turning the DC OFFSET control from one end to the other causes a ±50-volt swing at the cathode of V1133B. The cathode of V1133B drives ±0.25 ma through R1146 via R1150. The DC OFFSET control ±100-volt swing drives ±0.5 ma through R1149 via R1160. The resulting voltage drop of ±1 volt across both R1146 and R1149 is the offset voltage sent to the Preamplifier and gate generator. The two points of offset injection assure that there is no offset current in R1147 so that the offset system is not affected by changing the setting of the MILLIVOLTS/CM switch.

The DC OFFSET control may be used to null certain levels of the input signal to measure amplitude. The OFFSET MONITOR jack provides a voltmeter connection to read the effective dc offset voltage X100. The offset voltage is also useful for measuring small signals riding on larger signals.

Inverter

The Inverter is an X1 amplifier pair (10 k input, 10 k feedback) for each channel. Its function is to invert the dis-

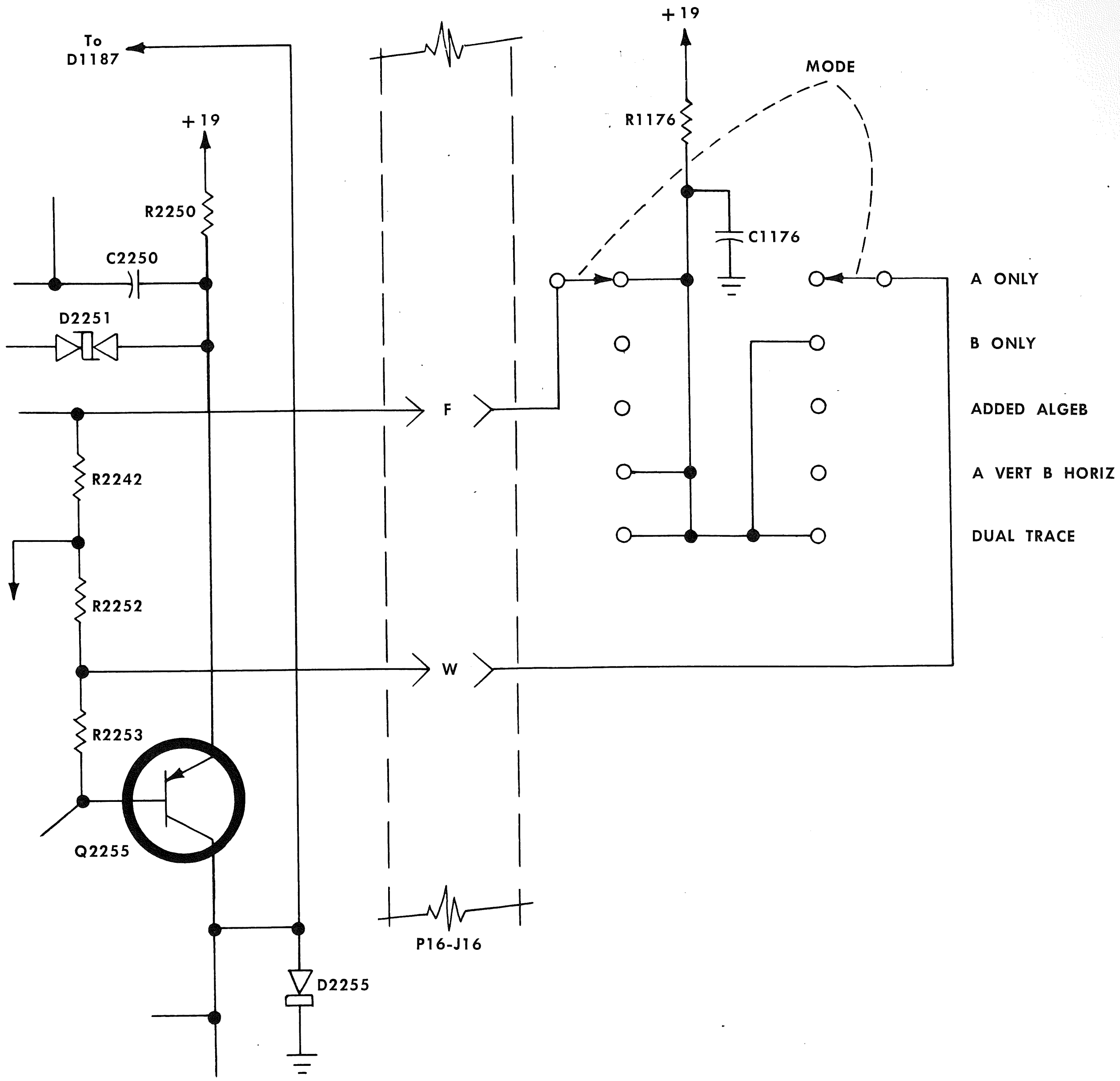


Fig. 3-7. MODE switch connections to the Dual Trace multivibrator.

play when the front-panel DISPLAY switch is in the INVERTED position. When the DISPLAY switch is in the NORMAL position, the inverter is bypassed by interconnecting wiring in the Type 4S3 main frame.

Q1164 is collector coupled to Q1163. D1167 is a voltage-offset Zener to raise the voltage at the base of Q1163 above that at the collector of Q1164 without signal attenuation. Q1163 is an output emitter follower. R1161, the A INVERTER ZERO control, and R1162 are a dc-balance network to adjust the output dc level, eliminating trace shift when moving the DISPLAY switch from NORMAL to INVERTED. R1163 is the feedback resistor.

Dual Trace (Model 3)

The Dual Trace subchassis determines which channel is displayed by the Type 661 (under some conditions, the signals from both channels are fed to the Type 661). Because of the various modes of operation possible in dual-trace, both the A and B channel will be discussed.

Two diode switches, D1186-D1187 and D2186-D2187, control passage of the signal. A multivibrator, Q2245 and Q2255, controls the switching diodes. Multivibrator operation is controlled by the front-panel MODE switch. In the A ONLY, B ONLY, and A VERT-B HORIZ modes, only one side

of the multivibrator conducts. In the ADDED ALGEB mode, neither side conducts, and in the DUAL TRACE mode, the multivibrator free-runs at a switching rate of about 50 kc. Q2264 provides a dual-trace blanking signal to the Type 661 when the multivibrator switches.

A 0.25-μsec delay line couples the output signal from the Type 4S3 to the Type 661. The delay allows the signal to phase properly with the Timing Unit unblanking of the Type 661 crt.

Refer to Fig. 3-6 and the Dual Trace and the Interconnectors and Switching schematics during the following discussion. Each common-base amplifier, Q1184 and Q2184, is fed signals from the DISPLAY switch for its channel. The Channel A signal arrives through R1184, the Channel B signal arrives through R2182 and R2184. The amplifier emitter circuits includes positioning controls (R1180 and R2180) in parallel with the emitter return resistors (R1185 and R2185). Positioning is by current injection into the emitter circuits through R1181 and R2181. The major emitter current comes from the +19-volt supply through MODE switch SW2190 and to the emitters through R1185 and R2185. In the ADDED ALGEB position of the MODE switch, current limiting resistor R1179 is inserted in the emitter circuit to keep the common output voltage level the same as when only one transistor is conducting.

The current at both common-base amplifier collectors is switched between two paths by the multivibrator to connect or disconnect them from the common collector load, R1189. There is essentially no change in the current of either transistor whether it is connected to the output or not.

The input impedance is that of series input resistor R1184 in Channel A and R2182 and R2184 in Channel B. Since the emitters of both transistors rest at about +0.2 volt, R1183 and R2183 are used to offset the input voltage to zero. The —4.5-volt collector voltage is offset to zero (for the output lead) by the series combination of R1191 and R1192.

Fig. 3-7 shows the MODE switch connections that set the operating conditions of the multivibrator. During single-channel operation, with only one side of the multivibrator conducting, the conducting transistor saturates and Zener diode D2251 conducts. In A ONLY operation, multivibrator transistor Q2255 operates in saturation, and its collector is held at about +0.4 volt by D2255. This reverse biases both D2258 and D1187 so that Q1184 supplies the output signal. Since transistor Q2245 is cut off, R2248 forward biases both D2248 and D2187, bypassing Q2184 current from the output.

Operation in the A VERT-B HORIZ mode sets the multivibrator and the amplifiers the same as in the A ONLY mode. The Channel B signal bypasses the Dual Trace circuit and is fed separately to the Type 661 horizontal deflection system. In the B ONLY mode, operation of the multivibrator and amplifier transistors is the reverse, with Q1184 disconnected and Q2184 supplying the output signal.

In the ADDED ALGEB mode, neither multivibrator transistor conducts. The output of both amplifiers is combined in the common-collector circuit at R1189. The output to the delay line is the algebraic sum of the A and B signals. The current of each amplifier is halved by R1179 (Fig. 3-6) so that the output dc level will keep the display on the crt.

In the DUAL TRACE mode, Q2245 and Q2255 operate as a free-running multivibrator at about 50 kc. The common-base amplifiers pass signals alternately, providing a dual-trace display.

During multivibrator operation, neither transistor saturates, and Zener diode D2251 does not conduct. The multivibrator switching time constant, located between the emitters of Q2245 and Q2255, is composed of C2251 in series with the emitter-return resistor (R2240 or R2250) of the nonconducting transistor. The collector-to-base coupling circuits (R2246-C2246 and R2256-C2256) do not set the time of operation; the capacitors are for high-frequency coupling to assure fast switching.

Blanking Circuit

Blanking transistor Q2264 normally rests in cutoff with its base at about +0.8 volt. As the multivibrator switches, C2240 or C2250 couple about a —2-volt signal to the base of Q2264 to turn it on. The turn-on pulse lasts only about 0.5 μsec, but it is heavy enough to saturate Q2264 and give it a storage time of about 1 to 1.5 μsec. There is some positive overshoot immediately before the —2-volt pulse. This is kept from the base of Q2264 by D2262 so that the storage time of Q2264 will be fairly consistent, and the crt will be properly blanked during the time the dual-trace multivibrator is switching channels.

SECTION 4
MAINTENANCE

Visual Inspection

The Type 4S3 and P6038 Probe should be inspected occasionally for such visible defects as poor connections, broken or damaged ceramic strips, improperly seated tubes, transistors, or probe diodes, and heat-damaged parts. The remedy for most visible defects is obvious; however, particular care must be taken if heat-damaged parts are detected. Overheating can be caused by other, less apparent troubles in the circuit. For this reason, it is essential to determine the actual cause of overheating before the parts are replaced; otherwise, the damage may be repeated.

Recalibration

The Type 4S3 and P6038 Probe are stable instruments and should provide many hours of trouble-free operation. To maintain measurement accuracy, however, we suggest a calibration check after each 500 hours of operation (or every six months if used intermittently). Complete calibration instructions are contained in Section 5 of this manual. The calibration procedure includes steps which will help check for proper operation of various circuits. Minor troubles not apparent during regular operation will often be revealed during calibration. Some troubles can often be isolated or eliminated by calibrating the instrument.

PARTS REMOVAL AND REPLACEMENT

General Information

Removal or replacement procedures for most parts in the instrument are obvious. However, some parts require special procedures. Removal and replacement of these parts is discussed in the following paragraphs.

Many components in the instruments are mounted in a particular way to reduce stray inductance and capacitance. Therefore, carefully install replacement components to duplicate lead length, lead dress, and location of the original component.

After replacing any electrical components, be sure to check the calibration of the instruments. Components of the same type may exhibit slightly different characteristics, and may affect calibration.

Removal of Subchassis Circuit Boards

Most of the circuitry of the Type 4S3 is located on subchassis circuit boards. Each subchassis has a 22-contact connector that mates with the main-frame cables. Maintenance is made easier by the use of a special subchassis extender, and special extension cables that permit the subchassis to be operated outside the Type 661 (identified at the beginning of the calibration procedure). The Type 4S3 will operate correctly with any subchassis extended for testing.

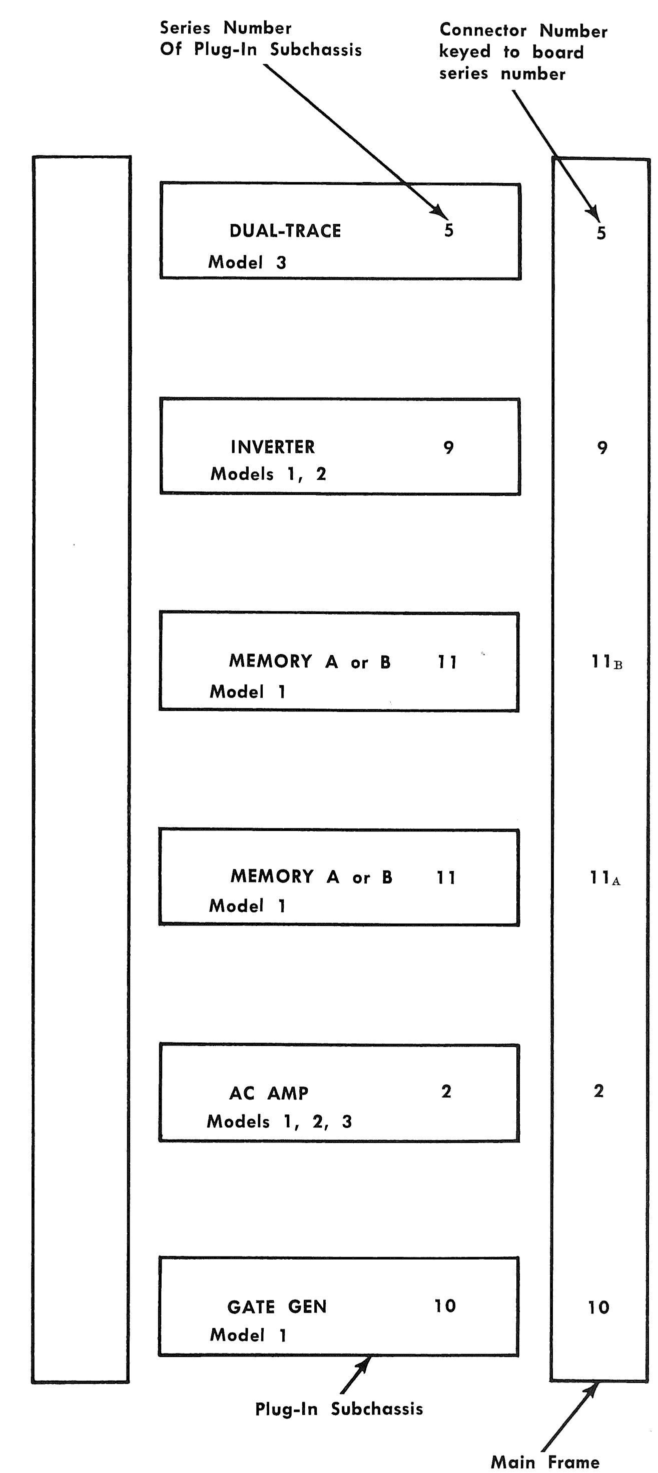


Fig. 4-1. Type 4S3 plug-in board keying system (S/N 101 to date).

A subchassis is removed by pressing down on the two tabs located at each side of the unit. The removal tabs apply lifting pressure to the subchassis, aiding in disconnecting them from the interconnecting socket.

Installation of a subchassis requires careful observation of the mating connector at the base of the unit. A number located just to the right (front panel facing you) of the interconnecting socket identifies which subchassis will operate in that location. The number is identified on each schematic as a "series" number (the Gate Generator is series 10). The series number is both a circuit guide and a physical position guide, and mates with a number on the top lip of each subchassis. See Fig. 4-1.

To replace a subchassis, align all pins and the two plastic tips with their proper position at the interconnecting socket, and apply heavy hand pressure to push the unit fully into position. Take care not to turn small screwdriver adjustments, as that will change the calibration. If the Gate Generator is being installed, you may wish to connect the five small cables to the subchassis after it is in place.

Tubes and Transistors

Tubes and transistors should not be replaced unless they are actually defective. If tubes or transistors are removed and found to be acceptable, be sure to return them to their original sockets. This will avoid recalibration because of different tube or transistor characteristics.

The best way to check a tube or transistor is by substitution. That is, replace the suspected tube or transistor with one of the same type that you know is good. Then, check to see if the instrument operates properly. If not, return the original tube or transistor to its socket.

Wafer Switches

Individual wafers are normally not replaced in the switch assemblies. If one wafer is defective, the entire switch assembly should be replaced. Switches can be ordered from Tektronix either wired or unwired.

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

The MILLIVOLTS/CM switches can be removed after first removing the aluminum brace located right above the switches. Mounting bolts for the brace have captive nuts, so remove the four bolts, slide the brace to the side, and lift out.

Soldering Precautions

In the production of Tektronix instruments, a silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond may be broken by repeated use of ordinary tin-lead solder, or by excessive heating of the terminal strip with a soldering iron. Occasional use of ordinary 60/40 solder is permissible if applied with moderate heat. For general repair work, however, solder used for the ceramic strips should contain about 3% silver. If this type of solder is not available locally, it may be purchased directly from Tektronix in one-pound rolls (part number 251-514).

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

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

Ceramic Terminal Strips

To remove a ceramic terminal strip, first unsolder all leads and components connected to it. Then pry the strip, with yokes attached, out of the chassis. The spacers may come out with the yokes; if not, they can be pulled out separately. If they are not damaged, the spacers may be used with the new strip assembly.

Another way to remove a strip from the chassis is to use diagonal cutters to cut off one side of each yoke holding the strip. This frees the strip, and the remainder of the yokes can then be pulled free of the chassis with a pair of pliers. Ceramic strips are supplied with yokes attached so it is not necessary to salvage the old yokes.

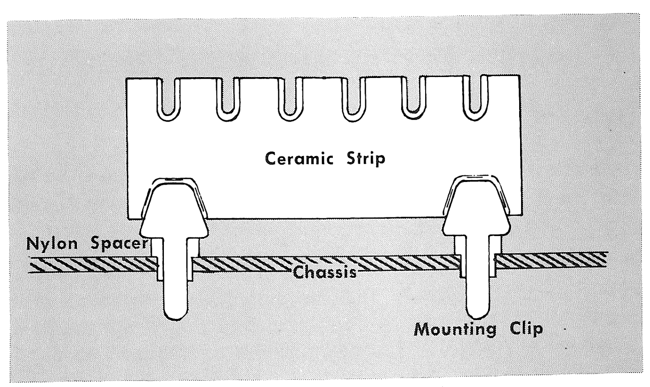


Fig. 4-2. Ceramic strip replacement.

After removing a damaged strip and yoke assembly, place the spacers into the holes in the chassis and insert the yokes into the spacers. Be sure the yokes are completely seated in the spacers. If necessary, use a soft-faced mallet to tap the yokes into the spacers. Fig. 4-2 shows the assembled ceramic strip.

P6038 Probe

The P6038 Probe should be inspected if it is dropped or if damage is obvious. Inspect the inside of the probe by grasping the cable strain-relief boot about 3/4 inch from the probe body, then turn the probe body counterclockwise

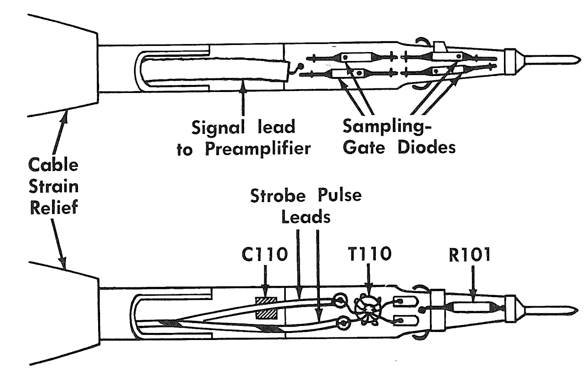


Fig. 4-3. Inside view of P6038 Probe.

about six complete turns to free the securing threads and allow the body to be removed from the tip end.

The cable strain-relief boot should not be forced back from its normal position, as a special tool is required to reinstall it.

The sampling-gate diodes are snapped in place. If the probe has been dropped, one or more of the diodes may have slipped out of one of its clips. Fig. 4-3 shows the proper location of the diodes and their polarity. Return a diode to its clips by applying pressure on the lead, not on the ceramic body. (Diodes can be broken by finger pressure on the body.)

If any diodes fail, a selected set of four is available by ordering Tektronix Part No. 152-144. The diodes come in two pairs. Each pair is to be placed side-by-side, either at the tip end or at the cable end. Do not mix diode locations on diode sets. Diode set replacement requires complete recalibration.

If any other parts require replacement, send your probe to your nearest Tektronix Field Repair Center. Do not attempt any soldering as a special positioning jig is required to set proper tolerances.

To replace the probe body, take care that the threads do not rub against any components, or the cable dielectric foam, and reverse the removal procedure. Gentle handling is important; the P6038 Probe is not intended for rugged use.

TROUBLESHOOTING

General Information

The Type 4S3 derives its operating voltage from the oscilloscope, and depends on the oscilloscope and the Timing Unit for its display. Therefore, be sure that the oscilloscope is not the source of trouble.

If trouble symptoms occur in the Type 4S3, try to isolate them by quick operational and visual checks. First, check the settings of all controls. Then operate the controls to see what effect, if any, they have on the trouble symptom. The normal or abnormal operation of each control may help establish the trouble symptoms.

After the trouble symptoms are established, look first for simple troubles. Check to see that the pilot light of the oscilloscope is on, feel for any irregularities in the operation of the controls, listen for any unusual sound, see that the tube filaments are lit, check all power-supply voltages, and visually check the entire instrument. The type of trouble symptom will generally indicate the checks to make.

Trouble Symptoms

1. A display that may appear to be a trouble symptom can occur when triggering information stops arriving from the Timing Unit. Each display dot is the result of a pulse from the Timing Unit arriving at the Type 4S3 Gate Generator. If the information stops — even in the middle of a trace — sampling stops immediately. The spot does not extinguish, but it stops moving horizontally across the crt and starts drifting up or down the crt and ultimately goes out of sight. This is normal, and is not to be confused with trouble in the Type 4S3. It is the Memory drifting, without repeated correction. Should the Timing Unit information begin again, the dot will return to the crt and the interrupted trace will be completed.

2. If the display appears to compress or limit at one end of the VERT POSITION control range, set the DC OFFSET control for zero volts at the OFFSET MONITOR jack. Then reduce the input signal to 1 volt or less, peak-to-peak. If the symptom continues, recalibration of the Type 4S3 is necessary.

3. If less than 1 nsec of delay cable is used between the Type 661 DELAYED PULSE connector and the P6038 input, the Delayed Pulse tunnel diode may be triggered falsely by the probe kickout. Use at least 1 nsec of 50-ohm cable between the DELAYED PULSE connector and the 50-ohm termination when observing the Type 661 Delayed Pulse output.

4. If the dots are spread all over the crt, the SMOOTHING control is too far clockwise and the system loop gain is much greater than unity. Turn the SMOOTHING control counterclockwise.

Testing Precaution

When observing waveforms in the Type 4S3 circuitry, always make certain that the test-oscilloscope frame is connected to the Type 4S3 frame. Then if you wish to look at fast pulses inside the Type 4S3 circuits that are differential in nature, observe the following. The Tektronix P6034 and P6035 signal probes, used on one sampling system to observe another (such as with a Type 4S1 or Type 4S2), can be used singly to make a differential measurement. If the circuit being measured is not at ground potential, both the probe center conductor and ground return must be ac-coupled. The center conductor can be ac-coupled using a General Radio Type 874-K in-line capacitor. The ground return can be ac-coupled (for fast signals) with a 0.001-μf capacitor at the probe ground clip. Use short leads. If the test oscilloscope frame is not connected to the Type 4S3 frame, 60-cycle stray pickup between the chassis can damage components in the Type 4S3.

