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1. GENERAL INFORMATION

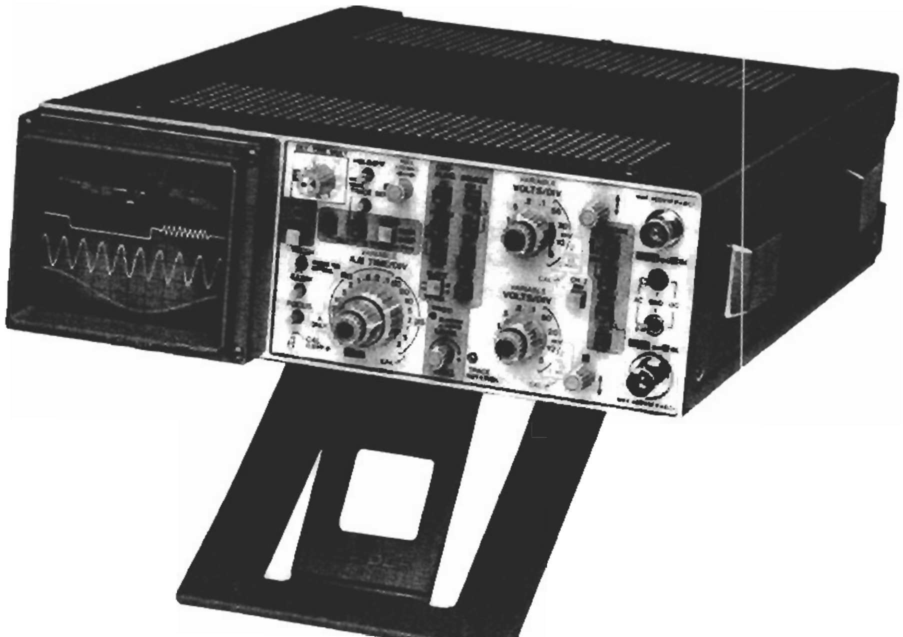


Figure 1-1. Model LBO-325 Dual-trace Oscilloscope

1-1 INTRODUCTION

The LBO-325, shown in Figure 1-1, is a 60 MHz dual-trace oscilloscope with many quality features: high fidelity pulse response, dual timebases with sweep delay and alternate sweep, flexible triggering facilities, a bright CRT display, channel 1 output, and a delay line. Yet, all these features appear in a device small enough to fit in an attache case, and which weighs a mere nine pounds!

Amplitude measurement accuracy is enhanced by precision step attenuators and a CRT with illuminated internal graticule. Similarly, time-interval measurements are enhanced by a calibrated delay-time multiplier and sweep magnification.

The triggering facilities of the LBO-325 include several features that provide a near guarantee of stable triggering no matter what the signal characteristics, due to frequency-selective coupling filters, trigger holdoff, and a trigger pick-off that alternates between the two vertical channels.

1-2 SPECIFICATIONS

Specifications for the model LBO-325 oscilloscope are given in Table 1-1. Specifications for the model LP-060X scope probes are given in Table 1-2.

Table 1-1
LBO-325 SPECIFICATIONS

Vertical Amplifiers (Ch. 1 & 2)

Bandwidth (−3 dB, 8 div.)	
DC coupled	DC to 60 MHz normal DC to 5 MHz magnified
AC coupled	10 Hz to 60 MHz normal 10 Hz to 5 MHz magnified
Risetime	5.8 nS normal 70 nS magnified
Deflection Coefficients	5 mV/cm to 5 V/cm in 10 calibrated steps, 1-2-5 sequence. Continuously variable between steps. 5X magnifier adds 1 mV/cm, and 2 mV/cm steps for frequencies up to 5 MHz.
Accuracy	±3% normal ±5% magnified
Input Impedance	1 megohm ±1.5%, 30pF ±5 pF
Maximum Input Voltage	400 V (DC plus AC peak)

Vertical Display Modes	CH-1 only, CH-2 only, CH-1 & CH-2 displayed alternately, CH-1 & CH-2 chopped (switched at 250 kHz rate), CH-1 & CH-2 added, CH-1 & CH-2 subtracted (by inverting CH-2)
Channel 1 Output	50 mV/div into 50 ohms
Signal Delay	20 nS nominal

Horizontal Amplifier (X-Y Mode)

Bandwidth (−3 dB)	
DC coupled	DC to 1 MHz
AC coupled	10 Hz to 1 MHz
Phase Shift	<3° at 100 kHz
Deflection Coefficients	Same as Vertical Amplifier
Accuracy	Same as Vertical Amplifier
Input Impedance	Same as Vertical Amplifier
Maximum Input Voltage	Same as Vertical Amplifier

Timebase Generators

Display Modes	Main timebase only, Main timebase intensified and delayed timebase, Delayed timebase only.
Main (A) Timebase Speeds	0.2μS/cm to 0.2 S/cm in 19 calibrated steps, 1-2-5 sequence. Continuously variable between steps.
Delayed (B) Timebase Speeds	.2μS/cm to 0.5 mS/cm in 11 calibrated steps, 1-2-5 sequence.
Magnifier	10X deflection increase at any timebase, setting extends fastest sweep speeds of main and delayed timebases to 20 nS/cm.
Accuracy	±3% normal, ±5% magnfied
Delay Time	Continuously-variable multiplier with 1000 divisions. Accuracy approximately ±3%.
Delayed Timbase Jitter	1 part in 10,000

Triggering

Sources	Channel 1, Channel 2, Alternate, Line, External
A Timebase Modes	Auto, Normal
B Timebase Modes	Immediate (after delay time) Triggered (after first trigger occuring after delay time)
Coupling	AC, HF Reject, TV Vertical, TV Horizontal
Slope	+ or −
Holdoff	Normal, Variable up to one sweep
Sensitivity (INT trigger)	30 Hz to 10 MHz: 0.5 div. 2 Hz to 60 MHz: 1.5 div.
Sensitivity (EXT trigger)	30 Hz to 10 MHz: 0.2 V p-p 2 Hz to 60 MHz: 0.6 V p-p
Auto Trigger Cutoff	30 Hz for above sensitivities
Input Impedance	1 megohm, 20 pF
Maximum Input Voltage	400 V (DC plus AC peak)

Calibrator

Output Voltage	500 mV p-p ±2%, positive-going, ground referenced
Frequency	Approximately 1 kHz
Waveform	Fast-rise square wave

Z-Axis Modulation

Level for Blanking	+2.5 to +8 V (TTL compatible)
Coupling	DC
Input Impedance	18 k-ohms
Bandwidth	1 MHz
Maximum Input Voltage	50 V (DC plus AC peak)

CRT Display

Type	3.5-inch PDA
Phosphor	P31
Accelerating Potential	12 kV/2 kV
Graticule	Internal 6.35 mm square divisions, 8 divs. high and 10 divs. wide. Central axes subdivided into 1.28 mm gradnations.
Graticule Illumination	Continuously variable

Physical & Environmental Data

Size (W × H × D)	9 × 3 × 11⅜ inches 230 × 75 × 290 mm
Weight	9 lbs. (4.1 kg)
Ambient Operating Temperature	0° - 40°C (32°F - 104°F)

Power Requirements

Line Voltage	100, 120, 200, 220, 240 Vac ±10%
Line Frequency	50 - 60 Hz
Power Consumption	30 W

Supplied Accessories

Instruction Manual
Two (2) type LP-060X Probes
Two (2) BNC-to-binding post Adapters
Line Cord
Spare Fuse
Front Cover
Viewing Hood
Carrying Case

Table 1-2
LP-060X SPECIFICATIONS

10X Position

Input Impedance	10 megohms in parallel with 25 pF
Voltage Division Ratio	10:1 ±2%
Bandwidth	DC-60 MHz
Maximum Input Voltage	600 V (DC plus AC peak)

1X Position

Input Impedance	1 megohm (scope input resistance) in parallel with approximately 250 pF (combined probe and scope capacitance)
Bandwidth	DC-5 MHz
Maximum Input Voltage	600 V (DC plus AC peak)

2. OPERATING INSTRUCTIONS

This section contains the information needed to operate the LBO-325 and utilize it in a variety of basic and advanced measurement procedures. Included are the identification and function of controls, connectors, and indicators, startup procedures, basic operating routines, and selected measurement procedures.

2-1 FUNCTION OF CONTROLS, CONNECTORS, AND INDICATORS

Before turning on this instrument, familiarize yourself with the controls, connectors, indicators, and other features described in this section. The following descriptions are keyed to the items called out in Figures 2-1 to 2-4.

2-1-1 Display Block

Refer to Figure 2-1 for references (1) to (8).

(1)	CAL connector	Provides a fast-rise square wave of precise amplitude for probe adjustment and vertical amplifier calibration.
(2)	INTEN control	To adjust the brightness of the CRT display. Clockwise rotation increases brightness. Push in to extend for making adjustment, then push again to recess.
(3)	FOCUS control	To obtain maximum trace sharpness. Push in to extend for making adjustments, then push again to recess.
(4)	TRACE ROTATION control	Provides screwdriver adjustment of trace alignment with regard to the horizontal graticule lines of the CRT.
(5)	ILLUM control	To adjust graticule illumination. Clockwise rotation increases graticule brightness. Push in to extend for making adjustments, then push again to recess.
(6)	POWER lamp	Lights when power is on.
(7)	POWER switch	Push in to turn instrument power on and off.
(8)	CRT	Display device having graticule lines inscribed on the inner surface for parallax-free measurements. Blue filter provides good contrast and pleasing display.

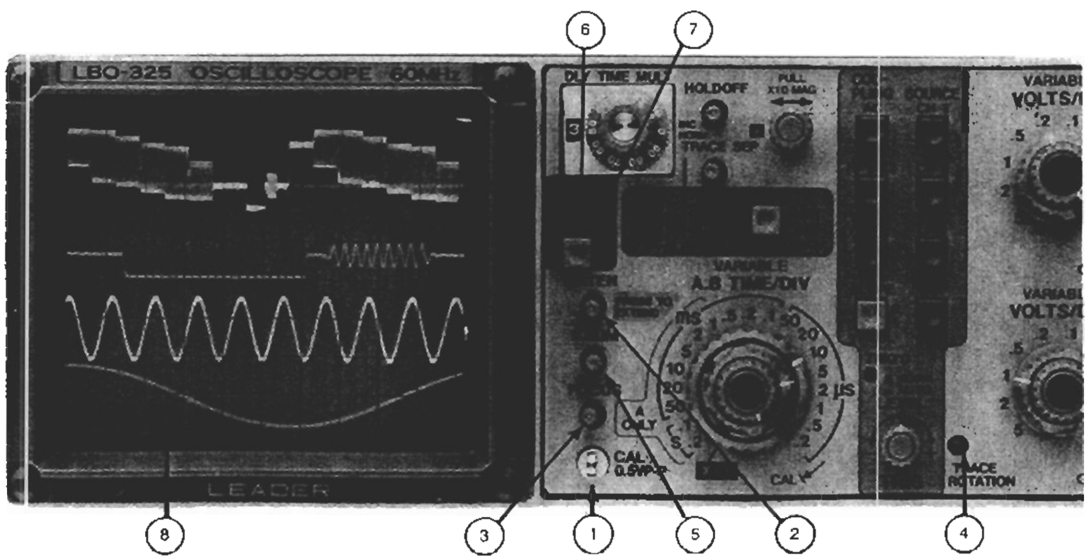


Figure 2-1. Display block

2-1-2 Vertical Amplifier Block

Refer to Figure 2-2 for references (9) to (17), and Figure 2-4 for reference (18).

(9)	CH 1 or X IN connector	For applying an input signal to vertical-amplifier channel 1, or the X-axis (horizontal) amplifier during X-Y operation.
(10)	CH 2 or Y IN connector	For applying an input signal to vertical-amplifier channel 2, or the Y-axis (vertical) amplifier during X-Y operation.
(11)	VOLTS/DIV switches	To select the calibrated deflection factor of the input signals fed to the vertical amplifiers.
(12)	VARIABLE controls	Provide continuously-variable adjustment of deflection factor between steps of the VOLTS/DIV switches. VOLTS/DIV calibrations are accurate only when the VARIABLE controls are click-stopped in their fully clockwise position.
(12)	PULL X5 MAG switches	To increase the vertical amplifier sensitivity by 5 times. The effective scale factor of the most sensitive position of the VOLTS/DIV switch is thereby increased to 1 mV/div.

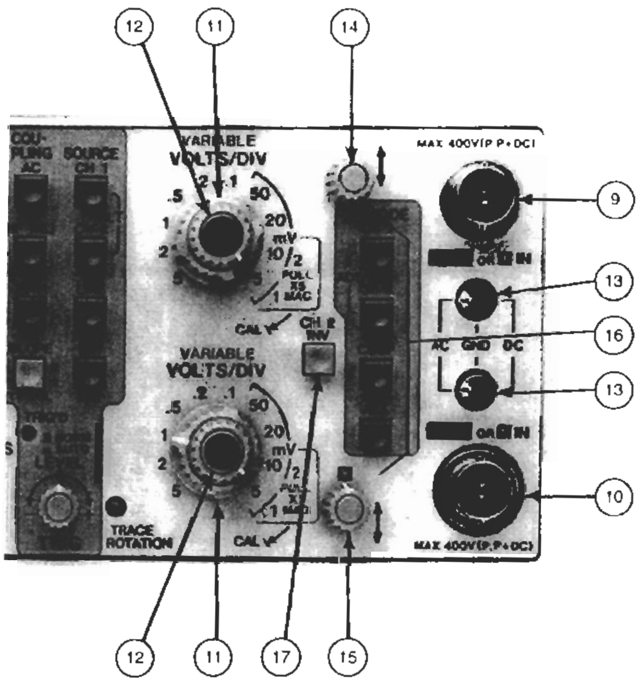


Figure 2-2. Vertical amplifier block

(13)	AC/GND/DC switches	To select the method of coupling the input signals to the vertical amplifiers. AC position connects a capacitor between the input connector and its associated amplifier circuitry to block any DC component in the input signal. GND position connects the amplifier input to ground instead of the input connector, so a ground reference can be established. DC position connects the amplifier inputs directly to the associated input connector, thereby passing all signal components on to the amplifiers.
(14)	CH 1 Vertical Position Control	For vertically positioning trace 1 on the CRT screen. Clockwise rotation moves the trace up. Inoperative during X-Y operation.
(15)	CH 2 Vertical or Y Position Control	For vertically positioning trace 2 on the CRT screen. Clockwise rotation moves the trace up. Adjusts the Y axis of the trace during X-Y operation.
(16)	V MODE switches	To select the vertical-amplifier display mode. CH 1 pushbutton displays only the channel 1 input signal on the CRT when pressed. CH 2 pushbutton displays only the channel 2 input signal on the CRT when pressed. ADD mode is attained by pressing both the CH 1 and CH 2 pushbuttons simultaneously. The resulting single trace is the algebraic sum of the channel 1 and channel 2 input signals. This results in a differential display if the CH 2 INV pushbutton is also pressed in. CHOP pushbutton displays the input signals of both channels when pressed. The CRT beam is switched between channels at a 250 kHz rate during the horizontal sweep to achieve this multichannel display. ALT pushbutton also displays the input signals of both channels when pressed. However, the CRT beam is switched between channels at the end of each sweep to achieve this multi-channel display.
(17)	CH 2 INV switch	Inverts the polarity of the channel 2 signal when pushed in.

(8) CH I OUTPUT connector — Provides a channel I signal output suitable for driving a frequency counter or other instrument.

2-1-3 Sweep and Trigger Block

Refer to Figure 2-3 for references (20) to (28) and (30) to (34), and to Figure 2-4 for reference (29).

(20) A TIME/DIV switch — To select either the calibrated sweep rate of the main (A) timebase, the delay time range for delayed-sweep operation, or X-Y operation.

(21) B TIME/DIV switch — To select the calibrated sweep rate of the delayed (B) timebase.

(22) Time VARIABLE control — Provides continuously-variable adjustment of sweep rate between steps of the A TIME/DIV switch. TIME/DIV calibrations are accurate only when the Time VARIABLE control is click-stopped fully clockwise.

(23) DLY TIME MULT control — To determine the exact starting point within the A timebase delay range at which the B timebase will begin sweeping. The absolute delay time is equal to the sweep time rate (A TIME/DIV) multiplied by the DLY TIME MULT setting.

(24) Horizontal or X Position control — To adjust the horizontal position of the traces displayed on the CRT. Clockwise rotation moves the trace(s) to the right. During X Y operation, this control must be used for X-axis positioning.

(24) PULL X10 MAG switch (on Hor. Pos. control) — To expand the horizontal deflection by 10 times, thus increasing horizontal sensitivity by 10 times for X-Y operation. The effective sweep rate is also increased by 10 times, making 20 nS per div. the highest sweep rate available.

(25) TRACE SEP control — Permits adjusting the distance between corresponding A and B traces when the ALT sweep mode is selected. Push in to extend for making adjustments, then push in again to recess.

(26) HOR DISP switches — To select the sweep mode.

A pushbutton sweeps the CRT at the main (A) timebase rate when pressed.

B pushbutton sweeps the CRT at the rate selected by the B TIME/DIV switch, after a delay determined by the A TIME/DIV switch and DLY TIME MULT control. The trace(s) displayed over the full CRT graticule width corresponds to the intensified section of A trace displayed during ALT operation.

ALT sweep is selected by simultaneously pressing both A and B pushbuttons. This displays A- and B-timebase traces, with the section of the A-timebase trace corresponding to the B trace intensified. The location of the intensified section is determined by the DLY TIME MULT control and TRIG'D switch settings.

(27) TRIG'D switch — When released, the B sweep begins immediately after the delay time, as determined by the A TIME/DIV switch and DLY TIME MULT control.

When pressed in, the B sweep is triggered by the first trigger pulse occuring after the delay time. The effective delay time is adjustable only in whole increments of the time between trigger pulses. Moreover, if TV-V trigger coupling is selected for the A timebase, TV-H trigger coupling is automatically inserted in the B-timebase trigger circuits.

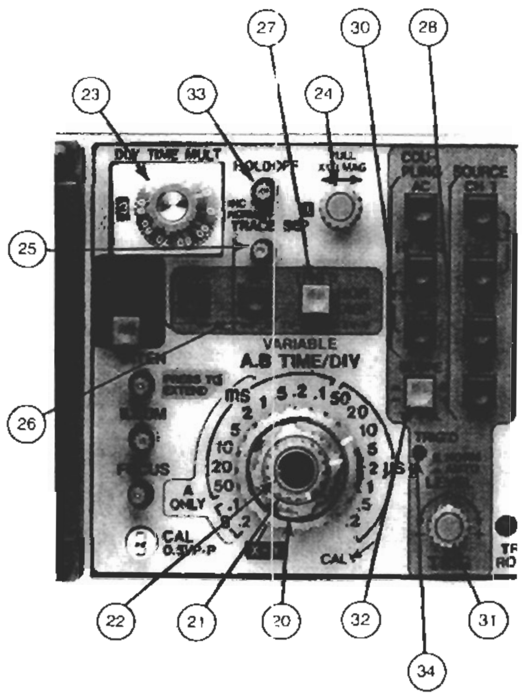


Figure 2-3. Sweep and trigger block

(28) SOURCE switches

CH 1 pushbutton selects the channel 1 signal as the trigger source when pressed.

CH 2 pushbutton selects the channel 2 signal as the trigger source when pressed.

Simultaneously pressing both CH 1 and CH 2 pushbuttons selects a trigger mode that allows a stable display of two asynchronous signals on the CRT. Must be used in conjunction with the ALT V MODE.

LINE pushbutton selects a trigger derived from the AC power line when pressed. This permits the scope to stablely display line-related components of a signal even if they are very small compared to other components of that signal.

EXT pushbutton selects the signal applied to the EXT TRIG IN connector when pressed.

(29) EXT TRIG IN connector

Rear-panel connector for applying an external signal to the trigger circuits.

(30) COUPLING switches

To select the frequency characteristics of the trigger-circuit coupling.

AC pushbutton inserts a large capacitor in the trigger-coupling chain to remove any DC components from the trigger signal. AC signals below 2 Hz also are attenuated, as is the case in all of the following trigger-coupling modes.

HF REJ pushbutton inserts a filter in the trigger-coupling chain that removes signal components higher in frequency than 100 kHz.

TV H pushbutton inserts a shaping filter (TV sync separator) whose high-frequency output is used for triggering.

HF REJ and TV H pushbuttons pressed simultaneously insert a shaping filter (TV sync separator) whose low-frequency output is used for triggering.

(31) TRIG switch (on LEVEL control)

To select the triggering mode. When pushed in (AUTO position), sweep free runs and a baseline is displayed in the absence of a signal. Automatically switches to triggered sweep when a signal of 30 Hz or higher is present and other trigger controls are properly set.

When pulled out (NORM position), sweep occurs only when a trigger signal is present and other trigger controls are properly set. No trace is visible if any trigger requirement is missing.

(31) LEVEL control

To select the trigger-signal amplitude at which triggering occurs. When rotated clockwise, the trigger point moves toward the positive peak of the trigger signal. When this control is rotated counterclockwise, the trigger point moves towards the negative peak of the trigger signal.

(32) SLOPE switch

To select the positive or negative slope of the trigger signal for initiating sweep.

(33) HOLDOFF control

Allows triggering on certain complex signals by changing holdoff (dead time) of the main (A) timebase. This avoids triggering on intermediate trigger points within the repetition cycle of the desired display. The holdoff time is increased with clockwise rotation. Push in to extend for making adjustments, then push again to recess.

NORM (fully counterclockwise rotation) is best for ordinary signals.

(34) TRIG'D lamp

Indicates when the sweep generator is being triggered.

2-1-4 Miscellaneous Features

Refer to Figure 2-4 for references (35) to (42) and (19).

(35)	FUSE Holder	Receptacle permits quick fuse replacement without opening case. Insert No. 2 Philips screwdriver in cross slot and rotate CCW to remove cap and fuse. When replacing fuse, make sure its ratings match those shown in the FUSE DATA chart.
(36)	Power Connector	Permits removal or replacement of AC power cord.
(37)	FUSE DATA chart	Indicates the proper fuse rating for each operating-voltage range.
(38)	Back-panel Bumpers	Support the oscilloscope for vertical operation and protects the back-panel features.
(39)	Bottom Feet	Support the oscilloscope for shelf mounting.
(40)	Side Feet	Support the oscilloscope in a horizontal position when used with the carrying handle.
(41)	Tiltstand	Front position stand angles the oscilloscope for bench top operation and the back position angles the scope for vertical operation.
(42)	Ground Connector	Provides an attachment point for a separate ground lead.
(19)	Z AXIS IN connector	For applying signal to intensity modulate the CRT.

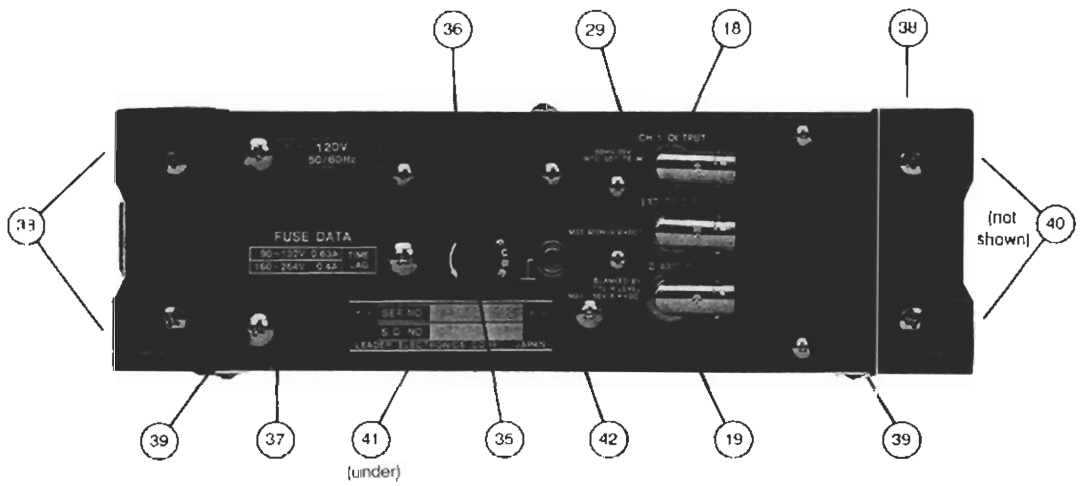


Figure 2-4. Rear panel and case features

2-2 INITIAL OPERATION

Before the instrument is operated for the first time, perform the following procedures **in the order listed** to ensure satisfaction and prevent damage to the instrument.

2-2-1 Power Connections

The instrument is normally shipped wired for a 120-volt power source but can be adapted to operate from power sources with ±10% of the rated values given in Table 2-1. Operation with a voltage less than 10% of the rated value may result in improper performance of the instrument and a voltage more than 10% in excess of the rated value may damage the power supply circuitry. To change the operating voltage, consult Leader service personnel at the address given on the back of this manual.

2-2-2 Installation

The LBO-325 will operate in either a horizontal or vertical position, so it is highly suited for field or laboratory work. The LBO-325 is shipped installed in a soft Carrying Case. It can be operated while in this case by opening the protective flaps at the front and back. In fact, the instrument can be operated while suspended at waist height by looping the shoulder strap over the back of your neck! This is a great convenience when working with equipment too large to be put on a workbench.

In more conventional situations, the instrument can be positioned on a benchtop, riser shelf, or on the floor. If the instrument is placed on a riser shelf above the workbench, leave the Tiltstand (41) in the closed position (as shipped). For benchtop mounting, it is advantageous to have the front of the instrument tilted upward for straight-on viewing. Unlatch the Tiltstand by lifting the bottom-most portion away from the case, then snap the tab slot into the front catch (See Figure 2-5).

If lack of working space requires that the instrument be placed on the floor, you can stand the LBO-325 on end as shipped. The Back-panel Bumpers (38) will support the instrument. You can also position the scope at a high tilt angle by means of the Tiltstand. In this case the tab slot is snapped into the rear catch (See Figure 2-5).

The LBO-325 is designed to operate over a temperature range of 0°C to +40°C (32°F to 104°F) and a humidity range of 0 to 90%. Operation in a more severe environment may shorten the life of the instrument.

Operation in a powerful magnetic field may distort the waveform or tilt the trace. This is most likely to occur if the instrument is operated close to equipment having large motors or power transformers.

2-2-3 Preliminary Control Settings and Adjustments

Before placing the instrument in use, set up and check the instrument as follows:

1. Set the following controls as indicated.

VOLTS/DIV switches (11)	.2V
VARIABLE controls (12)	Fully CW
PULL X5 MAG switches (12)	Pushed in
AC/GND/DC switches (13)	AC
Vertical Position controls (14) and (15)	Index up
V MODE switches (16)	ALT pressed
CH 2 INV switch (17)	Out
A TIME/DIV switch (20)	.2 mS
Time VARIABLE control (22)	Fully CW
Horizontal Position control (24)	Index up
PULL X10 MAG switch (24)	Pushed in
HOR DISP switches (26)	A pressed
SOURCE switches (28)	CH 1 pressed
COUPLING switches (30)	AC pressed
TRIG switch (31)	Pushed in
LEVEL control (31)	0
SLOPE switch (32)	Out
HOLDOFF control (33)	NORM
INTEN control (2)	Mid rotation
FOCUS control (3)	Mid rotation
ILLUM control (5)	Fully CCW

2. Insert the Line Cord into the Power Connector (36), then plug the Line Cord into a convenient AC receptacle.
3. Press in the POWER switch (7). Shortly, two traces should appear. If the traces are **extremely** bright, turn the INTEN control (2) counterclockwise. Otherwise, let the instrument warm up for a few minutes.

   CAUTION: A burn-resistant fluorescent material is used in the CRT. However, if the CRT is left with an extremely bright dot or trace for a very long time, the fluorescent screen may be damaged. Therefore, if a measurement requires high brightness, be certain to turn down the INTEN control immediately afterward. Also, get in the habit of turning the brightness down if the scope is left unattended for a long time.

4. Turn the INTEN control to adjust the brightness to the desired amount.
5. Turn the FOCUS control (3) for a sharp trace.
6. Turn the CH 1 Vertical Position control (14) to move the CH 1 trace two divisions down from the top of the graticule. Turn the CH 2 Vertical Position control (15) to move the CH 2 trace two divisions up from the bottom of the graticule.
7. See if the traces are precisely parallel with the graticule lines. If they are not, adjust the TRACE ROTATION control (4) with a small screwdriver.
8. Turn the Horizontal Position control (24) to align the left edge of the traces with the left-most graticule line.
9. Connect the CH 1 or X IN (9) and CH 2 or Y IN (10) connectors to the CAL connector (1). Two square-wave displays, each two divisions in amplitude, should appear on the screen. If necessary, adjust the LEVEL control (31) for a stable display.
10. Disconnect the vertical inputs from the calibrator output.