Circuit Isolation Technique

If one channel of the Type 4S3 has no trace but the other channel operates, or if there is a trace but no signal, use the following circuit isolation procedure.

Use a 15-mc (or greater) bandwidth test oscilloscope such as a Tektronix Type 530- or 540-Series with a Type H or L plug-in unit and a 10X Probe. Externally trigger the test oscilloscope from the Type 661 Delayed Pulse. Use a coaxial cable between the two oscilloscopes.

Set the test-oscilloscope controls as follows:

TRIGGERING MODE	AC
TRIGGER SLOPE	— EXT.
TIME/CM	0.5 μsec/cm
VOLTS/CM	1 volt, ac coupled

1. Connect the three extension cables listed at the beginning of the calibration procedure to operate the Type 4S3 outside the Type 661.

2. Free run the Timing Unit at 10 nsec/cm and 5 samples/cm.

3. Short the feedback loop by grounding terminal B for Channel A or Y for Channel B of J11. The trace should leave the crt. This permits isolation of the defective circuit.

4. Set the Type 4S3 MILLIVOLTS/CM switch to 10 and check for a signal at the Ac Amplifier output (terminal U for Channel A, or F for Channel B of J12). Adjustment of the RISETIME BAL control should alter or even invert the pulse polarity. If it does, the trouble is after the Ac Amplifier. (Note the control position and restore to same position at end of this step.) See Fig. 4-4 for a typical grounded-feedback signal at the Ac Amplifier output. (The picture was taken before adjusting the RISETIME BAL control.)

5. If there is no pulse in step 4, move the test-oscilloscope probe to the Ac Amplifier input (terminal Y for Channel A, or B for Channel B of J12). Set the MILLIVOLTS/CM switch to 2. If there is a pulse, (Fig. 4-5) and its amplitude can be altered as in step 4, the trouble is in the Ac Amplifier.

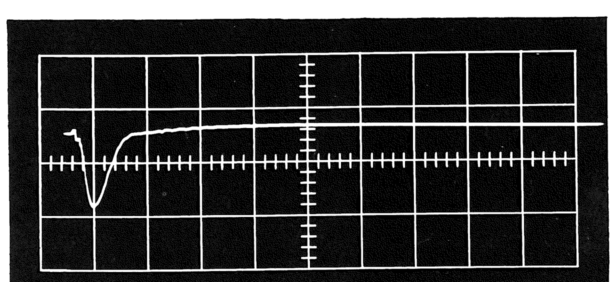


Fig. 4-4. Typical Ac Amplifier output signal. Type 4S3: Feedback shorted; DC OFFSET-Zero, MILLIVOLTS/CM-10. Test oscilloscope: 1 volt/cm, 0.5 μsec/cm, externally triggered.

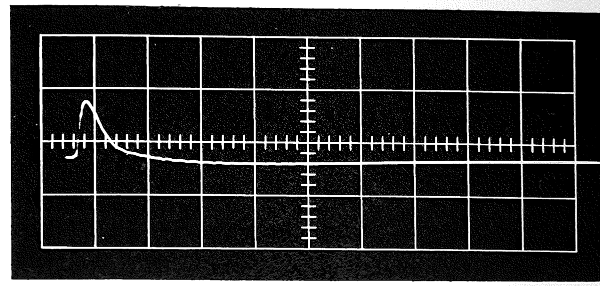


Fig. 4-5. Typical Ac Amplifier input signal. Type 4S3: Feedback shorted, DC OFFSET-zero, MILLIVOLTS/CM-2. Test oscilloscope; 0.5 volt/cm, 0.5 μsec/cm, externally triggered.

6. If the circuits up to the Memory are operating, dc couple the test oscilloscope to the Memory output (terminal X of J13 for Channel A, terminal X of J14 for Channel B). Set the MILLIVOLTS/CM switch to 200. There should be a pulse similar to Fig. 4-6 and the output dc voltage should be adjustable from about −8 to +9 volts by turning the SMOOTHING BALANCE control. The Memory output is normally 600 mv/cm.

7. Remove the feedback short. Dc couple the test oscilloscope (0.5 volt/cm) to the Memory output. Set the SMOOTHING BALANCE for zero volts output. The test oscilloscope can now display sampling waveforms, expanded in time. If an input signal cannot be displayed by the test oscilloscope, the trouble is in the Memory. If it does display the signal, but no display can be obtained on the crt, the trouble is in the Inverter, Dual Trace, or Type 661 Vertical circuits.

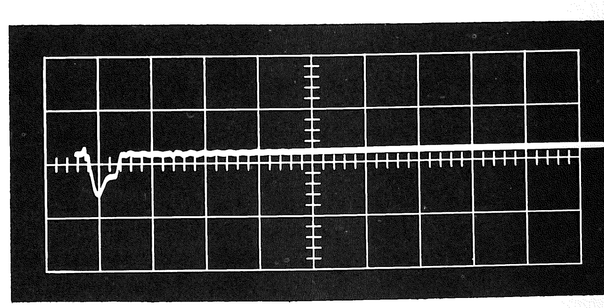


Fig. 4-6. Normal Memory output signal. Type 4S3: Feedback not shorted, trace centered, MILLIVOLTS/CM-200. Test oscilloscope: 0.5 volt/cm, 0.5 μsec/cm, externally triggered.

SECTION 5

CALIBRATION

Introduction

The following paragraphs outline a procedure for calibrating the Type 4S3. The instrument should not require frequent recalibration, but occasional adjustments will be necessary when tubes and other components are changed. Also, a periodic recalibration is desirable from the standpoint of preventive maintenance.

Apparent troubles in the instrument are occasionally the result of improper calibration of one or more circuits. Consequently, calibration checks should be an integral part of any troubleshooting procedure. Abnormal indications occurring during calibration checks will often aid in isolating troubles to a definite circuit or stage.

In the instructons that follow, the steps are arranged in the proper sequence for a complete calibration of the instrument and to avoid unnecessary repetition of checks or adjustments.

Equipment Required

The following equipment, or its equivalent, is required to perform a complete calibration of the Type 4S3 along with the P6038 Probes.

1. A calibrated Type 661 Oscilloscope with a calibrated Type 5T1A or Type 5T1 Timing Unit.

2. A dc voltmeter with a sensitivity of at least 20,000 ohms/volt.

3. A precision voltmeter with an accuracy of at least 0.2%.

4. An ohmmeter.

5. A test oscilloscope with a bandpass of at least 15 mc and a deflection factor of at least 5 millivolts/div, such as a Tektronix Type 530- or 540-Series with a Type L or H plug-in unit.

6. A 10X Attenuator probe for use with the test oscilloscope, such as a Tektronix P6006 Probe, Tektronix Part No. 010-125 with UHF connector, or 010-127 with BNC connector.

7. Two special flexible interconnecting cables to connect between the Type 4S3 and the Type 661. Tektronix Part No. 012-064.

8. A special 32" 50-ohm cable with Gremar connectors to connect between the Type 4S3 and the Type 661. Tektronix Part No. 012-070.

9. A special subchassis extender board. Tektronix Part No. 012-069.

10. A 50-ohm coaxial cable, RG-8A/U with GR connectors, 10-nsec signal delay. Tektronix Part No. 017-501.

11. Two nonterminating 50-ohm GR-To-P6038 Adapters. (Fig. 2-1) Tektronix Part No. 017-076. (BNC-To-P6038 Adapters are available, Tektronix Part No. 103-038).

12. If the test oscilloscope (item 5) has a UHF input connector, then use these items:

a. GR-To-UHF Adapter (GR Type 874-QUP). Tektronix Part No. 017-023.

b. BNC 50-ohm Termination. Tektronix Part No. 011-049. Part No. 017-022.

c. UHF 50-ohm Termination. Tektronix Part. No. 011-045.

If the test oscilloscope has a BNC input connector, use these items:

a. GR-To-BNC Adapter (GR Type 874-QBPA). Tektronix Part No. 017-065.

b. BNC 50-ohm Termination. Tektronix Part No. 011-049.

c. BNC-To-P6038 Adapter. Tektronix Part No. 103-038.

13. A 0.2-μf or 0.25-μf, 25-volt capacitor.

14. A 500-ohm or 1 k potentiometer.

15. Two 50-ohm, 1% fixed resistors, and the following 10% resistors: 680 ohms, 1800 ohms, 3800 ohms, 9.5 k, 19 k, 38 k, and 96 k.

16. A clip lead about 2½ feet long.

17. A small-bit, insulated screwdriver.

18. A No. 6, 3/16" nut driver.

19. If calibrating the system with a new P6038 Probe:

a. 2X, 50-ohm Attenuator such as the Tektronix 2XT, Part No. 017-046.

b. GR 874-T, 50-ohm coaxial Tee connector.

c. Two 50-ohm 30-cm air lines, GR 874-L30, or two identical signal delay coaxial cables.

d. 50-watt soldering iron and some 60/40 solder.

e. Tweezers, or small needle-nose pliers.

PRELIMINARY PROCEDURE

Make a complete visual check of the instrument. If calibration is being done as a result of trouble, check for correct transistors, tubes and sampler diodes and that they are in their correct locations. The P6038 Probe sampler diodes have a red dot on their cathode end. (See Fig. 4-3). Memory-gate diodes have a red dot at their cathode end also. If a transistor has four leads, see that all four are plugged into the socket.

Use an ohmmeter to check the resistance of each interconnecting plug lead to ground as shown in Tables 5-1 and 5-2. Disconnect probes when making these resistance measurements.

Set the Type 4S3 front-panel controls as follows when making resistance measurements:

MILLIVOLTS/CM	200
VARIABLE	CALIBRATED
VERT POSITION	Midrange
DC OFFSET	Midrange
DISPLAY	NORMAL
MODE	A ONLY
SMOOTHING	Midrange
Noise-Risetime	LOW NOISE

TABLE 5-1

Resistance to ground at P1 (see Fig. 5-1). All subchassis in place.

Pin No.	Circuit	Ohmmeter Range	Resistance
1	117 vac	X100 k	inf.
2	6.3 vac	X100 k	inf.
3	—19 v	X10	9-15 Ω
4	—25.2 v	X100 k	inf.
5	—100 v	X1 k	2-2.5 k
6	staircase in	X100 k	inf.
7	gnd	X10	0
8	(B) out to Horiz	X100 k	inf.
9	braid for 21	X10	0
10	(B) vert. out.	X1 k	8-11 k
11	(A) vert. out.	X1 k	8-11 k
12	gnd	X10	0
13	117 vac	X100 k	inf.
14	6.3 vac	X100 k	inf.
15	+300 v	X1 k	17 k
16	+400 v	X100 k	inf.
17	+100 v	X1 k	9 k
18	+19 v	X100	400-500 Ω
19	staircase out	X100 k	inf.
20	braid for 8	X100 k	inf.
21	blanking out	X100 k	10-50 meg
22	braid for 10	X100 k	inf.
23	braid for 11	X100 k	inf.
24	vert sig. out.	X1 k	4-5 k

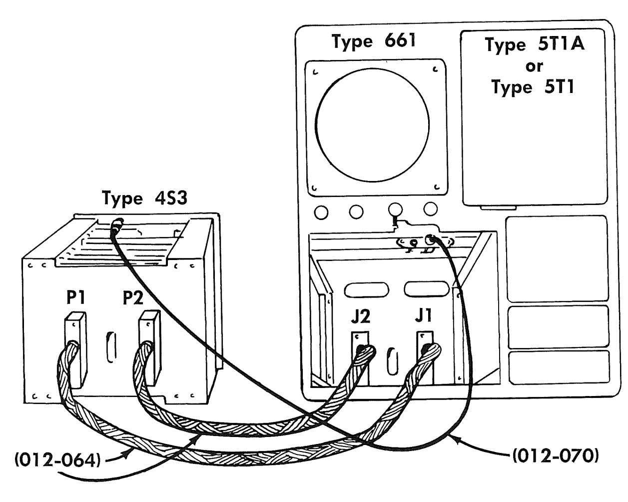


Fig. 5-1. Location of cables for operating Type 4S3 outside of Type 661.

TABLE 5-2

Resistance to ground at P2, all subchassis in place.

Pin No.	Circuit	Ohmmeter Range	Resistance
1	open	X100 k	inf.
2	—12.6 v	X100 k	inf.
3	chop out	X1 k	10 k
4	(B) ÷ 1,2,5 gnd	X100 k	inf.
5	÷ 2	X100 k	inf.
6	(A) Dec.* Unit gnd	X100 k	2 meg
7	open	X100 k	inf.
8	Dec. 3	X100 k	inf.
9	open	X100 k	inf.
10	open	X100 k	inf.
11	braid for 23	X100 k	inf.
12	(B) vert. out.	X1 k	8-11 k
13	open	X100 k	inf.
14	braid for 3	X10	0
15	(A) ÷ 1,2,5 gnd	X100 k	inf.
16	÷ 1	X100 k	inf.
17	÷ 5	X100 k	inf.
18	(B) Dec. Unit gnd	X100 k	2 meg
19	Dec. 2	X100 k	inf.
20	Dec. 4	X100 k	inf.
21	milli	X100 k	inf.
22	volt	X100 k	inf.
23	(A) vert. out	X1 k	8-11 k
24	braid for 12	X100 k	inf.

* Decimal

After making any resistance measurements, install the Type 5T1A Timing Unit into the Type 661 Oscilloscope. Connect the Type 4S3 to the oscilloscope with the interconnecting cables as shown in Fig. 5-1. Connect the P6038 Probe to the correct PROBE INPUT connector. Pull out the Ac Amplifier subchassis, and reinstall with a subchassis extender board. Set the INTENSITY control fully counterclockwise. Turn on the oscilloscope and do step 1 only. Then allow the instrument to warm up for 30 minutes and repeat step 1.

If the Timing Unit is a Type 5T1A, leave the Type 661 HORIZONTAL DISPLAY switch at SWEEP MAGNIFIER X1 throughout the entire calibration procedure.

If the Timing Unit is a Type 5T1, it will be necessary to use the Type 661 Sweep Magnifier to obtain a sufficiently fast sweep rate to check the risetime.

The following procedure is written for a system with a Type 5T1A Timing Unit. If you use a Type 5T1 and the procedure specifies a sweep rate greater than 1 nsec/cm, you must use the Type 661 Sweep Magnifier.

NOTE

There are two calibration procedures included here. The first is for recalibration using the P6038 Probes shipped with the Type 4S3. The second is for calibration with a replacement P6038 Probe(s) that will likely have balance and time coincidence different from the probe previously in use.

Recalibration With Supplied P6038 Probes

Set the Type 4S3 controls as stated under "Preliminary Procedure" at the beginning of this section. Set the Type 5T1A controls as follows:

SAMPLES/CM	5
TRIGGERING SOURCE	FREE RUN
TRIGGERING POLARITY	+
RECOVERY TIME	MIN.
THRESHOLD	0
TIME EXPANDER	X1
TIME POSITION	Fully clockwise
TIME DELAY (Type 5T1 only)	Counterclockwise
SWEEP TIME/CM	5 nSEC
VARIABLE	CALIBRATED

Set the Type 661 controls as follows:

SWEEP MAGNIFIER	X1
AMPLITUDE/TIME CALIBRATOR	OFF
POSITION	Midrange
INTENSITY	2 or 3 o'clock

1. Dc Offset Adjustment

a. Connect the Channel A P6038 Probe into the 50-ohm system shown in Fig. 5-2.

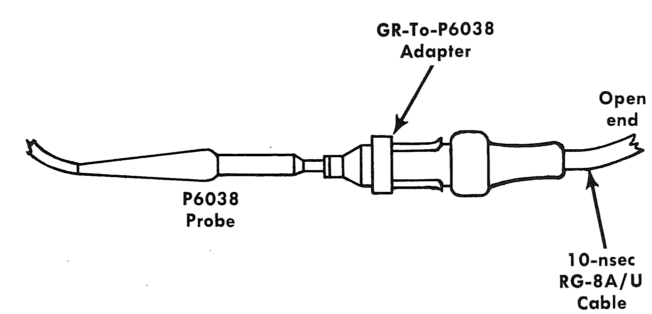


Fig. 5-2. P6038 Probe tip in 50-ohm system.

b. Use either the test oscilloscope, dc coupled, or the 20,000 ohm/volt meter and adjust both DC OFFSET controls for zero volts at the OFFSET MONITOR jacks.

c. Adjust the VERT POSITION controls to center both channel traces, first with the MODE switch at A ONLY; then with the Channel B P6038 Probe connected in the 50-ohm system shown in Fig. 5-2, center both traces with the MODE switch at B ONLY.

d. The OFFSET controls should stay at zero volts through step 8. If at any time prior to the end of step 8, the display cannot be properly positioned with the VERT POSITION control, temporarily position the display with the DC OFFSET control. Then readjust the DC OFFSET controls to zero volts as in step 1(b).

2. Memory Gate Width Adjustment

a. Connect the Channel A P6038 Probe to the 50-ohm system shown in Fig. 5-2. Set the MODE switch to A ONLY, and the MILLIVOLTS/CM switch to 100.

b. Connect the open end of the 50-ohm system 10-nsec cable to the Type 661 DELAYED PULSE connector. A 7.5- to 8.5-cm Delayed Pulse negative-step waveform should appear. If not, turn the Type 5T1A TIME POSITION control (Type 5T1 TIME DELAY control) until the pulse appears. The Type 5T1A TIME POSITION control has enough range to bring several pulses into view. Each succeeding pulse is of lower amplitude, and all are caused by reflections within the 10-nsec cable. Set the TIME POSITION control clockwise to display the negative pulse with the greatest amplitude. (Type 5T1 TIME DELAY control counterclockwise).

c. Set the Type 5T1A SWEEP TIME/CM switch to 1 nSEC Adjust the Type 4S3 Channel A SMOOTHING control and the Type 5T1A TIME POSITION control until the pulse fall has between two and four dots. Do not adjust the SMOOTHING control so far clockwise that the pulse overshoots. See Fig. 5-3.

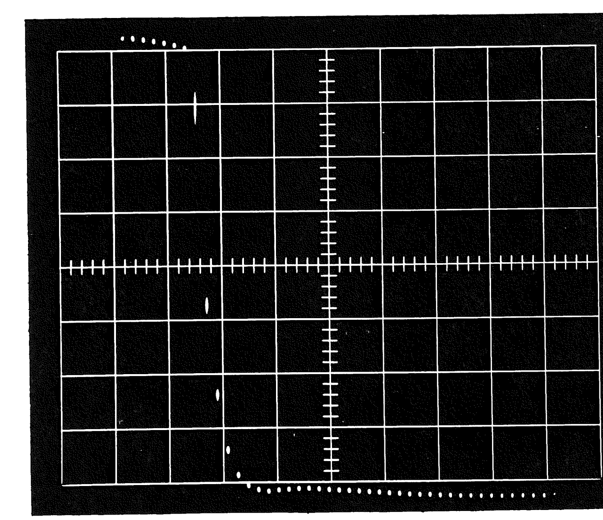


Fig. 5-3. Proper adjustment of SMOOTHING control.

d. Set the MEMORY GATE WIDTH control (see Fig. 5-4) fully counterclockwise. Then slowly turn it clockwise until the vertical distance between dots of the pulse fall is maximum. (Not display amplitude; watch only dots in pulse fall.) If you continue to turn the MEMORY GATE WIDTH control, an incorrect second maximum may occur. Repeat the adjustment to be sure the MEMORY GATE WIDTH control is adjusted for the first maximum.

3. Smoothing Balance Adjustment

a. Disconnect the 10-nsec cable from the Type 661 DELAYED PULSE connector. Leave the P6038 Probe connected to the cable and adapter.

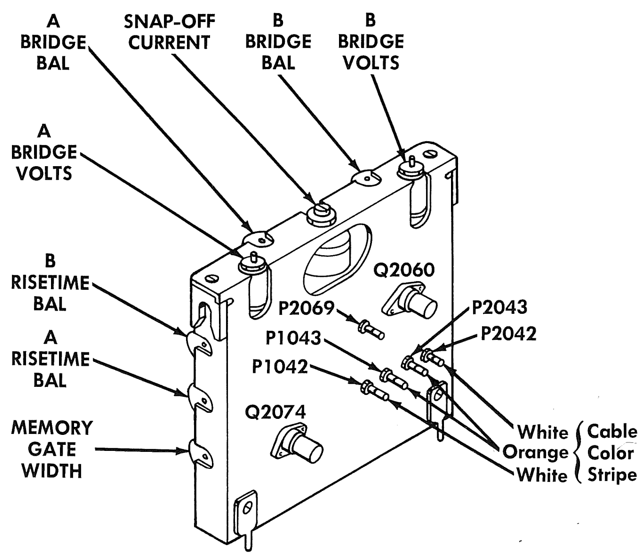


Fig. 5-4. Location of adjustments and connectors on Gate Generator subchassis.

b. Adjust the SMOOTHING BALANCE control (on the Channel A Memory subchassis, located right behind the Ac Amplifier subchassis) for no trace shift while turning the Channel A SMOOTHING control from fully counterclockwise to about 2 o'clock.

c. Set the MODE switch to B ONLY. Insert the Channel B P6038 Probe into the cable and adapter and repeat for Channel B. (Channel B SMOOTHING BALANCE is located on the second subchassis behind the Ac Amplifier.)

4. Risetime Check and/or Adjustment

a. Reconnect the 10-nsec cable to the Type 661 DELAYED PULSE connector.

b. Set the Type 5T1A TIME EXPANDER switch to X20 (Type 5T1: set the Type 661 SWEEP MAGNIFIER to X20). Sweep rate is now 100 psec/cm.

c. Set the Type 4S3 controls as follows:

MODE	A ONLY
DISPLAY	INVERTED
MILLIVOLTS/CM	200
VARIABLE	For 8-cm display.
SMOOTHING	Unity loop gain, see Section 1, SMOOTHING
Noise-Risetime	FAST RISETIME

d. Center the pulse rise using the Type 5T1A TIME POSITION control and the Type 4S3 VERT POSITION control.

e. Check the system risetime as shown in Fig. 5-5.

NOTE

If using a Type 661 Oscilloscope with a serial number under 270, and if the Delayed Pulse Generator has not been modified (Replacement Kit 050-072), the Delayed Pulse risetime is between 100 and 150 psec. The system risetime when operating properly will then be 385 to 390 psec. See "Pulse Risetime Measurements" in Section 2 of this manual. If using a Type 661 Oscilloscope with a serial number 270 and above, or if the Delayed Pulse Generator has been modified, the Delayed Pulse risetime is 50 psec or less. The system risetime when operating properly will then be 350 psec, as shown in Fig. 5-5.

f. If the system risetime is longer than 350 psec, 10% to 90% (or 390 psec), adjust the SNAP-OFF CURRENT control a few degrees clockwise. Repeat step 2. Recheck the risetime. If still not fast enough, check the system risetime of Channel B. If Channel B is fast enough, go back to Channel A and adjust the A BRIDGE VOLTS control a few degrees clockwise. Balance both channels for the same risetime.

The reverse of the above applies if Channel A has a fast enough risetime and Channel B does not. The final adjustment is when both channels show the same risetime characteristic.