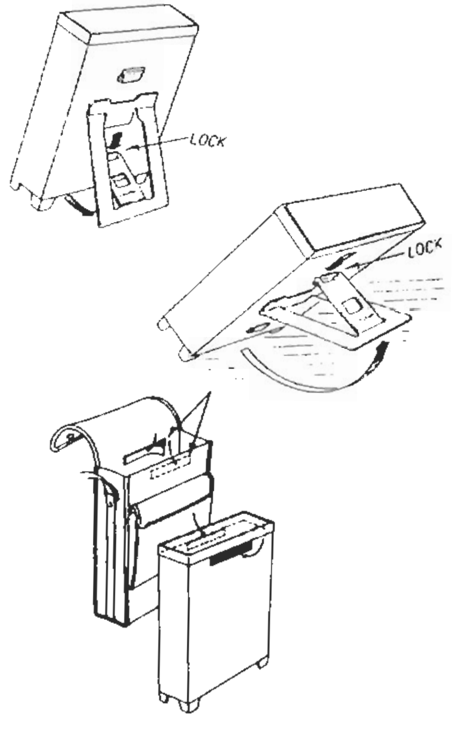


Figure 2-5. Tiltstand operation

DIRECTIONS FOR PLACING THE LBO-325 IN ITS CARRYING CASE

1. Unlatch the tiltstand from its closed position.
2. Slowly insert the oscilloscope in the carrying case making sure that you pass the unlatched tiltstand through the middle (widest) opening of the bottom side of the case.
3. Gently push the scope in the case making sure that the bottom feet of the oscilloscope (rear of the oscilloscope) show through the openings at the rear of the case.
4. Make sure that the tiltstand latches show through the first and last openings of the bottom side of the case.
5. Latch the tiltstand to its closed position using the latch nearest the back end of the oscilloscope.
6. Remove the protective plastic from the adhesive side of the velcro material (inner top side of the case) and press the case against the oscilloscope so that the adhesive side of the velcro material adheres to the scope surface.
7. Repeat Step No. 6 for the bottom side of the case.
8. For vertical positioning pull tiltstand out and lock tongue (inner portion) onto the rear latch.
9. For horizontal positioning pull tiltstand out and lock tongue (inner portion) into the front latch.

2-3 BASIC OPERATING PROCEDURES

The following paragraphs in this section describe how to operate the LBO-325, beginning with the most elementary operating modes, and progressing to the less frequently-used and/or more complex modes.

2-3-1 Signal Connections

There are three methods of connecting an oscilloscope to the signal you wish to observe. They are: a simple wire lead, coaxial cable, and scope probes.

A simple lead wire may be sufficient when the signal level is high and the source impedance low (such as TTL circuitry), but it is not often used. Unshielded wire picks up hum and noise; this distorts the observed signal when the signal level is low. Also, there is the problem of making secure mechanical connection to the input connectors. A binding post-to-BNC adapter (supplied accessory) is advisable in this case.

Coaxial cable is the most popular method of connecting an oscilloscope to signal sources and equipment having output connectors. The outer conductor of the cable shields the central signal conductor from hum and noise pickup. These cables are usually fitted with BNC connectors on each end, and specialized cables and adaptors are readily available for mating with other types of connectors.

Scope probes are the most common method of connecting the oscilloscope to circuitry. These probes are available with 1X attenuation (direction connection), 10X and 100X attenuation. The 10X and 100X attenuator probes increase the effective input impedance of the probe/scope combination to 10 megohms shunted by a few picorafads. The reduction in input capacitance is the most important reason for using attenuator probes at high freqnencies, where capacitance is the major factor in loading down a circuit and distorting the signal.

Despite their high input impedance, scope probes do not pickup appreciable hum or noise. As was the case with coaxial cable, the outer conductor of the probe cable shields th central signal conductor. Scope probes are also qnite convenient from a mechanical standpoint. Quality probes have a spring-loaded hook end that qnickly and securely holds the probe to wiring and component leads (see Figure 2-6). This hook can be removed to expose a straight tip, excellent for use on the non-component side of a pc board or for quickly moving from one point to another.

To determine if a direct connection with shielded cable is permissible, you must know the source impedance of the circuit you are connecting to, the highest frequencies involved, and the capacitance of the cable. If any of these factors are unknown, use a 10X low-capacitance probe.

An alternative connection method at high frequencies is **terminated** coaxial cable. A feed-thru terminator having an impedance equal to that of the signal-source impedance is connected to the oscilloscope input connector. A coaxial cable of matching impedance connects the signal source to the terminator. This technique allows using cahles of nearly any practical length without signal loss.

If a low-resistance ground connection between oscilloscope and circuit is not established, enormous amounts of hum (noise) will appear in the display signal. Generally, the outer conductor of shielded cable provides the ground connection. If you are using plain lead wire, be certain to first connect a ground wire between the LBO-325 Ground connector (42) and the chassis or ground bus of the circuit under test.

WARNING: The LBO-325 has an earth-grounded chassis (via the 3-prong power cord). Be certain the device to which you connect the scope is transformer operated. Do NOT connect this oscilloscope or any other test equipment to "AC/DC," "hot chassis," or "transformerless" devices. Similarly, do NOT connect this scope directly to the AC power line or any other circuitry connected directly to the power line. Damage to the instrument and severe injury to the operator may result from failure to heed this warning.

2-3-2 Single-trace Operation

Single-trace operation with single timebase and internal triggering is the most elementary operating mode of the LBO-325. Use this mode when you wish to observe only a single signal, and not be distracted by additional traces on the CRT. Since the LBO-325 is fundamentally a two-channel instrument, you have a choice for single channel operation. Channel 1 has an output terminal; use channel 1 if you also want to measure frequency with an external counter while observing the waveform. Channel 2 has a polarity-inverting switch. While this adds flexibility, it is not used in ordinary single-trace operation.

The LBO-325 is set up for single-trace operation as follows:

1. Set the following control as indicated below. Any controls not mentioned here or in the following steps can be neglected. Note that the trigger source selected (CH 1 or CH 2 SOURCE (28)) must match the single channel (CH 1 or CH 2 V MODE (16)).

AC/GND/DC switches (13)	AC
PULL X5 MAG switches (12)	Pushed in
VARIABLE controls (12)	Fully CW
V MODE switch (16)	CH 1 (CH 2)
CH 2 INV switch (17)	Out
INTEN control (2)	APS*
FOCUS control (3)	APS*
POWER switch (7)	Pushed in
Time VARIABLE control (22)	Fully CW
PULL X10 MAG switch (24)	Pushed in
Horizontal Position control (24)	APS*
HOR DISP switches (26)	A
COUPLING switches (30)	AC
SOURCE switches (28)	CH 1 (CH 2)
SLOPE switch (26)	+
TRIG switch (31)	Depressed
LEVEL control (31)	APS*
HOLDOFF control (33)	NORM

* As previously set. Adjustment may occasionally be necessary to suit the circumstances.

2. Use the corresponding Vertical Position control (14) or (15) to set the trace to the center of the CRT.
3. Connect the signal to be observed to the corresponding Input connector (9) or (10), and adjust the corresponding VOLTS/DIV switch (11) so the signal is displayed on the CRT.

CAUTION: Do not apply a signal greater than 400V (DC + AC peak).

4. Set the A TIME/DIV switch (20) so the desired number of cycles of signal are displayed. For some measurements 50-100 cycles (appears like a solid baud) works best. Adjust the LEVEL control (31) if necessary for a stable display.
5. If the signal you wish to observe is so weak that even the 5 mv position of the VOLTS/DIV switch cannot produce sufficient trace height for triggering or a useable display, pull the VARIABLE control (12) knob. This produces 2 mV/div sensitivity when the VOLTS/DIV switch is set to 10 mv, and 1 mV/div when it is set to 5 mV/div. However, the channel bandwidth decreases to 5 MHz and noise may become noticeable when this is done.
6. If the signal you wish to observe is so high in frequency that even the .2μS position of the A TIME/DIV switch results in too many cycles displayed, pull the PULL X10 MAG switch (24). This increases the effective sweep speed by a factor of 10, so .2μS/div becomes 20 nS/div, .5μS/div becomes 50 nS/div, etc. The 20 nS/div sweep speed achieveable by magnification is fast enough to display a single cycle of a 5 MHz signal across the CRT face.
7. If the signal you wish to observe is either DC or too low in frequency that AC coupling attenuates or distorts the signal, position the AC/GND/DC switch (13) to DC.

CAUTION: If the observed waveform is low-level AC, ensure that it is not imposed on a high-amplitude DC voltage.

2-3-3 Triggering Alternatives

The LBO-325 operator may choose from a wide selection of trigger options. These are categorized as trigger-source options, coupling options, trigger mode, and trigger-point selection.

Trigger Mode Selection. When the NORM trigger mode is selected, the CRT beam is not swept horizontally across the face of the CRT until a sample of the signal to be observed triggers the timebase. However this trigger mode may sometimes be inconvenient because the trace does not appear on the CRT screen in the absence of an input signal, or if the trigger controls are improperly set. Since the absence of the trace can also be due to an improperly-set vertical Position control or VOLTS/DIV switch, much time can be consumed determining the cause. The AUTO trigger mode solves this problem by causing the timebase to automatically free run when not triggered. This yields a single horizontal line with no signal, and a vertically-deflected but non-synchronized display when vertical signal is present but the trigger controls improperly set. This immediately indicates what is wrong. The only disadvantage with AUTO operation is that signals below 30 Hz cannot, and complex signals of any frequency may not, reliably trigger the timebase. Therefore, the usual practice is to leave the TRIG switch (31) depressed, but pull for NORM if any signal (particularly one below 30 Hz) fails to produce a stable display.

Trigger Source Options. Trigger signal can be obtained from the signal applied to the vertical inputs, or from a separate source of the same or a harmonically-related frequency. The SOURCE switch (28) offers several choices.

The CH 1 and CH 2 buttons offer a choice of one of the two input channels as the trigger source. The choice of channels remains even if the trigger channel is not displayed; the only

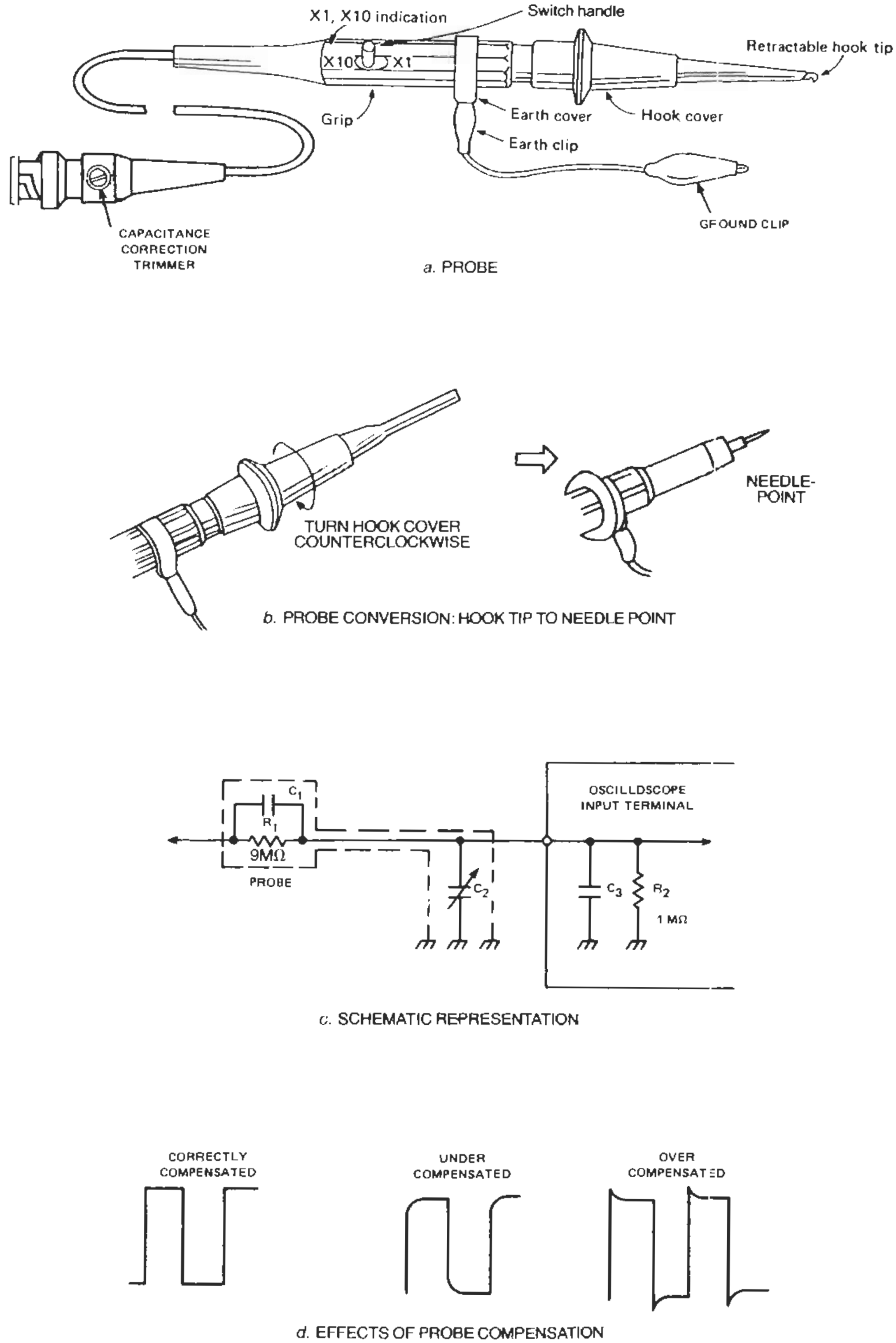


Figure 2-6. Direct/Low Capacitance Probe LP-060X

requirement is that signal be applied to the trigger-source channel and the associated VOLTS/DIV switch be set to provide sufficient signal amplitude. The minimum trigger amplitude is approximately half a major division below 10 MHz, and increases to 1½ major divisions at 60 MHz. If possible, use at least a full division below 10 MHz, and two divisions above 10 MHz.

If both channels are displayed, and the two signals are different but harmonically-related frequencies, trigger from the lowest-frequency channel if possible. This will ensure that both traces are stable.

Press the ALT button when you want to display **two** signals **not** harmonically related to each other (720 Hz and 939 Hz, for example). However, ALT V MODE **must** be used with ALT trigger source.

The LINE position provides trigger signal at the local power line frequency. This is valuable when observing a low-level ripple component imposed on a large DC voltage, or within a mixture of other AC voltages. The line-frequency trigger will sync a signal at any reasonable multiple of the power-line frequency.

The EXT position uses whatever signal is applied to the EXT TRIG IN connector (29) as the trigger source.

> **CAUTION:** Do not apply a signal greater than 400V (DC plus AC peak). Further, use a 0.1μF blocking capacitor in series with this input if the trigger signal consists of a small AC signal imposed on a large DC level.

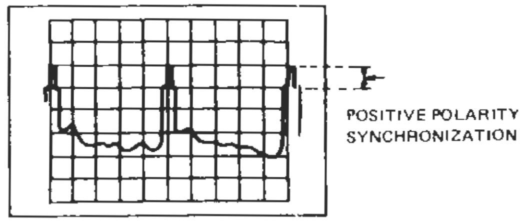
Using any trigger source **not** derived from the channel you are watching has the advantage that changes in the amplitude of the signal under observation (either directly or by resetting the VOLTS/DIV switch) will not cause the display to lose sync, even if the amplitude of the observed signal falls below a screen division. External trigger has the advantage that complex and/or noisy signals can be stably displayed as long as the trigger signal is free from noise.

Trigger Coupling Options. The various trigger coupling options for the main (A) timebase increase the probability of stable triggering on extremely complex signals, such as those containing several frequencies and/or hum and noise.

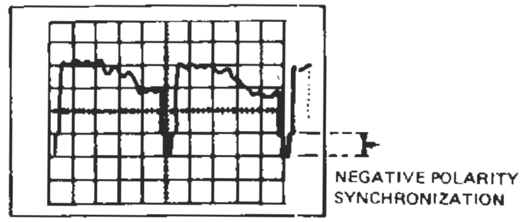
The COUPLING switches (30) insert frequency-selective filters that pass certain frequencies on to the trigger circuitry and reject others. The AC pushbutton removes any DC component in the trigger signal. Use AC coupling for most signals.

The HF REJ pushbutton cuts off frequencies above 100 kHz, passing only signals in the 2 Hz to 20 kHz range. Use this to remove high-frequency noise mixed with a low-frequency signal.

TV V and TV H coupling inserts a TV sync separator into the trigger circuit, so a clean trigger signal at either the vertical or horizontal rep rate can be removed from a composite video signal. TV V coupling is also effective in securing stable triggering at the low frequency (60 or 70 Hz) of an audio intermodulation distortion test signal. To trigger the scope at the vertical (frame) rate, simulataneously press the HF REJ and TV H pushbuttons. To trigger the scope at the horizontal (line) rate, press the TV H pushbutton. When either of the TV pushbuttons are used, the SLOPE switch (32) must be matched to the polarity of the video signal. Leave the SLOPE pushbutton out (+ position) for positive-sync signals (Figure 2-7a), and depressed (− position) for negative-sync video signals (Figure 2-7b).



a. Position of SLOPE Switch (32): +

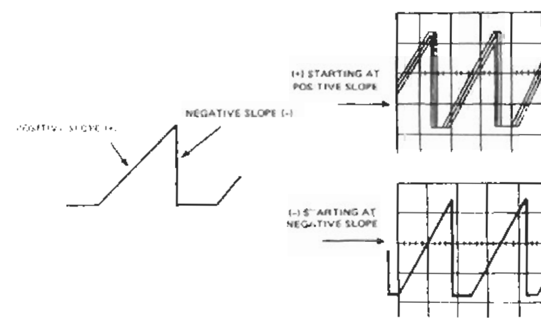


b. Position of SLOPE Switch (32): −

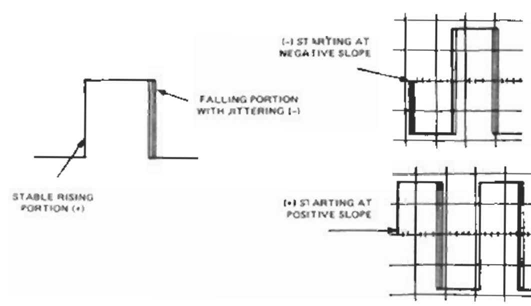
Figure 2-7. Selection of SLOPE Switch Position for TV Signals

Trigger Point Selection. For a stable display, the timebase must be triggered at the exact same point on the recurrent waveform each time the timebase is swept. This is sometimes difficult so the LBO-325 has three controls that enable the operator to achieve this condition. They are the LEVEL control (31), the SLOPE switch (32), and the HOLDOFF control (33).

The SLOPE switch determines whether the sweep will begin on a positive-going or negative-going slope of the trigger signal (see Figure 2-8). In some cases the choice of



A SAWTOOTH WAVEFORM

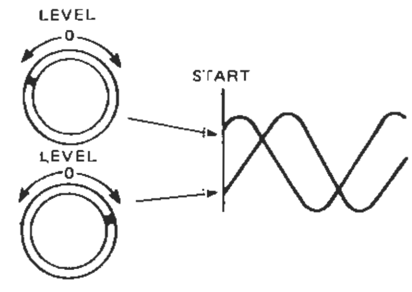


B. SQUARE WAVE

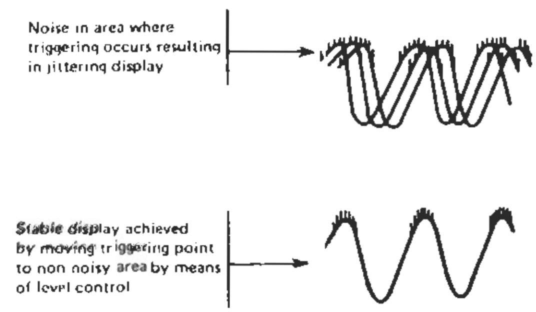
Figure 2-8. SLOPE Switch Setting

slope is unimportant, in others it is vitally important to attain a stable and/or jitter-free display. Always select the steepest and most stable slope or edge. For example, small changes in the amplitude of the sawtooth shown in Figure 2-8a will cause jittering if the timebase is triggered on the positive (ramp) slope, but have no effect if triggering occurs on the negative slope (a fast-fall edge). In the example shown in Figure 2-8b, both leading and trailing edges are very steep (fast rise and fall times). However, this particular pulse is the output of a leading-edge triggered monostable, and has inherent pulse-width jitter. Triggering from the jittering trailing edge will cause the entire trace to jitter, making observation difficult. Triggering from the stable leading edge (+ slope) yields a trace that has only the trailing-edge jitter of the original signal. If you are ever in doubt, or have an unsatisfactory display, try both slope settings to obtain the optimum display.

The LEVEL control determines the point on the selected slope at which the main (A) timebase will be triggered. The effect of the LEVEL control on the displayed trace is shown in Figure 2-9a. The 0, + and − panel markings for this control refer to the waveform's center crossing and points on the waveform more positive (+) and more negative (−) than this. If the trigger slope is very steep, as with square waves or digital pulses, there will be no apparent change in the displayed trace until the LEVEL control is rotated past the most positive or most negative trigger point, whereupon the display will free run (AUTO sweep mode) or disappear completely (NORM sweep mode). Try to trigger at the mid point of slow-rise waveforms (such as sine and triangular waveforms), since these are usually the areas on such waveforms with the lowest noise level. As Figure 2-9b shows, triggering on a noisy area will cause instability in the display.



a. Effect of LEVEL Control Adjustment on Triggering Starting Position



b. Elimination of Jittering Display by LEVEL Control Adjustment

Figure 2-9. LEVEL Control Adjustment

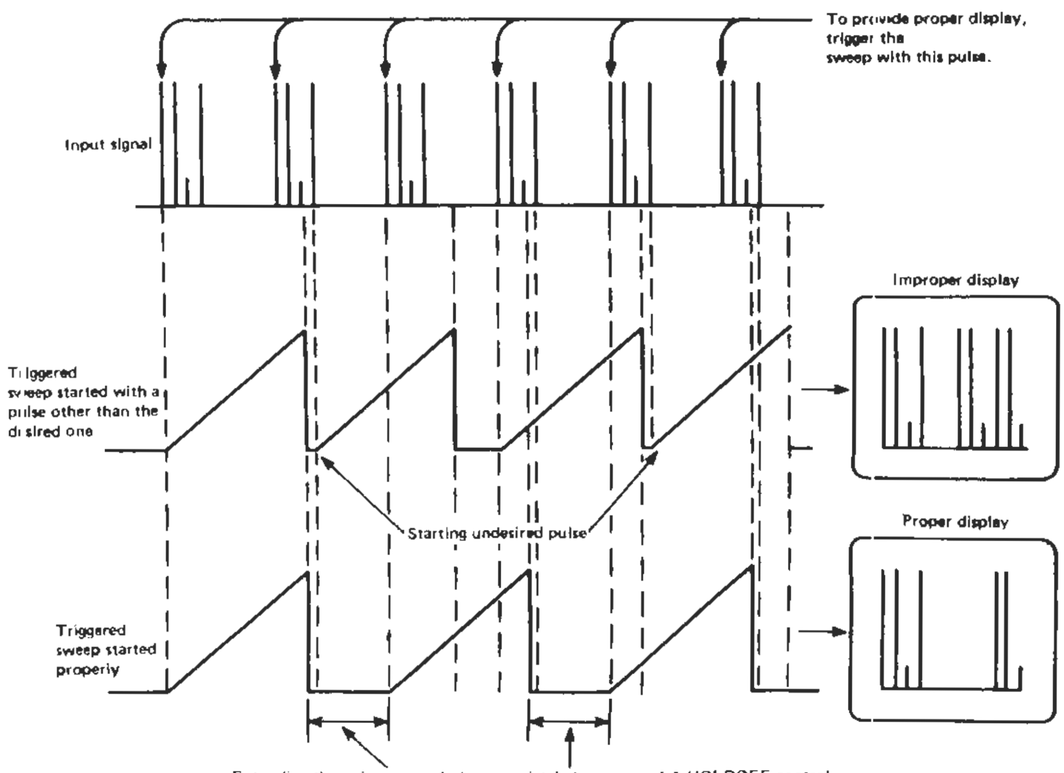


Figure 2-10. HOLDOFF Control Adjustment

The larger the amplitude of the trigger signal **inputted** to the trigger circuits, the greater is the degree of rotation (control range) over which the LEVEL control will maintain a stable display. With internally-derived trigger, the actual trigger amplitude is proportional to the number of graticule divisions occupied by the trace. Therefore, the trigger point is more critical with small signals than large. This is one reason why it is important to use as much trace height as practical for the number of traces displayed.

The HOLDOFF control is used for special circumstances only. It allows the operator to adjust the mandatory sweep retrace time between the end of one sweep and the start of the next (in response to a trigger pulse). This prevents the triggering of subsequent sweeps by the wrong trigger pulse in a complex waveform. During the normal operation, leave the the HOLDOFF control set at NORM. When viewing complex waveforms containing multiple trigger points per repetition, rotate the HOLDOFF control clockwise until the proper waveform is secured, as shown in Figure 2-10. For example, the waveform shown contains three pulses in each group capable of triggering the timebase, but sweep must begin only on the first pulse in each burst to obtain the proper display. In the lower display, the sweep retrace time has been extended enough to make it impossible for the last pulse in the second burst to start the next sweep.

2-3-4 Probe Compensation and Use

The LP-060X probes furnished with the LBO-325 can be set for either low-capacitance operation (10X attenuation) or direct connection (1X attenuation). The selection is made by sliding the switch handle on the probe body (see Figure 2-6a) to the desired attenuation.

At either attenuation setting you have a choice of spring-loaded hook tip or straight tip (see Figure 2-6b). The hook tip is for "hands off" connections to wiring, components, or test points. Pull back the flange on the hook cover to expose the hook to the circuit under observation.

When 1X attenuation is selected, the probe simply operates as a section of a shielded cable. The signal source "senses" the 1 megohm input resistance of the LBO-325 in parallel with 30 pF input capacitance **and** the 200 pF or so cable capacitance of the probe. Because of this capacitance, 1X attenuation is generally used only at low frequencies and/or with low-impedance signal sources. Although many conditions (source impedance, source capacitance, frequency, allowable error, etc.) are factors in attenuation choice, the impedance and frequency limits beyond which 1X operation of the LP-060X should generally be avoided are 1 MHz with 50-ohm sources, and 50 kHz with 1000-ohm sources.

When 10X attenuation is selected, the probe forms a compensated voltage divider (see Figure 2-6c) that has a constant division ratio at all frequencies. Moreover, the signal sources "senses" only a fraction of the cable capacitance (about 25 pF), so error-causing capacitance loading of high impedance sources is greatly reduced. Because of this, 10X probes are used for measurements and waveform observation much more than any other connecting device. Note however, that the probes must be properly adjusted or "compensated" to achieve the error-reducing benefits of 1X attenuation. To do this, proceed as follows:

1. Connect a probe to the CH 1 or X-IN connector (9) and the CAL connector (1).

   NOTE: For best results, connect the probe ground lead to the other channel's input connector.

2. Set the channel 1 VOLTS/DIV switch (11) to 20 mV, and the A TIME/DIV switch (20) to .2 mS.
3. Press the CH 1 V MODE pushbutton (16), and the CH 1 SOURCE pushbutton (28).
4. With a small screwdriver, adjust the capacitance-correction trimmer (Figure 2-6a) for a correctly-compensated square wave (Figure 2-6d).
5. Press the CH 2 V MODE (16) and CH 2 SOURCE (28) pushbuttons, and perform Steps 1, 2, and 4 for channel 2 with the **other** probe.

2-3-5 Dual-trace Operation

Dual-trace operation is the major operating mode of the LBO-325. As was the case with **Single-trace Operation**, you have a choice here too; not of channel selection, but of how to display the two channels. The LBO-325 is set up for dual-trace operation as follows:

1. Set the following controls as indicated below. Any control not mentioned here or in the following steps can be neglected for this procedure.

PULL X5 MAG switches (12)	Pushed in
VARIABLE controls (12)	Fully CW
AC/GND/DC switches (13)	AC
CH 2 INV switch (17)	Out
INTEN control (2)	APS*
FOCUS control (3)	APS*
POWER switch (7)	Pushed in
Time VARIABLE control (22)	Fully CW
Horizontal Position control (24)	APS*
PULL X10 MAG switch (24)	Pushed in
HOR DISP switches (26)	A pressed
COUPLING switches (30)	AC pressed
SLOPE switch (32)	+
TRIG switch (31)	Pushed in
LEVEL control (31)	0
HOLDOFF control (33)	NORM

* As previously set. Adjustment may occasionally be necessary to suit the circumstances.

2. Press either ALT or CHOP V MODE pushbutton (16). Press ALT for relatively high frequency displays (A TIME/DIV switch set at .2 mS or faster); press CHOP for relatively low-frequency displays (A TIME/DIV switch set at .5 mS or slower). If the CHOP pushbutton is pressed when fast sweep speeds are used, the displayed traces will appear broken (as in Figure 2-11) when signals are applied. If the ALT pushbutton is pressed when slow sweep speeds are used, the display will flicker excessively.

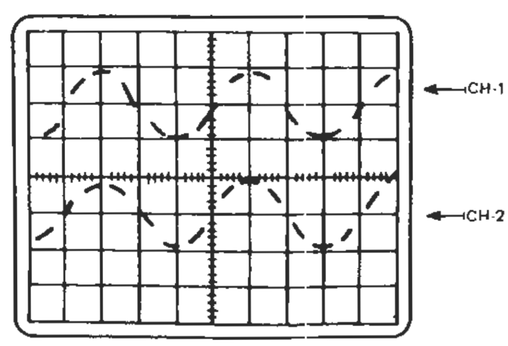


Figure 2-11. CHOP display at sweep speeds above 0.5 mS/div

3. Use the vertical Position controls (14 and 15) to set the CH 1 trace about two divisions down from the top graticule line, and the CH 2 trace about two divisions up from the bottom graticule line.
4. Connect the signals to be observed to the CH 1 and CH 2 IN connectors (9) and (10), and adjust the VOLTS/DIV switches (11) so the displayed signals are totally on screen and clear of each other.

> **CAUTION:** Do not apply signals greater than 400 V (DC + AC peak).

5. Set the A TIME/DIV switch so the desired number of cycles are displayed. For some measurements just 2 or 3 cycles are best; for other measurements 50-100 cycles (appearing like a solid band) works best. Be certain the display mode (ALT or CHOP) selected is consistent with this sweep speed (as per Step 2). Adjust the LEVEL control (31), if necessary, for a stable display.
6. If both channels are displaying signals of the same frequency, trigger from the channel having the steepest-slope waveform. If the signals are different but harmonically-related frequencies, trigger from the channel carrying the lowest frequency. Also, bear in mind that if you disconnect the signal to the channel serving as the trigger source, the entire display will free run.
7. If the signals are different frequencies **not** harmonically related, press the ALT V MODE and ALT SOURCE (28) pushbuttons regardless of the A TIME/DIV switch setting.
8. If a signal you wish to observe is so low in amplitude that even the 5 mV position of the VOLTS/DIV switch cannot produce sufficient trace height for stable triggering, pull the PULL X5 MAG switch (12). This produces 2 mV/div sensitivity when the VOLTS/DIV switch is set to 10 mV, and 1 mV/div when it is set to 5 mV. However, the channel bandwidth decreases to 5 MHz, and slight trace noise appears, when this is done.
9. If the signal you wish to observe is so high in frequency that even the .2 μS position of the A TIME/DIV switch results in too many cycles displayed, pull the PULL X10 MAG switch (24). This increases the effective sweep speed by a factor of 10, so .5 uS becomes 50 nS/div, 1 uS becomes 100 nS/div, etc. The 20 nS/div sweep speed achieveable by magnification is fast enough to display a single cycle of a 5 MHz signal across the face of the CRT.
10. If the signal you wish to observe is either DC or low enough in frequency that AC coupling attenuates or distorts the signal, set the AC/GND/DC switch (13) to DC.

> **CAUTION:** If the observed waveform is low-level AC, make certain it is not riding on a high-amplitude DC voltage.

2-3-6 Additive and Differential Operation

Additive and differential operation are forms of two-channel operation where two signals are combined to display one trace. In additive operation, the resultant trace represents the algebraic **sum** of the CH 1 and CH 2 signals. In differential operation, the resultant trace represents the algebraic **difference** between the CH 1 and CH 2 signals.

To set up the LBO-325 for additive operation, proceed as follows:

1. Set up the dual-trace operation per paragraph 2-3-5, Steps 1 to 6 and 8 to 10.
2. Make sure both VOLTS/DIV switches (11) are set to the same position; and the VARIABLE controls (12) are click-stopped in their CAL position. If the signal levels are very different, set both VOLTS/DIV switches to the position producing a large on-screen display of the **high-amplitude** signal.
3. Trigger from the channel having the highest-amplitude signal.
4. Simultaneously press the CH 1 and CH 2 V MODE pushbuttons. The single trace resulting is the algebraic sum of the channel 1 and channel 2 signals. Either or both of the Vertical Position controls (14) and (15) can be used to shift the resultant trace.

> **NOTE:** If the input signals are in-phase, the amplitude of the resultant trace will be the arithmetic sum of the individual traces (e.g., 4.2 div + 1.2 div = 5.4 div). If the input signals are 180° out of phase, the amplitude of the resultant trace will be the arithmetic difference of the two traces (e.g., 4.2 div − 1.2 div = 3.0 div).

5. If the peak-to-peak amplitude of the resultant trace is very low, turn **both** VOLTS/DIV switches to increase the display height. Make sure both VOLTS/DIV controls are set to the same position, or the resultant display will be erroneous.

To set up the LBO-325 for differential operation, proceed as follows:

1. Set up for dual-trace operation per paragraph 2-3-5, Steps 1 to 6 and 8 to 10.
2. Ensure that both VOLTS/DIV switches (11) are set to the same position, and the VARIABLE controls (12) are detented in the CAL position. If the signal levels are very different, temporarily set both VOLTS/DIV switches to the position needed to produce a large on-screen display of the **highest amplitude signal**.
3. Trigger from the channel having the highest amplitude signal.
4. Press the CH 2 INV pushbutton (17)
5. Simultaneously press the CH 1 and CH 2 V MODE pushbuttons. The single trace resultant is the algebraic sum of the channel 1 and channel 2 signals. Either or both of the Vertical Position controls (14) and (15) can be used to shift the resultant trace.

> **NOTE:** If the input signals are in-phase, the amplitude of the resultant trace will be the arithmetic difference of the individual traces (e.g., 4.2 div − 1.2 div = 3.0 div). If the input signals are 180° out of phase, the amplitude of the resultant trace will be the arithmetic sum of the two traces (e.g., 4.2 div + 1.2 div = 5.4 div).

6. If the peak-to-peak amplitude of the resultant trace is very low, turn **both** VOLTS/DIV switches to increase the waveform display height. Ensure that both VOLTS/DIV controls are set to the same position.

2-3-7 Delayed-Sweep Operation

This oscilloscope has two timebases, arranged so one (the A timebase) may provide a delay between a trigger event and the beginning of sweep by the other (B) timebase. This allows any selected protion of a waveform or pulse train to be spread over the entire screen. Delayed sweep can be used with either single-trace or dual-trace operation. For clarity, the accompanying illustration will show a single vertical channel.

The basic delayed sweep mode of the LBO-325 is **alternate** sweep, which displays both the main (A) and delayed (B) timebase traces for each vertical channel used. The next procedure shows how to display only the delayed (B) trace, but you must use alternate sweep first to determine exactly which portion of the main (A) sweep will be displayed as the B-sweep trace.

Alternate Sweep. To simultaneously display the A- and B-timebase traces, proceed as follows:

1. Adjust the VOLTS/DIV switch(es) (11) so the trace height(s) does not exceed 4 screen divisions if one vertical channel is used, or 2 screen divisions if both vertical channels are used. This is simply to ensure that there is room for all traces later.
2. For the same reason, position the trace(s) so there is room near each trace currently displayed for an additional trace of equal amplitude. You can leave room either above or below the displayed traces, but it must be the **same for both traces** if both vertical channels are used.
3. Make sure the TRIG'D pushbutton (27) is out, the INTEN control (2) is turned up for a bright display, and the B TIME/DIV switch (21) is set to a faster sweep than is the A TIME/DIV switch.
4. Press the B HOR DISP pushbutton (26) while holding in the A pushbutton (i.e., **both** the A and B HOR DISP pushbuttons must be locked in the recessed position).
5. Use the **TRACE SEP** control (25) to move the delayed (B) trace(s) to the vacant area(s) above or below the main (A) timebase trace(s).
6. The section of the main (A) timebase trace(s) corresponding to the B sweep time will be brighter than the rest of the main timebase trace(s), as shown in Figure 2-12. Adjust the INTEN control if necessary for a proper display.

> **NOTE:** The main (A) trace(s) will look like a partial trace if brightness is insufficient. If the brightness is excessive, the B-intensified portion of the A trace(s) will be indistinguishable from the rest of the A trace(s). Furthermore, the intensified portion of the A trace(s) will be quite small if there is a large difference between the settings of the A and B TIME/DIV switches.

7. Turn the B TIME/DIV switch (21) until the intensified portion of the trace widens to an **amount** equal to the portion of the trace you wish to magnify.
8. Turn the DLY TIME MULT control (23) to **position** the intensification over the portion of the A timebase trace(s) you wish to magnify.

B Sweep Only. After you have set the DLY TIME MULT control and B TIME/DIV switch according to the **Alternate Sweep** procedure, you can reduce screen clutter by eliminating the main (A) timebase trace(s). To do this, simply press the B HOR DISP pushbutton again. The A pushbutton will pop out and the A timebase trace(s) will disappear. This allows you to increase the screen height of the B timebase trace(s).

> **NOTE:** The B timebase trace(s) will move to the portion of the CRT screen formerly occupied by the A trace(s).

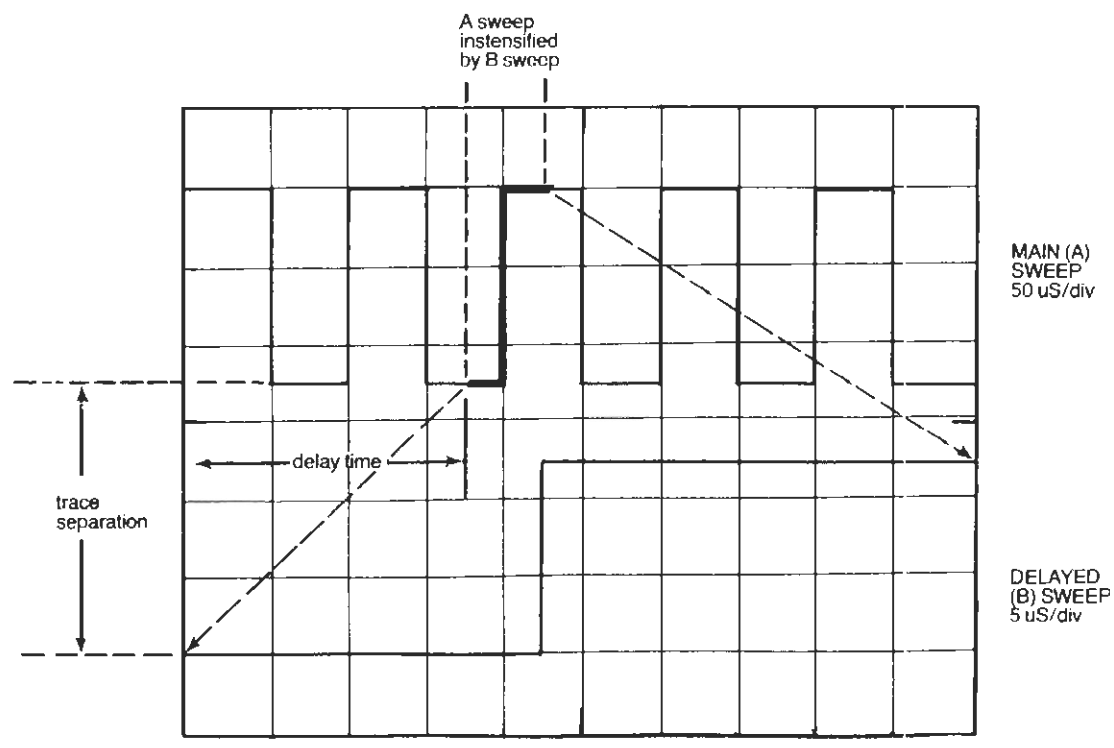


Figure 2-12. Delayed sweep display of one vertical channel

Triggered B Sweep. In basic delayed sweep, the B timebase is **not** triggered by a signal event; it begins when the main sweep (A timebase) ends. This is readily seen in the alternate sweep mode. The only problem with this is that main timebase jitter becomes apparent in the B sweep when at high ratios of A to B TIME/DIV switch settings (100:1 and up). To circumvent this, the B sweep can be triggered by the signal itself or a time-related trigger signal. The DLY TIME MULT control then determines the **minimum** delay time between A and B sweeps; the actual delay time will be that plus the additional time until the next available trigger. The result is that actual delay time is variable only with step resolution, in increments of the interval between triggers.

The B timebase is triggered internally, using the same trigger-signal supplied to the A timebase. For triggered B sweep, proceed as follows:

1. Set up the scope for basic delayed sweep as described in the preceding paragraphs.
2. Press in the TRIG'D pushbutton (27). The B timebase is now triggering on a signal related in time to the A timebase trigger. The start of the B sweep will always be a leading or trailing edge of the trigger signal, turning the DLY TIME MULT control will not change this.

> **NOTE:** If TV V trigger coupling is selected for the main (A) timebase, the delayed (B) timebase will be triggered by the TV H output of the sync separator. This facilitates inspection of complex signals containing composite sync, such as VITS, VIRS, and various coding signals found in the vertical interval.

2-3-8 X-Y Operation

The internal timebases of the LBO-325 are not utilized in X-Y operation; deflection in both the vertical **and** horizontal directions is via external signals. One of the vertical input channels serves as the X-axis (horizontal) signal processor, so horizontal and vertical axes have identical control facilities.

All of the V MODE, HOR DISP, trigger SOURCE, trigger COUPLING, and trigger mode switches, as well as their associated controls and connectors, are inoperative in the X-Y mode.

To set up the LBO-325 for X-Y operation, proceed as follows:

1. Turn the A TIME/DIV switch (20) fully counter-clockwise to the X-Y position.

> **CAUTION:** Reduce the trace intensity, to reduce the risk of undeflected spot damage to the CRT phosphor.

2. Apply the vertical signal to the CH 2 or Y IN connector (10), and the horizontal signal to the CH 1 or X IN connector (9). Once the spot is deflected, restore normal brightness.
3. Adjust the trace height with the CH 2 VOLTS/DIV switch (11), and the trace width with the CH 1 VOLTS/DIV switch. The VARIABLE controls (12) and PULL X5 MAG switches (12) for both channels can be used if needed.

> **NOTE:** Further horizontal (X-axis) magnification is available from the PULL X10 MAG switch (24), but is unlikely to be needed.

4. Adjust the trace position vertically (Y-axis) with the CH 2 Vertical or Y Position control (15). Adjust the trace position horizontally (X-axis) with the Horizontal Position control (24); the CH 1 Vertical Position control has no effect during X-Y operation.
5. The vertical (Y-axis) signal can be inverted via the CH 2 INV pushbutton (17).

2-3-9 Intensity Modulation

Intensity modulation, also known as Z-axis modulation, is an operational mode wherein an external signal controls the brightness of the CRT trace. Its main applications are in video display and time or frequency marking. When so used, it is often in conjunction with X-Y operation (described in paragraph 2-3-8).

To intensity modulate the CRT, simply connect the modulating signal to the Z AXIS IN connector (19) on the back panel. The necessary modulating signal amplitude for minimum/maximum trace brightness is dependent upon the front panel intensity control. At normal brightness levels, a TTL signal will be sufficient.

> **CAUTION:** Do not apply a signal greater than 50V (DC + AC peak).

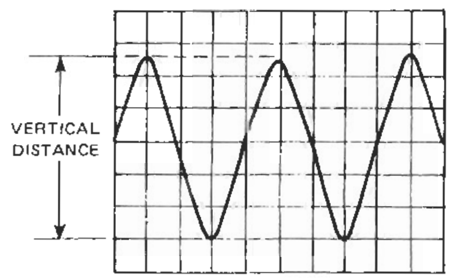


Figure 2-13. Peak-to-peak voltage measurement

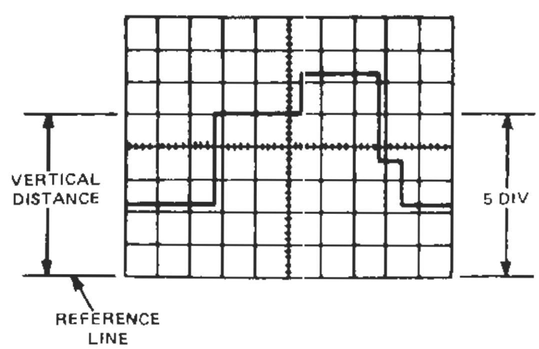


Figure 2-14. Instantaneous voltage measurement

2-4 MEASUREMENT APPLICATIONS

This contains instructions for using the LBO-325 for specific measurement procedures. However, this is but a small sampling of the many applications possible for this oscilloscope. These particular applications were selected to demonstrate certain controls and features not fully covered in BASIC OPERATING PROCEDURES, to clarify certain operations by example, or for their importance and universality.

2-4-1 Amplitude Measurement

The modern triggered-sweep oscilloscope has two major measurement functions. The first of these is amplitude. The oscilloscope has an advantage over most other forms of amplitude measurement in that complex as well as simple waveforms can be totally characterized (i.e., complete voltage information is available).

Oscilloscope voltage measurements generally fall into one of two types: peak-to-peak or instantaneous. Peak-to-peak (p-p) measurement simply notes the total amplitude between extremes without regard to polarity reference. Instantaneous voltage measurement indicates the exact voltage measurement from each and every point on the waveform to a ground reference. When making either type of measurement, ensure that the VARIABLE controls (12) are detented fully clockwise in the CAL position.

Peak-to-Peak Voltages. To measure peak-to-peak voltage, proceed as follows.

1. Set up the LBO-325 for vertical mode desired per the instructions in 2-3 BASIC OPERATING PROCEDURES.
2. Adjust the TIME/DIV switch (20) or (21) to display two or three cycles of waveform, and set the VOLTS/DIV switch (11) for the largest-possible totally-on-screen display.
3. Use the appropriate Vertical Position control (14) or (15) to position the negative signal peaks on the nearest horizontal graticule line below the signal peaks, per Figure 2-13.
4. Use the Horizontal Position control (24) to position one of the positive peaks on the central vertical graticule line. This line has additional calibration marks equal to 0.2 major division each.
5. Count the number of divisions from the graticule line touching the negative signal peaks to the intersection of the positive signal with the central vertical graticule line. Multiply this number by the VOLTS/DIV switch setting to obtain the peak-to-peak voltage of the waveform. For example, if the VOLTS/DIV switch were set to 2V, the waveform shown in Figure 2-13 would be 11.2V p-p (5.6 div × 2V).
6. If X5 vertical magnification is used, divide the Step 5 voltage by 5 to obtain the correct p-p voltage. However if 10X attenuator probes are used, multiply the VOLTS/DIV by 10 to obtain this correct p-p voltage.
7. If measuring a sine wave below 100 Hz, or a rectangular wave below 1000 Hz, set the AC/GND/DC switch (13) to DC.

> **CAUTION:** Ensure that the waveform is not imposed on a higher-amplitude DC voltage.

Instantaneous Voltages. To measure instantaneous voltage, proceed as follows.

1. Set up the LBO-325 for the vertical mode desired per the instructions in 2-3 BASIC OPERATING PROCEDURES.
2. Adjust the applicable TIME/DIV switch (20) or (21) for one complete cycle of waveform and set the VOLTS/DIV switch (11) for a trace amplitude of 4 to 6 divisions (see Figure 2-14).
3. Set the AC/GND/DC switch (13) to GND.
4. Use the appropriate Vertical Position control (14) or (15) to set the baseline on the central horizontal graticule line. However, if you know the signal voltage is wholly positive, use the bottommost graticule line. If you know the signal voltage to be negative, use the uppermost graticule line.

   > **NOTE:** The Vertical Position controls must not be touched again until the measurement is completed.

5. Set the AC/GND/DC switch to DC. The polarity of all points above the ground reference line is positive; all points below the ground-reference line are negative.

   > **CAUTION:** Ensure that the waveform is not imposed on a high-amplitude DC voltage before changing the AC/GND/DC switch setting.

6. Use the Horizontal Position control (24) to position any point of interest on the central vertical graticule line. This line has additional calibration marks equal to 0.2 major division each. The voltage relative to ground at any point selected is equal to the number of divisions from that point to the ground-reference line multiplied by the VOLTS/DIV setting. In the example used for Figure 2-14, the voltage for a 0.5V/div scale is 2.5V (5.0 div × .5V)
7. If X5 vertical magnification is used, divide the Step 6 voltage by 5. However, if 10X attenuator probes are used, multiply the voltage by 10.

2-4-2 Differential Measurement Techniques

Differential measurement techniques allow direct measurement of the voltage drop across "floating" components (both ends above ground), and measurement of very small signals in electrically-noisy environments (such as exists near high-power AC machinery).

The control setting for different operations were explained in paragraph **2-3-6 Additive and Differential Operation**. The technique for making the physical connections are shown in Figure 2-15. Figure 2-15a shows the simple technique for measuring high-level signals on floating signals. In this example, the AC voltage drop (ripple) across a power choke is observed and measured. The ground terminals from the two probes or cables are simply connected to the chassis or ground bus of the circuit under observation. Figure 2-15b shows the connection technique needed for low-level signals in a noisy environment (strong AC fields). Using a separate ground connection and **not** connecting the probe shields to the circuit under test avoids ground loops and EMI pickup.

2-4-3 Time Interval Measurements

The second major measurement function of the triggered-sweep oscilloscope is the measurement of time interval. This is possible because of the calibrated timebase results in each division of the CRT screen representing a known time interval.

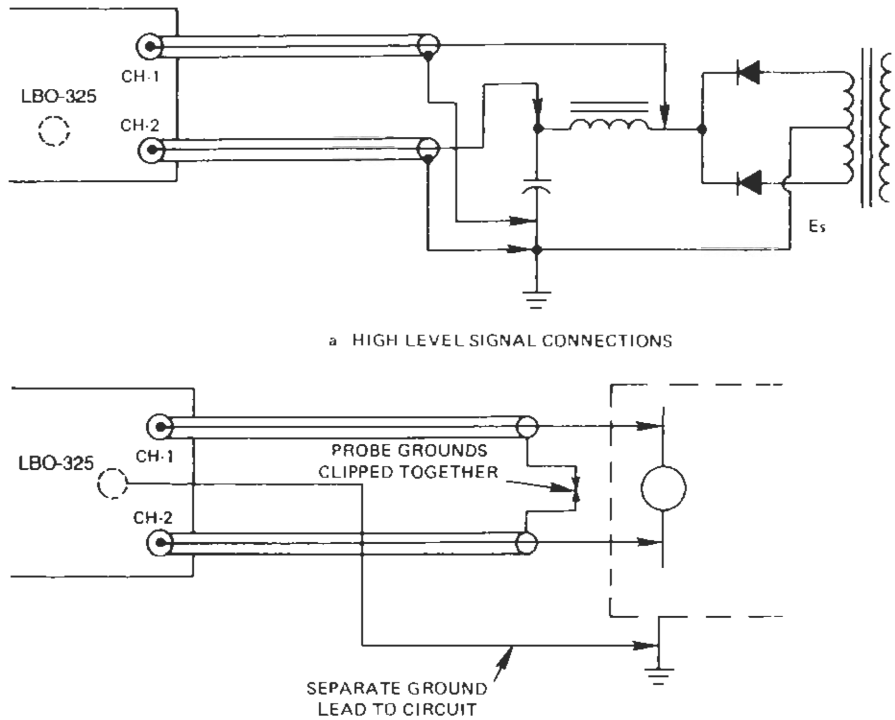


Figure 2-15. Connection techniques for differential measurements

Basic Technique. The basic technique for measuring time interval is described in the following steps. This same technique applies to the more specific procedures and variations that follow.

1. Set up the LBO-325 as described in **2-3-2 Single-trace Operation.**
2. Set the A TIME/DIV switch (20) so the interval you wish to measure is totally on screen and as large as possible. Ensure that the Time VARIABLE control (22) is detented fully clockwise in the CAL position. If not, any time interval measurements made under this condition will be inaccurate.
3. Use the Vertical Position control (14) or (15) to position the trace so the central horizontal graticule line passes through the points on the waveform between which you want to make the measurement.
4. Use the Horizontal Position control (24) to set the left-most measurement point on a nearby vertical graticule line.
5. Count the number of horizontal graticule divisions between the Step 4 graticule line and the second measurement point. Measure to a tenth of a major division. Note that each minor division on the central horizontal graticule line is 0.2 major division.
6. To determine the time interval between the two measurement points, multiply the number of horizontal divisions counted in Step 5 by the setting of the A TIME/DIV switch. If the PULL X10 MAG switch (24) is pulled (X10 magnification), be certain to divide the TIME/DIV switch setting by 10.

Period, Pulse Width, and Duty Cycle. The basic technique described in the preceding paragraph can be used to determine pulse parameters such as period, pulse width, duty cycle, etc.

The period of a pulse or any other waveform is the time it takes for one full cycle of the signal. In Figure 2-16, the distance between points (A) and (C) represent one cycle; the time interval of this distance is the period. The time scale for the CRT display of Figure 2-16 is 10 mS/div, so the period is 70 milliseconds in this example.

Pulse width is the distance between points (A) and (B). In our example it is conveniently 1.5 divisions, so the pulse width is 15 milliseconds. However, 1.5 divisions is a rather small distance for accurate measurements, so it is adviseable to use a faster sweep for this particular measurement. Increasing the sweep speed to 2 mS/div as in Figure 2-16b presents a large display, allowing more accurate measurement. An alternative technique useful for pulses less than a division wide is to the pull the PULL X10 MAG switch (24) for X10 magnification, and reposition the pulse on screen with the Horizontal Position control (24). Pulse width is also called **on** time in some applications. The distance between points (B) and (C) is then called **off** time. This can be measured in the same manner as pulse width.

When pulse width and period time are known, duty cycle can be calculated. Duty cycle is the percentage of the period (or total of **on** and **off** times) represented by the pulse width (**on** time).

$$\text{Duty cycle (\%)} = \frac{\text{PW (100)}}{\text{Period}} = \frac{A \rightarrow B\ (100)}{A \rightarrow C}$$

$$\text{Duty cycle of example} = \frac{15\ \text{mS X100}}{70\ \text{mS}} = 21.4\%$$

Lead and Lag Time. When two signals have the same frequency, but not the same phase, one signal is said to be **leading**, and the other **lagging**. To measure this lead/lag time, proceed as follows:

1. Set up the LBO-325 as described in **2-3-5 Dual-trace Operation**, connecting one signal to the CH-1 IN connector (9) and the other to the CH-2 IN connector (10).

   NOTE: At high frequencies use identical and correctly-compensated probes, or equal lengths of the same type of coaxial cable to ensure equal delay times.

2. Set the trigger SOURCE switch (28) for the channel with the leading signal (CH-1 in the Figure 2-17 example).
3. Use the A TIME/DIV switch (20) to display the time difference as large as possible (Figure 2-17b).
4. Use the CH-1 Vertical Position control (14) to position the bottom of the channel 1 trace slightly below the central horizontal graticule line, and the CH-2 Vertical Position control (15) to position the top of the channel 2 trace slightly above the line.
5. Use the Horizontal Position control (24) to align the left-most trace edge (of channel 1 in this case) with a nearby vertical graticule line. The horizontal distance between this line and the point at which the leading edge of the other trace crosses the central horizontal graticule line represents the time difference between the two signals. The channel 1 signal may be said to be leading the channel 2 trace, or the channel 2 trace may be said to be lagging the channel 1 trace.
6. Ensure that the Time VARIABLE control (22) is detented fully clockwise in its CAL position. Then, count the number of horizontal divisions between the leading edges of the traces and multiply this number by the setting of the A TIME/DIV switch to determine the difference. For example, the time difference in Figure 2-17b is 10 microseconds (5.0 div × 2 µS).

If the points between which the time difference exists are less than 1 major division apart and located in the middle of complex waveforms that are otherwise in phase, use the delayed (B) timebase as described in **2-3-7 Delayed Timebase Operation** to select and expand that section of the complex waveform. After doing that, follow the same technique as described in the preceding paragraph. As an alternative, pull the PULL X10 MAG switch (24) to expand the traces, and reposition the section with the same difference on screen with the Horizontal Position control.

If the points between which the time difference exists are more than 1 but less than 5 major divisions apart, the High Accuracy Technique described next will yield the greatest accuracy.

High Accuracy Technique. Closely spaced points within a complex waveform can be measured using the DLY TIME MULT control. The linearity error of this control is only a fraction of a percent, far less than the error possible over a small portion of the timebase sweep.

The delay-time technique can be used with single-trace time measurements (pulse width, period, etc.) or dual-trace measurements (lead and lag time). The technique, after the trace or traces are set up according to the desired procedure, is as follows:

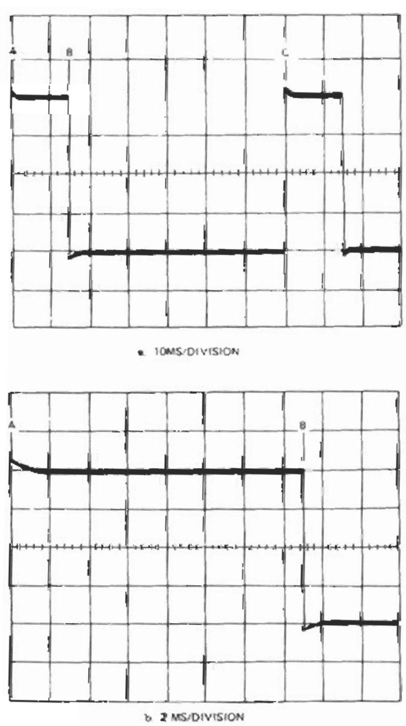


Figure 2-16. Time Interval Measurements

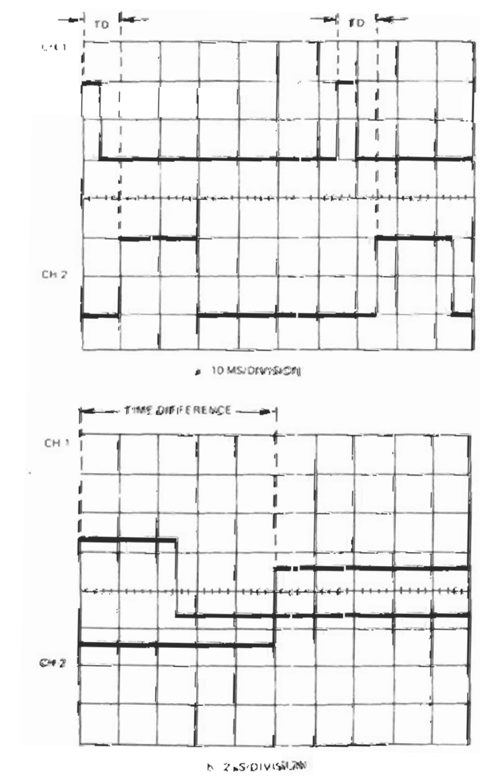


Figure 2-17. Measuring lead and lag time

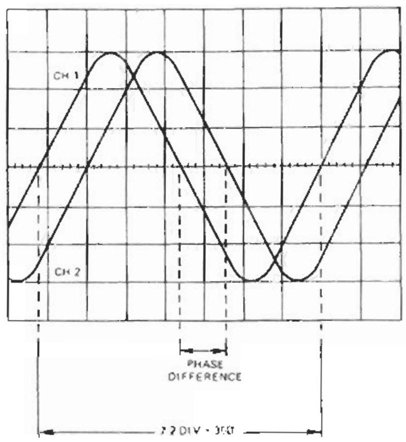


Figure 2-18. Dual-trace method of phase measurement

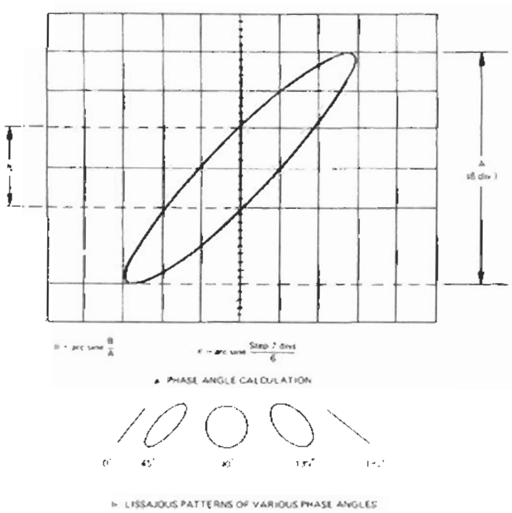


Figure 2-19. Lissajous method of phase measurement

1. Set the B TIME/DIV switch (21) to a position 50 to 100 times (5 to 6 positions) faster than the A TIME/DIV switch setting.
2. Press both the A and B HOR DISP pushbuttons (26), then position the intensified area over the first measurement point by means of the DLY TIME MULT control (23).
3. Press the B HOR DISP pushbutton and carefully adjust the DLY TIME MULT control to position the first measurement point exactly over the central vertical graticule line. Record the DLY TIME MULT dial reading.
4. Rotate the DLY TIME MULT control to position the second measurement point over the central vertical graticule line. Record the DLY TIME MULT dial reading.
5. Subtract the Step 3 reading from the Step 4 reading. For example, if the DLY TIME MULT control setting was 4.86 in Step 3, and 7.38 in Step 4, the difference is 2.52.
6. Multiply the Step 5 number by the A TIME/DIV switch setting to find the time difference.