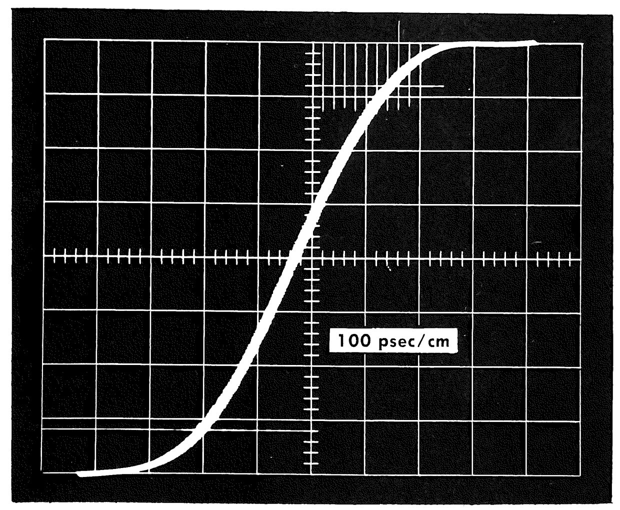


Fig. 5-5. Correctly adjusted system for 0.35-nsec risetime. Graticule specially scribed for this picture.

NOTE

Turning the SNAP-OFF CURRENT control further clockwise can cause the Type 4S3 risetime to be less than 0.35 nsec. Operation at a faster risetime is possible for special applications, but excessive pulse overshoot and/or noise is usually present. Noise and overshoot limits (see Characteristics section of this manual) do not apply when operating your system at risetimes faster than 0.35 nsec.

5. Memory Gate Width Check

a. Set the system controls as stated on page 5-3 and repeat the procedure through step 2.

b. Recheck the risetime of both channels.

6. Bridge Voltage Balance Adjustment

a. Place the P6038 Probe in the 50-ohm system shown in Fig. 5-2.

b. Set the Type 4S3 controls as follows:

MILLIVOLTS/CM	200
VARIABLE	CALIBRATED
DISPLAY	NORMAL
Noise-Risetime	LOW NOISE
SMOOTHING	Counterclockwise
DC OFFSET	Zero volts at OFFSET MONITOR jack.
MODE	A ONLY
VERT POSITION	Midrange, dot at top center.

c. Set the Type 5T1A for a free-running sweep at 5 nsec/cm and 100 samples/cm.

d. If the trace is not centered when the VERT POSITION control is at midrange, adjust the A BRIDGE BALANCE control (Fig. 5-4) to center it.

e. Set the Noise-Risetime switch to FAST RISETIME. Adjust the A RISETIME BAL control until the trace is at the same position as when the Noise-Risetime switch was at LOW NOISE.

f. Repeat the preceding step at the 50, 10, 5, and 2 positions of the MILLIVOLTS/CM switch. The final adjustment of the VERT POSITION, A BRIDGE BALANCE, A RISETIME BAL, and MILLIVOLTS/CM controls is such that the trace will stay within 2 cm of vertical center at any position of the MILLIVOLTS/CM and Noise-Risetime switches.

g. Recheck risetime, and if necessary, repeat step 6 (a) through (f).

h. Repeat this procedure for other channel.

7. Bridge Volts Check

a. Set the Type 4S3 Noise-Risetime switch to LOW NOISE.

b. Remove the $4\frac{1}{4} \times 4\frac{3}{4}$ Preamplifier bottom shield.

c. Use the test oscilloscope and 10X probe, dc coupled, to measure the bridge volts at the four test points shown in Fig. 5-6. (Do not measure these voltages with the 20,000 ohm/volt meter.) Minimum voltage at each test point is 1.5 volts + or —. If any bridge-volts test point has less than 1.5 volts (+ or —), do the following:

Repeat step 4 (a) through (c). Then, at step 4 (f), turn the BRIDGE VOLTS control to make the risetime faster. Switch back to LOW NOISE and check that the low bridge volts reading is now at least 1.5 volts. Set the Noise-Risetime switch to FAST RISETIME and slow the pulse risetime down to 350 psec by turning the SNAP-OFF CURRENT control clockwise.

d. Set the other channel risetime using its BRIDGE VOLTS control.

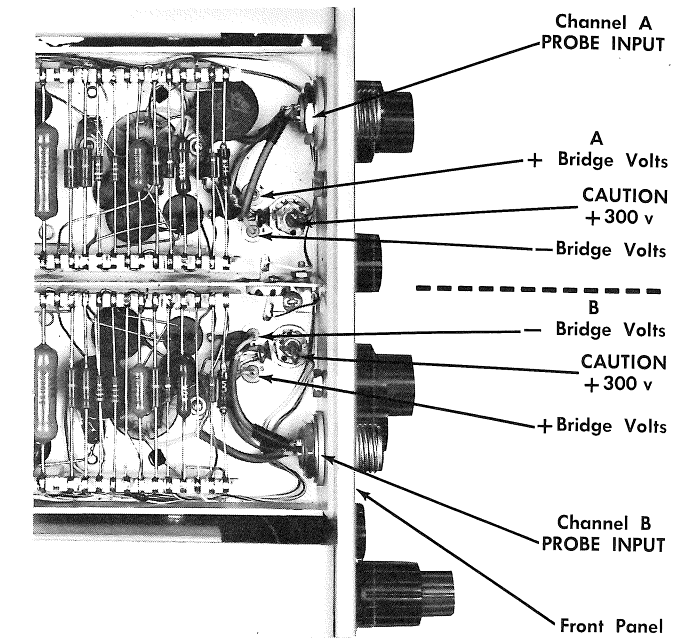


Fig. 5-6. Bridge-volts test points, located underneath $4\frac{1}{4}'' \times 4\frac{3}{4}''$ preamplifier bottom shield.

e. Rebalance the system as described in steps 5 and 6. Recheck both channel risetimes. Then recheck the bridge volts at all four test points.

8. Inverter Balance Adjustment

a. Recheck the SMOOTHING BALANCE adjustments in step 3.

b. Free run the Timing Unit at 5 nsec/cm and 100 samples/cm.

c. Set the DC OFFSET control for zero volts at the OFFSET MONITOR jack.

d. Center the trace with the VERT POSITION control.

e. Operate the DISPLAY switch back and forth. If there is a trace shift over about 2 mm, observe the trace position at NORMAL. Set the DISPLAY switch to INVERTED, and adjust the A INVERTER ZERO to return the trace to the same position as it was at NORMAL.

f. Repeat this procedure for the other channel.

NOTE

The DC OFFSET controls no longer need to be set for zero volts at the OFFSET MONITOR jack.

9. Gain Adjustment

a. Set the Type 661 controls as follows:

Amplitude/Time Calibrator	
mV AMPLITUDE	1000
μ SEC/CYCLE	1

b. Check the peak-to-peak amplitude of the calibrator output with the test oscilloscope using the setup shown

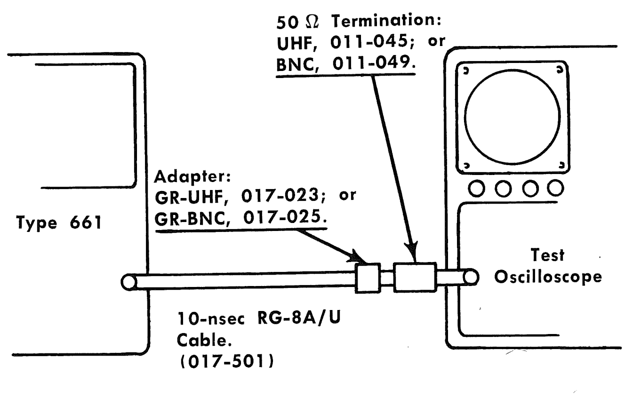


Fig. 5-7. Checking the Amplitude/Time Calibrator peak-to-peak amplitude.

in Fig. 5-7. Adjust per the Type 661 calibration procedure.

c. Set the Type 5T1A controls as follows:

TRIGGERING POLARITY	CAL.
RECOVERY TIME	MIN.
THRESHOLD	Near the — sign
SAMPLES/CM	100
TIME EXPANDER	X1
SWEEP TIME/CM	.5 μSEC

d. Set the Type 4S3 controls as follows:

MILLIVOLTS/CM (both)	200
VARIABLE (both)	CALIBRATED
MODE	B ONLY
SMOOTHING (both)	Centered

e. Connect the Channel B P6038 Probe to the Type 661 Amplitude/Time Calibrator by adding a coax-to-probe adapter (item 12 of "Equipment Required") to the termination shown in Fig. 5-7.

f. Adjust the Timing Unit THRESHOLD control for a stable sine-wave display.

g. If the display amplitude is other than 5 cm peak-to-peak, adjust the B CAL control (located on top of the Dual-Trace subchassis).

h. Connect the Channel A P6038 Probe to the calibrator; set the MODE switch to A ONLY.

i. If the display amplitude is other than 5 cm peak-to-peak, adjust the front-panel A-B BAL control.

10. Noise Check

a. Set the Type 661 Amplitude/Time Calibrator mV AMPLITUDE switch to 10.

b. Set the Type 4S3 MILLIVOLTS/CM switch to 20, and the Noise-Risetime switch to LOW NOISE. Locate the display with the VERT POSITION and/or DC OFFSET controls.

c. Adjust for unity loop gain with the SMOOTHING control. Set the SMOOTHING control so the display peak-to-peak amplitude is the same at 5 samples/cm as it is at 1000 samples/cm. Leave the Timing Unit SAMPLES/CM switch at 100.

d. Double the display amplitude by turning the VARIABLE control clockwise. Use the top of the trace so the trace width is not included in the measurement.

e. Set the MILLIVOLTS/CM switch to 2. The deflection factor is now 1 mv/cm.

f. Disconnect the coaxial cable from the Type 661 Amplitude/Time Calibrator. Remove the termination and connect the probe to the cable as shown in Fig. 5-2. Turn off the Amplitude/Time Calibrator. Set the Type 5T1A POLARITY switch to —, and the SOURCE switch to FREE RUN.

g. Disregarding 10% of the noise peaks, the residual noise should be ½ mv (½ cm) or less.

h. Set the Noise-Risetime switch to FAST RISETIME. Disregarding 10% of the noise peaks, the residual noise should be about 1 mv.

i. Repeat this procedure for the other channel.

NOTE

If the noise peaks are significantly higher than the stated limits, look for one or more of the following possible causes.

Possible Noise Causes

1. High-energy radio-frequency radiation in the vicinity of the sampling system.

2. Imbalance between the SNAP-OFF CURRENT and the BRIDGE VOLTS controls. This is usually due to insufficient bridge voltage. Recheck step 7.

3. A high degree of bridge volts imbalance, such as a ratio of 5 to 1 or greater between + and — volts to one of the probes. This indicates defective sampling diodes or incorrect adjustment. If you are certain the adjustment procedure was performed correctly, new diodes are required. The diode location and part numbers are in the Maintenance section of this manual.

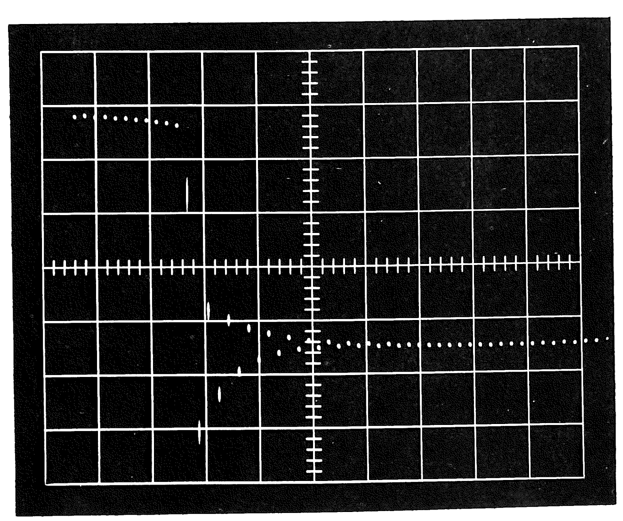


Fig. 5-8. Loop gain slightly greater than unity.

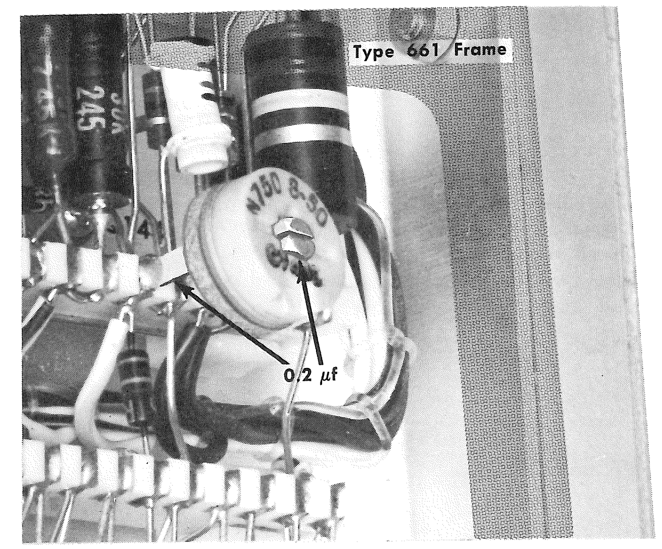


Fig. 5-9. Adding 0.2-μf capacitor to C146B of Type 5T1A.

11. AC Amplifier C1107 and C2107 Adjustment

a. Set up the system as stated on page 5-3, except set the MILLIVOLTS/CM switch to 200.

b. Use Channel A first. Turn the SMOOTHING control slowly clockwise past midrange until the first few dots of the display begin to disperse as shown in Fig. 5-8.

c. With a small-bit screwdriver (insulated to the very tip), adjust C1107 so the dispersed dots are farthest apart. Repeat for Channel B.

d. Recheck the Memory Gate Width, step 2.

12. Memory Drift Check

a. Set the Type 5T1A controls as follows:

SWEEP TIME/CM	100 μSEC
SAMPLES/CM	50
TIME EXPANDER	X1
RECOVERY TIME	MIN.

b. Set the Type 4S3 controls as follows:

MILLIVOLTS/CM	200
VARIABLE	CALIBRATED
MODE	A ONLY

Trace centered.

c. Locate C146B at the upper rear of the Type 5T1A, as shown in Fig. 5-9. Place a 0.2-μf (or 0.25-μf) capacitor across the terminals of C146B as illustrated. (This increases the trigger circuit hold-off time so the free-run rate is about 18 msec between samples or about the same as a 50 cycle/second trigger.)

NOTE

The Type 5T1 has C146B in instruments serial number 377 and above. For units with serial number 366 and below, use the base and collector leads of Q144 for temporary connection of the 0.2-μf capacitor.

d. Observe the trace; it should widen a bit, but not more than 2 mm. If the trace is wider, it means the Memory circuit has excessive drift. Recheck the SMOOTHING BALANCE adjustment, step 6. Drift can be due to a gassy V1133, or Memory Gate diode leakage. If V1133 is replaced, repeat the test after a least ten minutes warm-up. Recheck the SMOOTHING BALANCE and INVERTER ZERO control settings for the channel affected.

e. Repeat this procedure for Channel B.

13. Check MILLIVOLTS/CM Switch Positions

To check the accuracy of each setting of the MILLIVOLTS/CM switch, use a system such as shown in Fig. 5-10 with the resistances listed in Table 5-3 in series with the 500-ohm potentiometer. Repeat for Channel B.

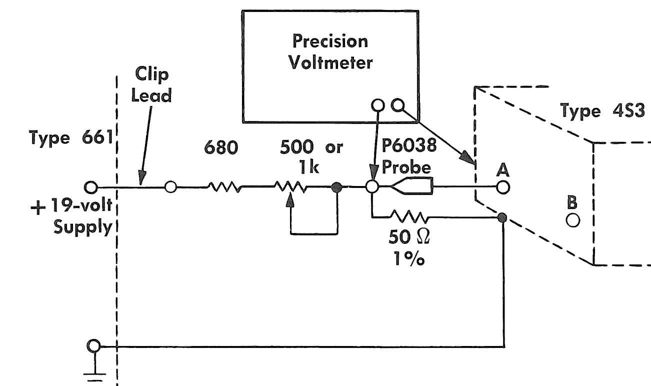


Fig. 5-10. Circuit used to set Type 4S3 gain.

TABLE 5-3
MILLIVOLTS/CM Switches Check

Approx. Series Resistance	Voltmeter Reading	MV/CM Switch Setting	Vertical Deflection	Tolerance
680 Ω	1.00 v	200	5 cm	0%
1800 Ω	0.50 v	100	5 cm	2%
3800 Ω	0.25 v	50	5 cm	2%
9.5 k	0.10 v	20	5 cm	2%
19 k	0.050 v	10	5 cm	2%
38 k	0.025 v	5	5 cm	4%
96 k	0.010 v	2	5 cm	5%

14. Final Check

a. Turn off the Type 661 and restore the Ac Amplifier to its proper seat.

b. Install the Type 4S3 into the Type 661 right away (don't let it cool).

c. Turn on the Type 661 and let it warm up for ten minutes with the side panels in place.

d. Recheck the RISETIME BAL adjustment, step 6. Step 6(f) should require only a minor adjustment of the DC OFFSET control away from zero volts if the RISETIME BAL control needs adjustment at 5 or 2 mv/cm.

Recalibration With New P6038 Probes

A new P6038 Probe is either a probe with a new set of sampling diodes, or a new probe never used before with your Type 4S3. If installing a new probe, be sure to place the correct color band in its proper place.

1. Setup and Preliminary Procedure

Preset the Type 4S3 internal controls for the channel with the new probe as follows:

RISETIME BAL	Centered
BRIDGE BALANCE	Centered
SNAP-OFF CURRENT (Only for 2 new probes)	Between 90° and 180° from clockwise end
BRIDGE VOLTS	Centered

Free run the Timing Unit and locate the trace with the Type 4S3 MILLIVOLTS/CM switch at 200. Center the VERT POSITION control, adjust DC OFFSET control for zero volts at the OFFSET MONITOR jack, and adjust one or both of the BRIDGE BALANCE and RISETIME BAL controls to position the trace at the graticule centerline.

Perform the previous procedure through step 12 and then do step 2 of this procedure.

2. Time Coincidence Check

a. Free run the Timing Unit at 1 nsec/cm.

b. Connect a 2X Attenuator to the Type 661 DELAYED PULSE connector.

c. Connect a GR Tee connector to the attenuator and a 30-cm GR-874-L30 air line to each side of the Tee. (You can use two **identical** signal-delay coaxial cables in place of the air lines.)

d. Connect the two P6038 Probes to the ends of the air lines using GR-to-Probe adapters. Make sure all connections are properly mated.

e. Set the Type 4S3 MODE switch to DUAL TRACE and adjust both channel VARIABLE (and/or MILLIVOLTS/CM) controls to obtain two equal amplitude 8-cm displays. Line up the display carefully so the pulse vertical amplitudes and positions are identical.

f. Set the Timing Unit TIME EXPANDER switch to X10 to produce a sweep rate of 100 psec/cm. The time difference between the 50% rise points of the two pulses should be no more then 60 psec.

g. If the time difference is greater than 60 psec, recheck the dual-display vertical alignment. Determine which channel signal is on the right. That channel must be adjusted so it samples the signal earlier, or the other channel must be adjusted so it samples the signal later. Write down the channel and the number of psec and direction of adjustment needed.

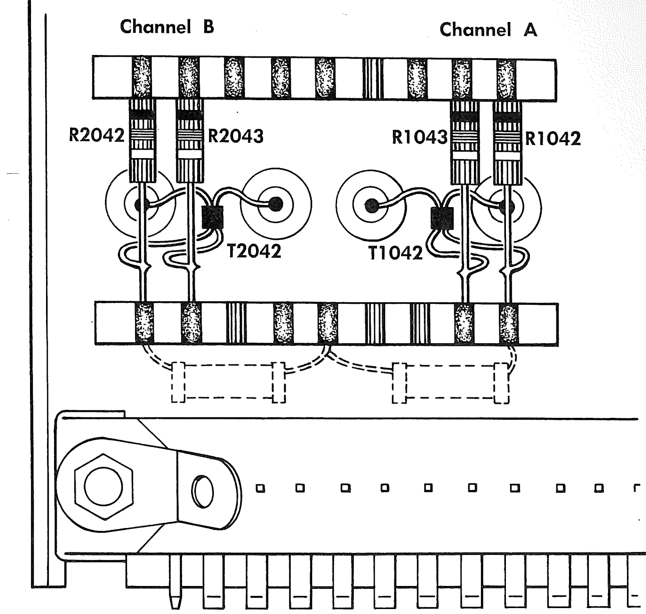


Fig. 5-11. Gate generator parts location for adjusting channel time coincidence.

3. Time Coincidence Adjustment

a. Turn off the Type 661.

b. Remove the Type 4S3 Gate Generator subchassis and locate the parts displayed in Fig. 5-11.

c. Use a 50-watt soldering iron and move the leads of either T1042 or T2042 as noted in step 2 (g). Moving the leads (1 cm equals about 30 psec) toward the resistors delays the time of sampling, and moving the leads away from the resistors makes the time of sampling earlier. For example, if you had decided that Channel B was sampling 70 psec after Channel A (10 psec out of tolerance), you would move the leads of T2042 at least 1 cm closer to the ceramic strip. If there was not 1 cm of lead length on R2042 and R2043, you would move the leads of T1042 1 cm toward resistors R1042 and R1043. Keep the leads side-by-side as you place them at their new position.

d. Reinstall the Type 4S3, warm up the system 10 minutes and recheck the time coincidence.

SECTION 6
PARTS LIST AND SCHEMATICS

PARTS ORDERING INFORMATION

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

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 including any suffix, instrument type, serial number, and modification number if applicable.