2-4-4 Phase Difference Measurements

Phase difference or phase angle between two signals can be measured using the dual trace feature of the oscilloscope or by operating the oscilloscope in the X-Y mode. When measuring phase shift or signal-processing devices, the test setup shown in Figure 2-21 can be used.

Dual-trace Method. This method works with any type of waveform (sine, triangle, rectangular, complex pulse, etc.). In fact, it will usually work even if different waveforms are being compared. This method and its variations are effective in measuring small or large differences in phase, at any frequency up to 60 MHz.

To measure phase difference by the dual-trace method, proceed as follows:

1. Set up the LBO-325 as described in **2-3-5 Dual-trace Operation**, connecting one signal to the CH 1 or X IN connector (9) and the other to the CH 2 or Y IN connector (10).

   NOTE: At high frequencies use identical and correctly-compensated probes, or equal lengths of the same type of coaxial cable to ensure equal delay times, or erroneous time measurements will result.
2. Set the trigger SOURCE switch (28) to the channel with the least noise and most stable trace. Temporarily move the other channel's trace off the screen by means of its Vertical Position control.
3. Center the stable (trigger source) trace with its Vertical Position control, and adjust its amplitude to exactly 6 vertical division by means of its VOLTS/DIV switch (11) and VARIABLE control (12).
4. Use the LEVEL control (31) to ensure the trace crosses the central horizontal line at or near the beginning of the sweep. (See Figure 2-18.)
5. Use the A TIME/DIV switch (20), the Time VARIABLE control (22), and the Horizontal Position control (24) to display one cycle of trace over 7.2 divisions. When this is done, each major horizontal division represents 50°, and each minor division represents 10°.
6. Move the off-screen trace back on the CRT with its Vertical Position Control, precisely centering it vertically. Use the associated VOLTS/DIV switch and VARIABLE control to adjust its amplitude to exactly 6 vertical divisions.
7. The horizontal distance between corresponding points on the waveform is the phase difference. For example, in the Figure 2-18 illustration the phase difference is 6 minor divisions, or 60°. Use the Horizontal Position control (24) to align one of the mid-cycle zero crossings with a graticule calibration to facilitate this measurement.
8. If the phase difference is less than 50° (one major division), pull the PULL X10 MAG switch (24) and use the Horizontal Position control (24) (if needed) to position the measurement area back on screen. With 10X magnification, each major horizontal division is 5°, and each minor division is 1°.

Lissajous Pattern Method. This method is used primarily with sine waves. Measurements are possible at frequencies up to 1 MHz, the bandwidth of the horizontal amplifier.

To measure phase difference by the Lissajous pattern method, proceed as follows:

1. Turn the A TIME/DIV switch (20) fully counterclockwise to the X-Y position.

   CAUTION: Reduce the trace intensity, to reduce the risk of undeflected spot damage to the CRT phosphor.

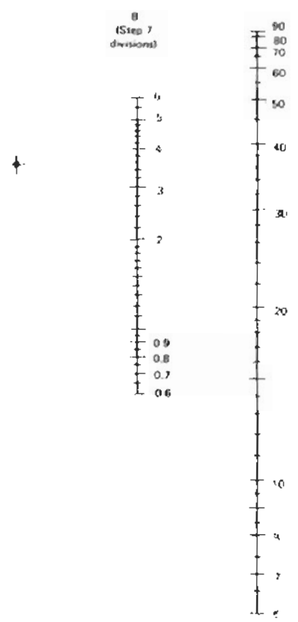


Figure 2-20. Phase angle nomograph

2. Make certain the CH 2 INV switch (17) is out. This will introduce a 180° error if pushed in.
3. Connect one signal to the CH 1 or X IN connector (9), and the other signal to the CH 2 or Y IN connector (10).
4. Center the trace vertically with the CH 2 Vertical Position control (15), and adjust the CH 2 VOLTS/DIV switch (11) and VARIABLE control (12) for a trace height of exactly 6 divisions.
5. Adjust the CH 1 VOLTS/DIV control (11) for the largest possible on-screen display.
6. **Precisely** center the trace horizontally with the Horizontal Position control (24).
7. Count the number of divisions subtended by the trace along the central vertical graticule line (dimension B). You can now shift the trace vertically with the CH 2 or Y Position control to a major division line for easier counting.
8. The phase difference (angle 0) between the two signals is equal to the arc sine of dimension B ÷ A (the Step 7 number divided by 6). For example, the Step 7 value of the Figure 2-19a pattern is 2.0. Dividing this by 6 yields .3334, whose arc sine is 19.5 degrees.
9. The simple formula in Figure 2-19a works for angles less than 90°. For angles over 90° (leftward tilt), add 90° to the angle found in Step 7. Figure 2-19b shows the Lissajous patterns of various phase angles; use this as a guide in determining whether or not to add the additional 90°
10. The sine-to-angle conversion can be accomplished by using trig tables or a trig calculator. However, if the sine is between 0.1 and 1.0, you can use the Figure 2-20 monograph so the edge passes through the cross mark and the number of divisions measured in Step 7 (B dimension). When this is done the edge will also intersect the phase-angle column.

2-4-5 Distortion Comparison

The dual-trace feature of the LBO-325 offers a quick method of checking for distortion caused by a signal-processing device (such as an amplifier). To do this, proceed as follows:

1. Connect the output of a signal generator (of frequency suitable to the device under test) to the CH 1 or X IN connector (9) and the input of the Device Under Test (DUT).
2. Connect the CH 2 or Y IN connector (10) to the output of the device or its load (see Figure 2-21).
3. Increase the signal to the DUT until the channel 2 trace or on RMS AC voltmeter indicates the desired output level.
4. If the DUT has reversed the phase, press the CH 2 INV pushbutton (17).
5. Superimpose the two traces with the Vertical Position controls (14) and (15), and use the VARIABLE control (12) of the **highest** amplitude trace to achieve the best trace match.
6. Any **uniform horizontal** displacement of the trace is simply phase difference (described in paragraph 2-4-4). Any other differences in shape indicate distortion caused by the DUT, such as slew rate or frequency distortion, ringing, etc.

2-4-6 Frequency Measurement

When a precise determination of frequency is needed, a frequency counter is obviously the first choice. A counter can be connected to the CH 1 OUTPUT connector (18) for convenience when both scope and counter are used. However, an oscilloscope alone can be used to measure frequency when a counter is not available, or modulation and/or noise makes a counter unuseable.

Frequency is the reciprocal of period. Simply measure the period "t" of the unknown signal as instructed in **2-4-3 Time Inverval Measurements**, and calculate the frequency "f" using the formula f = 1/t. If a calculator is available, simply enter the period and press the 1/x key. Period in seconds (S) yields frequency in Hertz (Hz); period in milliseconds (mS) yields frequency in kilohertz (kHz); period in microseconds (uS) yields frequency in megahertz (MHz). The accuracy of this technique is limited by the timebase calibration accuracy (see Table of Specifications).

2-4-7 Risetime Measurement

Risetime is the time required for the leading edge of a pulse to rise from 10% to 90% of the total pulse amplitude. Falltime is the time required for the trailing edge of a pulse to drop from 90% of total pulse amplitude to 10%. Risetime and falltime, which may be collectively called transition time, are measured in essentially the same manner.

To measure rise and fall time, proceed as follows:

1. Connect the pulse to be measured to the CH 1 or X IN connector (9), and set the AC/GND/DC switch (13) to AC.
2. Adjust the A TIME/DIV switch (20) to display **about** 2 cycles of the pulse. Make certain the Time VARIABLE control (22) is detented fully clockwise in the CAL position.
3. Center the pulse vertically with the channel 1 Vertical Position control (14).
4. Adjust the CH 1 VOLTS/DIV switch (11) to set the positive pulse peak exceed the 100% graticule line, and

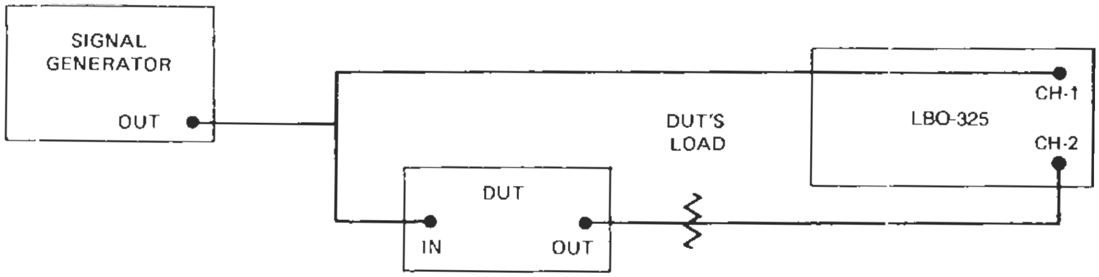


Figure 2-21. Test setup for distortion comparison and phase measuremen'

the negative pulse peak exceed the 0% line, then rotate the VARIABLE control (12) counterclockwise until the positive and negative pulse peaks rest exactly on the 100% and 0% graticule lines. (See Figure 2-22a.)

5. Use the Horizontal Position (24) controls to shift the trace so the leading edge passes through the intersection of the 10% and central vertical graticule lines.
6. If the risetime is slow compared to the period, no further control manipulations are necessary. If the risetime is fast (leading edge almost vertical), pull the PULL X10 MAG switch (24) for 10X magnification and reposition the trace as in Step 5. (See Figure 2-22b.)
7. Count the number of horizontal divisions between the central vertical line (10% point) and the intersection of the trace with the 90% line.
8. Multiply the number of divisions counted in Step 7 by the setting of the A TIME/DIV switch to find the measured risetime. If 10X magnification was used, divide the TIME/DIV setting by 10. For example, if the A timebase setting in Figure 2-22b was .1 μS (100 nS), the risetime would be 36 nanoseconds (100 nS ÷ 10 = 10 nS; 10 nS × 3.6 div = 36 nS).
9. To measure falltime, simply shift the trace horizontally until a trailing edge passes through the 10% and central vertical graticule lines, and repeat Steps 7 and 8.
10. The rise and fall times measured thus far include the 5.8 nS transition time of the LBO-325, and approximately 8.3 nS transition time of the scope/probe combination. These errors are negligible if the measured rise and fall times are 25 nS or longer. For shorter transition times, correct the measured rise and fall times using one of the following formulas:

SCOPE ONLY	SCOPE & PROBE
$t_c = \sqrt{t_m^2 - 34}$	$t_c = \sqrt{t_m^2 - 68}$

t_c = corrected transition time t_m = measured transition time

Continuing with our example, the 36 nS risetime measured in Step 8 represents an actual risetime of 35.0 nS for the pulse when corrected for scope and probe risetime as follows:

$$t_c = \sqrt{36^2 - 68} = \sqrt{1228} = 35.0 \text{ nS}$$

This is less than a 3% error, so the correction was really not necessary. However, if the measured transition time were well below our 25 nS benchmark, say 14 nS, the resulting time difference (error) would be substantial (24% in the following example).

$$t_c = \sqrt{14^2 - 68} = \sqrt{128} = 11.3 \text{ nS}$$

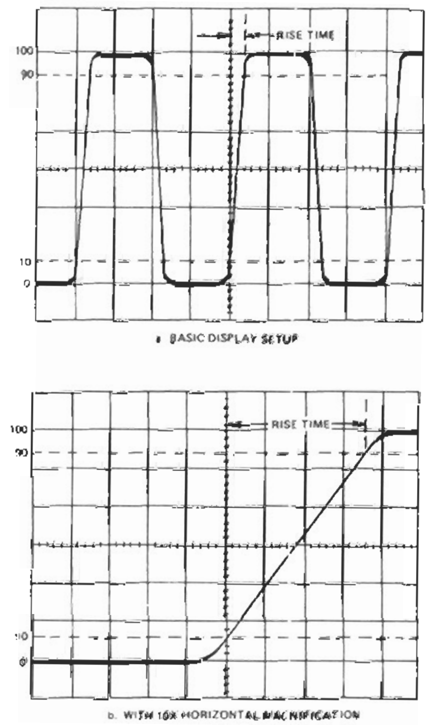


Figure 2-22. Risetime measurement

2-4-8 −3dB Bandwidth Measurement

Bandwidth measurement usually involves finding the −3 dB response point in the frequency-response curve or a circuit or device. This can easily be determined without the need for calculations or dB conversions by using the following "trick":

1. Connect the output of a constant-amplitude signal generator (of appropriate frequency range) to the input of the device under test (DUT). Connect the output of the DUT to the CH 1 IN connector (9).
2. Set the generator to a frequency **well within** the passband of the DUT, then adjust the generator output level to produce the desired DUT output level.
3. Set the CH 1 VOLTS/DIV control (11) to the **highest setting** that produces **over 7 divisions** trace height.
4. Use the CH 1 VARIABLE VOLTS/DIV control (12) and CH 1 Vertical Position control (14) to make the trace

height **exactly** 7 divisions, and touching the second highest and bottom-most graticule lines.

5. Increase the generator frequency until the trace height decreases to exactly 5 divisions. This is the upper −3 dB response point. The frequency can be determined from the signal-generator dial, or with a frequency counter connected to the CH 1 OUTPUT connector (18).
6. Restore the generator to its Step 2 frequency, then decrease the generator frequency until the trace height decreases to exactly 5 divisions. This is the lower −3 dB response point.

2-4-9 HF Current Measurement

The normal method for measuring current with an oscilloscope is to pass the current through a resistor, and measure the voltage drop across the resistor. This technique is applicable to both AC and DC currents. However, an additional technique is possible with high-frequency AC. Instead of inserting a resistor, a wire or component lead carrying the AC current, is passed through a current transformer. This has the advantage of measuring the AC signal component without upsetting the DC circuit conditions.

High-performance current transformers are commercially available. For non-critical applications you can build your own. Construction details are given in Figure 2-23a for a unit that provides a 1V/1A current-conversion ratio into a 50-ohm termination over a 3 kHz to 30 MHz frequency range. This device is flat within ±0.2 dB from 19 kHz - 7 MHz, so will provide fairly good accuracy at the TV line frequency.

To use the transformer, connect the coax to the CH 1 or X IN connector (9) via a 50-ohm feed-thru termination. Unsolder one end of the wire or component lead carrying the current you wish to measure, and pass it through the insulating sleeve in the current transformer. Then resolder the lead and energize the circuit.

2-4-10 Percentage Modulation Measurements

The wide vertical-amplifier bandwidth of the LBO-325 allows amplitude modulation measurements on RF carriers as high as 60 MHz. Either the trapezoidal (Figure 2-24a) or envelope (Figure 2-24b) display technique can be used; the following procedure gives a setup that allows either to be selected at the flick of a switch. To measure the percentage amplitude modulation of a signal generator or transmitter, proceed as follows:

1. Connect a sample of the modulated signal to the CH 2 or Y IN connector (10). Connect a sample of the audio modulating signal to the CH 1 or X IN connector (9).
2. Press the ALT or CHOP V MODE pushbutton (16), the CH 1 SOURCE pushbutton (28), and the AC COUPLING pushbutton (30).
3. Adjust the VOLTS/DIV switches (11) for trace heights of 3 to 4 screen divisions, and center the channel 2 trace with the CH 2 or Y Position control (15).
4. Set the A TIME/DIV switch (20) to a setting that will display about 2 cycles of the modulating signal. For the 400 Hz sine wave commonly used in signal generators and for transmitter testing, the suggested timebase setting is

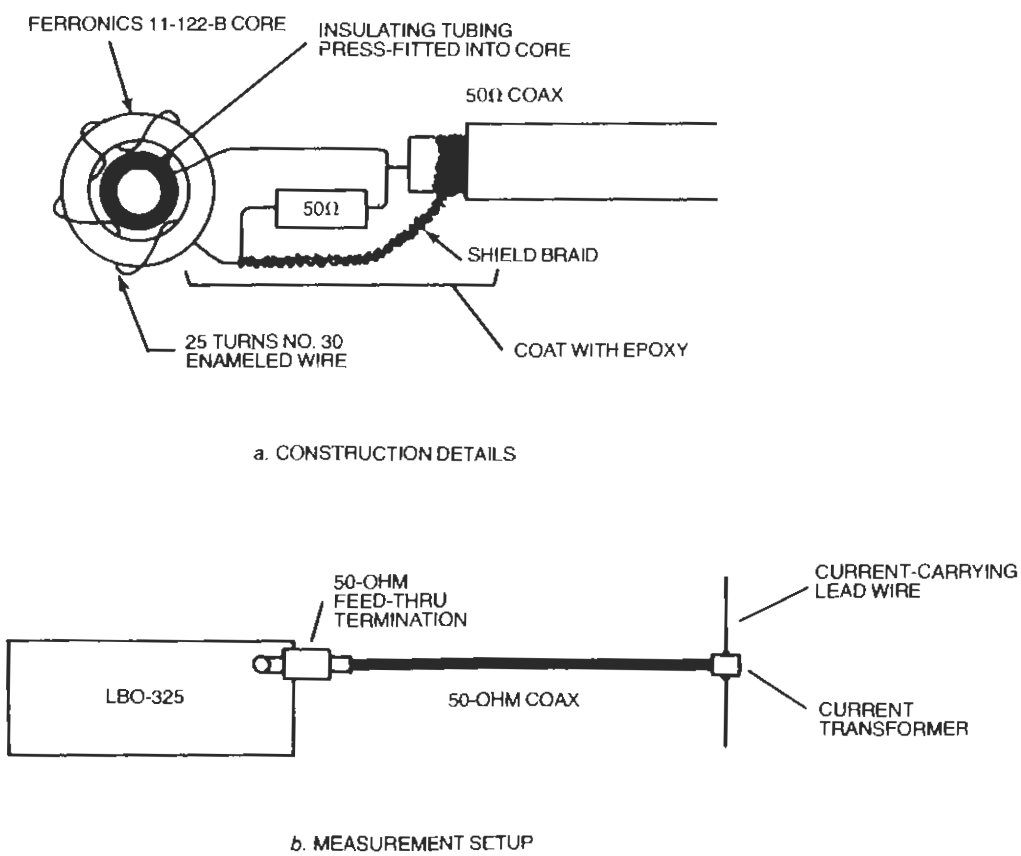


Figure 2-23. HF current transformer

.5 mS/div. Adjust the LEVEL control (31) if necessary for a stable display.

5. The scope now shows the envelope display and the modulating (audio) signal. To display the trapezoidal pattern, rotate the A TIME/DIV switch fully CCW to its X-Y position.
6. The percentage modulation is calculated by measuring the A and B dimensions (see Figures 2-24a and 2-24b) of the displayed waveforms against the Y-axis, and using the measured values in the following formula:

$$\text{Percent modulation} = \frac{A - B}{A + B} \times 100$$

7. Overmodulation (modulation exceeding 100%) cannot be readily calculated, but is easily noticed. (See Figure 2-24c.)

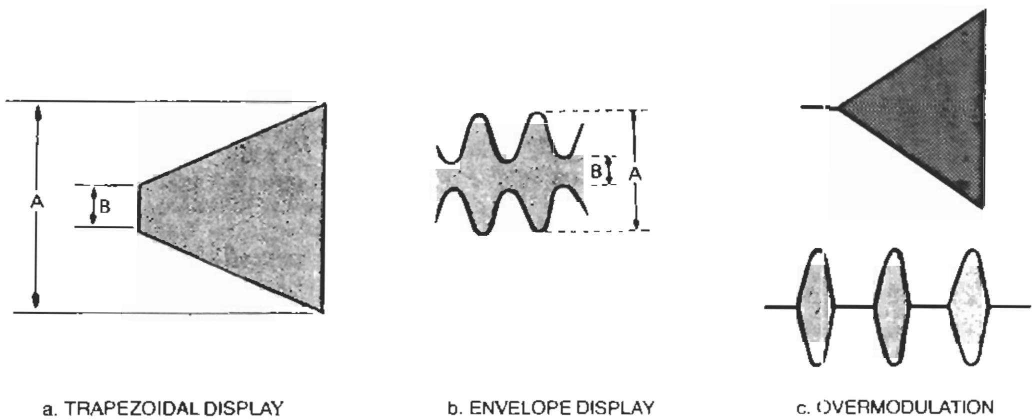


Figure 2-24. Amplitude modulation displays

3. PARTS LIST

T-3553 POWER SUPPLY

Symbol No.	Description			
	RESISTORS			
R1	Carbon	27KΩ	5%	1/6W
R2	Metal Glaze	33KΩ	5%	1W
R3	Carbon	6.8Ω	5%	1/6W
R4	Metal Glaze Chip	10KΩ	5%	1/16W
R5	Metal Glaze Chip	9.1KΩ	1%	1/8W
R6	Metal Glaze	100KΩ	1%	1/6W
R7	Metal Glaze Chip	330KΩ	5%	1/16W
R8	Metal Glaze Chip	8.2KΩ	1%	1/8W
R9	Metal Glaze Chip	82KΩ	5%	1/16W
R10	Metal Glaze Chip	82KΩ	5%	1/16W
R11	Metal Glaze Chip	22KΩ	5%	1/16W
R12	Carbon	1Ω	5%	1/2W
R13	Metal Glaze Chip	220Ω	5%	1/16W
R14	Metal Glaze Chip	220Ω	5%	1/16W
R15	Metal Glaze Chip	560Ω	5%	1/16W
R16	Metal Glaze Chip	560Ω	5%	1/16W
R17	Carbon	1Ω	5%	1/2W
R18	Carbon	1Ω	5%	1/2W
R19	Metal Glaze Chip	11KΩ	1%	1/8W
R20	Metal Glaze Chip	2.7KΩ	1%	1/8W
R21	Metal Glaze Chip	8.2KΩ	1%	1/8W
R22	Metal Glaze Chip	8.2KΩ	1%	1/8W
R23	Metal Glaze	2.2KΩ	5%	1W
R24	Carbon	6.8Ω	5%	1/6W
R25	Metal Glaze Chip	10KΩ	5%	1/16W
R26	Metal Glaze Chip	9.1KΩ	1%	1/8W
R27	Metal Glaze Chip	330KΩ	5%	1/16W
R28	Metal Glaze	36KΩ	1%	1/6W
R29	Metal Glaze Chip	8.2KΩ	1%	1/8W
R30	Carbon	3.3KΩ	5%	1/6W
R31	Metal Glaze Chip	220Ω	5%	1/16W
R32	Metal Glaze Chip	33KΩ	1%	1/8W
R33	Metal Glaze Chip	3.9KΩ	1%	1/8W
R34	Not Used			
R35	Not Used			
R36	Not Used			
R37	Not Used			
R38	Not Used			
R39	Not Used			
R40	Not Used			
R41	Metal Glaze	22KΩ	1%	1/2W
R42	Metal Glaze Chip	680Ω	5%	1/16W
R43	Metal Glaze Chip	47Ω	5%	1/16W
R44	Metal Glaze Chip	4.7KΩ	5%	1/16W
R45	Carbon	82KΩ	5%	1/4W
R46	Metal Glaze Chip	910Ω	5%	1/16W
R47	Not Used			
R48	Metal Glaze Chip	180Ω	5%	1/16W
R49	Metal Glaze Chip	47Ω	5%	1/16W
R50	Metal Glaze Chip	22KΩ	5%	1/16W
R51	Metal Glaze Chip	47Ω	5%	1/16W
R52	Metal Glaze Chip	680Ω	5%	1/16W
R53	Carbon	680Ω	5%	1/6W
	VARIABLE RESISTORS			
VR1	Carbon Film	1KΩ	20%	1/3W
	CAPACITORS			
C1	Electrolytic	47μF		250V
C2	Ceramic Chip	0.01μF		50V
C3	Ceramic Chip	0.001μF		50V
C4	Electrolytic	100μF		200V
C5	Ceramic Chip	0.01μF		50V
C6	Ceramic Chip	0.001μF		50V
C7	Ceramic Chip	0.01μF		50V
C8	Electrolytic	2200μF		35V
C9	Electrolytic	4.7μF		35V
C10	Electrolytic	4.7μF		35V

Symbol No.	Description		
C11	Electrolytic	2200μF	25V
C12	Electrolytic	2200μF	25V
C13	Electrolytic	10μF	25V
C14	Electrolytic	10μF	25V
C15	Electrolytic	4.7μF	25V
C16	Electrolytic	4.7μF	25V
C17	Electrolytic	2.2μF	50V
C18	Electrolytic	100μF	16V
C19	Electrolytic	100μF	16V
C20	Not Used		
C21	Electrolytic	2.2μF	250V
C22	Electrolytic	10μF	200V
C23	Electrolytic	100μF	25V
C24	Ceramic	0.01μF	50V
C25	Mica	100pF	50V
(C26 – C41 Not Used)			
C42	Ceramic	0.01μF	500V
C43	Ceramic	0.01μF	500V
C44	Electrolytic	2.2μF	200V
C45	Ceramic Chip	0.01μF	50V
C46	Electrolytic	22μF	16V
C47	Electrolytic	47μF	10V
C48	Ceramic Chip	0.01μF	50V
C49	Electrolytic	22μF	16V
	TRANSISTORS		
Q1	NPN	2 SD 859-Q	
Q2	NPN	2 SC 3138	
Q3	NPN	2 SC 3138	
Q4	PNP	2 SA 1012	
Q5	PNP	2 SA 1162-Y	
Q6	NPN	2 SC 2562-Y	
Q7	NPN	2 SC 2712-Y	
Q8	NPN	2 SD 859-Q	
Q9	NPN	2 SC 3138	
Q10	NPN	2 SC 3138	
Q11	PNP	2 SA 1012	
Q12	PNP	2 SA 1162-Y	
(Q13 – Q20 Not Used)			
Q21	PNP	2 SA 1245	
Q22	PNP	2 SA 1209-S	
Q23	NPN	2 SC 2911-S	
Q24	NPN	2 SC 3120	
	DIODES		
D1	Detector	1 GZ 61	
D2	Detector	1 GZ 61	
D3	Detector	1 GZ 61	
D4	Detector	1 GZ 61	
D5	Detector	MA 151K	
D6	Detector	MA 151K	
D7	Bridge Rectifier	2W 02	
D8	Not Used		
D9	Bridge Rectifier	2W 02	
D10	Detector	1 QZ 61	
(Q11 - Q20 Not Used)			
Q21	Detector	MA 151K	
	INTEGRATED CIRCUITS		
IC1	Op. Amp	MC 1458-CP1	
IC2	Regulator	M 5236-L	
IC3	Regulator	HA 7805-P	
IC4	Regulator	M 5230-L	
	FUSE		
F1	Normal	BEQ 500 mA	100V - 120V
	PRINTED CIRCUIT BOARD T-3553A POWER SUPPLY		