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

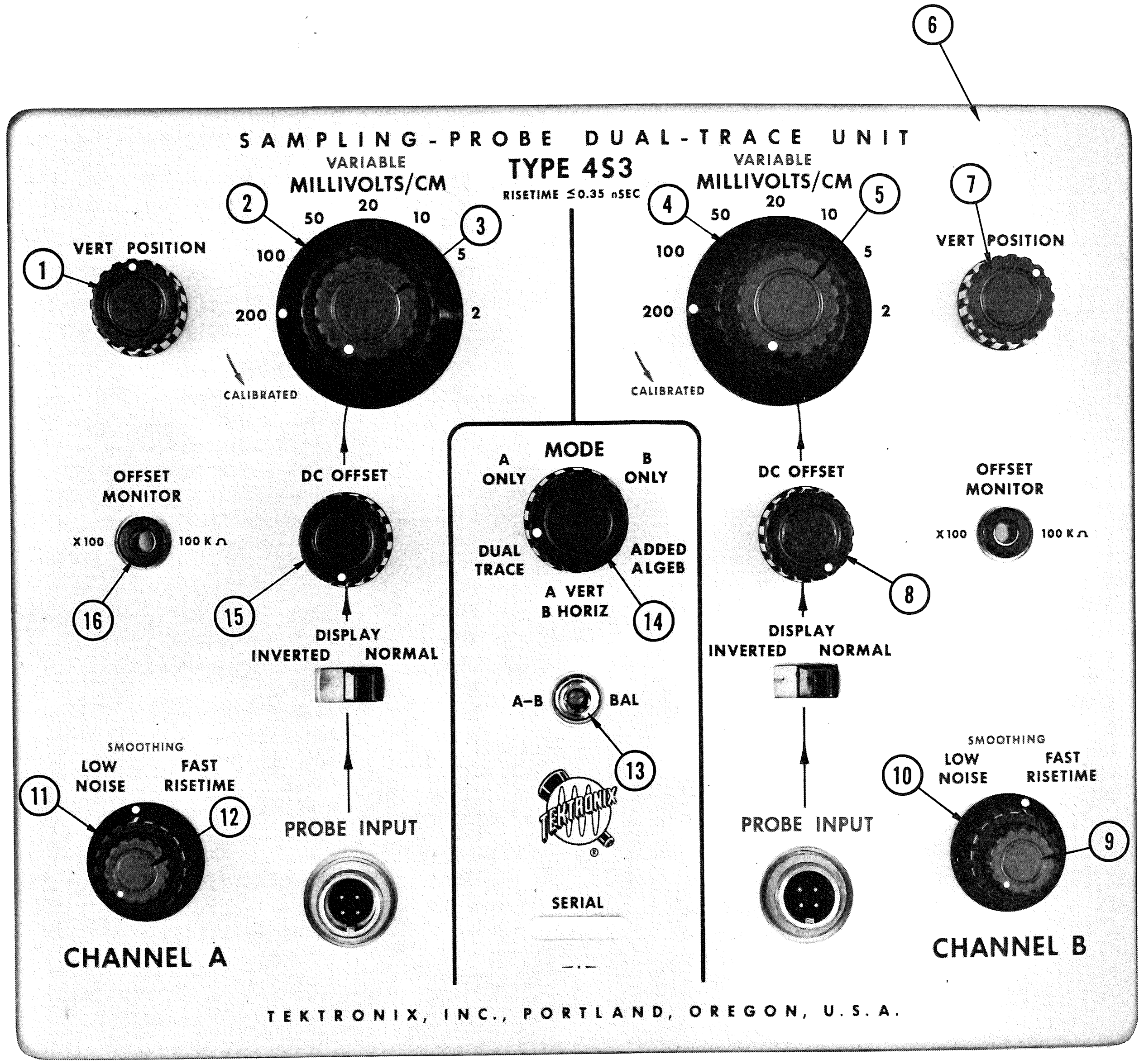
ABBREVIATIONS AND SYMBOLS

a or amp	amperes	mm	millimeter
BHS	binding head steel	meg or M	megohms or mega (10^6)
C	carbon	met.	metal
cer	ceramic	μ	micro, or 10^{-6}
cm	centimeter	n	nano, or 10^{-9}
comp	composition	Ω	ohm
cps	cycles per second	OD	outside diameter
crt	cathode-ray tube	OHS	oval head steel
CSK	counter sunk	p	pico, or 10^{-12}
dia	diameter	PHS	pan head steel
div	division	piv	peak inverse voltage
EMC	electrolytic, metal cased	plstc	plastic
EMT	electroyltic, metal tubular	PMC	paper, metal cased
ext	external	poly	polystyrene
f	farad	Prec	precision
F & I	focus and intensity	PT	paper tubular
FHS	flat head steel	PTM	paper or plastic, tubular, molded
Fil HS	fillister head steel	RHS	round head steel
g or G	giga, or 10^9	rms	root mean square
Ge	germanium	sec	second
GMV	guaranteed minimum value	Si	silicon
h	henry	S/N	serial number
hex	hexagonal	t or T	tera, or 10^{12}
HHS	hex head steel	TD	toroid
HSS	hex socket steel	THS	truss head steel
HV	high voltage	tub.	tubular
ID	inside diameter	v or V	volt
incd	incandescent	Var	variable
int	internal	w	watt
k or K	kilohms or kilo (10^3)	w/	with
kc	kilocycle	w/o	without
m	milli, or 10^{-3}	WW	wire-wound
mc	megacycle		

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
(screwdriver symbol)	Internal screwdriver adjustment.
(rectangle symbol)	Front-panel adjustment or connector.

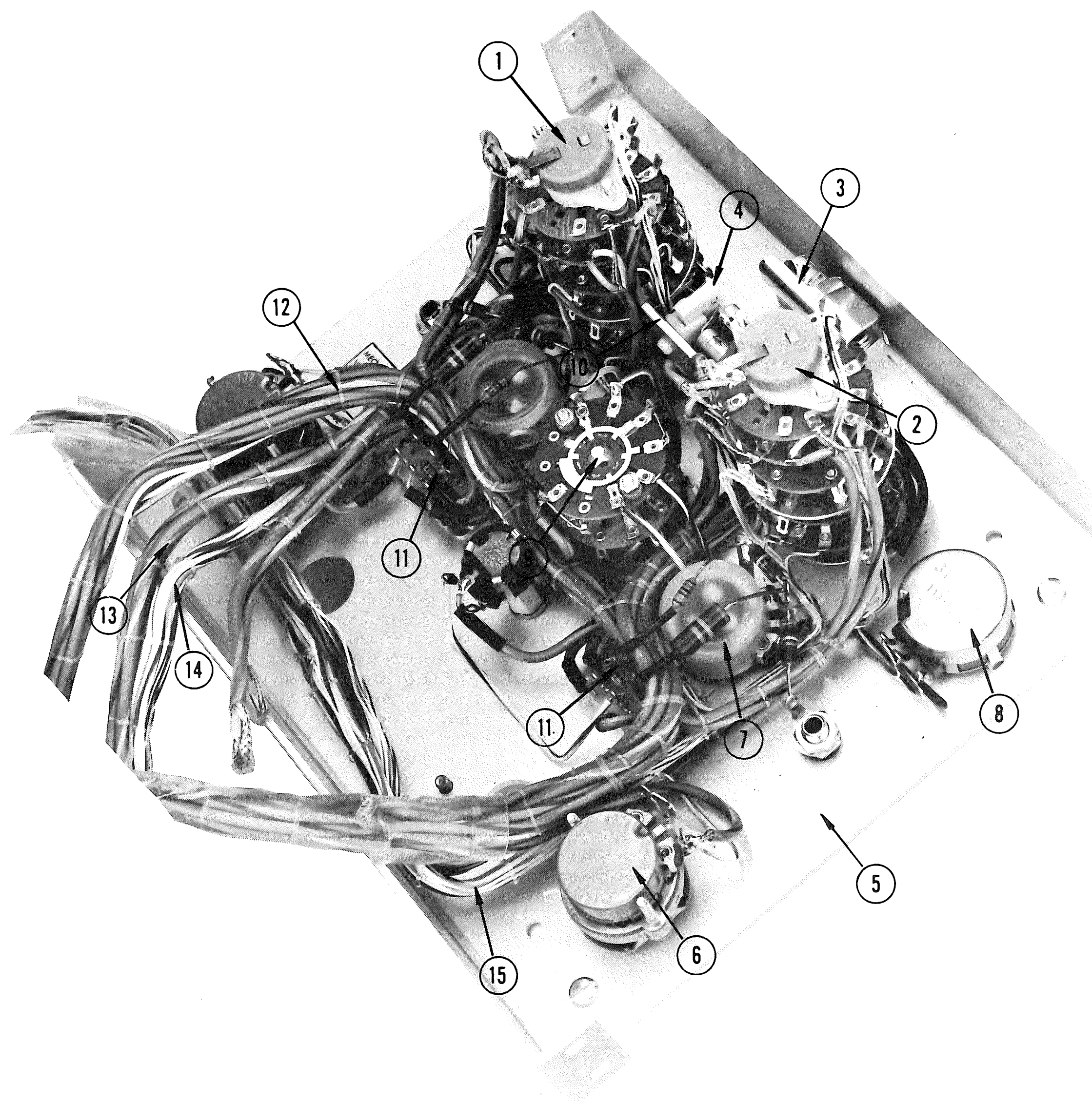
FRONT VIEW



FRONT VIEW

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	Q T Y.	DESCRIPTION
1	366-148			1	KNOB, vert position, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
2	366-160			1	KNOB, MILLIVOLTS/CM, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
3	366-038			1	KNOB, VARIABLE, red
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
4	366-160			1	KNOB, MILLIVOLTS/CM, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
5	366-038			1	KNOB, VARIABLE, red
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
6	333-759			1	PANEL, front, 4S3
7	366-148			1	KNOB, VERT POSITION, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
8	366-148			1	KNOB, DC OFFSET, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
9	366-255			1	KNOB, SMOOTHING, red
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
10	366-249			1	KNOB, LOW NOISE-FAST RISETIME, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
11	366-255			1	KNOB, SMOOTHING, red
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
12	366-249			1	KNOB, LOW NOISE-FAST RISETIME, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
13	358-054			1	BUSHING, banana jack, $^1/_4$-32 x $^{13}/_{32}$ inch
	- - - -			-	Mounting Hardware: (not included)
	210-471			1	NUT, pot mini, hex, alum, $^1/_4$-32 x $^5/_{16}$ inch
14	366-113			1	KNOB, MODE, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
15	366-148			1	KNOB, DC OFFSET, charcoal
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x $^3/_{16}$ inch HSS allen head
16	136-140			2	SOCKET, Banana jack
	- - - -			-	Mounting Hardware For Each: (not included)
	210-223			1	LUG, solder, $^1/_4$ inch hole lock
	210-465			2	NUT, hex, brass $^1/_4$-32 x $^3/_8$ inch
	210-895			1	WASHER, insulating black nylon

SUBPANEL AND SWITCHES



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SUBPANEL AND SWITCHES

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	262-565			1	SWITCH, MILLIVOLTS/CM CHANNEL B wired
	- - - -			-	Includes:
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	260-434			1	SWITCH, MILLIVOLTS/CM CHANNEL B unwired
	- - - -			-	Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, pot internal 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/6-32 x 1/2 inch
	210-840			1	WASHER, pot flat
2	262-565			1	SWITCH, MILLIVOLTS/CM CHANNEL A wired
	- - - -			-	Includes:
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	260-434			1	SWITCH, MILLIVOLTS/CM CHANNEL A unwired
	- - - -			-	Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, pot internal 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, pot flat
3	214-222			1	SPRING, striker, copper beryllium, 1 11/32 inch
	- - - -			-	Mounting Hardware: (not included)
	210-004			2	LOCKWASHER, internal #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-082			2	SCREW, 4-40 x 3/4 inch FHS socket head
	361-029			1	SPACER, latch spring Delrin
4	124-149			2	STRIP, ceramic, 7/16 inch x 7 notches
	- - - -			-	Mounting Hardware For Each: (not included)
	361-007			2	SPACER, nylon
5	387-802			1	PLATE, subpanel, 6-3/4 x 8 3/16 inch
	- - - -			-	Mounting Hardware: (not included)
	211-559			8	SCREW, 6-32 x 3/8 inch FHS 100° CSK
6	- - - -			-	Pot Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, pot internal 3/8 x 1/2 inch
	210-013			4	LOCKWASHER, pot internal 3/8 x 11/16 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, pot flat
7	200-263			2	COVER, dust pot 17/32 X 1 inch
8	- - - -			-	Pot Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, pot internal 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, pot flat
9	262-550			1	SWITCH, MODE, wired
	- - - -			-	Includes:
	260-514			1	SWITCH, MODE, unwired
	- - - -			-	Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, pot internal 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, pot flat
10	406-781			1	BRACKET, diode, alum 1 3/8 x 1 3/4 x 5/8 inch
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal #6
	211-407			2	NUT, hex, 6-32 x 1/4 inch
	211-538			2	SCREW, 6-32 x 5/16 inch FHS 100° CSK
11	260-447			2	SWITCH, DISPLAY
	- - - -			-	Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, internal #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
12	179-717			1	CABLE, harness, signal
13	179-718			1	CABLE, harness, subpanel signal
14	179-795			1	CABLE, harness, subpanel power
15	179-796			1	CABLE, harness, digital readout

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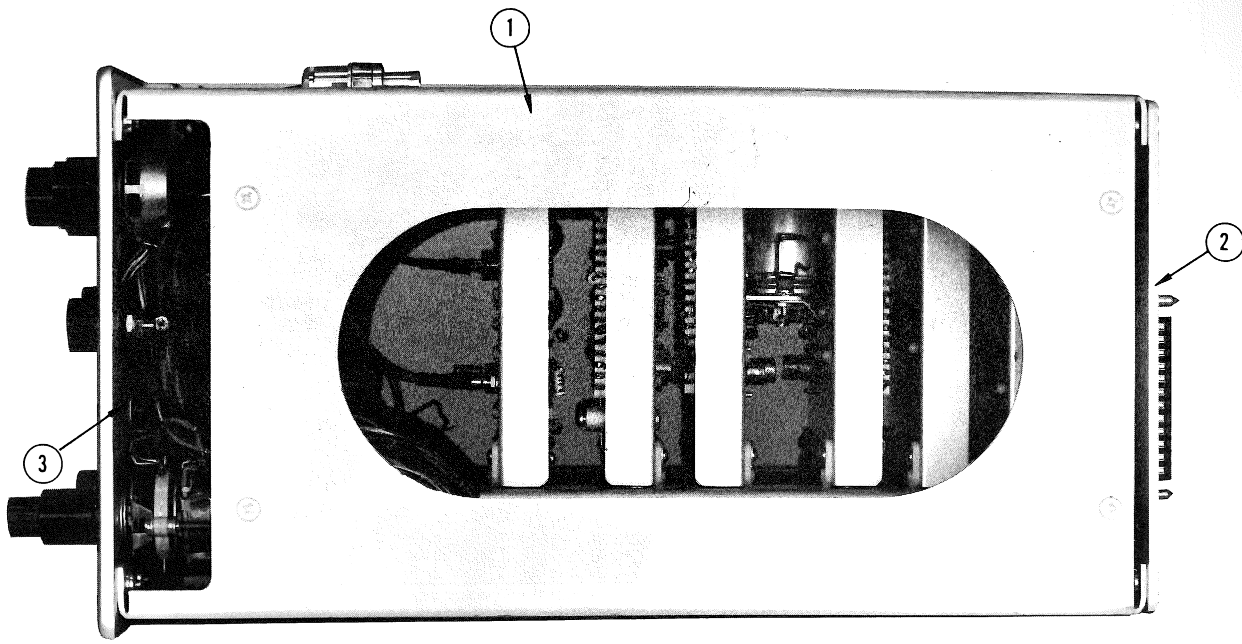
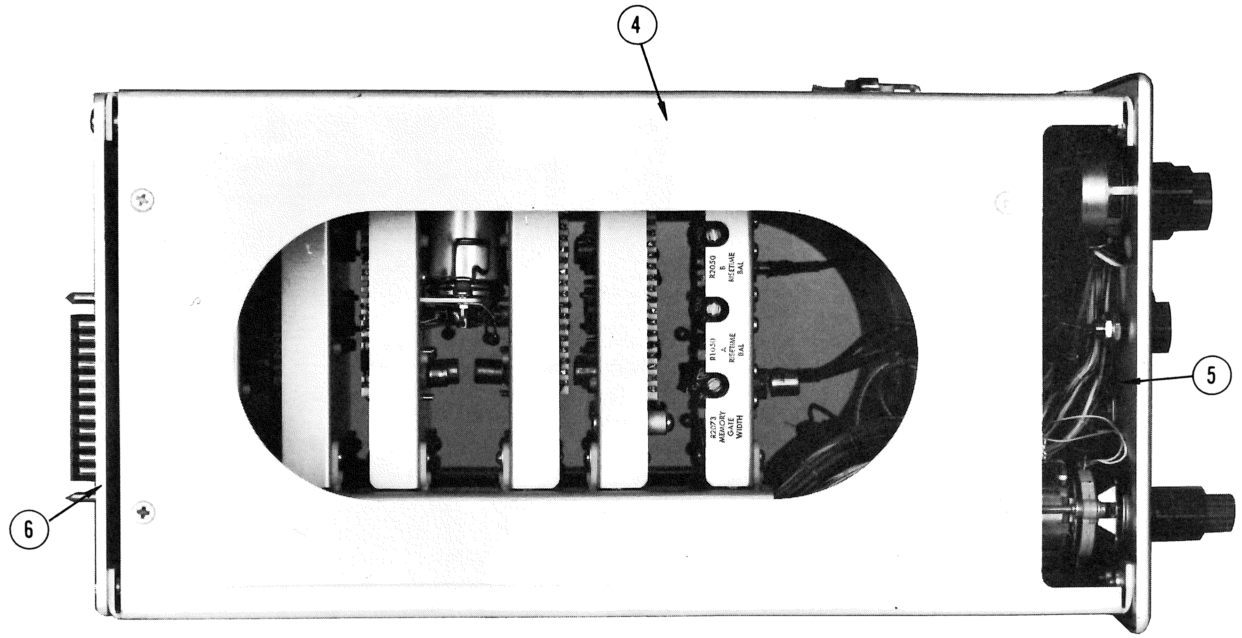
RIGHT AND LEFT SIDE





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RIGHT AND LEFT SIDE

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	426-146			1	FRAME, side rail, right
	- - - -			-	Mounting Hardware: not included)
	211-510			4	SCREW, 6-32 x 3/8 inch BHS
	211-559			4	SCREW, 6-32 x 3/8 inch FHS 100° CSK
	213-107			4	SCREW, thread forming, 4-40 x 1/4 inch FHS
	384-594			4	ROD, spacer, nylon, 1/4 dia x 1 21/64 inch long
	387-811			1	PLATE and bracket assembly
2	Pg. 6-10			-	REAR VIEW
3	Pg. 6-5			-	SUBPANEL
4	426-147			1	FRAME, side rail, left
	- - - -			-	Mounting Hardware: (not included)
	211-510			4	SCREW, 6-32 x 3/8 inch BHS
	211-559			4	SCREW, 6-32 x 3/8 inch FHS 100° CSK
	213-107			4	SCREW, thread forming, 4-40 x 1/4 inch FHS
	384-594			4	ROD, spacer, nylon, 1/4 dia x 1 21/64 inch long
	387-627			1	PLATE and bracket assembly
5	Pg. 6-5			-	SUBPANEL
6	Pg. 6-10			-	REAR VIEW

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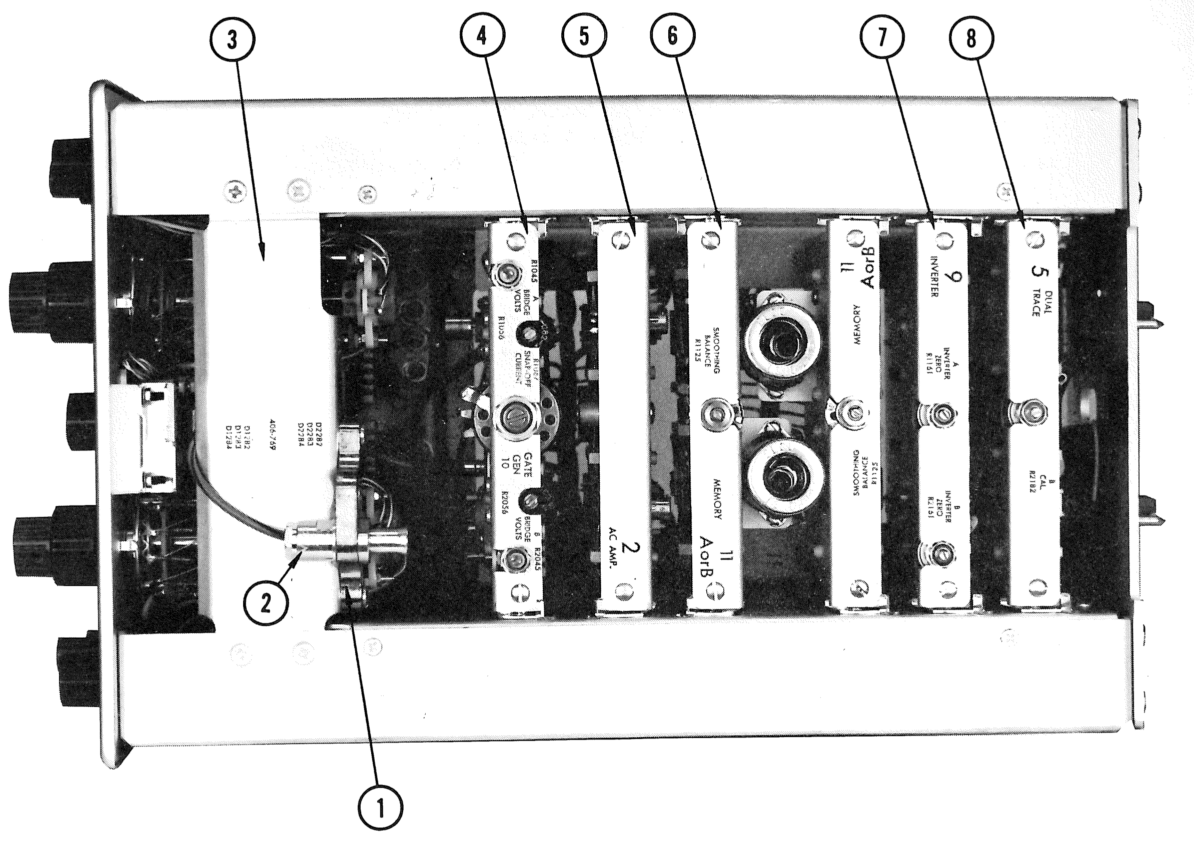
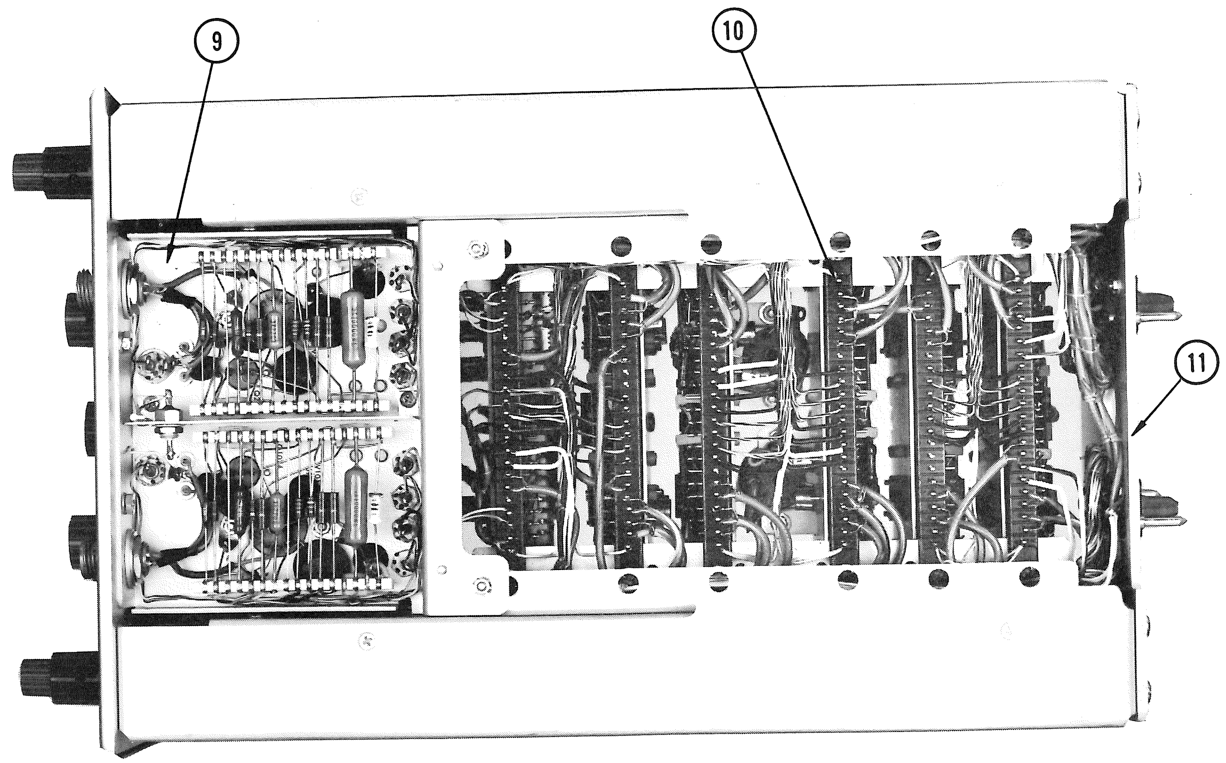
TOP AND BOTTOM





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TOP AND BOTTOM

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	426-152			1	MOUNT, 500 Ω line connector
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal #6
	210-407			2	NUT, hex, 6-32 x $\frac{1}{4}$ inch
	211-511			2	SCREW, 6-32 x $\frac{1}{2}$ inch BHS
2	131-221			1	CONNECTOR, 50 Ω
	- - - -			-	Mounting Hardware: (not included)
	358-172			1	BUSHING, brass, $\frac{9}{16}$ dia x $\frac{25}{64}$ inch long
3	406-769			1	BRACKET, alum, $6\frac{7}{32}$ x $1\frac{1}{2}$ x $\frac{3}{4}$ inch
	- - - -			-	Mounting Hardware: (not included)
	211-559			4	SCREW, 6-32 x $\frac{3}{8}$ inch FHS
4	Pg. 6-17			-	GATE GENERATOR chassis
5	Pg. 6-12			-	AC AMP chassis
6	Pg. 6-12			-	MEMORY chassis
7	Pg. 6-15			-	INVERTER chassis
8	Pg. 6-15			-	DUAL TRACE chassis
9	Pg. 6-19			-	PREAMP chassis
10	131-220			2	CONNECTOR, 22 contact female
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			1	LOCKWASHER, internal #6
	210-407			1	NUT, hex, 6-32 x $\frac{1}{4}$ inch
	211-578			1	SCREW, 6-32 x $\frac{7}{16}$ inch PHS
11	Pg. 6-10			-	REAR VIEW

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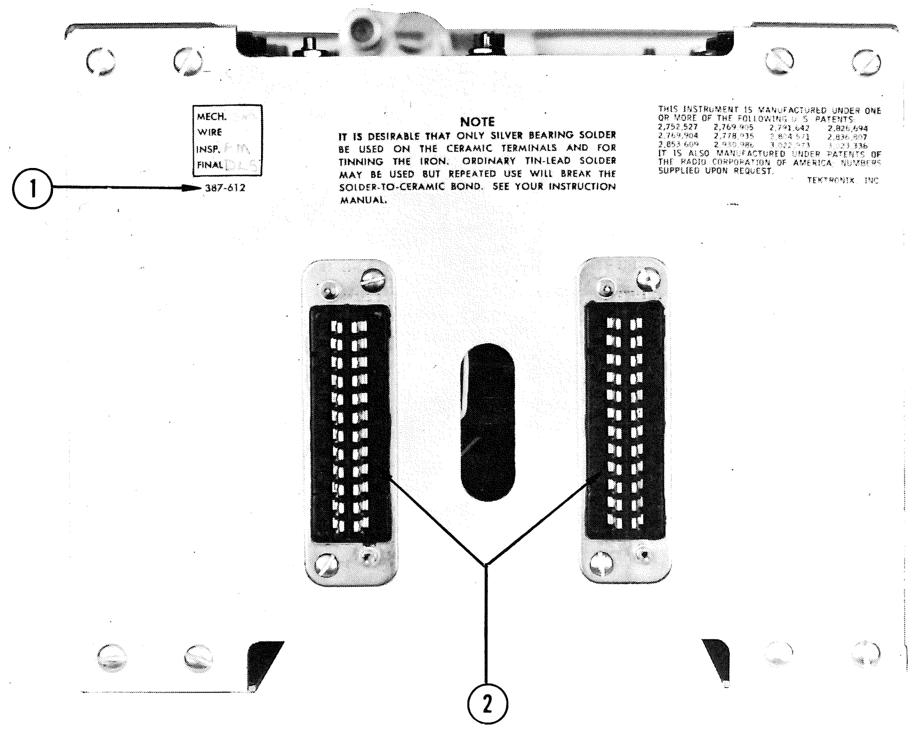
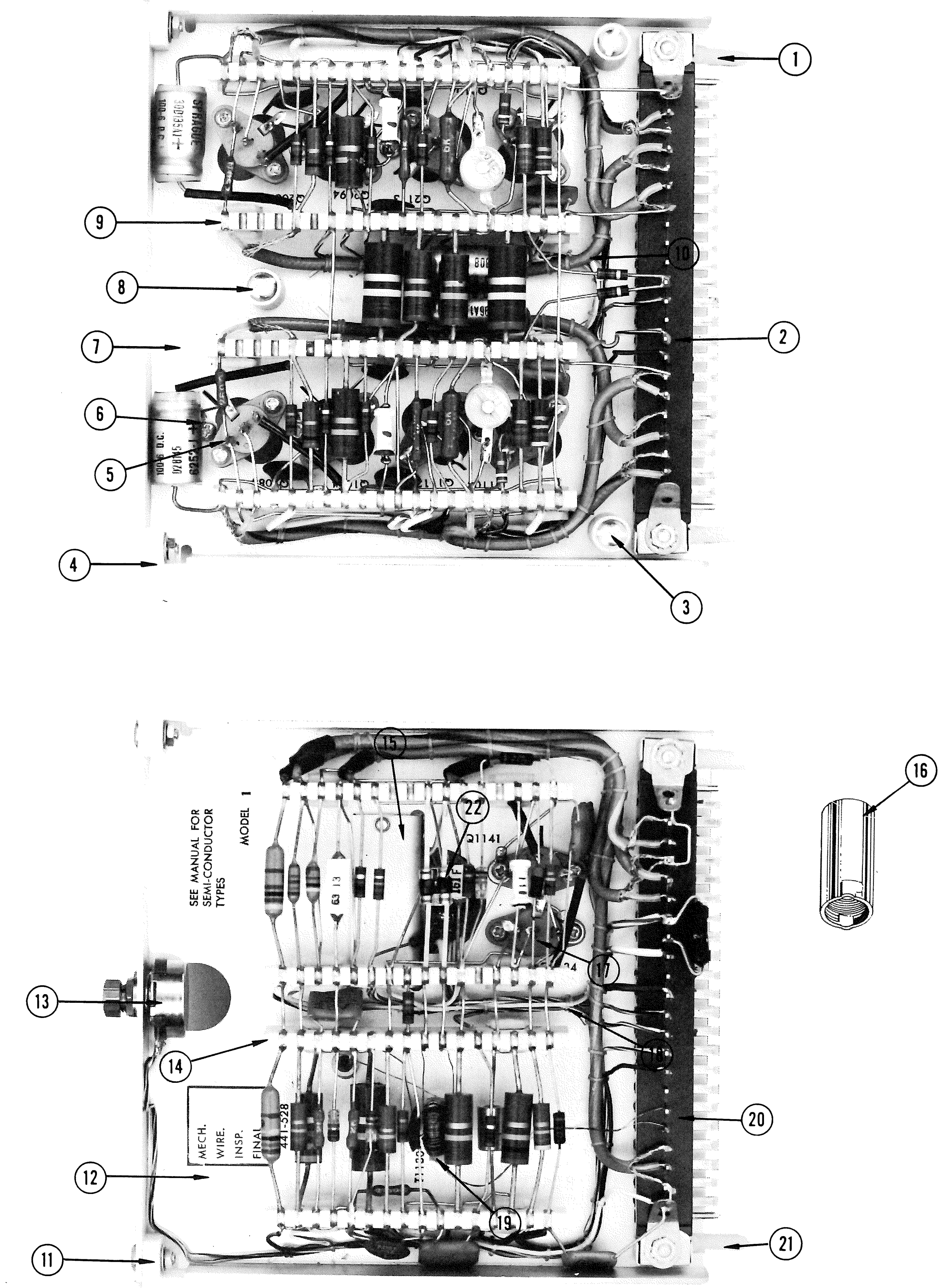
REAR VIEW



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	387-612			1	PLATE, rear frame, alum, $7^{13}/_{16} \times 6^{5}/_{16}$ inch
	- - - -			-	Mounting Hardware: (not included)
	211-510			8	SCREW, 6-32 x $^{3}/_{8}$ inch BHS
2	131-149			2	CONNECTOR, chassis mount, 24 contact
	- - - -			-	Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, internal #4
	210-201			1	LUG, solder, SE4
	210-406			2	NUT, hex, 4-40 x $^{3}/_{16}$ inch
	211-008			2	SCREW, 4-40 x $^{1}/_{4}$ inch BHS

AC AMP AND MEMORY CHASSIS



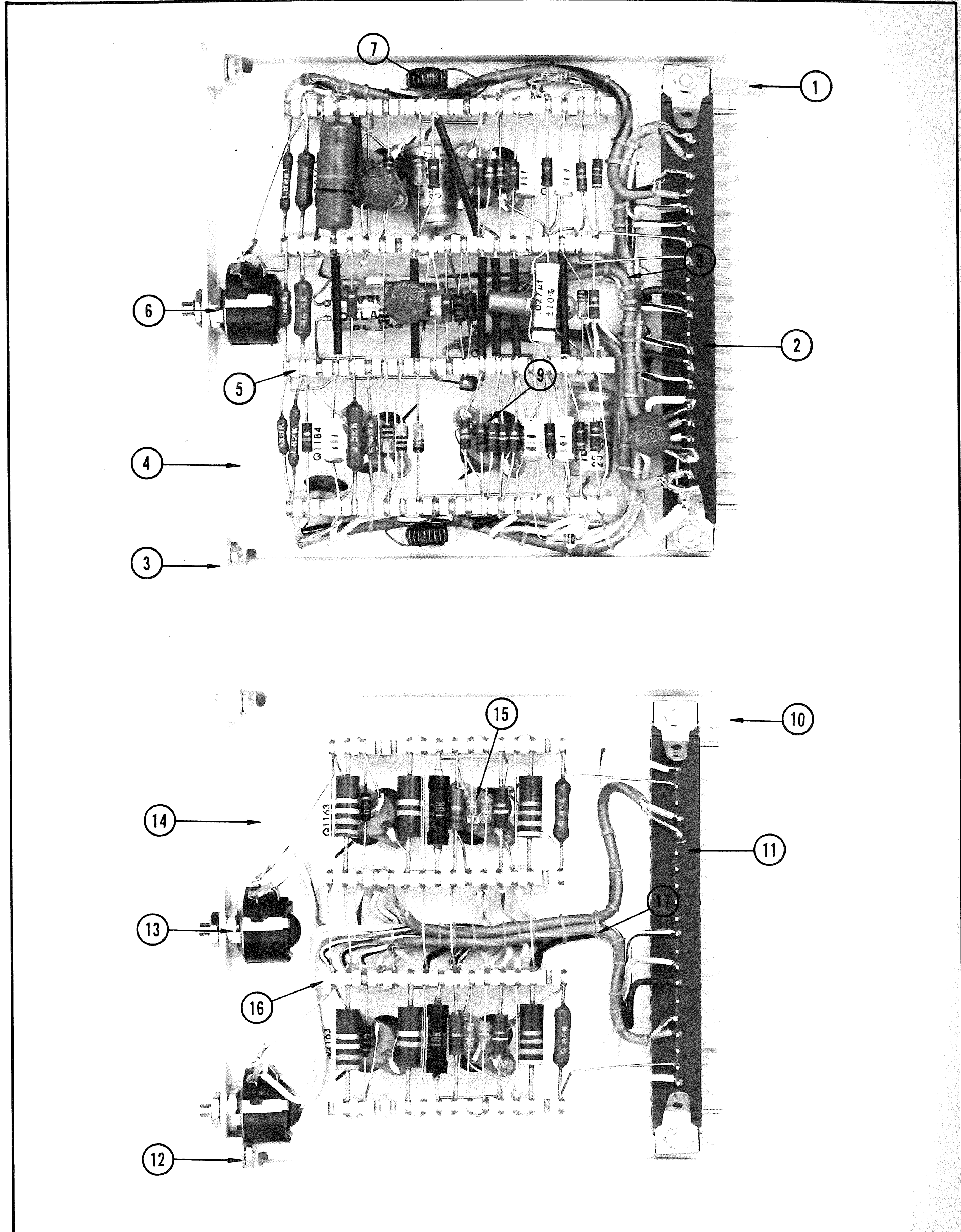
AC AMP AND MEMORY CHASSIS

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
	605-002			1	AC AMP, assembly
	- - - -			-	Includes:
1	384-593			2	ROD, pin index nylon, 3/8 x 9/16 x 15/16 inch long
2	131-218			1	CONNECTOR, 22 contact
	- - - -			-	Mounting Hardware: (not included)
	210-003			2	LOCKWASHER external #4
	210-201			2	LUG, solder #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	210-851			2	WASHER, 3/8 inch OD flat
	211-016			2	SCREW, 4-40 x 5/8 inch RHS
3	385-160			3	ROD, spacer, 5/16 inch alum rod
	- - - -			-	Mounting Hardware For Each: (not included)
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
4	352-039			2	HOLDER, nylon, 13/32 x 9/16 x 3/4 inch
	- - - -			-	Mounting Hardware For Each: (not included)
	210-004			1	LOCKWASHER, internal #4
	210-406			1	NUT, hex, 4-40 x 3/16 inch
	211-011			1	SCREW, 4-40 x 5/16 inch BHS
5	136-095			8	SOCKET, 4 pin, transistor
	- - - -			-	Mounting Hardware For Each: (not included)
	211-081			2	SCREW, 2-56 x 9/16 inch RHS
	361-035			2	SPACER, transistor socket
6	210-215			5	LUG, solder peewee
	- - - -			-	Mounting Hardware For Each: (not included)
	213-055			1	SCREW, thread forming, 2-56 x 3/16 inch PHS
7	441-424			1	CHASSIS, AC AMP
8	337-492			1	SHIELD, AC AMP (not shown)
	- - - -			-	Mounting Hardware For Each: (not included)
	211-593			3	SCREW, 6-32 x 5/16 inch RHS
9	124-145			4	STRIP, ceramic, 7/16 inch x 20 notches
	- - - -			-	Mounting Hardware For Each: (not included)
	361-008			2	SPACER, nylon
10	179-626			1	CABLE, harness
	605-010			2	MEMORY CHASSIS, assembly
	- - - -			-	Includes:
11	352-039			2	HOLDER, nylon, 13/32 x 9/16 x 3/4 inch
	- - - -			-	Mounting Hardware For Each: (not included)
	210-004			1	LOCKWASHER, internal #4
	210-406			1	NUT, hex, 4-40 x 3/16 inch
	211-011			1	SCREW, 4-40 x 5/16 inch BHS
12	441-528			2	CHASSIS, MEMORY
13	- - - -			-	Pot Mounting Hardware: (not included)
	210-465			1	NUT, hex, brass, 1/4-32 x 3/8 x 3/32 inch
14	124-146			4	STRIP, ceramic, 7/16 inch x 16 notches
	- - - -			-	Mounting Hardware For Each: (not included)
	361-008			2	SPACER, nylon
15	136-085			1	SOCKET, 9 pin, shielded base (not shown)
	- - - -			-	Mounting Hardware: (not included)
	210-004			2	LOCKWASHER, internal #4
	210-201			1	LUG, solder, SE4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-033			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
	213-044			2	SCREW, 5-32 x 3/16 inch PHS
	406-765			1	BRACKET, socket mount, alum., 1 7/16 x 7/8 x 9/16 inch
16	337-008			1	SHIELD, tube with spring, 1 1/32 inch ID
17	136-095			2	SOCKET, 4 pin, transistor
	- - - -			-	Mounting Hardware For Each: (not included)
	213-113			2	SCREW, 2-56 x 3/16 inch RHS
18	179-628			1	CABLE, harness

AC AMP AND MEMORY CHASSIS

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
19	426-121			1	MOUNT, toroid nylon, 15/32 x 1/8 x 9/64 inch
	- - - -			-	Mounting Hardware: (not included):
	361-007			1	SPACER, nylon
20	131-218			1	CONNECTOR, 22 contact
	- - - -			-	Mounting Hardware: (not included):
	210-003			2	LOCKWASHER, external #4
	210-201			2	LUG, solder, SE4
	210-406			2	NUT, 4-40 x 3/16 inch
	210-851			2	WASHER, 3/8 inch OD flat
	211-016			2	SCREW, 4-40 x 5/8 inch RHS
21	384-593			2	ROD, pin, index, nylon, 3/8 x 9/16 x 15/16 inch long
22	344-061			4	CLIP, diode

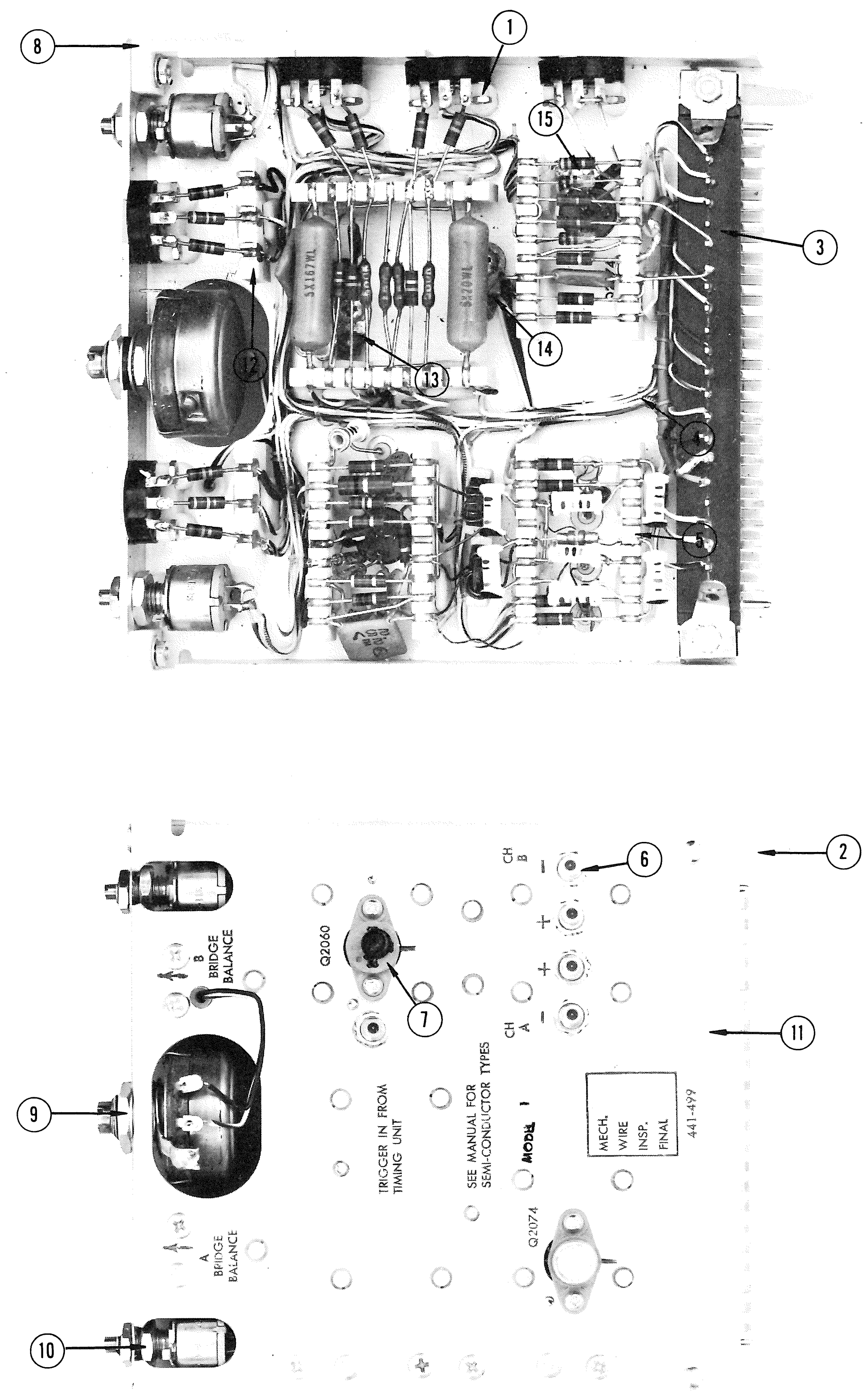
DUAL TRACE AND INVERTER CHASSIS



DUAL TRACE AND INVERTER CHASSIS

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	Q T Y.	DESCRIPTION
	605-004			1	DUAL TRACE CHASSIS, assembly
	- - - -			-	Includes:
1	384-593			2	ROD, pin, index, nylon, 3/8 x 9/16 x 15/16 inch long
2	131-218			1	CONNECTOR, 22 contact, male
	- - - -			-	Mounting Hardware: (not included)
	210-003			2	LOCKWASHER, external #4
	210-201			2	LUG, solder, SE4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	210-851			2	WASHER, 3/8 inch OD, flat
	211-016			2	SCREW, 4-40 x 5/8 inch RHS
3	352-039			2	HOLDER, nylon, 13/32 x 9/16 x 3/4 inch
	- - - -			-	Mounting Hardware For Each: (not included)
	210-004			1	LOCKWASHER, internal #4
	210-406			1	NUT, hex, 4-40 x 3/16 inch
	210-011			1	SCREW, 4-40 x 5/16 inch BHS
4	441-471			1	CHASSIS, DUAL TRACE
5	124-145			4	STRIP, ceramic, 7/16 inch x 20 notches
	- - - -			-	Mounting Hardware For Each: (not included)
	361-008			2	SPACER, nylon
6	- - - -			-	Pot Mounting Hardware: (not included)
	210-046			1	LOCKWASHER, steel, minipot
	210-583			1	NUT, hex, brass, 5/16 x 1/16 inch double chamfer
7	426-121			3	MOUNT, toroid, nylon, 15/32 x 1/8 x 9/64 inch
	- - - -			-	Mounting Hardware For Each: (not included)
	361-007			1	SPACER, nylon
8	179-715			1	CABLE, harness
9	136-095			5	SOCKET, 4 pin transistor
	- - - -			-	Mounting Hardware For Each: (not included)
	211-081			2	SCREW, 2-56 x 9/16 inch RHS
	361-035			2	SPACER, nylon transistor socket
	605-009			1	INVERTER CHASSIS, assembly
	- - - -			-	Includes:
10	384-593			2	ROD, pin, index, nylon, 3/8 x 9/16 x 15/16 inch long
11	131-218			1	CONNECTOR, 22 contact, male
	- - - -			-	Mounting Hardware: (not included)
	210-003			2	LOCKWASHER, external #4
	210-201			2	LUG, solder, SE4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	210-851			2	WASHER, 3/8 inch OD, flat
	210-016			2	SCREW, 4-40 x 5/8 inch RHS
12	352-039			2	HOLDER, nylon, 13/32 x 9/16 x 3/4 inch
	- - - -			-	Mounting Hardware For Each: (not included)
	210-004			1	LOCKWASHER, internal #4
	210-406			1	NUT, hex, 4-40 x 3/16 inch
	210-011			1	SCREW, 4-40 x 5/16 inch BHS
13	- - - -			-	Pot Mounting Hardware: (not included
	210-046			1	LOCKWASHER, steel, minipot
	210-583			1	NUT, hex, brass, 5/16 x 1/16 inch double chamfer
14	441-479			1	CHASSIS, INVERTER
15	136-095			4	SOCKET, 4 pin transistor
	- - - -			-	Mounting Hardware: (not included)
	211-081			2	SCREW, 2-56 x 9/16 inch RHS
	361-035			2	SPACER, nylon transistor socket
16	124-146			4	STRIP, ceramic, 7/16 inch x 16 notches
	- - - -			-	Mounting Hardware For Each: (not included)
	361-008			2	SPACER, nylon
17	179-628			1	CABLE, harness