Symbol No.	Description			

T-3590A BLANKING

Symbol No.	Description			
	RESISTORS			
R1	Metal Glaze Chip	100KΩ	5%	1/16W
R2	Carbon	22KΩ	5%	1/4W
R3	Metal Glaze Chip	2.2KΩ	5%	1/16W
R4	Metal Glaze Chip	2.2KΩ	5%	1/16W
R5	Metal Glaze Chip	18KΩ	1%	1/8W
R6	Metal Glaze Chip	10KΩ	5%	1/16W
R7	Metal Glaze Chip	1.2KΩ	5%	1/16W
R8	Metal Glaze Chip	10KΩ	5%	1/16W
R9	Metal Glaze Chip	100KΩ	5%	1/16W
R10	Metal Glaze Chip	100KΩ	5%	1/16W
R11	Metal Glaze Chip	100KΩ	5%	1/16W
R12	Metal Glaze Chip	22KΩ	5%	1/16W
R13	Metal Glaze Chip	1KΩ	5%	1/16W
R14	Metal Glaze Chip	1.6KΩ	1%	1/8W
R15	Metal Glaze Chip	47Ω	5%	1/16W
R16	Metal Glaze Chip	1.1KΩ	1%	1/8W
R17	Metal Glaze Chip	47Ω	5%	1/16W
R18	Metal Glaze Chip	2.2KΩ	5%	1/16W
R19	Metal Glaze Chip	2.2KΩ	5%	1/16W
	CAPACITORS			
C1	Ceramic Chip	0.01μF		50V
C2	Ceramic	0.1μF		50V
C3	Ceramic	0.1μF		50V
C4	Ceramic	0.01μF		50V
C5	Ceramic Chip	0.01μF		50V
C6	Ceramic Chip	0.01μF		50V
C7	Tantalum	22μF	20%	16V
	TRANSISTORS			
Q1	PNP	2 SA 1245		
Q2	NPN	2 SC 2712-G		
Q3	NPN	2 SC 3120		
	DIODES			
D1	Detector	MA 151WA		
D2	Detector	MA 151WA		
D3	Detector	MA 151WA		
D4	Detector	1 SS 99		
D5	Detector	1 SS 99		
D6	Detector	1 SS 99		
D7	Detector	MA 151K		
	INTEGRATED CIRCUITS			
IC1	H CMOS	TC 74 HC 04P		
IC2	H CMOS	TC 74 HC 76P		
IC3	H CMOS	TC 74 HC 02P		
	PRINTED CIRCUIT BOARD T-3590A BLANKING			

T-3591A HIGH VOLTAGE

Symbol No.	Description			
	RESISTORS			
R1	Carbon	2.2Ω	5%	1/2W
R2	Metal Glaze Chip	100Ω	5%	1/16W
R3	Not Used			
R4	Carbon	47KΩ	5%	1/2W
R5	Carbon	330KΩ	5%	1/16W
R6	Metal Glaze Chip	56KΩ	5%	1/16W
R7	Carbon	10MΩ	5%	1/2W
R8	Metal Glaze Chip	1.5KΩ	5%	1/16W
R9	Metal Glaze Chip	220KΩ	5%	1/16W
R10	Metal Glaze Chip	1KΩ	5%	1/16W
R11	Metal Glaze Chip	100Ω	5%	1/16W
R12	Carbon	22MΩ	5%	1W
R13	Carbon	1KΩ	5%	1/4W
R14	Metal Glaze Chip	47KΩ	5%	1/16W
R15	Metal Glaze Chip	4.7KΩ	5%	1/16W
R16	Carbon	5.6MΩ	5%	1/2W
R17	Carbon	10MΩ	5%	1W
R18	Metal Glaze Chip	100Ω	5%	1/16W
R19	Metal Glaze Chip	75KΩ	1%	1/8W
R20	Metal Glaze	2.2MΩ	1%	1/4W
R21	Metal Glaze	2.2MΩ	1%	1/8W
R22	Metal Glaze Chip	62KΩ	1%	1/8W
R23	Metal Glaze Chip	22Ω	5%	1/16W
R24	Metal Glaze Chip	3.3KΩ	5%	1/16W
	VARIABLE RESISTORS			
VR1	Carbon Film	50KΩ	20%	1/3W
VR2	Carbon Film	10KΩ	20%	1/3W
VR3	Metal Film	1.5MΩ	25%	1/2W
	CAPACITORS			
C1	Electrolytic	47μF		25V
C2	Ceramic	4700pF	10%	3KV
C3	Ceramic	1000pF		500V
C4	Ceramic	4700pF	10%	3KV
C5	Ceramic	4700pF	10%	3KV
C6	Ceramic	4700pF	10%	3KV
C7	Ceramic	4700pF	10%	3KV
C8	Ceramic	4700pF		500V
C9	Plastic Film	0.12μF		50V
C10	Ceramic Chip	0.01μF		50V
C11	Electrolytic	22μF		25V
C12	Metal Film	0.1μF	10%	63V
C13	Ceramic	470pF	10%	3KV
C14	Ceramic	4700pF	10%	3KV
	TRANSISTORS			
Q1	NPN	2 SD 568-L		
Q2	PNP	2 SA 1162-0.Y		
Q3	NPN	2 SC 2712-0.Y		
Q4	PNP	2 SA 1162-0.Y		
Q5	PNP	2 SA 1081-R		
Q6	PNP	2 SA 1091-R		
	DIODES			
D1	Rectifier	ED-3TV		
D2	Rectifier	ED-3TV		
D3	Detector	1 SS 83		
D4	Detector	1 SS 83		
D5	Detector	1 SS 83		
D6	Detector	1 SS 83		
D7	Zener	RD 36 EB (36V)		
D8	Detector	MA-151K		
D9	Detector	1S 1588		
D10	Detector	MA-151K		
	TRANSFORMERS			
T1	Power Transformer	J-529		
	TEST TERMINAL			
TP9	LC-2-S (ORANGE)			
	PRINTED CIRCUIT BOARD T-3591A HIGH VOLTAGE			

T-3554 VERTICAL INPUT AMPLIFIERS

Symbol No.	Description			
	RESISTORS			
R1	Carbon	10Ω	5%	1/6W
R2	Not Used			
R3	Metal Glaze	330KΩ	1%	1/2W
R4	Metal Glaze	1MΩ	0.5%	1/2W
R5	Metal Glaze Chip	5.6KΩ	5%	1/16W
R6	Metal Glaze Chip	5.6KΩ	5%	1/16W
R7	Metal Glaze Chip	100Ω	5%	1/16W
R8	Metal Glaze Chip	100Ω	5%	1/16W
R9	Metal Glaze Chip	47Ω	5%	1/8W
R10	Metal Glaze Chip	2.2KΩ	5%	1/16W
R11	Metal Glaze Chip	220Ω	5%	1/16W
R12	Metal Glaze Chip	5.6KΩ	5%	1/16W
R13	Metal Glaze Chip	680Ω	5%	1/16W

Symbol No.	Description			
R14	Metal Glaze Chip	120Ω	5%	1/16W
R15	Metal Glaze Chip	22KΩ	5%	1/16W
R16	Metal Glaze Chip	2.2KΩ	5%	1/16W
R17	Metal Glaze Chip	2.2KΩ	5%	1/16W
R18	Metal Glaze Chip	1KΩ	5%	1/16W
R19	Metal Glaze Chip	10Ω	5%	1/16W
R20	Metal Glaze Chip	240Ω	5%	1/16W
R21	Metal Glaze Chip	100Ω	5%	1/16W
R22	Metal Glaze Chip	3.3KΩ	1%	1/8W
R23	Metal Glaze Chip	47Ω	5%	1/16W
R24	Metal Glaze Chip	12KΩ	5%	1/16W
R25	Metal Glaze Chip	1KΩ	5%	1/16W
R26	Not Used			
R27	Metal Glaze Chip	47Ω	5%	1/16W
R28	Metal Glaze Chip	68Ω	5%	1/16W
R29	Metal Glaze Chip	68Ω	5%	1/16W
R30	Metal Glaze Chip	47Ω	5%	1/16W
R31	Metal Glaze Chip	330Ω	5%	1/16V
R32	Metal Glaze	1MΩ	0.5%	1/4W
R33	Metal Glaze Chip	6.8KΩ	1%	1/8W
R34	Metal Glaze	3.3KΩ	0.5%	1/6W
R35	Metal Glaze Chip	120KΩ	5%	1/16W
R36	Metal Glaze	510Ω	0.5%	1/6W
R37	Metal Glaze Chip	39Ω	5%	1/16w
R38	Metal Glaze Chip	22Ω	5%	1/16W
R39	Metal Glaze Chip	510Ω	1%	1/8W
R40	Metal Glaze Chip	130Ω	1%	1/8W
R41	Metal Glaze Chip	22Ω	5%	1/16W
R42	Metal Glaze Chip	270Ω	5%	1/8W
R43	Metal Glaze Chip	82Ω	5%	1/16W
R44	Metal Glaze Chip	47KΩ	5%	1/16W
R45	Metal Glaze Chip	56KΩ	5%	1/16W
R46	Metal Glaze Chip	33KΩ	5%	1/16W
R47	Metal Glaze Chip	270Ω	5%	1/16W
R48	Metal Glaze Chip	180Ω	5%	1/16W
R49	Metal Glaze Chip	2.2KΩ	5%	1/16W
R50	Metal Glaze Chip	2.2KΩ	5%	1/16W
R51	Not Used			
R52	Metal Glaze Chip	150Ω	5%	1/16W
R53	Metal Glaze	300Ω	0.5%	1/6W
R54	Metal Glaze Chip	1.8KΩ	5%	1/16W
R55	Not Used			
R56	Metal Glaze	300Ω	0.5%	1/6W
R57	Metal Glaze Chip	47Ω	5%	1/16W
R58	Metal Glaze Chip	270Ω	5%	1/16W
R59	Metal Glaze Chip	330Ω	5%	1/16W
R60	Metal Glaze Chip	10Ω	5%	1/16W
R61	Metal Glaze Chip	47Ω	5%	1/16W
(R62 - R100 Not Used)				
R101	Carbon	10Ω	5%	1/6W
R102	Not Used			
R103	Metal Glaze	330KΩ	1%	1/4W
R104	Metal Glaze	1MΩ	0.5%	1/2W
R105	Metal Glaze Chip	5.6KΩ	5%	1/16W
R106	Metal Glaze Chip	5.6KΩ	5%	1/16W
R107	Metal Glaze Chip	100Ω	5%	1/16W
R108	Metal Glaze Chip	100Ω	5%	1/16W
R109	Metal Glaze Chip	47Ω	5%	1/8W
R110	Metal Glaze Chip	2.2KΩ	5%	1/16W
R111	Metal Glaze Chip	220Ω	5%	1/16W
R112	Metal Glaze Chip	5.6KΩ	5%	1/16W
R113	Metal Glaze Chip	680Ω	5%	1/16W
R114	Metal Glaze Chip	120Ω	5%	1/16W
R115	Metal Glaze Chip	22KΩ	5%	1/16W
R116	Metal Glaze Chip	2.2KΩ	5%	1/16W
R117	Metal Glaze Chip	2.2KΩ	5%	1/16W
R118	Metal Glaze Chip	1KΩ	5%	1/16W
R119	Metal Glaze Chip	10Ω	5%	1/16W
R120	Metal Glaze Chip	240Ω	5%	1/16W
R121	Metal Glaze Chip	100Ω	5%	1/16W
R122	Metal Glaze Chip	3.3KΩ	1%	1/8W
R123	Metal Glaze Chip	47Ω	5%	1/16W
R124	Metal Glaze Chip	12KΩ	5%	1/16W
R125	Metal Glaze Chip	1KΩ	5%	1/16W
R126	Not Used			
R127	Metal Glaze Chip	47Ω	5%	1/16W

Symbol No.	Description			
R128	Metal Glaze Chip	68Ω	5%	1/16W
R129	Metal Glaze Chip	68Ω	5%	1/16W
R130	Metal Glaze Chip	47Ω	5%	1/16W
R131	Metal Glaze Chip	330Ω	5%	1/16W
R132	Metal Glaze	1MΩ	0.5%	1/4W
R133	Metal Glaze Chip	6.8KΩ	1%	1/8W
R134	Metal Glaze	3.3KΩ	0.5%	1/6W
R135	Metal Glaze Chip	120KΩ	5%	1/16W
R136	Metal Glaze	510Ω	0.5%	1/6W
R137	Metal Glaze Chip	39Ω	5%	1/16W
R138	Metal Glaze Chip	22Ω	5%	1/16W
R139	Metal Glaze Chip	510Ω	1%	1/8W
R140	Metal Glaze Chip	30Ω	1%	1/8W
R141	Metal Glaze Chip	22Ω	5%	1/16W
R142	Metal Glaze Chip	270Ω	5%	1/8W
R143	Metal Glaze Chip	82Ω	5%	1/16W
R144	Metal Glaze Chip	47KΩ	5%	1/16W
R145	Metal Glaze Chip	56KΩ	5%	1/16W
R146	Metal Glaze Chip	33KΩ	5%	1/16W
R147	Metal Glaze Chip	270Ω	5%	1/16W
R148	Metal Glaze Chip	80Ω	5%	1/16W
R149	Metal Glaze Chip	2.2KΩ	5%	1/16W
R150	Metal Glaze Chip	2.2KΩ	5%	1/16W
R151	Not Used			
R152	Metal Glaze Chip	50Ω	5%	1/16W
R153	Metal Glaze	300Ω	0.5%	1/6W
R154	Metal Glaze Chip	8KΩ	5%	1/16W
R155	Not Used			
R156	Metal Glaze	300Ω	0.5%	1/6W
R157	Metal Glaze Chip	47Ω	5%	1/16W
R158	Metal Glaze Chip	270Ω	5%	1/16W
R159	Metal Glaze Chip	330Ω	5%	1/16
R160	Metal Glaze Chip	0Ω	5%	1/16W
R161	Metal Glaze Chip	47Ω	5%	1/16W
	VARIABLE RESISTORS			
VR1	Metal Glaze	470Ω	25%	1/5V
VR2	Metal Glaze	00Ω	25%	1/5V
VR3	Metal Glaze	0KΩ	25%	1/5V
VR4				
VR5	Metal Glaze	22KΩ	25%	1/5V
(VR6 - VR100 Not Used)				
VR101	Metal Glaze	470Ω	25%	1/5W
VR102	Metal Glaze	00Ω	25%	1/5W
VR103	Metal Glaze	0KΩ	25%	1/5W
VR104				
VR105	Metal Glaze	22KΩ	25%	1/5W
	CAPACITORS			
C1	Metal Film	0.01µF	10%	630V
C2	Ceramic Chip	00pF	5%	50V
C3	Ceramic Chip	pF	0.25pF	50V
C4	Ceramic Chip	0.01µF		50V
C5	Ceramic Chip	0.01µF		50V
C6	Ceramic Chip	0.01µF		50V
C7	Ceramic Chip	0.01µF		50V
C8	Ceramic Chip	68pF	5%	50V
C9	Electroltyic	220µF		16V
C10	Ceramic Chip	0.01µF		50V
C11	Ceramic Chip	0.01µF		50V
C12	Ceramic Chip	2pF	5%	50V
C13	Ceramic Chip	0.01µF		50V
C14	Ceramic Chip	0.01µF		50V
C15	Not Used			
C16	Ceramic Chip	2pF	0.25pF	50V
C17	Not Used			
C18	Tantalum	22µF	20%	16V
C19	Ceramic Chip	0.01µF		50V
C20	Tantalum	22µF	20%	16V
C21	Ceramic Chip	0.01µF		50V
C22	Electrolytic	220µF		16V
C23	Ceramic Chip	0.01µF		50V
C24	Ceramic Chip	0.01µF		50V
C25	Ceramic Chip	0.01µF		50V
C26	Ceramic Chip	5pF	5%	50V
C27	Ceramic Chip	8pF	5%	50V

Symbol No.	Description			
C28	Not Used			
C29	Ceramic Chip	0.01μF		50V
C30	Ceramic Chip	0.01μF		50V
C31	Ceramic Chip	0.01μF		50V
C32	Ceramic Chip	0.01μF		50V
C33	Ceramic Chip	0.01μF		50V
(C34 – C100 Not Used)				
C101	Metal Film	0.01μF	10%	630V
C102	Ceramic Chip	100pF	5%	50V
C103	Ceramic Chip	1pF	0.25pF	50V
C104	Ceramic Chip	0.01μF		50V
C105	Ceramic Chip	0.01μF		50V
C106	Ceramic Chip	0.01μF		50V
C107	Ceramic Chip	0.01μF		50V
C108	Ceramic Chip	68pF	5%	50V
C109	Electrolytic	220μF		16V
C110	Ceramic Chip	0.01μF		50V
C111	Ceramic Chip	0.01μF		50V
C112	Ceramic Chip	12pF	5%	50V
C113	Ceramic Chip	0.01μF		50V
C114	Ceramic Chip	0.01μF		50V
C115	Not Used			
C116	Ceramic Chip	2pF	0.25pF	50V
C117	Not Used			
C118	Tantalum	22μF	20%	16V
C119	Ceramic Chip	0.01μF		50V
C120	Tantalum	22μF	20%	16V
C121	Ceramic Chip	0.01μF		50V
C122	Electrolytic	22μF		16V
C123	Ceramic Chip	0.01μF		50V
C124	Ceramic Chip	0.01μF		50V
C125	Ceramic Chip	0.01μF		50V
C126	Ceramic Chip	15pF	5%	50V
C127	Ceramic Chip	18pF	5%	50V
C128	Not Used			
C129	Ceramic Chip	0.01μF		50V
C130	Ceramic Chip	0.01μF		50V
C131	Ceramic Chip	0.01μF		50V
C132	Ceramic Chip	0.01μF		50V
C133	Ceramic Chip	0.01μF		50V
	VARIABLE CAPACITORS			
VC1	Ceramic	2P – 12pF		250V
VC2	Ceramic	2P – 12pF		250V
(VC3 – VC101 Not Used)				
VC102	Ceramic	2P – 12pF		250V
	TRANSITORS			
Q1	NPN	2 SC 3120		
Q2	NPN	2 SC 3120		
Q3	Dual FET	μPA 71A-L		
Q4	NPN	2 SC 3098		
Q5	Not Used			
Q6	NPN	2 SC 3098		
Q7	NPN	2 SC 3120		
Q8	PNP	2 SA 1245		
Q9	NPN	2 SC 3120		
Q10	PNP	2 SA 1245		
Q11	NPN	2 SC 3120		
Q12	NPN	2 SC 3120		
Q13	NPN	2 SC 3120		
(Q14 – Q100 Not Used)				
Q101	NPN	2 SC 3120		
Q102	NPN	2 SC 3120		
Q103	Dual FET	μPA 71A-L		
Q104	NPN	2 SC 3098		
Q105	Not Used			
Q106	NPN	2 SC 3098		
Q107	NPN	2 SC 3120		
Q108	PNP	2 SA 1245		
Q109	NPN	2 SC 3120		
Q110	PNP	2 SA 1245		
Q111	NPN	2 SA 3120		
Q112	NPN	2 SA 3120		
Q113	NPN	2 SA 3120		

Symbol No.	Description			
	DIODES			
D1	Detector	MA 157		
D2	Detector	MA 157		
D3	Detector	MA 157		
D4	Detector	MA 151A		
D5	Detector	MA 157		
D6	Detector	MA 157		
D7	Detector	MA 157		
(D8 – D100 Not Used)				
D101	Detector	MA 157		
D102	Detector	MA 157		
D103	Detector	MA 157		
D104	Detector	MA 151A		
D105	Detector	MA 157		
D106	Detector	MA 157		
D107	Detector	MA 157		
	INTEGRATED CIRCUIT			
IC1	OP AMP	TL 071 CP		
IC2	OP AMP	TL 071 CP		
	SWITCHES			
S1	Rotary	SRA[illegible] C4	CH 1 VOLTS/DIV VAR	
VR 4				
S2	Push	Q-54[illegible] SPEB-12	CH 2 INV	
(S3 – S100 Not Used)				
S101	Rotary	SRA[illegible] C4	CH 2 VOLTS/DIV VAR	
	PRINTED CIRCUIT BOARD			
	T-3554A VERTICAL INPUT AMPLIFIERS			
	T-3562A VERTICAL AMPLIFIER SUBSECTION			
	MISCELLANEOUS			
J10	Connector	5533-04 APB		

T-3555
VERTICAL PREAMPLIFIERS

	RESISTORS			
R1	Metal Glaze Chip	100Ω	5%	1/16W
R2	Metal Glaze Chip	2.2KΩ	5%	1/8W
R3	Metal Glaze Chip	2.2KΩ	5%	1/8W
R4	Metal Glaze Chip	100Ω	5%	1/16W
R5	Metal Glaze Chip	2.2KΩ	5%	1/16W
R6	Metal Glaze Chip	0Ω	5%	1/16W
R7	Metal Glaze Chip	180Ω	5%	1/16W
R8	Metal Glaze Chip	560Ω	5%	1/16W
R9	Metal Glaze Chip	2.7KΩ	5%	1/16W
R10	Metal Glaze Chip	47Ω	5%	1/16W
R11	Metal Glaze Chip	4.7KΩ	5%	1/16W
R12	Metal Glaze Chip	560Ω	5%	1/16W
R13	Metal Glaze Chip	390Ω	5%	1/16W
R14	Metal Glaze Chip	47Ω	5%	1/16W
R15	Metal Glaze Chip	560Ω	1%	1/8W
R16	Metal Glaze Chip	390Ω	5%	1/16W
R17	Metal Glaze Chip	47Ω	5%	1/16W
R18	Metal Glaze Chip	1.2KΩ	5%	1/8W
R19	Metal Glaze Chip	1.2KΩ	5%	1/8W
R20	Metal Glaze Chip	10KΩ	5%	1/16W
R21	Metal Glaze Chip	390Ω	5%	1/16W
R22	Factory Adjust			
R23	Metal Glaze Chip	270Ω	5%	1/16W
R24	Metal Glaze Chip	560Ω	5%	1/16W
R25	Metal Glaze Chip	270Ω	5%	1/16W
R26	Metal Glaze Chip	560Ω	5%	1/16W
R27	Metal Glaze Chip	47Ω	5%	1/16W
R28	Metal Glaze Chip	3.3KΩ	5%	1/16W
R29	Metal Glaze Chip	4.7KΩ	5%	1/16W
R30	Metal Glaze Chip	100Ω	5%	1/16W
R31	Metal Glaze Chip	330Ω	5%	1/16W
R32	Metal Glaze Chip	2.7KΩ	5%	1/16W
R33	Metal Glaze Chip	2.7KΩ	5%	1/16W
R34	Metal Glaze Chip	100Ω	5%	1/16W
R35	Metal Glaze Chip	10KΩ	5%	1/16W
R36	Metal Glaze Chip	4.7KΩ	5%	1/16W
R37	Metal Glaze Chip	47Ω	5%	1/16W

Symbol No.	Description			
R38	Metal Glaze Chip	47Ω	5%	1/16W
R39	Metal Glaze Chip	680Ω	5%	1/16W
R40	Metal Glaze Chip	1.5KΩ	5%	1/16W
R41	Metal Glaze Chip	1.5KΩ	5%	1/16W
R42	Metal Glaze Chip	6.8KΩ	5%	1/16W
R43	Metal Glaze Chip	330Ω	5%	1/16W
R44	Metal Glaze Chip	2.7KΩ	5%	1/16W
R45	Metal Glaze Chip	2.2KΩ	5%	1/16W
R46	Metal Glaze Chip	12KΩ	5%	1/16W
R47	Metal Glaze Chip	820Ω	5%	1/8W
R48	Metal Glaze Chip	2.2KΩ	5%	1/16W
R49	Metal Glaze Chip	2.2KΩ	5%	1/16W
R50	Metal Glaze Chip	47Ω	5%	1/16W
R51	Metal Glaze Chip	6.8KΩ	5%	1/16W
R52	Metal Glaze Chip	47Ω	5%	1/16W
R53	Metal Glaze Chip	1.5KΩ	5%	1/16W
R54	Metal Glaze Chip	47Ω	5%	1/16W
R55	Metal Glaze Chip	4.3KΩ	1%	1/8W
R56	Metal Glaze Chip	6.8KΩ	1%	1/8W
R57	Metal Glaze Chip	5.6KΩ	1%	1/8W
R58	Metal Glaze Chip	10KΩ	5%	1/16W
R59	Metal Glaze Chip	47KΩ	5%	1/16W
R60	Metal Glaze Chip	47KΩ	5%	1/16W
R61	Metal Glaze Chip	1KΩ	5%	1/8W
R62	Metal Glaze Chip	1KΩ	5%	1/8W
R63	Metal Glaze Chip	910Ω	5%	1/8W
R64	Metal Glaze Chip	560Ω	5%	1/8W
R65	Metal Glaze Chip	47Ω	5%	1/16W
R66	Carbon	270Ω	5%	1/2W
R67	Metal Glaze Chip	47Ω	5%	1/16W
R68	Metal Glaze Chip	560Ω	5%	1/8W
R69	Metal Glaze	620Ω	1%	1/2W
R70	Metal Glaze Chip	91Ω	1%	1/8W
R71	Factory Adjust			
R72	Metal Glaze Chip	91Ω	1%	1/8W
R73	Metal Glaze	620Ω	1%	1/2W
R74	Metal Glaze Chip	6.8KΩ	5%	1/16W
R75	Metal Glaze Chip	330Ω	5%	1/16W
R76	Metal Glaze Chip	100Ω	5%	1/16W
R77	Metal Glaze Chip	2KΩ	5%	1/8W
R78	Metal Glaze Chip	2KΩ	5%	1/8W
R79	Metal Glaze Chip	100Ω	5%	1/16W
R80	Metal Glaze Chip	2.2KΩ	5%	1/16W
R81	Metal Glaze Chip	82Ω	5%	1/16W
R82	Metal Glaze Chip	180Ω	5%	1/16W
R83	Metal Glaze Chip	560Ω	5%	1/16W
R84	Metal Glaze Chip	560Ω	5%	1/16W
R85	Metal Glaze Chip	47Ω	5%	1/16W
R86	Metal Glaze Chip	47Ω	5%	1/16W
R87	Metal Glaze Chip	3.3KΩ	5%	1/16W
R88	Metal Glaze Chip	3.3KΩ	5%	1/16W
R89	Metal Glaze Chip	390Ω	5%	1/16W
R90	Metal Glaze Chip	560Ω	1%	1/8W
R91	Metal Glaze Chip	390Ω	5%	1/16W
R92	Metal Glaze Chip	47Ω	5%	1/16W
R93	Metal Glaze Chip	2.7KΩ	5%	1/16W
R94	Metal Glaze Chip	2.7KΩ	5%	1/16W
R95	Metal Glaze Chip	4.7KΩ	5%	1/16W
R96	Metal Glaze Chip	4.7KΩ	5%	1/16W
R97	Metal Glaze Chip	1.2KΩ	5%	1/16W
R98	Metal Glaze Chip	1.2KΩ	5%	1/16W
R99	Factory Adjust			
R100	Metal Glaze Chip	10KΩ	5%	1/16W
R101	Metal Glaze Chip	390Ω	5%	1/16W
R102	Metal Glaze Chip	270Ω	5%	1/16W
R103	Metal Glaze Chip	270Ω	5%	1/16W
R104	Metal Glaze Chip	560Ω	5%	1/16W
R105	Metal Glaze Chip	6.8KΩ	5%	1/16W
R106	Metal Glaze Chip	560Ω	5%	1/16W
R107	Metal Glaze Chip	3.3KΩ	5%	1/16W
R108	Metal Glaze Chip	47Ω	5%	1/16W
R109	Metal Glaze Chip	4.7KΩ	5%	1/16W
R110	Metal Glaze Chip	100Ω	5%	1/16W
R111	Metal Glaze Chip	330Ω	5%	1/16W
R112	Metal Glaze Chip	100Ω	5%	1/16W
R113	Metal Glaze Chip	2.7KΩ	5%	1/16W
R114	Metal Glaze Chip	2.7KΩ	5%	1/16W