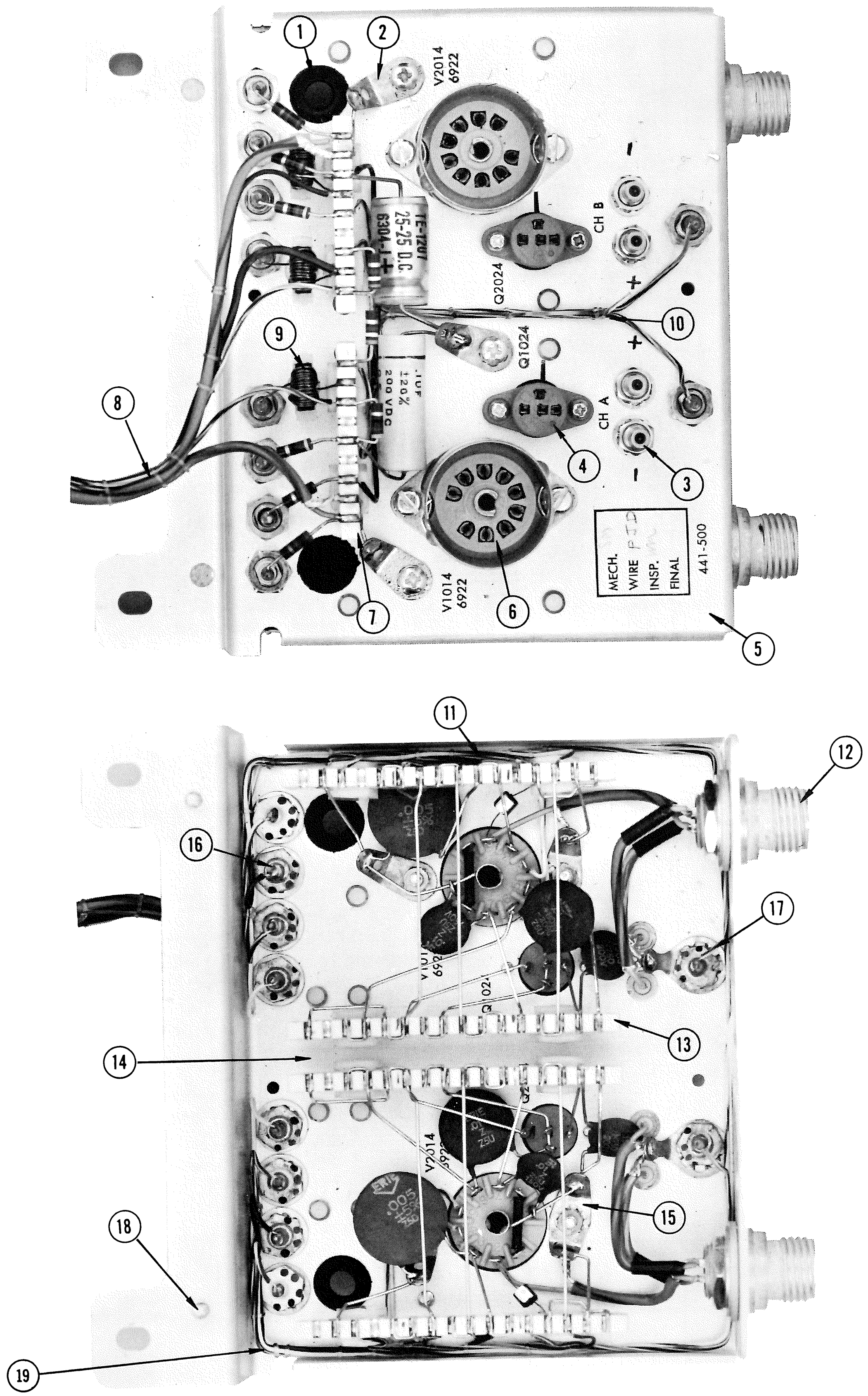
GATE GENERATOR CHASSIS



GATE GENERATOR CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	QTY.	DESCRIPTION
	605-0016-00			1	GATE GENERATOR CHASSIS, assembly
	- - - - - - -			-	Includes:
1	- - - - - - -			-	Pot Mounting Hardware: (not included w/pot)
	406-0635-00			1	BRACKET, pot mounting, delrin
	210-0438-00			2	NUT, hex, brass, 1-72 x $^{5}/_{32}$ inch
	213-0088-00			2	SCREW, thread forming, 4-40 x $^{1}/_{4}$ inch PHS
2	384-0593-00			2	ROD, pin, index, nylon, $^{3}/_{8}$ x $^{9}/_{16}$ x $^{15}/_{16}$ inch long
3	131-0218-00			1	CONNECTOR, 22 contact, male
	- - - - - - -			-	Mounting Hardware: (not included)
	210-0003-00			2	LOCKWASHER, external #4
	210-0201-00			2	LUG, solder, SE4
	210-0406-00			2	NUT, hex, 4-40 x $^{3}/_{16}$ inch
	210-0851-00			2	WASHER, $^{3}/_{8}$ inch OD, flat
	211-0016-00			2	SCREW, 4-40 x $^{5}/_{8}$ inch RHS
4	179-0783-00			1	CABLE, harness
5	124-0148-00			8	STRIP, ceramic, $^{7}/_{16}$ x 9 notches
	- - - - - - -			-	Mounting Hardware For Each: (not included)
	361-0007-00			2	SPACER, nylon
6	131-0156-00			5	CONNECTOR, coax, 50 Ω
7	136-0095-00	MODEL 1	MODEL 1	1	SOCKET, 4 pin, transistor
	136-0181-00	MODEL 2		1	SOCKET, 3 pin, transistor
	- - - - - - -			-	Mounting Hardware: (not included)
	213-0113-00	MODEL 1	MODEL 1	2	SCREW, thread forming, 2-56 x $^{3}/_{16}$ inch RHS
	354-0234-00	MODEL 2		1	RING, transistor socket
8	352-0039-00			2	HOLDER, nylon, $^{13}/_{32}$ x $^{9}/_{16}$ x $^{3}/_{4}$ inch
	- - - - - - -			-	Mounting Hardware For Each: (not included)
	210-0004-00			1	LOCKWASHER, internal #4
	210-0406-00			1	NUT, hex, 4-40 x $^{3}/_{16}$ inch
	211-0011-00			1	SCREW, 4-40 x $^{5}/_{16}$ inch BHS
9	- - - - - - -			-	Pot Mounting Hardware: (not included)
	210-0012-00			2	LOCKWASHER, pot, internal, $^{3}/_{8}$ x $^{1}/_{2}$ inch
	210-0413-00			2	NUT, hex, $^{3}/_{8}$-32 x $^{1}/_{2}$ inch
	210-0840-00			1	WASHER, pot, flat
10	- - - - - - -			-	Pot Mounting Hardware: (not included)
	210-0046-00			1	LOCKWASHER, steel
	210-0583-00			1	NUT, hex, brass, $^{1}/_{4}$-32 x $^{1}/_{16}$ inch thick
11	441-0499-00			1	CHASSIS, GATE Generator
12	124-0092-00			2	STRIP, ceramic, $^{7}/_{16}$ x 3 notches
	- - - - - - -			-	Mounting Hardware For Each: (not included)
	361-0007-00			2	SPACER, nylon
13	210-0204-00			1	LUG, solder, DE6
	- - - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			1	SCREW, thread forming, 5-32 x $^{3}/_{16}$ inch PHS
14	210-0201-00			1	LUG, solder, SE4
	- - - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			1	SCREW, thread forming, 5-322 x $^{3}/_{16}$ inch PHS
15	210-0215-00			3	LUG, solder, peewee
	- - - - - - -			-	Mounting Hardware For Each: (not included)
	213-0055-00			1	SCREW, thread forming, 2-56 x $^{3}/_{16}$ inch PHS
16	136-0095-00	MODEL 1	MODEL 1	1	SOCKET, 4 pin, transistor
	136-0182-00	MODEL 2		1	SOCKET, 4 pin, transistor
	- - - - - - -			-	Mounting Hardware: (not included)
	213-0113-00	MODEL 1	MODEL 1	2	SCREW, thread forming, 2-32 x $^{5}/_{16}$ inch, RHS
	354-0234-00	MODEL 2		1	RING, transistor socket

PREAMP CHASSIS



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PREAMP CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	DISC.	Q T Y.	DESCRIPTION
1	348-0003-00			2	GROMMET, rubber 5/16 inch
2	210-0201-00			5	LUG, solder SE4
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch PHS
3	131-0156-00			4	CONNECTOR, coax, 50 Ω
4	136-0095-00	100	269	2	SOCKET, 4 pin, transistor
	136-0181-00	270		2	SOCKET, 4 pin transistor
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0113-00	100	269	2	SCREW, thread forming, 2-56 x 5/16 inch RHS
	354-0234-00	270		1	RING, transistor socket
5	441-0500-00			1	CHASSIS, alum, 1 x 4 3/4 x 4 7/8 inch
	- - - - - -			-	Mounting Hardware: (not included)
	210-0004-00			2	LOCKWASHER, internal #4
	210-0006-00			2	LOCKWASHER, internal #6
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
6	136-0085-00			2	SOCKET, tube, 9 pin shielded base
	- - - - - -			-	Mounting Hardware For Each: (not included)
	211-0033-00			2	SCREW, 4-40 x 5/16 inch PHS
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
7	124-0148-00			2	STRIP, ceramic, 7/16 inch x 9 notches
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon
8	179-0784-00			1	CABLE, harness, power
9	426-0121-00			3	MOUNT, toroid, nylon
	- - - - - -			-	Mounting Hardware For Each: (not.included)
	361-0007-00			1	SPACER, nylon
10	179-0785-00			1	CABLE, harness, connector
11	179-0786-00			1	CABLE, harness, channel A
12	131-0281-00			2	CONNECTOR, chassis mount, 4 male conductor
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0559-00			1	NUT, brass, 7/16-28 x 9/16 inch
	210-0941-00			1	WASHER, steel, 11/16 inch OD
	210-0959-00			1	WASHER, alum probe connector
13	124-0146-00			4	STRIP, ceramic, 7/16 inch x 16 notches
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon
14	337-0580-00			1	SHIELD, interchannel (not shown)
	- - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch PHS
15	210-0204-00			2	LUG, solder DE6
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0406-00			1	NUT, hex, 4-40 x 3/16 inch
	211-0033-00			1	SCREW, 4-40 x 5/16 inch PHS
16	210-0011-00			2	LOCKWASHER, internal 1/4 inch
17	210-0223-00			2	LUG, solder, 1/4 inch lock round perimeter
18	337-0581-00			1	SHIELD, preamp (not shown)
19	179-0787-00			1	CABLE HARNESS, Channel B

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ACCESSORIES

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
	010-0156-00			2	PROBE, package, P6038
	070-0397-00			2	MANUAL, instruction (not shown)

ELECTRICAL PARTS

Values are fixed unless marked Variable.

Capacitors

Tolerance ±20% unless otherwise indicated.
Tolerance of all electrolytic capacitors are as follows (with exceptions):

3 V — 50 V = —10%, +250%
51 V — 350 V = —10%, +100%
351 V — 450 V = —10%, +50%

Ckt. No.	Tektronix Part No.	Description				S/N Range
C1006	281-548	27 pf	Cer	500 v		
C1013	281-559	.0015 μf	Cer	500 v		
C1015	283-029	.005 μf	Disc Type	500 v	5%	
C1017	281-559	.0015 μf	Cer	500 v		
C1018	281-559	.0015 μf	Cer	500 v		
C1019	283-003	.01 μf	Disc Type	150 v		
C1020	283-002	.01 μf	Disc Type	500 v		
C1027	283-054	150 pf	Disc Type	200 v	5%	
C1029	281-536	.001 μf	Cer	500 v	10%	
C1033	281-559	.0015 μf	Cer	500 v		
C1034	281-598	.001 μf	Cer	500 v		
C1037	285-572	.1 μf	PTM	200 v		
C1039	290-107	25 μf	EMT	25 v		
C1176	283-003	.01 μf	Disc Type	150 v		
C2006	281-548	27 pf	Cer	500 v		
C2013	281-559	.0015 μf	Cer	500 v		
C2015	283-029	.005 μf	Disc Type	500 v	5%	
C2017	281-559	.0015 μf	Cer	500 v		
C2018	281-559	.0015 μf	Cer	500 v		
C2019	283-003	.01 μf	Disc Type	150 v		
C2020	283-002	.01 μf	Disc Type	500 v		
C2027	283-054	150 pf	Disc Type	200 v	5%	
C2029	281-536	.001 μf	Cer	500 v	10%	
C2033	281-559	.0015 μf	Cer	500 v		

Diodes

Ckt. No.	Tektronix Part No.	Description		S/N Range
D1282	152-066	Silicon	1N3194	
D1283	152-066	Silicon	1N3194	
D1284	152-066	Silicon	1N3194	
D2282	152-066	Silicon	1N3194	
D2283	152-066	Silicon	1N3194	
D2284	152-066	Silicon	1N3194	

Inductors

Ckt. No.	Tektronix Part No.	Description	S/N Range
L1009	*120-311	Toroid 3T	
L1033	*120-312	Toroid 15T	
L1039	*120-312	Toroid 15T	
L2009	*120-311	Toroid 3T	
L2033	*120-312	Toroid 15T	

Resistors

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

Ckt. No.	Tektronix Part No.	Description					S/N Range
R1006	315-821	820 Ω	¼ w			5%	
R1008	309-155	40 k	½ w		Prec	1%	
R1009	318-004	1 meg	⅛ w		Prec	1%	
R1013	316-391	390 Ω	¼ w				
R1014	308-054	10 k	5 w		WW	5%	
R1015	308-230	2.7 k	3 w		WW	5%	
R1016	301-752	7.5 k	½ w			5%	
R1017	316-100	10 Ω	¼ w				
R1018	316-470	47 Ω	¼ w				
R1019	316-101	100 Ω	¼ w				
R1021	315-393	39 k	¼ w			5%	
R1022	315-333	33 k	¼ w			5%	
R1024	301-822	8.2 k	½ w			5%	
R1025	301-822	8.2 k	½ w			5%	
R1027	315-152	1.5 k	¼ w			5%	
R1037	316-470	47 Ω	¼ w				
R1080A	318-103	600 Ω	⅛ w		Prec	1%	
R1080B	318-083	200 Ω	⅛ w		Prec	1%	
R1080C	318-040	100 Ω	⅛ w		Prec	1%	
R1080D	318-104	60 Ω	⅛ w		Prec	1%	
R1080E	318-056	20 Ω	⅛ w		Prec	1%	
R1080F	318-052	10 Ω	⅛ w		Prec	1%	
R1080G	318-052	10 Ω	⅛ w		Prec	1%	
R1081	311-423	2.5 k		Var		SMOOTHING A	
R1147A	318-089	583 k	⅛ w		Prec	1%	
R1147B	318-088	229.7 k	⅛ w		Prec	1%	
R1147C	318-087	112 k	⅛ w		Prec	1%	
R1147D	318-086	53 k	⅛ w		Prec	1%	
R1147E	318-085	17.67 k	⅛ w		Prec	1%	
R1147F	318-073	5.88 k	⅛ w		Prec	1%	
R1149	321-601	2.141 k	⅛ w		Prec	¼%	
R1157	303-623	62 k	1 w			5%	
R1158	301-104	100 k	½ w			5%	
R1159	311-271	200 k		Var		DC OFFSET A	
R1160	321-606	203 k	⅛ w		Prec	¼%	

Resistors (Cont'd.)

Ckt. No.	Tektronix Part No.	Description					S/N Range
R1169	301-104	100 k	½ w			5%	
R1170	321-603	15 k	⅛ w		Prec	¼%	
R1171	321-604	30 k	⅛ w		Prec	¼%	
R1172	311-172	2.5 k		Var		A-B BAL	
R1173†	*311-296	7 k		Var		VARIABLE A	
R1176	301-101	100 Ω	½ w			5%	
R1179	315-912	9.1 k	¼ w			5%	
R1180	311-016	10 k		Var		VERT POSITION A	
R1283	301-225	2.2 meg	½ w			5%	
R2006	315-821	820 Ω	¼ w			5%	
R2008	309-155	40 k	½ w		Prec	1%	
R2009	318-004	1 meg	⅛ w		Prec	1%	
R2013	316-391	390 Ω	¼ w				
R2014	308-054	10 k	5 w		WW	5%	
R2015	308-230	2.7 k	3 w		WW	5%	
R2016	301-752	7.5 k	½ w			5%	
R2017	316-100	10 Ω	¼ w				
R2018	316-470	47 Ω	¼ w				
R2019	316-101	100 Ω	¼ w				
R2021	315-393	39 k	¼ w			5%	
R2022	315-333	33 k	¼ w			5%	
R2024	301-822	8.2 k	½ w			5%	
R2025	301-822	8.2 k	½ w			5%	
R2027	315-152	1.5 k	¼ w			5%	
R2080A	318-103	600 Ω	⅛ w		Prec	1%	
R2080B	318-083	200 Ω	⅛ w		Prec	1%	
R2080C	318-040	100 Ω	⅛ w		Prec	1%	
R2080D	318-104	60 Ω	⅛ w		Prec	1%	
R2080E	318-056	20 Ω	⅛ w		Prec	1%	
R2080F	318-052	10 Ω	⅛ w		Prec	1%	
R2080G	318-052	10 Ω	⅛ w		Prec	1%	
R2081	311-423	2.5 k		Var		SMOOTHING B	
R2147A	318-089	583 k	⅛ w		Prec	1%	
R2147B	318-088	229.7 k	⅛ w		Prec	1%	
R2147C	318-087	112 k	⅛ w		Prec	1%	
R2147D	318-086	53 k	⅛ w		Prec	1%	
R2147E	318-085	17.67 k	⅛ w		Prec	1%	
R2147F	318-073	5.88 k	⅛ w		Prec	1%	
R2149	321-601	2.141 k	⅛ w		Prec	¼%	
R2157	303-623	62 k	1 w			5%	
R2158	301-104	100 k	½ w			5%	
R2159	311-271	200 k		Var		DC OFFSET B	
R2160	321-606	203 k	⅛ w		Prec	¼%	
R2169	301-104	100 k	½ w			5%	
R2170	321-603	15 k	⅛ w		Prec	¼%	

† Concentric with SW1282. Furnished as a unit.

Resistors (Cont'd.)

Ckt. No.	Tektronix Part No.		Description				S/N Range
R2171	321-604	30 k	1/8 w		Prec	1/4%	
R2173[1]	*311-296	7 k		Var		VARIABLE B	
R2175	315-753	75 k	1/4 w			5%	
R2180	311-016	10 k		Var		VERT POSITION B	
R2283	301-225	2.2 meg	1/2 w			5%	

Switches

Ckt. No.	Unwired	Wired	Description	
SW1056[2]	311-423			LOW NOISE-FAST RISETIME A
SW1101	260-434	*262-565	Rotary	MILLIVOLTS/CM A
SW1171	260-447		Slide	DISPLAY A
SW1282[3]	*311-296			CALIBRATED A
SW2056[4]	311-423			LOW NOISE-FAST RISETIME B
SW2101	260-434	*262-565	Rotary	MILLIVOLTS/CM B
SW2171	260-447		Slide	DISPLAY B
SW2190	260-514	*262-550	Rotary	MODE
SW2282[5]	*311-296			CALIBRATED B

Transformers

T1002	276-535	Core, Toroid
T2002	276-535	Core, Toroid

Transistors

Q1024	*151-096	Tek Spec
Q2024	*151-096	Tek Spec

Electron Tubes

V1014	Use 154-371	7308
V2014	Use 154-371	7308

AC AMPLIFIER
Series 2

Complete Plug-In Chassis Use *610-061 (Model 3-up)

Ckt. No.	Tektronix Part No.		Description				Model No.
C1081	290-105	100 μf	EMT		6 v		
C1089	281-501	4.7 pf	Cer		500 v	±1 pf	
C1107	281-060	2-8 pf	Cer	Var			
C1108	283-026	.2 μf	Disc Type		25 v		
C1109	290-145	10 μf	EMT		50 v		

[1] Concentric with SW2282. Furnished as a unit.
[2] Concentric with R1081. Furnished as a unit.
[3] Concentric with R1173. Furnished as a unit.
[4] Concentric with R2081. Furnished as a unit.
[5] Concentric with R2173. Furnished as a unit.

Capacitors (Cont'd.)

Ckt. No.	Tektronix Part No.		Description				Model No.
C1113	283-023	.1 μf	Disc Type		10 v		
C1116	283-004	.02 μf	Disc Type		150 v		
C1119	283-004	.02 μf	Disc Type		150 v		
C2081	290-105	100 μf	EMT		6 v		
C2089	281-501	4.7 pf	Cer		500 v	±1 pf	
C2107	281-060	2-8 pf	Cer	Var			
C2108	283-026	.2 μf	Disc Type		25 v		
C2109	290-145	10 μf	EMT		50 v		
C2113	283-023	.1 μf	Disc Type		10 v		
C2116	283-004	.2 μf	Disc Type		150 v		
C2119	283-004	.2 μf	Disc Type		150 v		

Inductors

L1082	*120-306	Toroid, 40 turns, Single	X5-up
L2082	*120-306	Toroid, 40 turns, Single	X5-up

Resistors

R1082	303-164	160 k	1 w		5%	X4X
R1083	318-064	250 Ω	1/8 w	Prec	1%	
R1086	303-223	22 k	1 w		5%	
R1087	315-222	2.2 k	1/4 w		5%	
R1088	306-154	150 k	2 w			
R1089	318-074	11.8 k	1/8 w	Prec	1%	
R1095	303-153	15 k	1 w		5%	
R1096	319-042	1 k	1/4 w	Prec	1%	
R1097	315-392	3.9 k	1/4 w		5%	
R1105	301-473	47 k	1/2 w		5%	
R1107	309-388	6 k	1/2 w	Prec	1%	
R1108	301-561	560 Ω	1/2 w		5%	
R1109	316-101	100 Ω	1/4 w			
R1113	315-101	100 Ω	1/4 w		5%	
R1115	301-102	1 k	1/2 w		5%	
R1116	316-101	100 Ω	1/4 w			
R1119	316-102	1 k	1/4 w			
R2082	303-164	160 k	1 w		5%	X4X
R2083	318-064	250 Ω	1/8 w	Prec	1%	
R2086	303-223	22 k	1 w		5%	
R2087	315-222	2.2 k	1/4 w		5%	
R2088	306-154	150 k	2 w			
R2089	318-074	11.8 k	1/8 w	Prec	1%	
R2095	303-153	15 k	1 w		5%	
R2096	319-042	1 k	1/4 w	Prec	1%	
R2097	315-392	3.9 k	1/4 w		5%	
R2105	301-473	47 k	1/2 w		5%	
R2107	309-388	6 k	1/2 w	Prec	1%	
R2108	301-561	560 Ω	1/2 w		5%	
R2109	316-101	100 Ω	1/4 w			
R2113	315-101	100 Ω	1/4 w		5%	
R2115	301-102	1 k	1/2 w		5%	
R2116	316-101	100 Ω	1/4 w			
R2119	316-102	1 k	1/4 w			

Transistors

Ckt. No.	Tektronix Part No.	Description	Model No.
Q1084	151-015	2N1516	
Q1094	151-015	2N1516	
Q1104	151-015	2N1516	
Q1113	151-056	T1483	
Q2084	151-015	2N1516	
Q2094	151-015	2N1516	
Q2104	151-015	2N1516	
Q2113	151-056	T1483	

DUAL TRACE
Series 5
Complete Plug-In Chassis Use *610-090 (Model 3-up)

Capacitors

C1181	283-004	.02 μf	Disc Type	150 v	
C1189	283-004	.02 μf	Disc Type	150 v	
C1191	281-542	18 pf	Cer	500 v	10%
C2181	283-004	.02 μf	Disc Type	150 v	
C2189	283-004	.02 μf	Disc Type	150 v	
C2240	281-543	270 pf	Cer	500 v	10%
C2246	281-542	18 pf	Cer	500 v	10%
C2250	281-543	270 pf	Cer	500 v	10%
C2251	285-624	.027 μf	PTM	100 v	10%
C2256	281-542	18 pf	Cer	500 v	10%
C2266	290-107	25 μf	EMT	25 v	
C2268	290-107	25 μf	EMT	25 v	

Diodes

D1186	152-071	Germanium ED2007
D1187	152-071	Germanium ED2007
D1197	152-095	Silicon IN625
D1198	152-095	Silicon IN625
D2186	152-071	Germanium ED2007
D2187	152-071	Germanium ED2007
D2245	152-008	Germanium T12G
D2248	152-008	Germanium T12G
D2249	152-055	Zener 11 v ¼ w 5%
D2251	152-016	Zener RT6 6 v
D2255	152-008	Germanium T12G
D2258	152-008	Germanium T12G
D2262	152-008	Germanium T12G

Inductors

Ckt. No.	Tektronix Part No.	Description		Model No.
L1189	*120-304	Toroid 3T		
L1195	119-021	Delay Line	1500 Ω .25 μsec	
L2266	*120-266	Toroid 10T		
L2268	*120-266	Toroid 10T		

Resistors

R1181	315-563	56 k	¼ w			5%	
R1183	318-094	193 k	⅛ w		Prec	1%	
R1184	319-053	1.82 k	¼ w		Prec	1%	
R1185	309-429	16.5 k	½ w		Prec	1%	
R1189	318-105	5.62 k	⅛ w		Prec	1%	
R1191	324-415	205 k	1 w		Prec	1%	
R1192	309-387	3.32 k	½ w		Prec	1%	
R1195	315-272	2.7 k	¼ w			5%	
R1197	315-152	1.5 k	¼ w			5%	
R2181	315-563	56 k	¼ w			5%	
R2182	311-172	2.5 k		Var		B CAL.	
R2183	318-094	193 k	⅛ w		Prec	1%	
R2184	319-053	1.82 k	¼ w		Prec	1%	
R2185	309-429	16.5 k	½ w		Prec	1%	
R2189	319-031	1 meg	¼ w		Prec	1%	
R2195	315-623	62 k	¼ w			5%	
R2196	315-183	18 k	¼ w			5%	
R2199	315-363	36 k	¼ w			5%	
R2240	315-102	1 k	¼ w			5%	3
R2240	301-102	1 k	½ w			5%	4-up
R2242	315-223	22 k	¼ w			5%	
R2243	315-103	10 k	¼ w			5%	
R2246	315-273	27 k	¼ w			5%	
R2247	315-224	220 k	¼ w			5%	
R2248	315-202	2 k	¼ w			5%	3
R2248	301-102	1 k	½ w			5%	4-up
R2249	315-822	8.2 k	¼ w			5%	
R2250	315-102	1 k	¼ w			5%	3
R2250	301-102	1 k	½ w			5%	4-up
R2252	315-223	22 k	¼ w			5%	
R2253	315-103	10 k	¼ w			5%	
R2256	315-273	27 k	¼ w			5%	
R2257	315-224	220 k	¼ w			5%	
R2258	315-202	2 k	¼ w			5%	3
R2258	301-102	1 k	½ w			5%	4-up
R2261	315-332	3.3 k	¼ w			5%	
R2264	315-823	82 k	¼ w			5%	

Transistors

Q1184	151-076	2N2048
Q2184	151-076	2N2048
Q2245	151-076	2N2048
Q2255	151-076	2N2048
Q2264	151-015	2N1516

INVERTER
Series 9
Complete Plug-In Chassis Use *610-093 (Model 2-up)

Diodes

Ckt. No.	Tektronix Part No.	Description	Model No.
D1165	152-025	Germanium 1N634	
D1166	152-025	Germanium 1N634	
D1167	152-064	Zener 10 v 1/4 w 10%	
D2165	152-025	Germanium 1N634	
D2166	152-025	Germanium 1N634	
D2167	152-064	Zener 10 v 1/4 w 10%	

Resistors

Ckt. No.	Tektronix Part No.	Description					Model No.
R1161	311-153	10 k		Var		A INVERTER ZERO	2
R1161	311-0326-00	10 k		Var		A INVERTER ZERO	3-up
R1162	301-224	220 k	1/2 w			5%	
R1163	309-100	10 k	1/2 w		Prec	1%	
R1164	309-160	9.85 k	1/2 w		Prec	1%	
R1165	301-752	7.5 k	1/2 w			5%	
R1166	303-433	43 k	1 w			5%	
R1167	304-334	330 k	1 w				
R1168	304-223	22 k	1 w				
R2161	311-153	10 k		Var		B INVERTER ZERO	2
R2161	311-0326-00	10 k		Var		B INVERTER ZERO	3-up
R2162	301-224	220 k	1/2 w			5%	
R2163	309-100	10 k	1/2 w		Prec	1%	
R2164	309-160	9.85 k	1/2 w		Prec	1%	
R2165	301-752	7.5 k	1/2 w			5%	
R2166	303-433	43 k	1 w			5%	
R2167	304-334	330 k	1 w				
R2168	304-223	22 k	1 w				

Transistors

Ckt. No.	Tektronix Part No.	Description	Model No.
Q1163	151-058	RT5204	
Q1164	151-054	2N1754	
Q2163	151-058	RT5204	
Q2164	151-054	2N1754	

MEMORY A, B (2)
Series 11
Complete Plug-In Chassis Use *610-110

Capacitors

Ckt. No.	Tektronix Part No.	Description				Model No.
C1121	use 285-001	510 pf	Glass	300 v	1%	
C1122	283-026	.2 μf	Disc Type	25 v		
C1127	283-003	.01 μf	Disc Type	150 v		
C1128	283-026	.2 μf	Disc Type	25 v		
C1129	283-024	.1 μf	Disc Type	30 v		

Capacitors (Cont'd.)

Ckt. No.	Tektronix Part No.	Description				Model No.
C1132	use 285-000	160 pf	Glass	500 v	1%	
C1138	281-504	10 pf	Cer	500 v	10%	
C1140	283-024	.1 μf	Disc Type	30 v		
C1153	283-003	.01 μf	Disc Type	150 v		

Diodes

Ckt. No.	Tektronix Part No.	Description	Model No.
D1122	152-016	Zener RT6 6 v	
D1125	152-071	Germanium ED2007	
D1127	152-071	Germanium ED2007	
D1130, D1131	*152-083	Capacitance 0.6 pf up (1 pair)	1 & 2
D1130, D1131	*152-145	Ga As With Leads (1 pair)	3-up
D1136	152-066	Silicon 1N3194	
D1140	152-064	Zener 10 v 1/4 w 10%	
D1142	152-026	Germanium Q6-100	
D1143	152-008	Germainum T12G	
D1144	152-064	Zener 10 v 1/4 w 10%	

Resistors

Ckt. No.	Tektronix Part No.	Description					Model No.
R1120	306-104	100 k	2 w				
R1121	315-101	100 Ω	1/4 w			5%	
R1122	304-333	33 k	1 w				
R1123	318-034	2 k	1/8 w		Prec	1%	
R1124	318-034	2 k	1/8 w		Prec	1%	
R1125	311-343	1 k		Var		SMOOTHING BALANCE	
R1127	318-045	3.92 k	1/8 w		Prec	1%	
R1129	316-100	10 Ω	1/4 w				
R1130	309-058	2 Ω	1/2 w		Prec	1%	
R1134	301-563	56 k	1/2 w			5%	
R1135	316-101	100 Ω	1/4 w				
R1137	315-113	11 k	1/4 w			5%	X6-up
R1138	301-473	47 k	1/2 w			5%	
R1139	303-103	10 k	1 w			5%	
R1140	315-103	10 k	1/4 w			5%	
R1143	316-683	68 k	1/4 w				
R1144	303-153	15 k	1 w			5%	
R1145	315-820	82 Ω	1/4 w			5%	
R1146	321-602	3.908 k	1/8 w		Prec	1/4%	
R1150	321-605	186.2	1/8 w		Prec	1/4%	
R1151	301-513	51 k	1/2 w			5%	
R1152	315-101	100 Ω	1/4 w			5%	
R1153	315-101	100 Ω	1/4 w			5%	
R1154	323-602	107 k	1/2 w		Prec	1/4%	
R1155	323-603	1.5 meg	1/2 w		Prec	1/4%	
R1156	323-601	92 k	1/2 w		Prec	1/4%	

Transformer

Ckt. No.	Tektronix Part No.	Description	Model No.
T1130	*120-255	Toroid 3T	

Transistors

Ckt. No.	Tektronix Part No.	Description	
Q1134	*153-511	2N1516	selected
Q1141	151-067	2N1143	

Electron Tubes

Ckt. No.	Tektronix Part No.	Description
V1133	Use *157-102	7308, Selected

GATE GENERATOR
Series 10
Complete Plug-In Chassis Use *610-100

Capacitors

Ckt. No.	Tektronix Part No.	Value	Type	Voltage	Tolerance
C1042	281-578	18 pf	Cer	500 v	5%
C1043	281-578	18 pf	Cer	500 v	5%
C1062	281-536	.001 µf	Cer	500 v	10%
C1063	281-564	24 pf	Cer	500 v	5%
C1064	281-564	24 pf	Cer	500 v	5%
C1065	283-000	.001 µf	Disc Type	500 v	
C1066	281-536	.001 µf	Cer	500 v	10%
C1067	283-026	.2 µf	Disc Type	25 v	
C2042	281-578	18 pf	Cer	500 v	5%
C2043	281-578	18 pf	Cer	500 v	5%
C2060	283-000	.001 µf	Disc Type	500 v	
C2061	283-026	.2 µf	Disc Type	25 v	
C2062	283-067	.001 µf	Disc Type	200 v	10%
C2066	283-000	.001 µf	Disc Type	500 v	
C2069	281-536	.001 µf	Cer	500 v	10%
C2075	283-026	.2 µf	Disc Type	25 v	

Diodes

Ckt. No.	Tektronix Part No.	Description
D1062	*152-115	Snap-off, pretested
D2060	Use *152-0185-00	Silicon Replaceable by 1N3605
D2063	152-008	Germanium T12G
D2068	Use *152-0185-00	Silicon Replaceable by 1N3605
D2070	152-071	Germanium ED2007
D2074	152-071	Germanium ED2007

Inductor

Ckt. No.	Tektronix Part No.	Description	Model No.
L1065	*120-309	Toroid 6T	

Resistors

Ckt. No.	Tektronix Part No.	Value	Wattage			
R1042	316-102	1 k	¼ w			
R1043	316-102	1 k	¼ w			
R1044	316-223	22 k	¼ w			
R1045	311-350	500 k		Var		A BRIDGE VOLTS
R1047	318-096	1.5 meg	⅛ w		Prec	1%
R1048	318-115	750 k	⅛ w		Prec	1%
R1049	315-153	15 k	¼ w			5%
R1050	311-017	10 k	.1 w	Var		A RISETIME BAL
R1051	315-153	15 k	¼ w			5%
R1052	318-109	500 k	⅛ w		Prec	1%
R1054	315-104	100 k	¼ w			5%
R1055	315-103	10 k	¼ w			5%
R1056	311-082	2 meg	.1 w	Var		A BRIDGE BALANCE
R1057	315-103	10 k	¼ w			5%
R1058	315-474	470 k	¼ w			5%
R1062	317-510	51 Ω	1/10 w			5%
R1065	302-220	22 Ω	½ w			
R1066	308-104	167 Ω	5 w		WW	5%
R1067	311-413	1 k		Var		SNAP-OFF CURRENT
R1079	308-123	20 Ω	5 w		WW	5%
R2042	316-102	1 k	¼ w			
R2043	316-102	1 k	¼ w			
R2044	316-223	22 k	¼ w			
R2045	311-350	500 k		Var		B BRIDGE VOLTS
R2047	318-096	1.5 meg	⅛ w		Prec	1%
R2048	318-115	750 k	⅛ w		Prec	1%
R2049	315-153	15 k	¼ w			5%
R2050	311-017	10 k	.1 w	Var		B RISETIME BAL
R2051	315-153	15 k	¼ w			5%
R2052	318-109	500 k	⅛ w		Prec	1%
R2054	315-104	100 k	¼ w			5%
R2055	315-103	10 k	¼ w			5%
R2056	311-082	2 meg	.1 w	Var		B BRIDGE BALANCE
R2057	315-103	10 k	¼ w			5%
R2058	315-474	470 k	¼ w			5%
R2060	316-471	470 Ω	¼ w			
R2061	316-100	10 Ω	¼ w			
R2063	316-102	1 k	¼ w			
R2065	316-184	180 k	¼ w			
R2068	316-222	2.2 k	¼ w			

Resistors (Cont'd.)

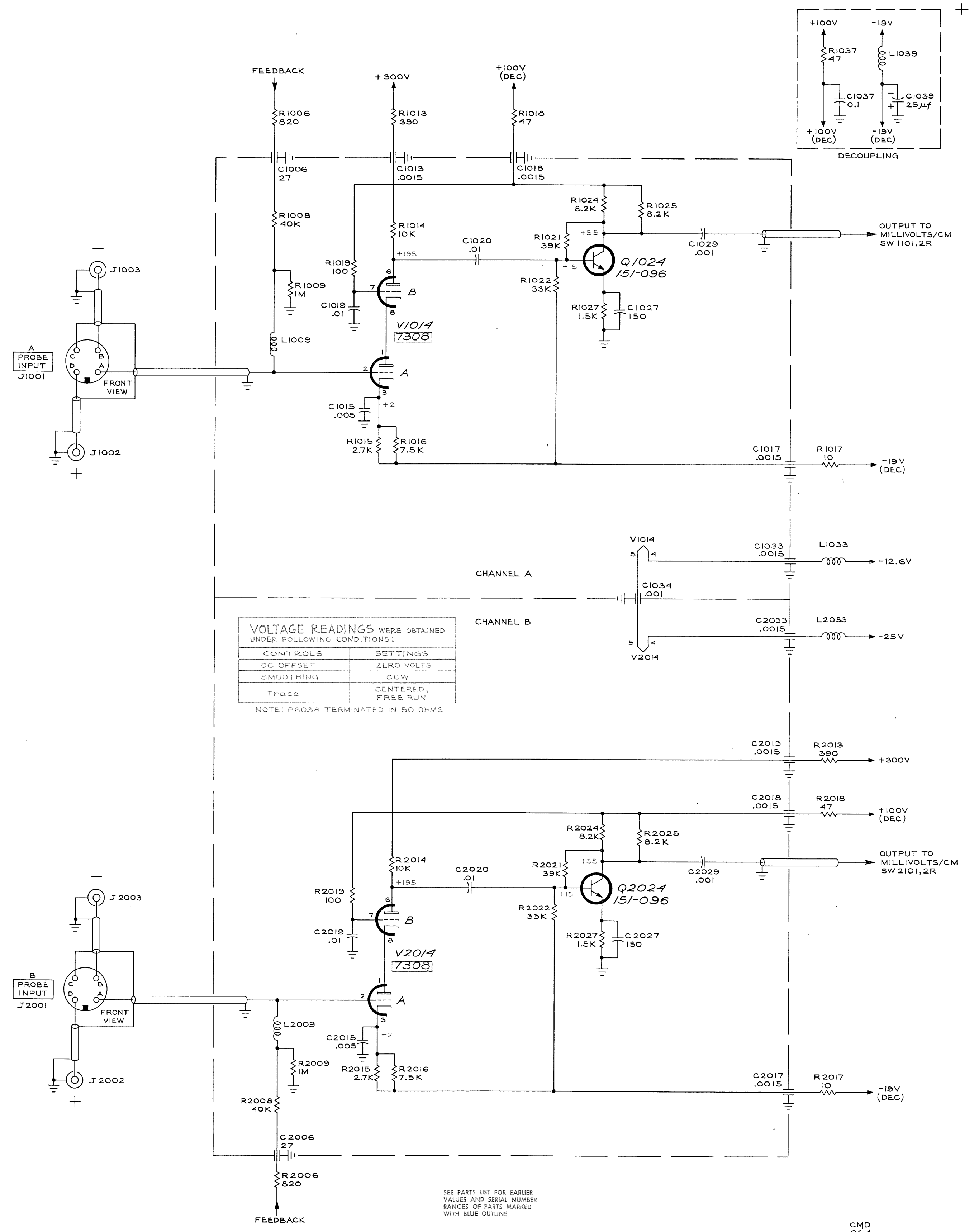
Ckt. No.	Tektronix Part No.		Description			Model No.
R2069	315-621	620 Ω	1/4 w		5%	
R2070	316-471	470 Ω	1/4 w			
R2071	315-432	4.3 k	1/4 w		5%	
R2072	316-332	3.3 k	1/4 w			
R2073	311-017	10 k	.1 w	Var	MEMORY GATE WIDTH	
R2074	316-221	220 Ω	1/4 w			
R2075	316-100	10 Ω	1/4 w			
R2077	315-621	620 Ω	1/4 w		5%	

Transformers

T1042	*120-286	Toroid 2T
T1064	*120-198	Toroid 4T
T2042	*120-286	Toroid 2T
T2060	*120-310	Toroid 3T