Symbol No.	Description			
R115	Metal Glaze Chip	10KΩ	5%	1/16W
R116	Metal Glaze Chip	4.7KΩ	5%	1/16W
R117	Metal Glaze Chip	27KΩ	5%	1/16W
R118	Metal Glaze Chip	10KΩ	5%	1/16W
R119	Carbon	10KΩ	5%	1/6W
R120	Carbon	10KΩ	5%	1/6W
R121	Metal Glaze Chip	33Ω	5%	1/16W
R122	Metal Glaze Chip	33Ω	5%	1/16W
R123	Not Used			
R124	Metal Glaze Chip	910Ω	5%	1/8W
R125	Metal Glaze Chip	47V	5%	1/16W
R126	Metal Glaze Chip	330Ω	5%	1/16W
R127	Metal Glaze Chip	5.6KΩ	5%	1/16W
R128	Metal Glaze Chip	5.6KΩ	5%	1/16W
R129	Metal Glaze Chip	10KΩ	5%	1/16W
R130	Metal Glaze Chip	33Ω	5%	1/16W
R131	Carbon	33Ω	5%	1/6W
R132	Carbon	470KΩ	5%	1/6W
(R133 – R150 Not Used)				
R151	Metal Glaze Chip	47Ω	5%	1/16W
R152	Metal Glaze Chip	47Ω	5%	1/16W
R153	Metal Glaze Chip	750Ω	5%	1/8W
R154	Metal Glaze Chip	750Ω	5%	1/8W
R155	Metal Glaze Chip	100Ω	5%	1/16W
R156	Metal Glaze Chip	820Ω	5%	1/16W
R157	Metal Glaze Chip	820Ω	5%	1/16W
R158	Metal Glaze Chip	680Ω	5%	1/8W
R159	Metal Glaze Chip	680Ω	5%	1/8W
R160	Metal Glaze Chip	47Ω	5%	1/16W
R161	Metal Glaze Chip	470Ω	5%	1/16W
R162	Metal Glaze Chip	2.7KΩ	5%	1/16W
R163	Metal Glaze Chip	5.6KΩ	5%	1/16W
R164	Metal Glaze Chip	820Ω	5%	1/16W
R165	Metal Glaze Chip	0Ω	5%	1/16W
R166	Metal Glaze Chip	220Ω	5%	1/8W
R167	Metal Glaze Chip	2.2KΩ	5%	1/16W
R168	Metal Glaze Chip	68Ω	5%	1/16W
R169	Metal Glaze Chip	1.5KΩ	5%	1/8W
R170	Metal Glaze Chip	1.8KΩ	5%	1/16W
R171	Metal Glaze Chip	220Ω	5%	1/8W
R172	Metal Glaze Chip	1KΩ	5%	1/8W
R173	Metal Glaze Chip	47Ω	5%	1/16W
R174	Metal Glaze Chip	47Ω	5%	1/16W
R175	Metal Glaze Chip	47Ω	5%	1/16W
R176	Metal Glaze Chip	750Ω	5%	1/8W
R177	Metal Glaze Chip	750Ω	5%	1/8W
R178	Metal Glaze Chip	100Ω	5%	1/16W
R179	Metal Glaze Chip	330Ω	5%	1/16W
R180	Metal Glaze Chip	820Ω	5%	1/16W
R181	Metal Glaze Chip	820Ω	5%	1/16W
R182	Metal Glaze Chip	680Ω	5%	1/8W
R183	Metal Glaze Chip	680Ω	5%	1/8W
R184	Metal Glaze Chip	47Ω	5%	1/16W
R185	Metal Glaze Chip	470Ω	5%	1/16W
R186	Metal Glaze Chip	2.7KΩ	5%	1/16W
R187	Metal Glaze Chip	5.6KΩ	5%	1/16W
R188	Metal Glaze Chip	2.2KΩ	5%	1/16W
R189	Metal Glaze Chip	1KΩ	5%	1/8W
R190	Metal Glaze Chip	220Ω	5%	1/8W
R191	Metal Glaze Chip	68Ω	5%	1/16W
R192	Metal Glaze Chip	270Ω	5%	1/16W
R193	Metal Glaze Chip	56Ω	5%	1/16W
R194	Metal Glaze Chip	56Ω	5%	1/16W
R195	Metal Glaze Chip	1.5KΩ	5%	1/8W
R196	Metal Glaze Chip	56Ω	5%	1/16W
	VARIABLE RESISTORS			
VR1	Carbon	500Ω	20%	1/3W
VR2	Carbon	2KΩ	20%	1/3W
VR3	Carbon	300Ω	20%	1/3W
VR4	Carbon	500Ω	20%	1/3W
VR5	Carbon	2KΩ	20%	1/3W
VR6	Carbon	500Ω	20%	1/3W
(VR7 – VR20 Not Used)				
VR21	Carbon	200Ω	20%	1/3W
VR22	Carbon	1KΩ	20%	1/3W

Symbol No.	Description		
	CAPACITORS		
C1	Electrolytic	22μF	25V
C2	Ceramic Chip	0.01μF	50V
C3	Ceramic Chip	0.01μF	50V
C4	Ceramic Chip	5pF 0.5pF	50V
C5	Ceramic Chip	0.01μF	50V
C6	Ceramic Chip	0.01μF	50V
C7	Ceramic Chip	0.01μF	50V
C8	Ceramic Chip	0.01μF	50V
C9	Electrolytic	22μF	25V
C10	Ceramic Chip	0.01μF	50V
C11	Ceramic Chip	0.01μF	50V
C12	Ceramic Chip	0.01μF	50V
C13	Ceramic Chip	Factory Adjust	50V
C14	Ceramic Chip	0.01μF	50V
C15	Electrolytic	22μF	25V
C16	Ceramic Chip	0.01μF	50V
C17	Ceramic Chip	0.01μF	50V
C18	Electrolytic	22μF	25V
C19	Ceramic Chip	0.01μF	50V
C20	Ceramic Chip	0.01μF	50V
C21	Ceramic Chip	0.01μF	50V
C22	Ceramic Chip	0.01μF	50V
C23	Ceramic Chip	Factory Adjust	50V
C24	Electrolytic	22μF	25V
C25	Ceramic Chip	Factory Adjust	50V
C26	Ceramic Chip	Factory Adjust	50V
C27	Ceramic Chip	0.01μF	50V
C28	Electrolytic	22μF	25V
C29	Ceramic Chip	0.01μF	50V
C30	Ceramic Chip	0.01μF	50V
C31	Ceramic Chip	5pF 0.5pF	50V
C32	Ceramic Chip	0.01μF	50V
C33	Ceramic Chip	0.01μF	50V
C34	Ceramic Chip	0.01μF	50V
C35	Ceramic Chip	0.01μF	50V
C36	Ceramic Chip	0.01μF	50V
C37	Ceramic Chip	0.01μF	50V
C38	Ceramic Chip	0.01μF	50V
C39	Electrolytic	22μF	25V
C40	Ceramic Chip	Factory Adjust	50V
C41	Ceramic Chip	0.01μF	50V
C42	Ceramic Chip	0.01μF	50V
C43	Ceramic Chip	0.01μF	50V
C44	Electrolytic	22μF	25V
C45	Ceramic Chip	0.01μF	50V
C46	Electrolytic	22μF	25V
C47	Ceramic Chip	0.01μF	50V
C48	Electrolytic	22μF	25V
C49	Ceramic Chip	0.01μF	50V
C50	Ceramic Chip	0.1μF	50V
C51	Ceramic Chip	0.1μF	50V
C52	Ceramic Chip	33pF 5%	50V
C53	Ceramic Chip	33pF 5%	50V
C54	Ceramic	0.1μF	50V
C55	Ceramic	0.1μF	50V
C56	Electrolytic	22μF	25V
C57	Ceramic Chip	0.01μF	50V
C58	Electrolytic	22μF	25V
C59	Ceramic Chip	0.01μF	50V
C60	Electrolytic	22μF	25V
C61	Ceramic Chip	0.01μF	50V
C62	Electrolytic	47μF	10V
C63	Ceramic Chip	0.01μF	50V
C64	Electrolytic	22μF	25V
C65	Not Used		
C66	Ceramic Chip	22pF 5%	50V
C67	Ceramic Chip	22pF 5%	50V
C68	Ceramic	0.1μF	50V
C69	Ceramic	0.1μF	50V
(C70 – C90 Not Used)			
C91	Ceramic Chip	0.01μF	50V
C92	Ceramic Chip	10pF 0.5pF	50V
C93	Ceramic Chip	0.01μF	50V
C94	Ceramic Chip	0.01μF	50V
C95	Ceramic Chip	0.01μF	50V
C96	Ceramic Chip	0.01μF	50V

Symbol No.	Description		
C97	Ceramic Chip	Factory Adjust	50V
C98	Electrolytic	22μF	25V
C99	Ceramic Chip	0.01μF	50V
C100	Ceramic Chip	Factory Adjust	50V
C101	Ceramic Chip	0.01μF	50V
C102	Ceramic Chip	10pF 0.5pF	50V
C103	Ceramic Chip	0.01μF	50V
C104	Not Used		
C105	Ceramic Chip	0.01μF	50V
C106	Ceramic Chip	0.01μF	50V
C107	Electrolytic	22μF	25V
C108	Ceramic Chip	0.01μF	50V
C109	Ceramic Chip	Factory Adjust	50V
C110	Mica	22pF	500V
C111	Mica	22pF	500V
	VARIABLE CAPACITORS		
VC1	Ceramic	2 - 12pF	250V
VC2	Ceramic	2 - 12pF	250V
VC3	Ceramic	2.5 - 20.5pF	250V
VC4	Ceramic	2 - 12pF	250V
	TRANSISTORS		
Q1	NPN	2 SC 3120	
Q2	NPN	2 SC 3120	
Q3	NPN	2 SC 3120	
Q4	NPN	2 SC 3120	
Q5	PNP	2 SA 1226-3.4	
Q6	PNP	2 SA 1226-3.4	
Q7	PNP	2 SA 1226-3.4	
Q8	PNP	2 SA 1226-3.4	
Q9	NPN	2 SC 2712-0.Y	
Q10	NPN	2 SC 2712-0.Y	
Q11	NPN	2 SC 1621-3.4	
Q12	NPN	2 SC 2712-0.Y	
Q13	NPN	2 SC 2712-0.Y	
Q14	NPN	2 SC 2712-0.Y	
Q15	NPN	2 SC 2712-0.Y	
Q16	PNP	2 SA 1226-3.4	
Q17	PNP	2 SA 1226-3.4	
Q18	NPN	2 SC 2712-0.Y	
Q19	PNP	2 SA 1162-Y.0	
Q20	NPN	2 SC 1907	
Q21	NPN	2 SC 1907	
Q22	NPN	2 SC 1621-3.4	
Q23	NPN	2 SC 3120	
Q24	NPN	2 SC 3120	
Q25	NPN	2 SC 3120	
Q26	NPN	2 SC 3120	
Q27	NPN	2 SC 3120	
Q28	NPN	2 SC 3120	
Q29	PNP	2 SA 1226-3.4	
Q30	PNP	2 SA 1226-3.4	
Q31	PNP	2 SA 1226-3.4	
Q32	PNP	2 SA 1226-3.4	
Q33	NPN	2 SC 2712-0.Y	
Q34	NPN	2 SC 2712-0.Y	
(Q35 – Q60 Not Used)			
Q61	PNP	2 SA 1226-3.4	
Q62	PNP	2 SA 1226-3.4	
Q63	NPN	2 SC 3120	
Q64	NPN	2 SC 3120	
Q65	NPN	2 SC 3120	
Q66	NPN	2 SC 3120	
Q67	PNP	2 SA 1226-3.4	
Q68	PNP	2 SA 1226-3.4	
Q69	NPN	2 SC 3120	
Q70	NPN	2 SC 3120	
Q71	NPN	2 SC 3120	
	DIODES		
D1	Detector	MA 151 WA	
D2	Detector	MA 151 WA	
D3	Detector	MA 151 WA	
D4	Detector	MA 151 WA	
D5	Detector	MA 151 A	
D6	Detector	MA 151 WA	

Symbol No.	Description			
(D7 – D20 Not Used)				
D21	Detector	MA 151 A		
D22	Not Used			
D23	Detector	MA 151 A		
D24	Detector	MA 151 A		
	INTEGRATED CIRCUIT			
IC1	C. MOS	74 HC 08		
IC2	C. MOS	74 HC 02		
IC3	C. MOS	74 HC 109		
IC4	C. MOS	74 HC 123		
IC5	TTL	74 LS 123		
	PRINTED CIRCUIT BOARD T-3555A VERTICAL PREAMPLIFIERS			

T-3556
VERTICAL FINAL AMPLIFER

Symbol No.	Description			
	RESISTORS			
R1	Metal Glaze	91Ω	1%	1/6W
R2	Metal Glaze	91Ω	1%	1/6W
R3	Carbon	100Ω	5%	1/6W
R4	Carbon	100Ω	5%	1/6W
R5	Metal Glaze	2KΩ	1%	1/6W
R6	Metal Glaze	2KΩ	1%	1/6W
R7	Carbon	150Ω	5%	1/6W
R8	Carbon	0Ω	5%	1/6W
R9	Carbon	Factory Adjust	5%	1/6W
R10	Carbon	390Ω	5%	1/6W
R11	Metal Glaze	430Ω	1%	1/6W
R12	Carbon	390Ω	5%	1/6W
R13	Carbon	100Ω	5%	1/6W
R14	Carbon	100Ω	5%	1/6W
R15	Metal Glaze	130Ω	1%	1/4W
R16	Metal Glaze	130Ω	1%	1/4W
R17	Metal Glaze	220Ω	1%	1/6W
R18	Carbon	220Ω	5%	1/6W
R19	Carbon	27Ω	5%	1/6W
R20	Carbon	Factory Adjust	5%	1/6W
R21	Carbon	Factory Adjust	5%	1/6W
R22	Carbon	27Ω	5%	1/6W
R23	Carbon	47Ω	5%	1/6W
R24	Carbon	47Ω	5%	1/6W
R25	Metal Glaze	680Ω	5%	1W
R26	Metal Glaze	680Ω	5%	1W
JP1	Carbon	0Ω	5%	1/6W
JP2	Carbon	0Ω	5%	1/6W
JP3	Carbon	0Ω	5%	1/4W
	VARIABLE RESISTORS			
VR1	Carbon	Factory Adjust	20%	1/3W
VR2	Carbon	200Ω	20%	1/3W
	CAPACITORS			
C1	Mica	Factory Adjust		500V
C2	Mica	Factory Adjust		500V
C3	Ceramic	0.01μF		50V
C4	Mica	Factory Adjust		500V
C5	Mica	47pF		500V
C6	Ceramic	0.01μF		50V
C7	Ceramic	0.01μF		50V
C8	Ceramic	0.01μF		50V
C9	Ceramic	0.001μF		500V
C10	Electrolytic	22μF		25V
C11	Electrolytic	22μF		25V
C12	Ceramic	0.01μF		50V
C13	Electrolytic	2.2μF		200V
	VARIABLE CAPACITORS			
VC1	Ceramic	4pF – 400pF		250V
VC2	Ceramic	4pF – 400pF		250V
VC3	Ceramic	4pF – 400pF		250V
	TRANSISTORS			
Q1	NPN	2 SC 2671		
Q2	NPN	2 SC 2671		

Symbol No.	Description			
Q3	NPN	2 SC 2671		
Q4	NPN	2 SC 2671		
Q5	NPN	2 SC 3600-D.E.F.		
Q6	NPN	2 SC 3600-D.E.F.		
	PRINTED CIRCUIT BOARD T-3556A VERTICAL FINAL AMPLIFIER			

T-3557
VERTICAL MODE

Symbol No.	Description			
	VARIABLE RESISTORS			
VR1	Carbon	20KΩ	20%	1/20W
VR2	Carbon	20KΩ	20%	1/20W
	CAPACITORS			
C1	Ceramic	0.01μF		50V
C2	Ceramic	0.01μF		50V
	SWITCHES			
S1	Push	Q-537 SUJ-40		
	PRINTED CIRCUIT BOARD T-3557 VERTICAL MODE			

T-3559
TRIGGER SOURCE AMPLIFIER

Symbol No.	Description			
	RESISTORS			
R1	Metal Glaze Chip	75Ω	5%	1/16W
R2	Metal Glaze Chip	47Ω	5%	1/16W
R3	Metal Glaze Chip	2.4KΩ	5%	1/8W
R4	Metal Glaze Chip	200Ω	5%	1/16W
R5	Metal Glaze Chip	2.4KΩ	5%	1/8W
R6	Metal Glaze Chip	47Ω	5%	1/16W
R7	Metal Glaze Chip	120Ω	5%	1/16W
R8	Metal Glaze Chip	630Ω	5%	1/16W
R9	Metal Glaze Chip	Factory Adjust	5%	1/16W
R10	Metal Glaze Chip	Factory Adjust	5%	1/16W
R11	Metal Glaze Chip	630Ω	5%	1/16W
R12	Metal Glaze Chip	130Ω	5%	1/16W
R13	Metal Glaze Chip	510Ω	1%	1/8W
R14	Metal Glaze Chip	1.5KΩ	5%	1/16W
R15	Metal Glaze Chip	47Ω	5%	1/16W
R16	Metal Glaze Chip	47Ω	5%	1/16W
R17	Metal Glaze Chip	6.2KΩ	5%	1/16W
R18	Metal Glaze Chip	47Ω	5%	1/16W
R19	Metal Glaze Chip	2.7KΩ	5%	1/16W
R20	Metal Glaze Chip	5.6KΩ	5%	1/16W
R21	Metal Glaze Chip	330Ω	5%	1/16W
R22	Metal Glaze Chip	100Ω	5%	1/16W
R23	Metal Glaze Chip	2.7KΩ	5%	1/16W
R24	Metal Glaze Chip	10KΩ	5%	1/16W
R25	Metal Glaze Chip	6.2KΩ	5%	1/16W
R26	Metal Glaze Chip	100Ω	5%	1/16W
R27	Metal Glaze Chip	4.7KΩ	5%	1/16W
R28	Metal Glaze Chip	1.8KΩ	5%	1/16W
R29	Metal Glaze Chip	3.3KΩ	5%	1/8W
R30	Metal Glaze Chip	220Ω	5%	1/16W
R31	Metal Glaze Chip	75Ω	5%	1/16W
R32	Metal Glaze Chip	47Ω	5%	1/16W
R33	Metal Glaze Chip	2.4Ω	5%	1/8W
R34	Metal Glaze Chip	200Ω	5%	1/16W
R35	Metal Glaze Chip	2.4KΩ	5%	1/8W
R36	Metal Glaze Chip	47Ω	5%	1/16W
R37	Metal Glaze Chip	Factory Adjust	5%	1/16W
R38	Metal Glaze Chip	Factory Adjust	5%	1/16W
R39	Metal Glaze Chip	120Ω	5%	1/16W
R40	Metal Glaze Chip	680Ω	5%	1/16W
R41	Metal Glaze Chip	680Ω	5%	1/16W
R42	Metal Glaze Chip	180Ω	5%	1/16W
R43	Metal Glaze Chip	1.5KΩ	5%	1/16W
R44	Metal Glaze Chip	47Ω	5%	1/16W
R45	Metal Glaze Chip	6.2KΩ	5%	1/16W
R46	Metal Glaze Chip	10KΩ	5%	1/16W
R47	Metal Glaze Chip	6.8KΩ	5%	1/16W

Symbol No.	Description			
R48	Metal Glaze Chip	10KΩ	5%	1/16W
R49	Metal Glaze Chip	6.8KΩ	5%	1/16W
R50	Metal Glaze Chip	100Ω	5%	1/16W
R51	Carbon	1MΩ	5%	1/2W
R52	Carbon	330KΩ	5%	1/2W
R53	Metal Glaze Chip	5.6KΩ	5%	1/16W
R54	Metal Glaze Chip	2.2KΩ	5%	1/16W
R55	Metal Glaze Chip	1KΩ	5%	1/16W
R56	Metal Glaze Chip	240Ω	5%	1/16W
R57	Metal Glaze Chip	47Ω	5%	1/16W
R58	Metal Glaze Chip	5.6KΩ	5%	1/16W
R59	Metal Glaze Chip	4.7KΩ	5%	1/16W
R60	Metal Glaze Chip	390Ω	5%	1/16W
R61	Metal Glaze Chip	47Ω	5%	1/16W
R62	Metal Glaze Chip	2.4KΩ	5%	1/8W
R63	Metal Glaze Chip	Factory Adjust	5%	1/16W
R64	Metal Glaze Chip	270Ω	5%	1/16W
R65	Metal Glaze Chip	820Ω	5%	1/16W
R66	Metal Glaze Chip	180Ω	5%	1/16W
R67	Metal Glaze Chip	1.5KΩ	5%	1/16W
R68	Metal Glaze Chip	47Ω	5%	1/16W
R69	Metal Glaze Chip	6.2KΩ	5%	1/16W
R70	Metal Glaze Chip	10KΩ	5%	1/16W
R71	Metal Glaze Chip	6.8KΩ	5%	1/16W
R72	Metal Glaze Chip	3.9KΩ	5%	1/16W
R73	Metal Glaze Chip	10KΩ	5%	1/16W
R74	Metal Glaze Chip	6.8KΩ	5%	1/16W
R75	Metal Glaze Chip	3.9KΩ	5%	1/16W
R76	Metal Glaze Chip	100KΩ	5%	1/16W
R77	Metal Glaze Chip	100KΩ	5%	1/16W
R78	Metal Glaze Chip	100KΩ	5%	1/16W
R79	Metal Glaze Chip	180Ω	5%	1/16W
R80	Carbon	6.8Ω	5%	1/6W
	VARIABLE RESISTORS			
VR1	Carbon	100Ω	20%	1/3W
VR2	Carbon	100Ω	20%	1/3W
VR3	Carbon	100Ω	20%	1/3W
	CAPACITORS			
C1	Ceramic Chip	0.01μF		50V
C2	Ceramic Chip	0.01μF		50V
C3	Ceramic Chip	Factory Adjust	5%	50V
C4	Ceramic Chip	Factory Adjust	5%	50V
C5	Ceramic Chip	0.01μF		50V
C6	Electrolytic	22μF		16V
C7	Plastic	0.012μF		50V
C8	Ceramic Chip	0.01μF		50V
C9	Ceramic Chip	0.01μF		50V
C10	Ceramic Chip	82pF		50V
C11	Ceramic Chip	0.01μF		50V
C12	Ceramic Chip	0.01μF		50V
C13	Ceramic Chip	Factory Adjust		10V
C14	Ceramic Chip	Factory Adjust		10V
C15	Ceramic Chip	0.01μF		10V
C16	Ceramic Chip	0.01μF		10V
C17	Electrolytic	22μF		16V
C18	Ceramic Chip	Factory Adjust		50V
C19	Ceramic Chip	Factory Adjust		50V
C20	Electrolytic	100μF		16V
C21	Electrolytic	22μF		25V
C22	Electrolytic (BP)	4.7μF		50V
C23	Metal Film	0.1μF	10%	63V
C24	Metal Film	0.01μF	10%	630V
C25	Electrolytic	22μF		25V
C26	Electrolytic	470μF		16V
C27	Ceramic Chip	0.01μF		50V
C28	Ceramic Chip	0.01μF		50V
C29	Ceramic Chip	0.01μF		50V
C30	Ceramic Chip	Factory Adjust		50V
C31	Ceramic Chip	0.01μF		50V
C32	Electrolytic	47μF		10V
C33	Ceramic Chip	0.01μF		50V
C34	Ceramic Chip	0.01μF		50V
C35	Electrolytic	47μF		10V
C36	Ceramic Chip	0.01μF		50V
C37	Ceramic Chip	0.01μF		50V

Symbol No.	Description		
	TRANSISTORS		
Q1	NPN	2 SC 3120	
Q2	NPN	2 SC 3120	
Q3	PNP	2 SA 1226-3.4	
Q4	PNP	2 SA 1162-Y	
Q5	PNP	2 SA 1226-3.4	
Q6	NPN	2 SC 2712-0.Y	
Q7	NPN	2 SC 3120	
Q8	NPN	2 SC 2712-0.Y	
Q9	NPN	2 SC 2712-0.Y	
Q10	NPN	2 SC 3120	
Q11	NPN	2 SC 3120	
Q12	PNP	2 SA 1226-3.4	
Q13	NPN	2 SC 1621-3.4	
Q14	NPN	2 SA 1621-3.4	
Q15	NPN	2 SC 2712-0.Y	
Q16	NPN	2 SC 2712-0.Y	
Q17	J. FET	2 SK 160A-K5.K6	
Q18	NPN	2 SC 2712-0.Y	
Q19	NPN	2 SC 3120	
Q20	PNP	2 SA 1162-GR	
Q21	PNP	2 SA 1226-3.4	
Q22	NPN	2 SC 2712-0.Y	
Q23	NPN	2 SC 2712-0.Y	
	DIODES		
D1	Detector	MA 151K	
D2	Detector	MA 151WA	
D3	Detector	MA 151K	
D4	Detector	MA 151K	
D5	Detector	MA 157	
D6	Detector	MA 151WA	
D7	Detector	MA 151K	
D8	Detector	MA 151K	
D9	Detector	MA 151K	
D10	Detector	MA 151WA	
D11	Detector	MA 151WA	
	INTEGRATED CIRCUITS		
IC1	C MOS	TC 74 HC02	
IC2	C MOS	TC 74 HC02	
	SWITCHES		
S1	Push	Q-537 SUJ 40	
S2	Push	Q-537 SUJ 40	
S3	Push	Q-537 SUJ 40	
S4	Push	Q-537 SUJ 40	
S5	Push	Q-537 SUJ 40	
S6	Push	Q-537 SUJ 40	
	PRINTED CIRCUIT BOARD		
	T-3559A TRIGGER SOURCE AMPLIFIER		
	MISCELLANEOUS		
J36	Connector	5533-04 APB	

T-3558
TRIGGER AMPLIFIER

	RESISTORS			
R1	Metal Glaze Chip	8.2KΩ	5%	1/16W
R2	Metal Glaze Chip	8.2KΩ	5%	1/16W
R3	Metal Glaze Chip	47Ω	5%	1/16W
R4	Metal Glaze Chip	330Ω	5%	1/16W
R5	Metal Glaze Chip	22Ω	5%	1/16W
R6	Metal Glaze Chip	680Ω	5%	1/16W
R7	Metal Glaze Chip	1.5KΩ	5%	1/8W
R8	Metal Glaze Chip	1.5KΩ	5%	1/8W
R9	Metal Glaze Chip	Factory Adjust	5%	1/16W
R10	Metal Glaze Chip	Factory Adjust	5%	1/16W
R11	Metal Glaze Chip	100Ω	5%	1/16W
R12	Metal Glaze Chip	470Ω	5%	1/16W
R13	Metal Glaze Chip	8.2KΩ	5%	1/16W

Symbol No.	Description			
R14	Metal Glaze Chip	6.8KΩ	5%	1/16W
R15	Metal Glaze Chip	47Ω	5%	1/16W
R16	Metal Glaze Chip	330Ω	5%	1/16W
R17	Metal Glaze Chip	22Ω	5%	1/16W
R18	Metal Glaze Chip	680Ω	5%	1/16W
R19	Metal Glaze Chip	100Ω	5%	1/16W
R20	Metal Glaze Chip	6.2KΩ	5%	1/16W
R21	Metal Glaze Chip	2.7KΩ	5%	1/16W
R22	Metal Glaze Chip	4.7KΩ	5%	1/16W
R23	Metal Glaze Chip	100Ω	5%	1/16W
R24	Metal Glaze Chip	4.7KΩ	5%	1/16W
R25	Metal Glaze Chip	2.7KΩ	5%	1/16W
R26	Metal Glaze Chip	6.2KΩ	5%	1/16W
R27	Metal Glaze Chip	47Ω	5%	1/16W
R28	Metal Glaze Chip	560Ω	1%	1/16W
R29	Metal Glaze Chip	560Ω	1%	1/16W
R30	Metal Glaze Chip	47Ω	5%	1/16W
R31	Metal Glaze Chip	560Ω	5%	1/8W
R32	Metal Glaze Chip	1.5KΩ	5%	1/16W
R33	Metal Glaze Chip	1.5KΩ	5%	1/16W
R34	Metal Glaze Chip	47Ω	5%	1/16W
R35	Metal Glaze Chip	220Ω	5%	1/16W
R36	Metal Glaze Chip	330Ω	5%	1/16W
R37	Metal Glaze Chip	820Ω	5%	1/16W
R38	Metal Glaze Chip	47Ω	5%	1/16W
R39	Metal Glaze Chip	47Ω	5%	1/16W
R40	Metal Glaze Chip	390Ω	5%	1/16W
R41	Metal Glaze Chip	47Ω	5%	1/16W
R42	Metal Glaze Chip	5.1KΩ	5%	1/16W
R43	Metal Glaze Chip	2KΩ	5%	1/16W
R44	Metal Glaze Chip	330Ω	5%	1/16W
R45	Metal Glaze Chip	47Ω	5%	1/16W
R46	Metal Glaze Chip	100Ω	5%	1/16W
R47	Carbon	820Ω	5%	1/6W
R48	Metal Glaze Chip	330Ω	5%	1/16W
R49	Metal Glaze Chip	47Ω	5%	1/16W
R50	Metal Glaze Chip	560Ω	5%	1/16W
R51	Metal Glaze Chip	100KΩ	5%	1/16W
R52	Metal Glaze Chip	10KV	5%	1/16W
R53	Metal Glaze Chip	100KΩ	5%	1/16W
R54	Metal Glaze Chip	4.7MΩ	5%	1/16W
R55	Metal Glaze Chip	100KΩ	5%	1/16W
R56	Metal Glaze Chip	10KΩ	5%	1/16W
R57	Metal Glaze Chip	470KΩ	5%	1/16W
R58	Metal Glaze Chip	100KΩ	5%	1/16W
R59	Metal Glaze Chip	10KΩ	5%	1/16W
R60	Metal Glaze Chip	10KΩ	5%	1/16W
R61	Metal Glaze Chip	6.8KΩ	5%	1/16W
R62	Metal Glaze Chip	6.8KΩ	5%	1/16W
R63	Metal Glaze Chip	10KΩ	5%	1/16W
R64	Metal Glaze Chip	22KΩ	5%	1/16W
R65	Metal Glaze Chip	180Ω	5%	1/16W
R66	Metal Glaze Chip	100KΩ	5%	1/16W
R67	Metal Glaze Chip	2.2KΩ	5%	1/16W
R68	Metal Glaze Chip	22KΩ	5%	1/16W
R69	Metal Glaze Chip	10KΩ	5%	1/16W
R70	Metal Glaze Chip	10KΩ	5%	1/16W
R71	Carbon	8.2KΩ	5%	1/6W
R72	Carbon	15Ω	5%	1/6W
R73	Carbon	15Ω	5%	1/6W
R74	Carbon	3.3KΩ	5%	1/6W
R75	Carbon	47Ω	5%	1/6W
R76	Carbon	1.2KΩ	5%	1/6W
	VARIABLE RESISTORS			
VR1	Carbon	2KΩ	20%	1/3W
VR2	Carbon	20KΩ	20%	1/20W
VR3	Carbon	20KΩ	20%	1/3W
	CAPACITORS			
C1	Electrolytic	10µF		25V
C2	Ceramic Chip	0.01µF		50V