Transistors

Q2060	151-083	2N964
Q2074	151-015	2N1516



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

CONTROLS	SETTINGS
DC OFFSET	ZERO VOLTS
SMOOTHING	CCW
Trace	CENTERED, FREE RUN

NOTE: P6038 TERMINATED IN 50 OHMS

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

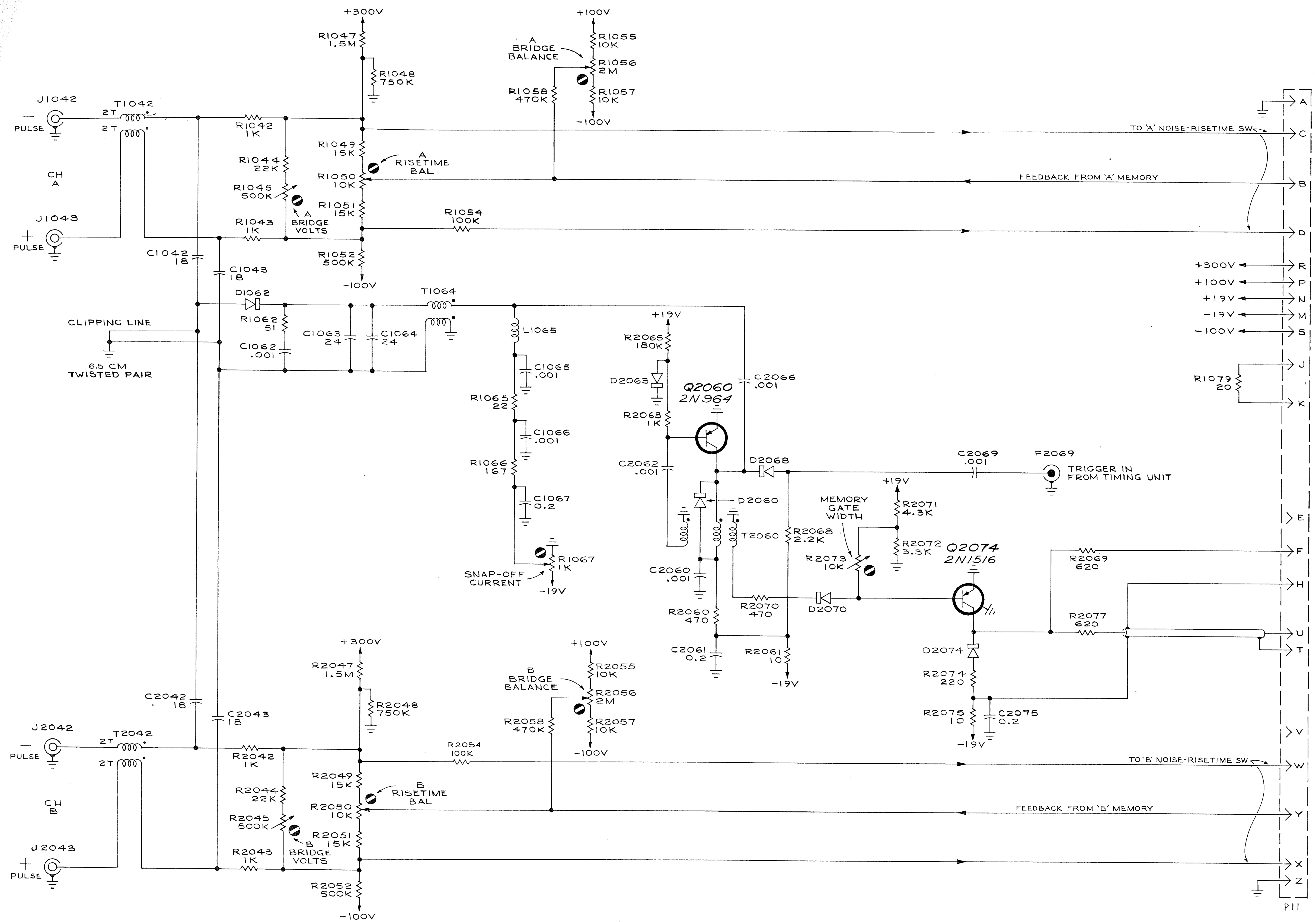
CMD
864

TYPE 453 PLUG-IN

B

PREAMPLIFIER

$10.00



TYPE 453 PLUG-IN

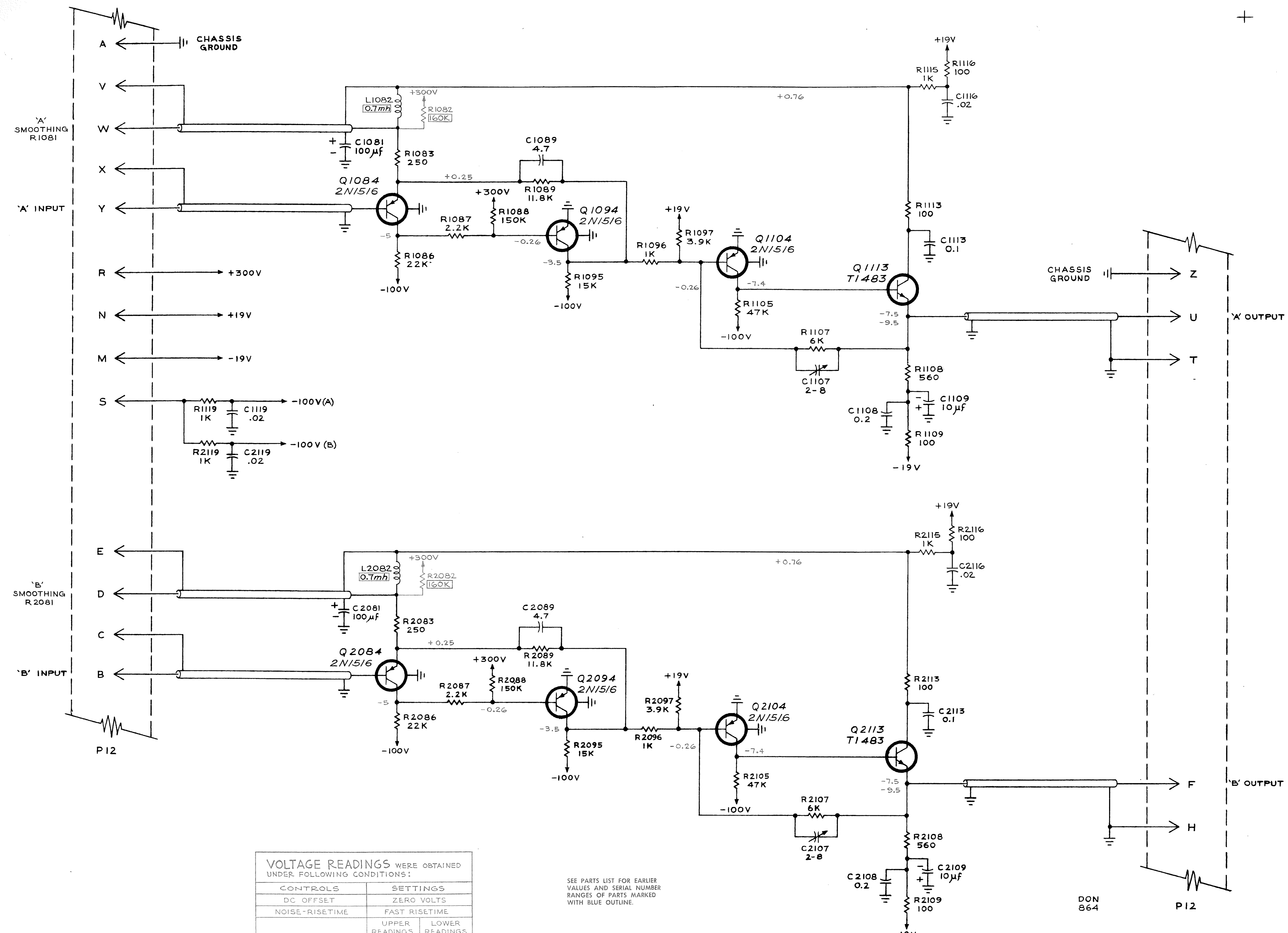
A

MRH
763

GATE GENERATOR

SERIES 10 MODEL 1

3
OBE
NIT
LOSCOPES



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

CONTROLS	SETTINGS	
DC OFFSET	ZERO VOLTS	
NOISE-RISETIME	FAST RISETIME	
	UPPER READINGS	LOWER READINGS
SMOOTHING	CW	CCW

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

DON 864

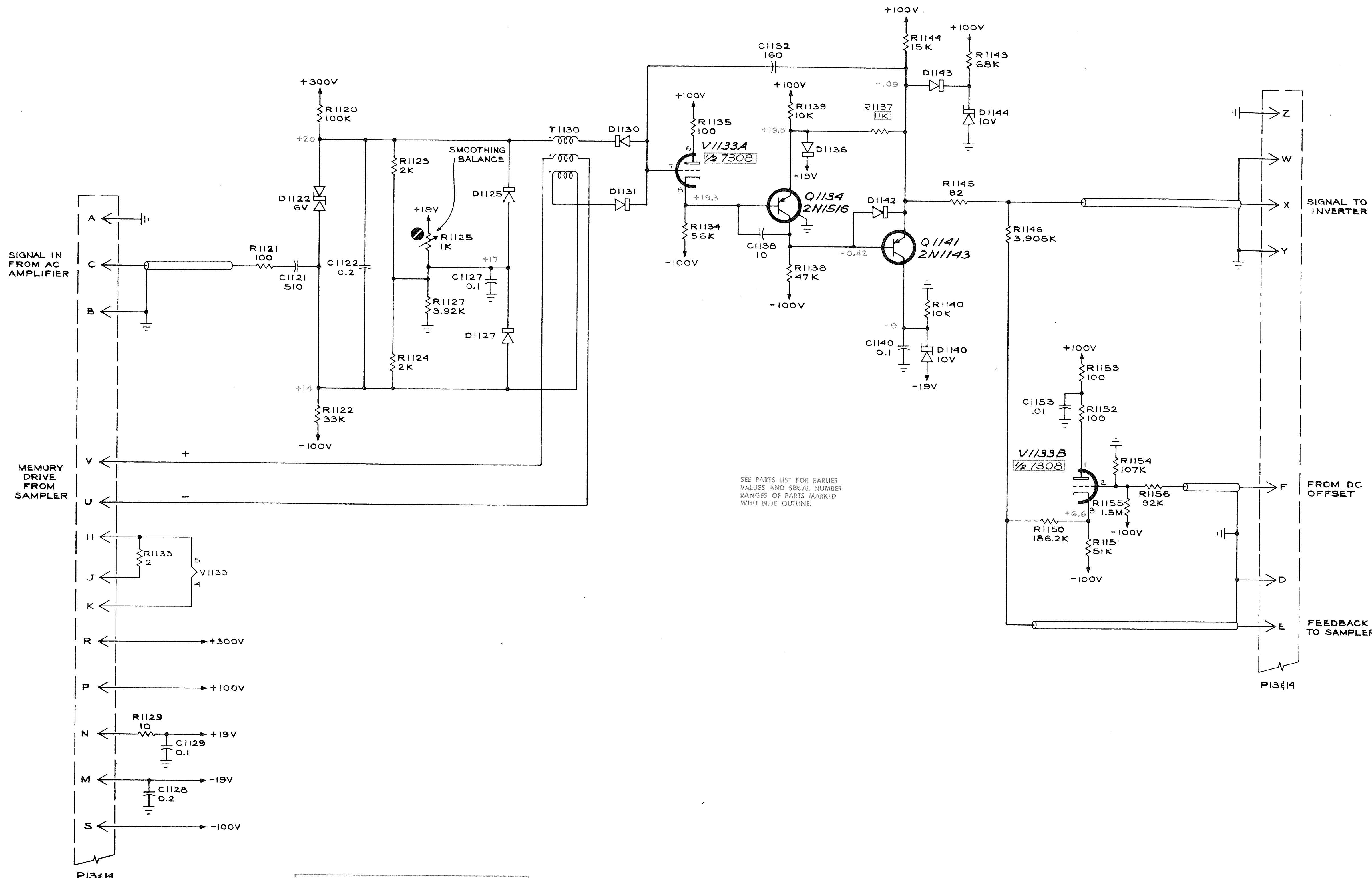
TYPE 4S3

B

AC AMPLIFIER

SERIES 2 MODELS 3,4,5

AMPLIFIER



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:	
CONTROLS	SETTINGS
DC OFFSET	ZERO VOLTS
Trace	Centered

TYPE 4S3

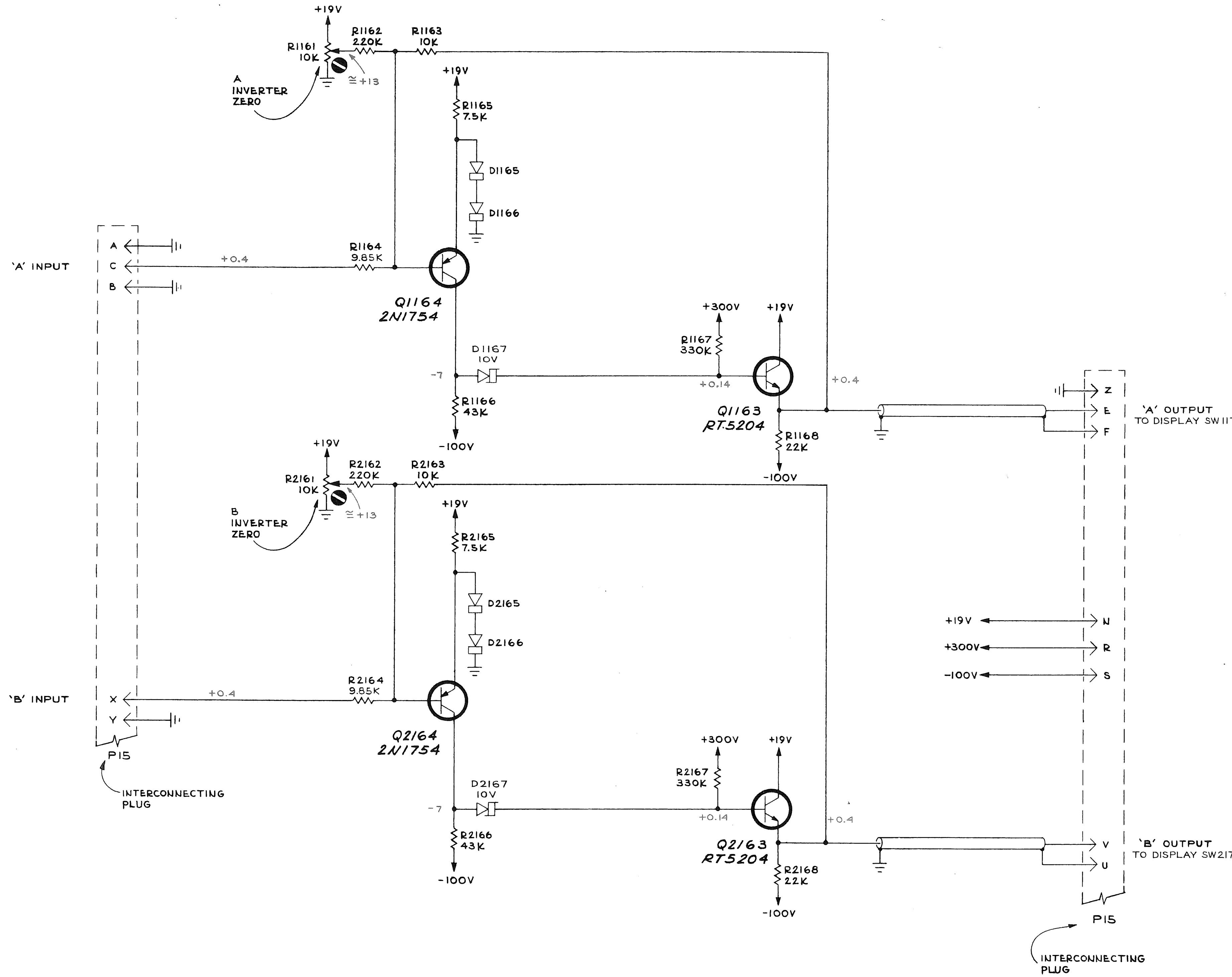
C

CMD
465

MEMORY

SERIES 11 MODEL 1,2,3,4,5,6

MEMORY



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

CONTROLS	SETTINGS
DISPLAY	INVERTED
Trace	Centered

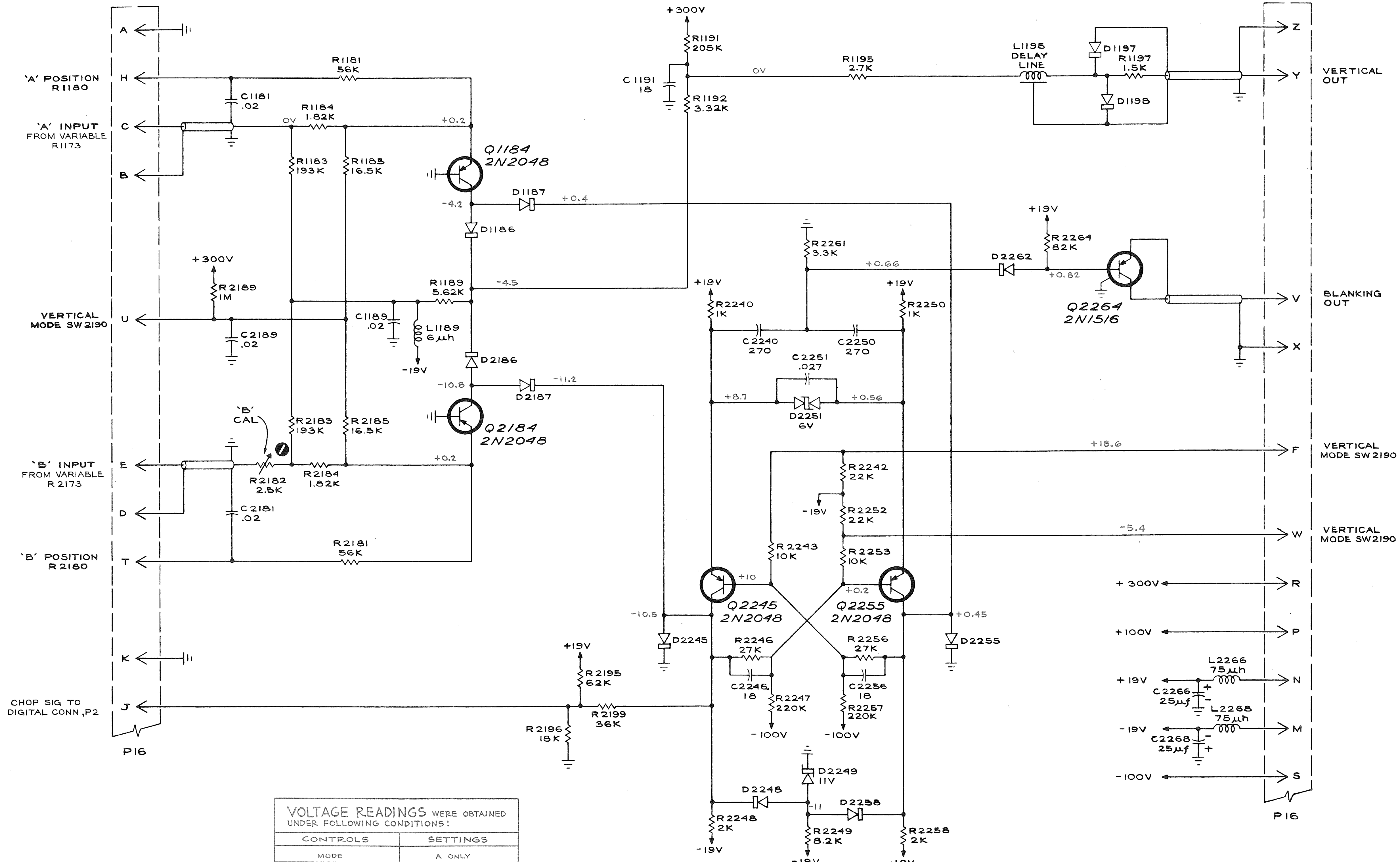
TYPE 4S3

A

JN
763

INVERTER

SERIES 9 MODEL 2



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

CONTROLS	SETTINGS
MODE	A ONLY
Trace	Centered

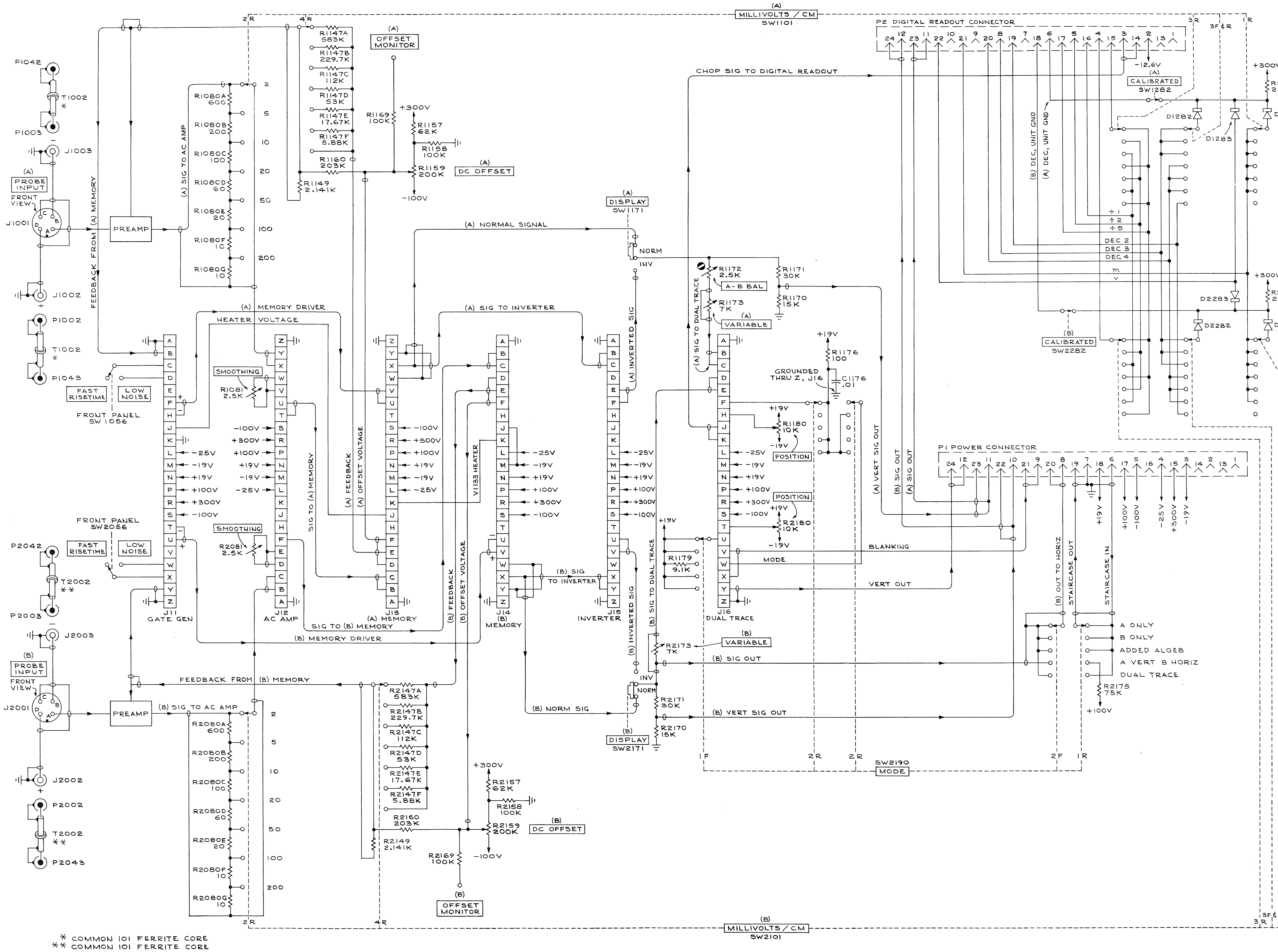
TYPE 4S3

A

CMD 763

DUAL TRACE

SERIES 5 MODEL 3



TYPE 453 PLUG-IN

A

MRH 763

INTERCONNECTORS & SWITCHING

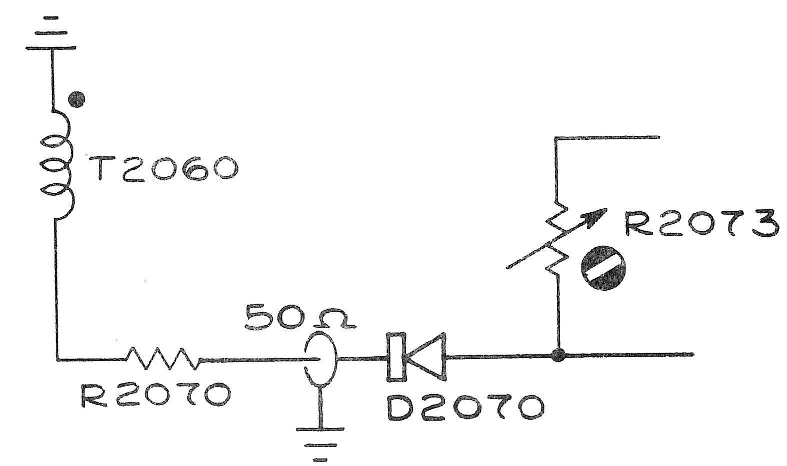
MANUAL CHANGE INFORMATION

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.

TYPE 4S3

SCHEMATIC CORRECTION



PARTIAL GATE GENERATOR
SERIES 10 MODEL 4

TYPE 4S3 TENT SN 324

PARTS LIST CORRECTION

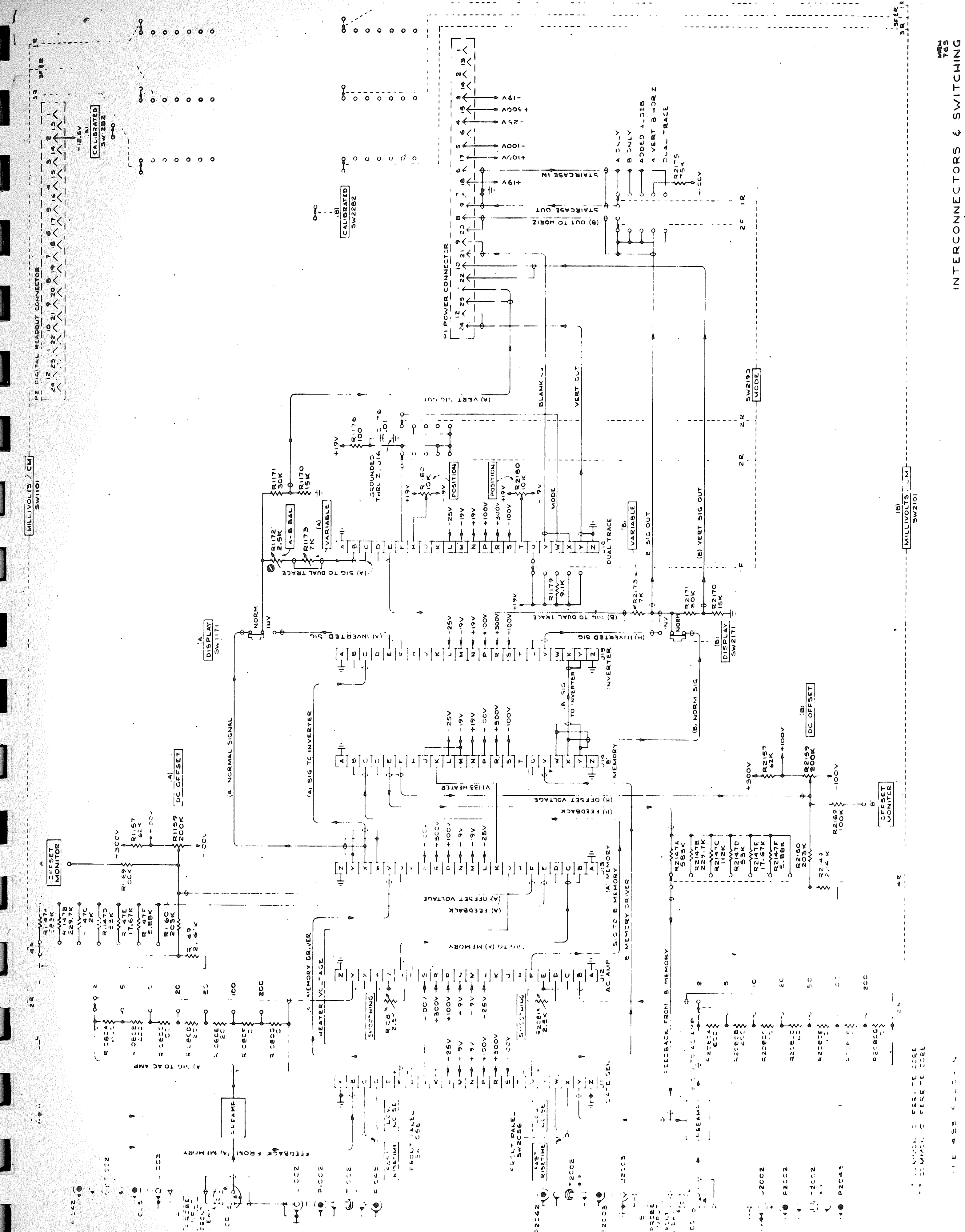
DELETE:

D1282, D1283, D1284, D2282, D2283, D2284	152-0066-00	1N3194		
R1158, R2158	301-0104-00	100 kΩ	½ W	5%
R1283, R2283	301-0225-00	2.2 MΩ	½ W	5%

CHANGE TO:

R1157, R2157	303-0623-00	62 kΩ	1 W	5%

SCHEMATIC CORRECTION
ON REVERSE SIDE



Page 2 of 2

M10,977/966