Symbol No.	Description			
C3	Electrolytic	22µF		25V
C4	Ceramic Chip	Factory Adjust		50V
C5	Ceramic Chip	Factory Adjust		50V
C6	Ceramic Chip	220pF	5%	50V
C7	Ceramic Chip	0.01µF		50V
C8	Electrolytic	22µF		25V
C9	Ceramic Chip	0.01µF		50V
C10	Ceramic Chip	220pF		50V
C11	Ceramic Chip	0.01µF		50V
C12	Ceramic Chip	0.01µF		50V
C13	Ceramic Chip	0.01µF		50V
C14	Ceramic Chip	0.01µF		50V
C15	Ceramic Chip	0.01µF		50V
C16	Ceramic Chip	0.01µF		50V
C17	Ceramic Chip	0.01µF		50V
C18	Ceramic Chip	0.01µF		50V
C19	Ceramic Chip	0.01µF		50V
C20	Electrolytic	22µF		25V
C21	Electrolytic	22µF		25V
C22	Electrolytic	22µF		25V
C23	Electrolytic	47µF		10V
C24	Electrolytic	47µF		10V
C25	Ceramic Chip	0.01µF		50V
C26	Metal Film	0.1µF	10%	63V
C27	Electrolytic	4.7µF		25V
C28	Ceramic Chip	0.01µF		50V
C29	Ceramic Chip	0.01µF		50V
C30	Ceramic Chip	0.01µF		50V
C31	Ceramic Chip	0.01µF		50V
C32	Plastic	0.056µF		50V
C33	Ceramic Chip	0.01µF		50V
C34	Tantalum	22µF		10V
	TRANSISTORS			
Q1	NPN	2 SC 3120		
Q2	NPN	2 SC 3120		
Q3	PNP	2 SA 1226-3.4		
Q4	PNP	2 SA 1226-3.4		
Q5	PNP	2 SA 1226-3.4		
Q6	PNP	2 SA 1226-3.4		
Q7	NPN	2 SC 3120		
Q8	NPN	2 SC 3120		
Q9	NPN	2 SC 3120		
Q10	NPN	2 SC 3120		
Q11	NPN	2 SC 3120		
Q12	NPN	2 SC 3120		
Q13	PNP	2 SA 1226-3.4		
Q14	NPN	2 SC 3120		
Q15	PNP	2 SA 1226-3.4		
Q16	NPN	2 SC 2712-0		
Q17	PNP	2 SA 1162-0		
Q18	PNP	2 SA 1162-0		
Q19	NPN	2 SC 2712-0		
Q20	PNP	2 SA 1162-0		
Q21	PNP	2 SA 1015-GR		
	DIODES			
D1	Detector	MA 151K		
D2	Detector	MA 151K		
D3	Detector	MA 151WK		
D4	Detector	MA 151K		
D5	LED	TLG-226		
D6	Detector	MA 151K		
	INTEGRATED CIRCUITS			
IC1	C. MOS	TC 4011 BP		
IC2	Comparator	CA 3290E		
IC3	Fast TTL	74 F 20 PC		
	COILS			
L1	1.0µH	±10%		
	SWITCHES			
S1	Push	Q-536A SUJ-40		
	PRINTED CIRCUIT BOARD T-3558A TRIGGER AMPLIFIER			
	MISCELLANEOUS			
J39	Connector	5533-20APB		

T-3560 SWEEP

Symbol No.	Description			
	RESISTORS			
R1	Metal Glaze Chip	100KΩ	5%	1/16W
R2	Metal Glaze Chip	100KΩ	5%	1/16W
R3	Metal Glaze Chip	82KΩ	5%	1/16W
R4	Metal Glaze Chip	10KΩ	5%	1/16W
R5	Metal Glaze Chip	390Ω	5%	1/16W
R6	Metal Glaze Chip	10KΩ	5%	1/16W
R7	Metal Glaze Chip	1.8KΩ	5%	1/16W
R8	Metal Glaze Chip	12KΩ	5%	1/16W
R9	Metal Glaze Chip	1KΩ	5%	1/16W
R10	Metal Glaze Chip	2.2KΩ	5%	1/16W
R11	Metal Glaze Chip	22KΩ	5%	1/16W
R12	Metal Glaze Chip	47Ω	5%	1/16W
R13	Metal Glaze Chip	1.5KΩ	5%	1/16W
R14	Metal Glaze Chip	4.7KΩ	5%	1/16W
R15	Metal Glaze Chip	27KΩ	5%	1/16W
R16	Metal Glaze Chip	330Ω	5%	1/16W
R17	Metal Glaze Chip	47Ω	5%	1/16W
R18	Metal Glaze Chip	330Ω	5%	1/16W
R19	Metal Glaze Chip	470Ω	5%	1/16W
R20	Metal Glaze Chip	510Ω	5%	1/16W
R21	Metal Glaze Chip	47Ω	5%	1/16W
R22	Metal Glaze Chip	3.3KΩ	5%	1/8W
R23	Metal Glaze Chip	10KΩ	5%	1/16W
R24	Metal Glaze Chip	100KΩ	5%	1/16W
R25	Metal Glaze Chip	1.8KΩ	5%	1/16W
R26	Metal Glaze Chip	10KΩ	5%	1/16W
R27	Metal Glaze Chip	12KΩ	5%	1/16W
R28	Metal Glaze Chip	2.2KΩ	5%	1/16W
R29	Metal Glaze Chip	330Ω	5%	1/16W
R30	Metal Glaze Chip	47Ω	5%	1/16W
R31	Metal Glaze Chip	330Ω	5%	1/16W
R32	Metal Glaze Chip	22KΩ	5%	1/16W
R33	Metal Glaze Chip	1KΩ	5%	1/16W
R34	Metal Glaze Chip	470Ω	5%	1/16W
R35	Metal Glaze Chip	47Ω	5%	1/16W
R36	Metal Glaze Chip	3.3KΩ	5%	1/8W
R37	Metal Glaze Chip	15KΩ	5%	1/16W
R38	Metal Glaze Chip	33KΩ	5%	1/16W
R39	Metal Glaze Chip	100Ω	5%	1/16W
R40	Metal Glaze Chip	5.6KΩ	5%	1/16W
R41	Metal Glaze Chip	8.2KΩ	5%	1/16W
R42	Metal Glaze Chip	47Ω	5%	1/16W
R43	Metal Glaze Chip	100Ω	5%	1/16W
R44	Metal Glaze Chip	4.7KΩ	5%	1/16W
R45	Metal Glaze Chip	4.7KΩ	5%	1/16W
R46	Metal Glaze Chip	2.2KΩ	5%	1/8W
R47	Metal Glaze Chip	1.2KΩ	5%	1/16W
R48	Metal Glaze Chip	1.2KΩ	5%	1/16W
R49	Metal Glaze Chip	100Ω	5%	1/16W
R50	Metal Glaze Chip	47Ω	5%	1/16W
R51	Metal Glaze Chip	750Ω	5%	1/16W
R52	Metal Glaze Chip	1KΩ	5%	1/16W
R53	Metal Glaze Chip	4.7KΩ	5%	1/16W
R54	Metal Glaze Chip	1KΩ	5%	1/16W
R55	Metal Glaze Chip	47Ω	5%	1/16W
R56	Metal Glaze Chip	2.4KΩ	5%	1/16W
R57	Metal Glaze Chip	4.7KΩ	5%	1/16W
R58	Metal Glaze Chip	10KΩ	5%	1/16W
R59	Metal Glaze Chip	470Ω	5%	1/16W
R60	Metal Glaze Chip	100Ω	5%	1/16W
R61	Metal Glaze Chip	10KΩ	5%	1/16W
R62	Metal Glaze Chip	10KΩ	5%	1/16W
R63	Metal Glaze Chip	1.8KΩ	5%	1/16W
R64	Metal Glaze Chip	10KΩ	5%	1/16W
R65	Metal Glaze Chip	1.5KΩ	5%	1/16W
R66	Metal Glaze Chip	1KΩ	5%	1/16W
R67	Metal Glaze Chip	820Ω	5%	1/16W
R68	Metal Glaze Chip	820Ω	5%	1/16W
R69	Metal Glaze Chip	33KΩ	5%	1/16W
R70	Metal Glaze Chip	2.7KΩ	5%	1/16W
R71	Metal Glaze Chip	0Ω	5%	1/16W
R72	Metal Glaze Chip	4.7KΩ	5%	1/16W
R73	Metal Glaze Chip	1KΩ	5%	1/16W
R74	Metal Glaze Chip	1KΩ	5%	1/16W
R75	Metal Glaze Chip	10KΩ	5%	1/16W
R76	Carbon	1.5MΩ	5%	1/6W
R77	Metal Glaze Chip	2.7KΩ	5%	1/16W
	VARIABLE RESISTROS			
VR1	Carbon	100KΩ	20%	1/20W
VR2	Carbon	50KΩ	20%	1/3W
VR3				
VR4	Carbon	50KΩ	20%	1/3W
VR5	Carbon	20KΩ	20%	1/20W
VR6	Carbon	5KΩ	20%	1/3W
VR7	Carbon	3KΩ	20%	1/3W
	RESISTOR ARRAYS			
RA1	LRM-2			
RA2	LRM-2			
	CAPACITORS			
C1	Tantalum	10μF		10V
C2	Ceramic Chip	100pF	5%	50V
C3	Metal Film	1μF	10%	63V
C4	Ceramic Chip	0.01μF		50V
C5	Ceramic Chip	0.01μF		50V
C6	Ceramic Chip	0.01μF		50V
C7	Tantalum Chip	4.7μF		10V
C8	Tantalum Chip	0.15μF		35V
C9	Tantalum Chip	0.68μF		20V
C10	Plastic	0.047μF	10%	50V
C11	Plastic	0.0018μF	10%	50V
C12	Ceramic Chip	150pF	5%	50V
C13	Ceramic Chip	22pF	5%	50V
C14	Ceramic Chip	0.01μF		50V
C15	Ceramic Chip	0.01μF		50V
C16	Metal Film	1μF	2%	250V
C17	Ceramic Chip	0.01μF		50V
C18	Ceramic Chip	1000pF		50V
C19	Ceramic Chip	0.01μF		50V
C20	Ceramic Chip	1000pF		50V
C21	Ceramic Chip	0.01μF		50V
C22	Plastic	1000pF	2%	125V
C23	Ceramic Chip	100pF		50V
C24	Ceramic Chip	180pF		50V
C25	Electrolytic	22μF		25V
C26	Electrolytic	22μF		25V
C27	Ceramic Chip	0.01μF		50V
C28	Electrolytic	47μF		10V
C29	Electrolytic	22μF		25V
C30	Ceramic Chip	0.01μF		50V
C31	Electrolytic	22μF		25V
C32	Ceramic Chip	100pF		50V
C33	Ceramic Chip	22pF	5%	50V
C34	Ceramic Chip	470pF	5%	50V
C35	Ceramic Chip	0.01μF		50V
C36	Tantalum	10μF		10V
C37	Ceramic Chip	0.01μF		50V
C38	Plastic	1000pF	2%	125V
C39	Ceramic Chip	100pF	5%	50V
C40	Ceramic Chip	180pF	5%	50V
C41	Ceramic Chip	1000pF		50V
C42	Ceramic Chip	1000pF		50V
C43	Ceramic Chip	1000pF		50V

Symbol No.	Description			
C44	Ceramic Chip	150pF	5%	50V
C45	Ceramic Chip	Factory Adjust		50V
C46	Ceramic Chip	1000pF		50V
C47	Ceramic Chip	1000pF		50V
C48	Plastic	0.082μF		50V
C49	Tantalum	10μF		10V
	VARIABLE CAPACITORS			
VC1	Ceramic	10 - 100pF		500V
	TRANSISTORS			
Q1	NPN	2 SC 2712-0		
Q2	NPN	2 SC 1621-3.4		
Q3	PNP	2 SA 811A-17 18		
Q4	NPN	2 SC 1621-3.4		
Q5	FET	μPA 71A-L		
Q6	NPN	2 SC 3120		
Q7	PNP	2 SA 1226-3.4		
Q8	NPN	2 SC 1621-3.4		
Q9	FET	μPA 71A-L		
Q10	NPN	2 SC 1621-3.4		
Q11	PNP	2 SA 811A-17 18		
Q12	NPN	2 SC 3120		
Q13	PNP	2 SA 1226-3.4		
Q14	PNP	2 SA 1226-3.4		
Q15	NPN	2 SC 1621-3.4		
Q16	PNP	2 SA 1226-3.4		
Q17	PNP	2 SA 1226-3.4		
Q18	NPN	2 SC 3120		
Q19	PNP	2 SA 1226-3.4		
Q20	NPN	2 SC 3120		
Q21	NPN	2 SC 3120		
Q22	NPN	2 SC 3120		
	DIODES			
D1	Detector	1SS 99		
D2	Detector	MA 157		
D3	Detector	MA 151K		
D4	Zener	02 CZ 4.3Y (4.3V)		
D5	Detector	1SS 99		
D6	Detector	MA 157		
D7	Detector	MA 151K		
D8	Detector	MA 151K		
D9	Detector	MA 151WK		
D10	Detector	MA 151K		
D11	Detector	1S 1588		
D12	Zener	RD3.3EB (3.3V)		
	INTEGRATED CIRCUITS			
IC1	Fast TTL	74 F 02 PC		
IC2	Fast TTL	74 F 02 PC		
IC3	C. MOS	MC 74 HC 123N		
IC4	C. MOS	TC 74 HC 00P		
IC5	Linear	TL 071 CP		
IC6	Fast TTL	74 F 74 PC		
IC7	C. MOS	TC 74 HC 02P		
IC8	Linear	TL 071 CP		
	PRINTED CIRCUIT BOARD			
	T-3560 SWEEP			
	MISCELLANEOUS			
J47	Connector	5533 14APB		

T-3561
HORIZONTAL AMPLIFIER

Symbol No.	Description			
	RESISTORS			
R1	Metal Glaze Chip	5.1KΩ	1%	1/8W
R2	Metal Glaze Chip	5.1KΩ	1%	1/8W
R3	Metal Glaze Chip	1.5KΩ	5%	1/16W
R4	Metal Glaze Chip	3.9KΩ	5%	1/16W
R5	Metal Glaze Chip	100KΩ	5%	1/16W
R6	Metal Glaze Chip	100KΩ	5%	1/16W
R7	Metal Glaze Chip	100KΩ	5%	1/16W
R8	Metal Glaze Chip	5.6KΩ	5%	1/16W
R9	Metal Glaze Chip	7.5KΩ	1%	1/8W
R10	Metal Glaze Chip	2.7KΩ	1%	1/8W
R11	Metal Glaze Chip	47Ω	5%	1/16W
R12	Metal Glaze Chip	3KΩ	1%	1/16W
R13	Metal Glaze Chip	47Ω	5%	1/16W
R14	Metal Glaze Chip	2.7KΩ	1%	1/8W
R15	Metal Glaze	1.5KΩ	1%	1/6W
R16	Metal Glaze	1.5KΩ	1%	1/6W
R17	Metal Glaze Chip	2.7KΩ	1%	1/8W
R18	Metal Glaze Chip	0Ω	5%	1/16W
R19	Metal Glaze Chip	150Ω	1%	1/8W
R20	Metal Glaze Chip	0Ω	5%	1/16W
R21	Metal Glaze Chip	1KΩ	1%	1/8W
R22	Metal Glaze Chip	1.2KΩ	1%	1/8W
R23	Metal Glaze Chip	100Ω	5%	1/16W
R24	Metal Glaze Chip	3.3KΩ	1%	1/8W
R25	Metal Glaze Chip	680Ω	5%	1/16W
R26	Metal Glaze Chip	680Ω	5%	1/16W
R27	Metal Glaze Chip	10Ω	5%	1/16W
R28	Metal Glaze Chip	820Ω	5%	1/16W
R29	Metal Glaze Chip	820Ω	5%	1/16W
R30	Metal Glaze Chip	10Ω	5%	1/16W
R31	Metal Glaze Chip	1KΩ	5%	1/16W
R32	Metal Glaze Chip	1KΩ	5%	1/16W
R33	Metal Glaze Chip	8.2KΩ	1%	1/8W
R34	Not Used			
R35	Metal Glaze Chip	220Ω	5%	1/16W
R36	Metal Glaze Chip	1.5KΩ	5%	1/8W
R37	Metal Glaze	18KΩ	5%	1W
R38	Metal Glaze Chip	150KΩ	5%	1/8W
R39	Metal Glaze Chip	47Ω	5%	1/16W
R40	Metal Glaze Chip	12KΩ	5%	1/16W
R41	Metal Glaze Chip	1.5KΩ	1%	1/8W
R42	Metal Glaze Chip	1.5KΩ	1%	1/8W
R43	Metal Glaze Chip	12KΩ	5%	1/16W
R44	Metal Glaze Chip	47Ω	5%	1/16W
R45	Metal Glaze Chip	2KΩ	1%	1/8W
R46	Metal Glaze Chip	150Ω	5%	1/16W
R47	Metal Glaze	18KΩ	5%	1W
R48	Not Used			
R49	Metal Glaze Chip	680Ω	5%	1/16W
R50	Metal Glaze Chip	150KΩ	5%	1/8W
R51	Metal Glaze Chip	8.2KΩ	1%	1/8W
R52	Metal Glaze Chip	1KΩ	5%	1/16W
R53	Metal Glaze Chip	100Ω	5%	1/16W
R54	Metal Glaze Chip	100Ω	5%	1/16W
R55	Carbon	47Ω	5%	1/6W
R56	Carbon	47Ω	5%	1/6W
R57	Carbon	22Ω	5%	1/6W
	VARIABLE RESISTORS			
VR1	Carbon	1KΩ	20%	1/3W
VR2	Carbon	10KΩ	20%	1/3W
VR3	Carbon	1KΩ	20%	1/3W
VR4	Carbon	2KΩ	20%	1/3W
VR5	Carbon	200Ω	20%	1/3W
VR6	Carbon	300Ω	20%	1/3W
	CAPACITORS			
C1	Electrolytic	22μF		25V
C2	Electrolytic	100μF		10V
C3	Ceramic Chip	0.01μF		50V
C4	Not Used			
C5	Not Used			
C6	Electrolytic	22μF		25V
C7	Ceramic Chip	10pF	0.5pF	50V
C8	Ceramic Chip	220pF	5%	50V
C9	Ceramic Chip	0.01μF		50V
C10	Ceramic Chip	0.01μF		50V
C11	Ceramic	0.001μF		500V
C12	Ceramic	0.01μF		500V
C13	Ceramic Chip	0.01μF		50V
C14	Composition	0.75pF	10%	500V

Symbol No.	Description			
C15	Electrolytic	22µF		25V
C16	Ceramic Chip	0.01µF		50V
C17	Ceramic Chip	0.01µF		50V
C18	Composition	0.75pF	10%	500V
C19	Ceramic	0.01µF		500V
C20	Ceramic	0.001µF		500V
C21	Ceramic	0.001µF		500V
C22	Electrolytic	22µF		200V
C23	Electrolytic	22µF		25V
C24	Electrolytic	22µF		25V
C25	Ceramic Chip	0.01µF		50V
C26	Mica	22pF		500V
C27	Tantalum	10µF		16V
C28	Tantalum	10µF		16V
	VARIABLE CAPACITORS			
VC1	Ceramic	4 - 40 pF		250V
VC2	Ceramic	4 - 40 pF		250V
	TRANSISTORS			
Q1	NPN	2 SC 3120		
Q2	NPN	2 SC 3120		
Q3	PNP	2 SA 1226-3.4		
Q4	PNP	2 SA 1226-3.4		
Q5	PNP	2 SA 1226-3.4		
Q6	PNP	2 SA 1226-3.4		
Q7	PNP	2 SA 1162-G		
Q8	PNP	2 SA 1162-G		
Q9	PNP	2 SA 1162-G		
Q10	PNP	2 SA 1162-G		
Q11	NPN	2 SC 3120		
Q12	PNP	2 SA 1209		
Q13	NPN	2 SC 2911		
Q14	NPN	2 SC 2911		
Q15	PNP	2 SA 1226-3.4		
Q16	PNP	2 SA 1209		
	DIODES			
D1	Detector	MA 151K		
D2	Detector	1S 1588		
D3	Detector	1S 1588		
D4	Detector	MA 151WK		
D5	Detector	MA 151WK		
	INTEGRATED CIRCUITS			
IC1	C MOS	TC 4053 BP		
	PRINTED CIRCUIT BOARD			
	T-3561A HORIZONTAL AMPLIFIER			
	MISCELLANEOUS			
J68	Connector	SSQ-7		

T-3563A HORIZONTAL DISPLAY

Symbol No.	Description			
	SWITCHES			
	Push	Q-535A SUJ 30		
	PRINTED CIRCUIT BOARD			
	T-3563A HORIZONTAL DISPLAY			

T-3564 INTENSITY

Symbol No.	Description			
	RESISTORS			
R1	Metal Glaze Chip	5.1KΩ	1%	1/8W
R2	Metal Glaze Chip	560Ω	5%	1/16W
R3	Metal Glaze Chip	510Ω	1%	1/8W
R4	Metal Glaze Chip	3.3KΩ	5%	1/16W
R5	Metal Glaze Chip	100KΩ	1%	1/8W
R6	Metal Glaze Chip	8.2KΩ	5%	1/16W
R7	Metal Glaze Chip	100KΩ	1%	1/8W
R8	Metal Glaze Chip	8.2KΩ	5%	1/16W
R9	Metal Glaze Chip	220KΩ	5%	1/16W
R10	Metal Glaze Chip	5.6KΩ	1%	1/8W
R11	Metal Glaze Chip	390Ω	1%	1/8W
R12	Metal Glaze Chip	10KΩ	5%	1/16W
R13	Carbon	5.6Ω	5%	1/2W
R14	Carbon	5.6Ω	5%	1/2W
R15	Metal Glaze Chip	4.7KΩ	5%	1/8W
	VARIABLE RESISTORS			
VR1	Carbon	5KΩ	20%	1/20W
VR2	Carbon	5KΩ	20%	1/20W
VR3	Carbon	20KΩ	20%	1/20W
VR4	Carbon	500Ω	20%	1/3W
	CAPACITORS			
C1	Electrolytic	47µF		10V
C2	Electrolytic	47µF		10V
C3	Plastic Film	6800pF	2%	50V
C4	Plastic Film	6800pF	2%	50V
C5	Ceramic Chip	27pF	5%	50V
C6	Ceramic Chip	0.01µF		50V
C7	Ceramic Chip	0.01µF		50V
C8	Ceramic Chip	0.01µF		50V
	TRANSISTORS			
Q1	PNP	2 SA 1162-0 or Y		
Q1	PNP	2 SB 435-0 or Y		
Q3	NPN	2 SC 2712-0 or Y		
Q4	NPN	2 SC 2712-0 or Y		
Q5	PNP	2 SA 1162-0 or Y		
	DIODES			
D1	Detector	MA 151K		
D2	Zener	RD5 1M-B2		
D3	Detector	MA 151K		
	LED	TLG-164		
	PRINTED CIRCUIT BOARD			
	T-3564A INTENSITY			
	MISCELLANEOUS			
J54	Connector	5533-10APB		

T-3565 CRT SOCKET

Symbol No.	Description			
	RESISTORS			
R1	Carbon	100KΩ	5%	1/2W
R2	Carbon	150Ω	5%	1/6W
R3	Carbon	150Ω	5%	1/6W
	VARIABLE RESISTORS			
VR1	Metal Glaze	220KΩ	25%	1/5W
	CAPACITORS			
C1	Ceramic	0.001µF		500V
C2	Ceramic	0.001µF		500V
C3	Ceramic	0.001µF		500V
	COILS			
L1	Choke	0.33µH		
L2	Choke	0.33µH		
	PRINTED CIRCUIT BOARD			
	T-3565A CRT SOCKET			
	MISCELLANEOUS			
CRT Socket No. 1339				

T-3572 HORIZONTAL POSITION

Symbol No.	Description			
	VARIABLE RESISTORS			
VR1	Carbon	20KΩ	20%	1/20W
	PRINTED CIRCUIT BOARD			
	T-3572A HORIZONTAL POSITION			

Symbol No.	Description				
T-3573 ROTATION					
	VARIABLE RESISTORS				
VR1	Carbon	20KΩ	20%	1/20W
	TRANSISTORS				
Q1	NPN	2SC 1818-Y		
Q2	PNP	2SA 1015-Y		
	PRINTED CIRCUIT BOARD T-3573A ROTATION			

Symbol No.	Description	
T-3641 CONNECTOR		
	MISCELLANEOUS	
P10	Connector	5532-04A
P36	Connector	5532-10A
P39	Connector	5532-20A
P47	Connector	5532-14A
P54	Connector	5532-10A
	PRINTED CIRCUIT BOARD T-3641 CONNECTOR	

4. BLOCK DIAGRAM AND SCHEMATICS

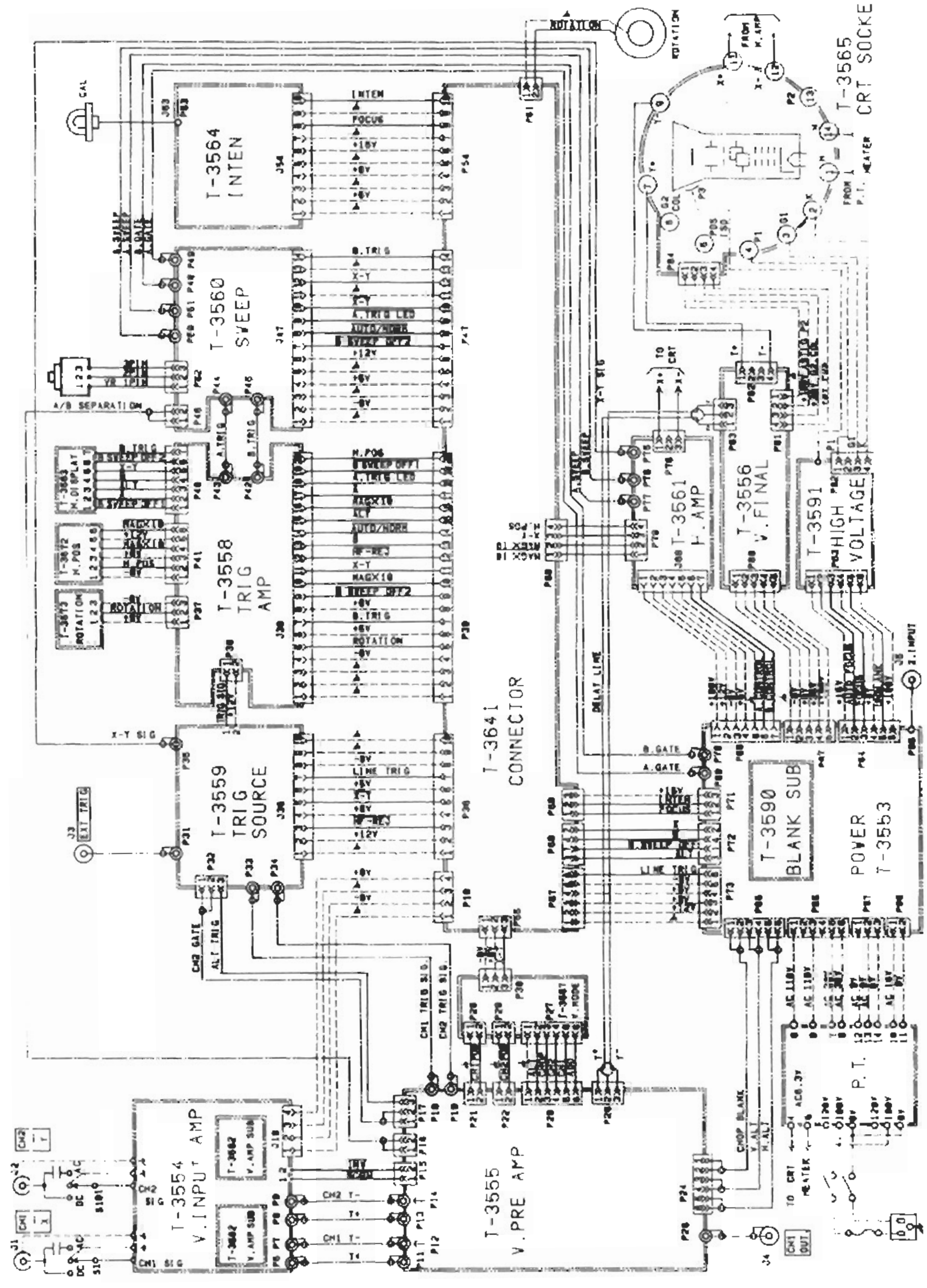


Fig. 4-1 LBO-325 Interconnectors
(Schematic 1A of 12)

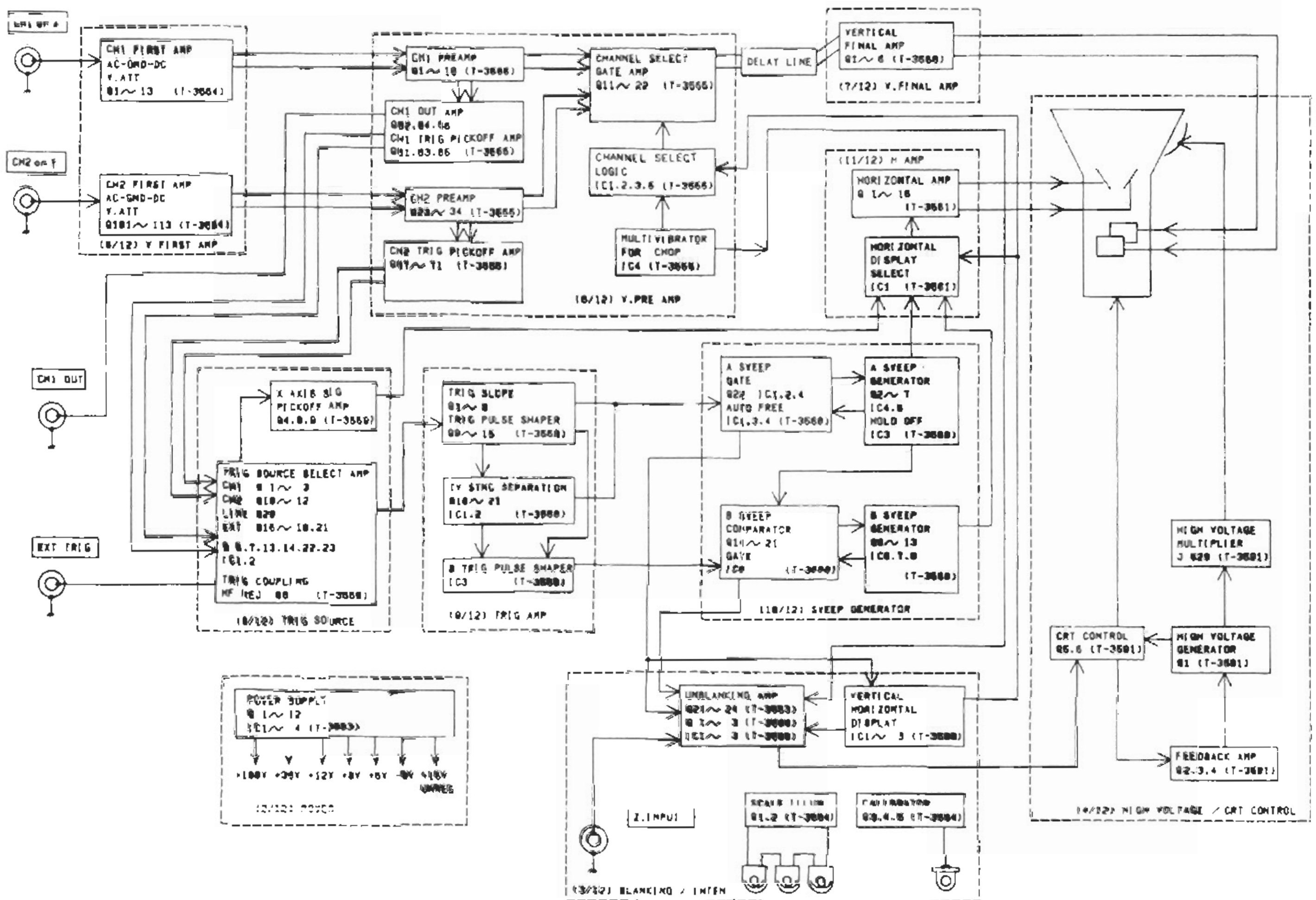


Fig. 4-2 LBO-325 Block Diagram
(Schematic 1B of 12)

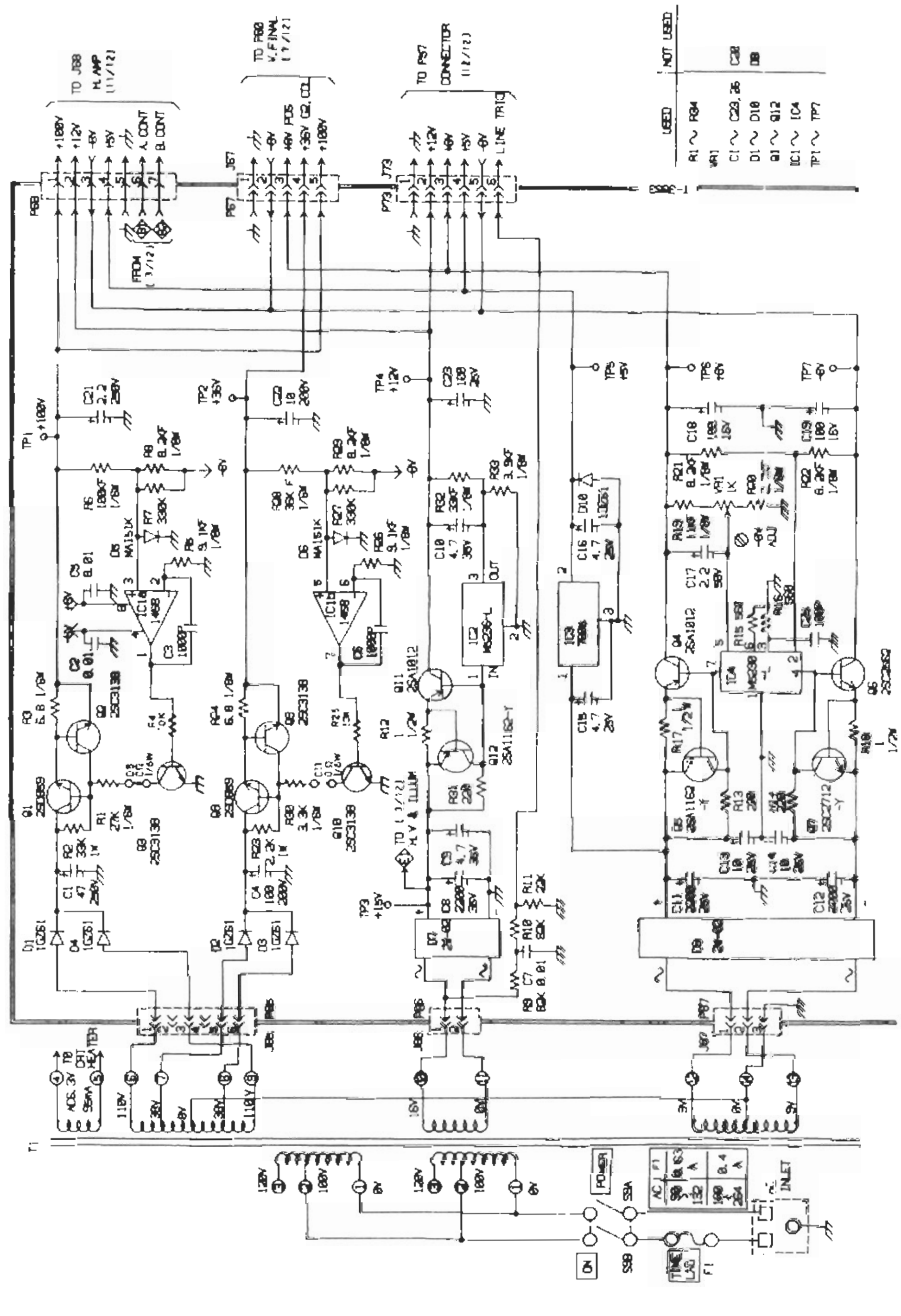


Fig. 4-3 LBO-325 Power Supply
(Schematic 2 of 12)

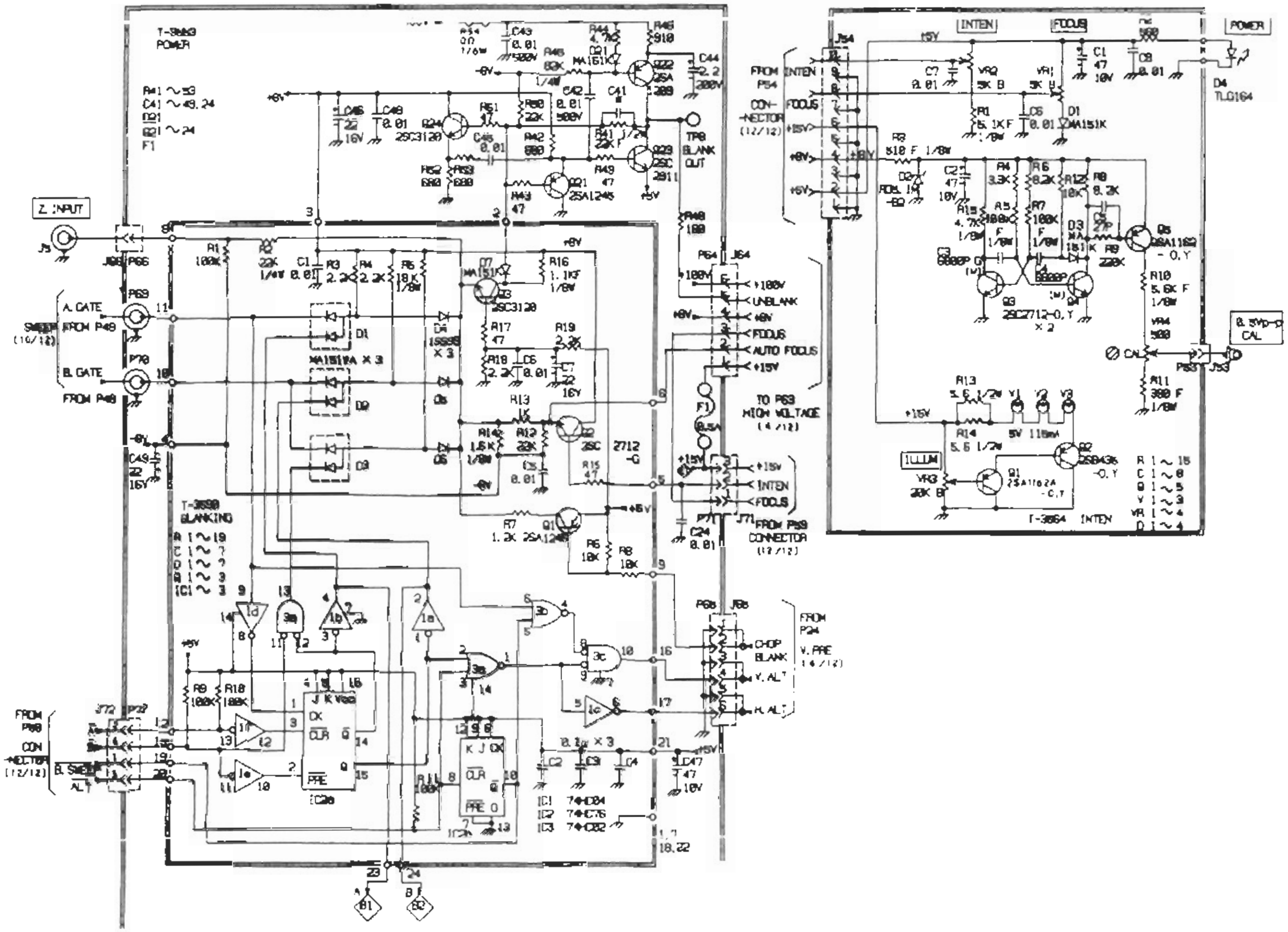


Fig. 4-4 LBO-325 Blanking and Intensity
(Schematic 3 of 12)

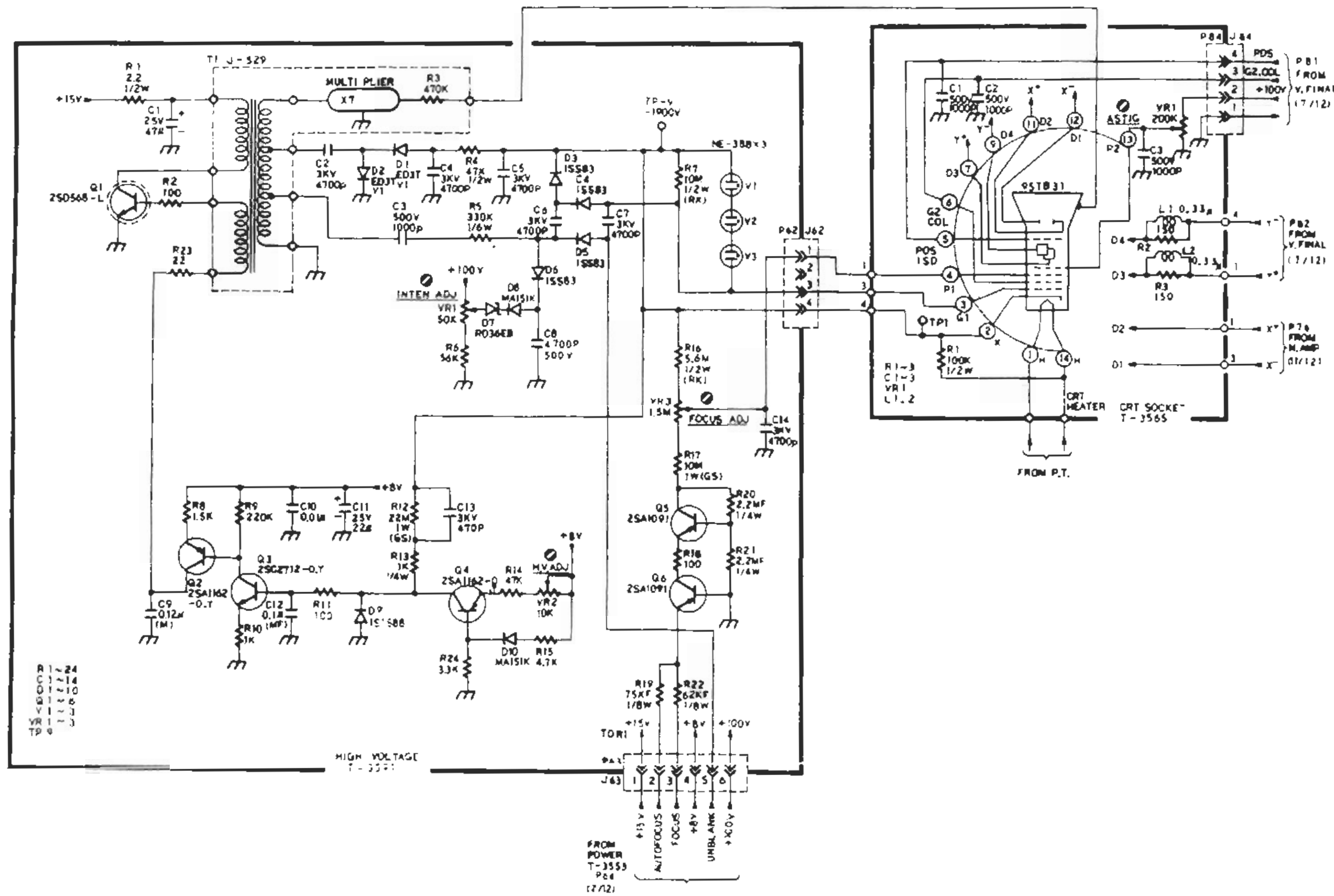


Fig. 4-5 LBO-325 High Voltage
(Schematic 4 of 12)

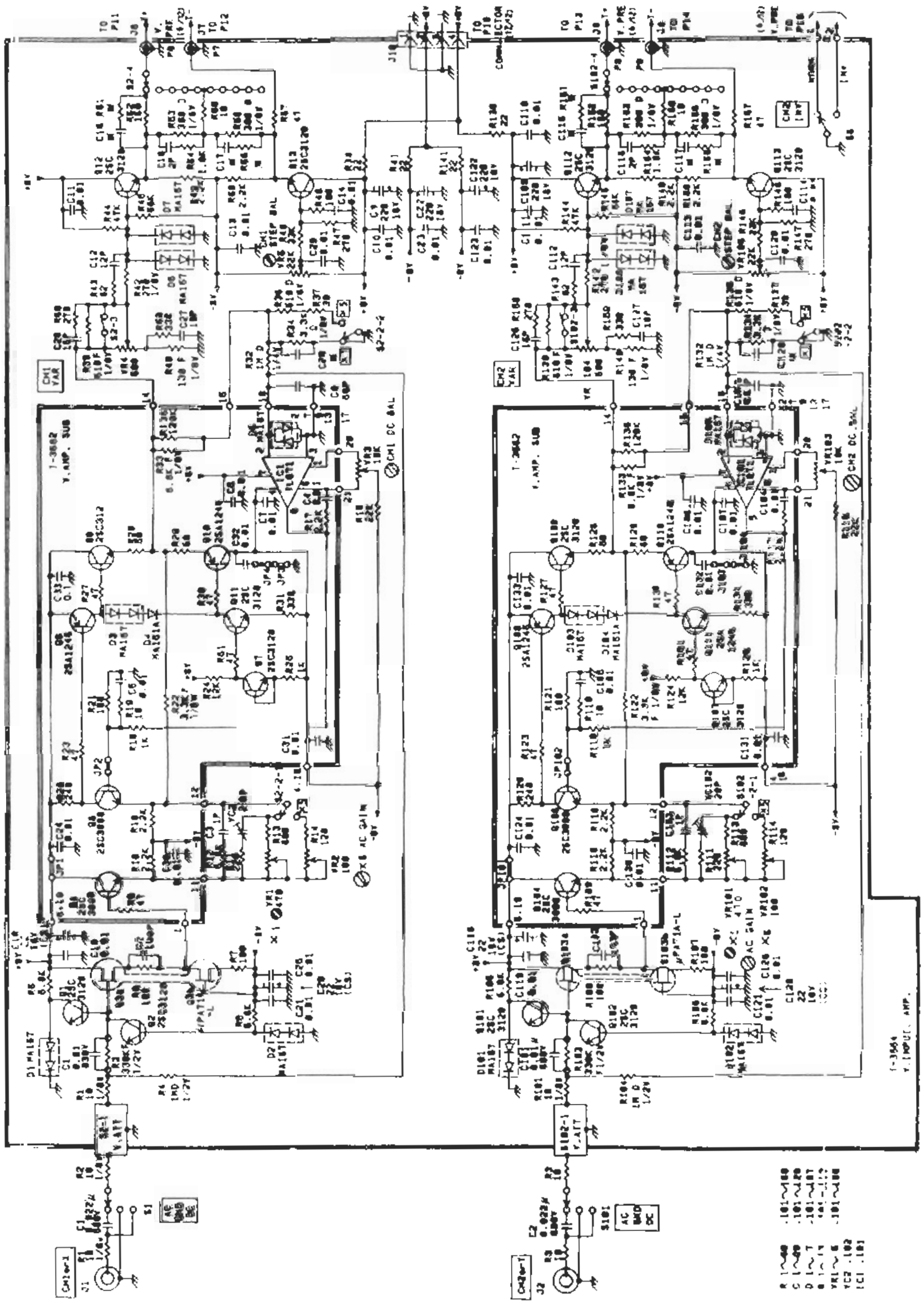


Fig. 4-6 LBO-325 Vertical Input Amplifiers (Schematic 5 of 12)

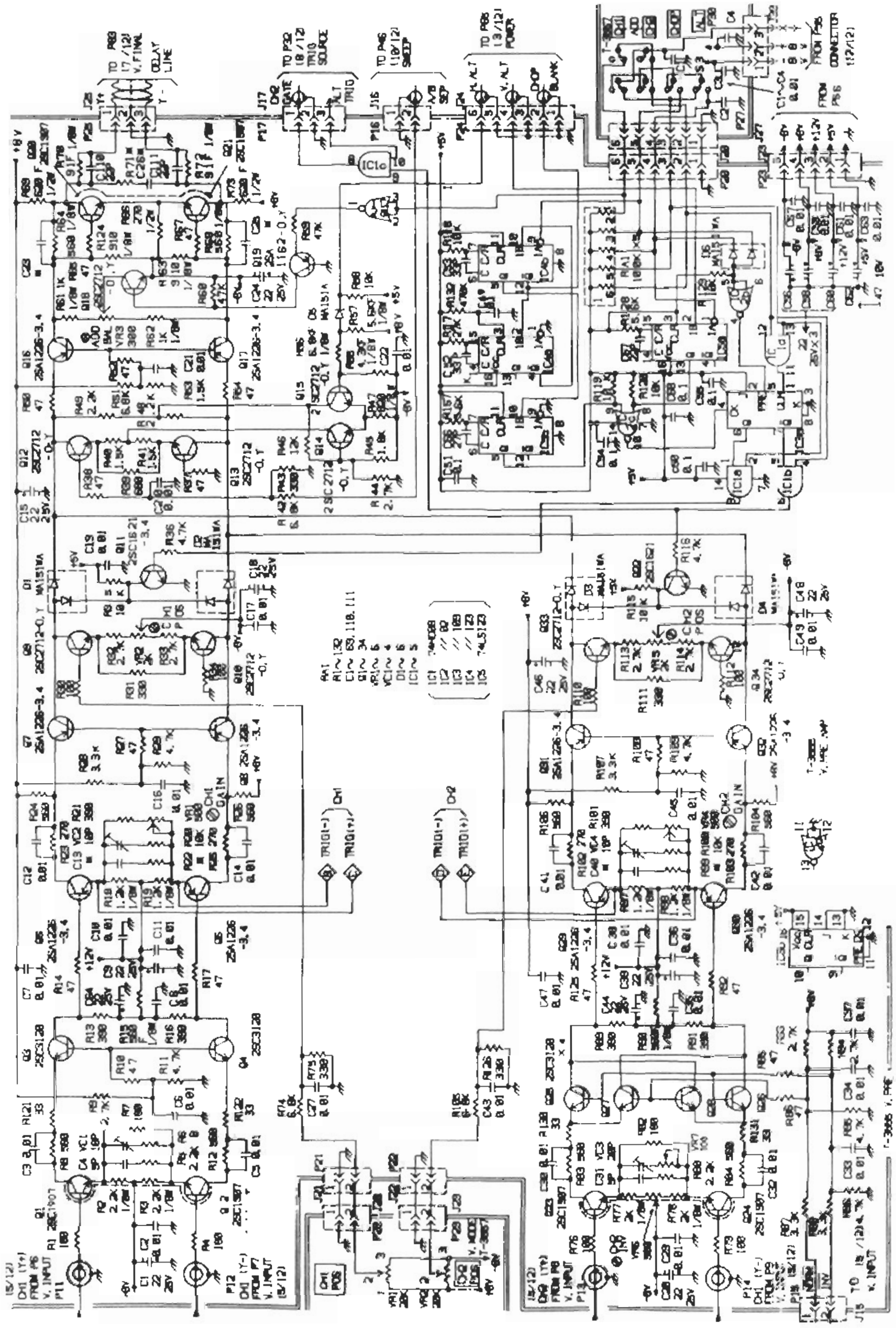


Fig. 4-7 LBO-325 Vertical Preamplifiers (Schematic 6 of 12)

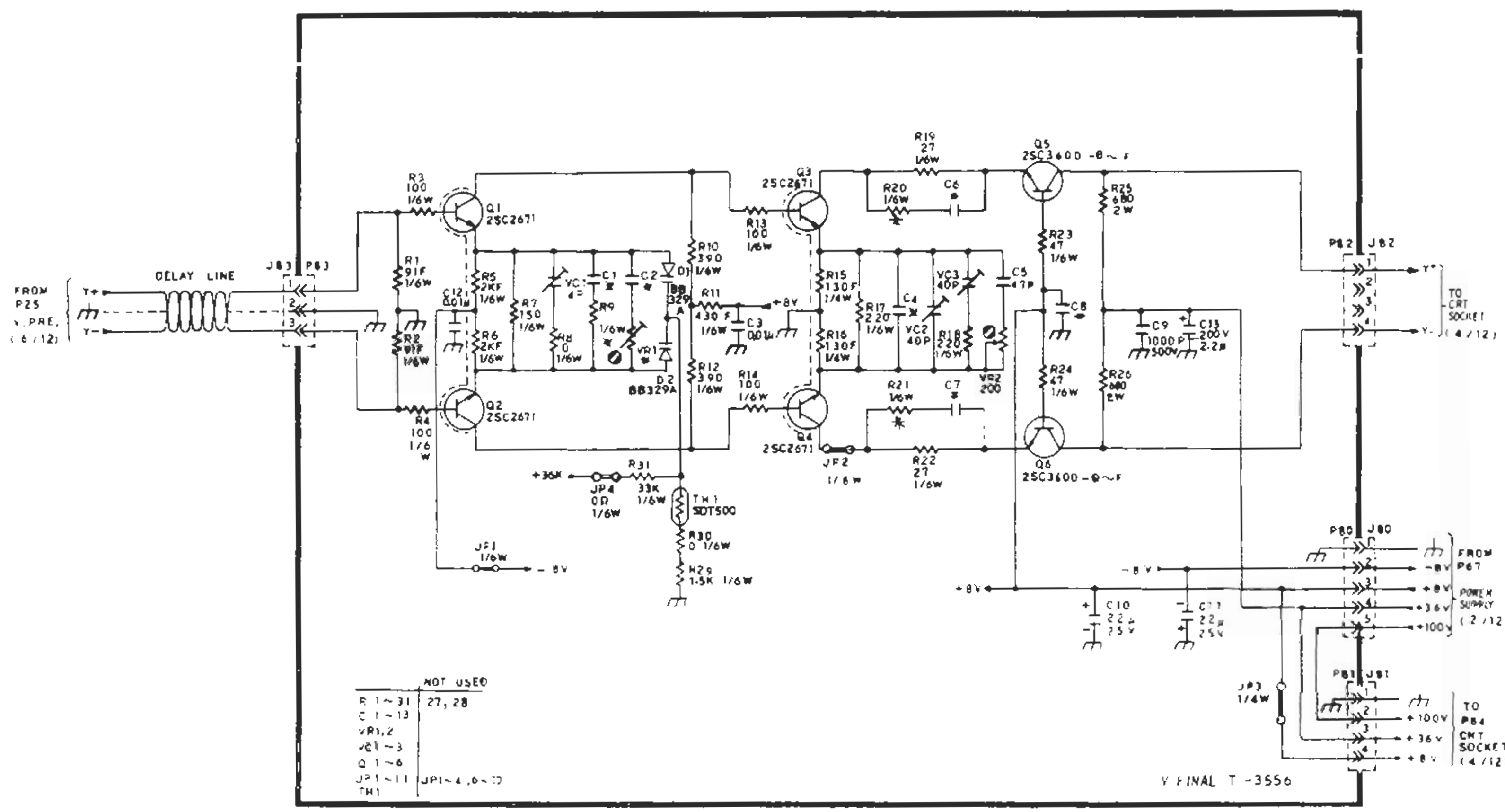


Fig. 4-8 LBO-325 Vertical Final Amplifier
(Schematic 7 of 12)

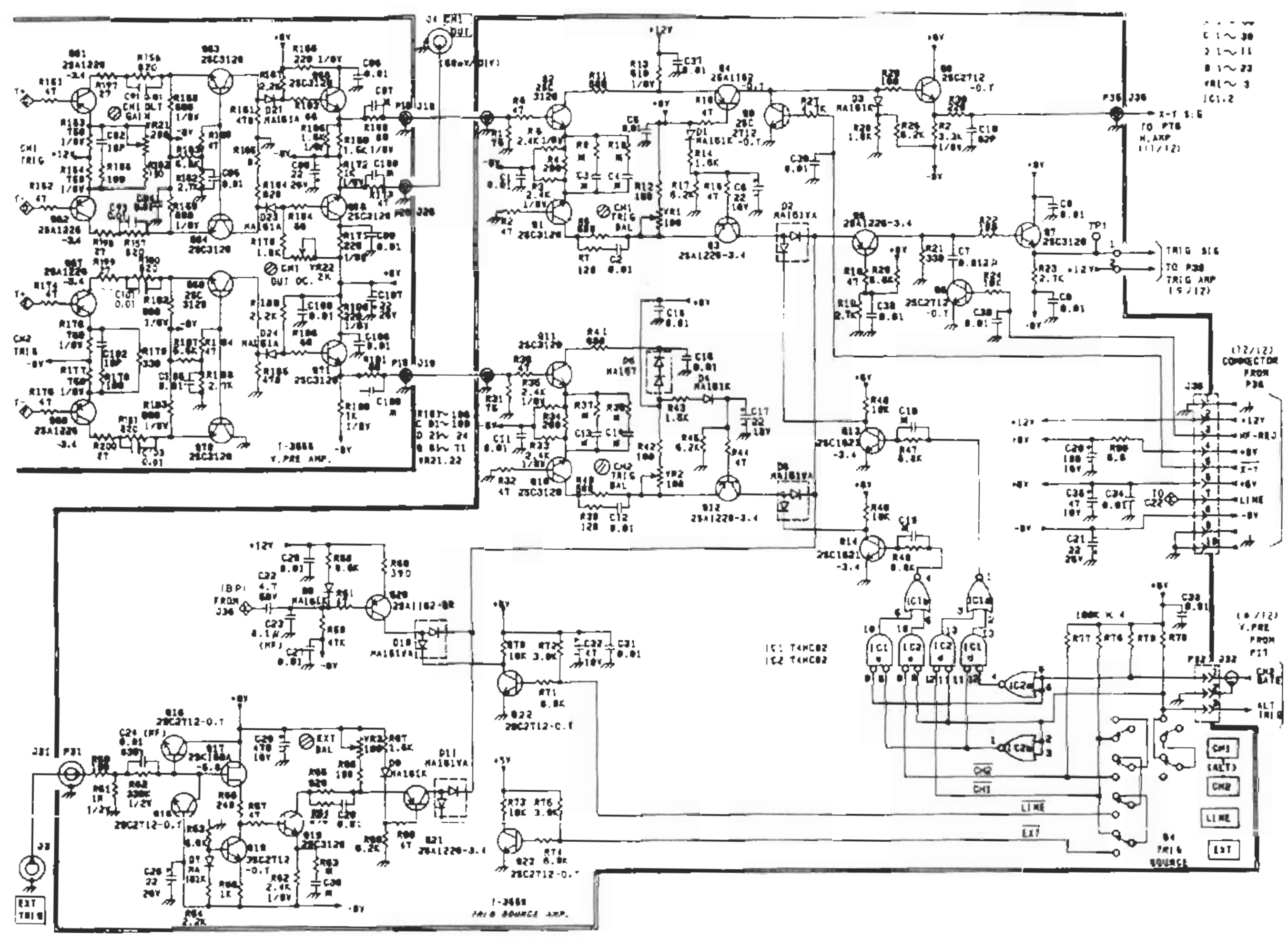


Fig. 4-9 LBO-325 Trigger Source Amplifier
(Schematic 8 of 12)

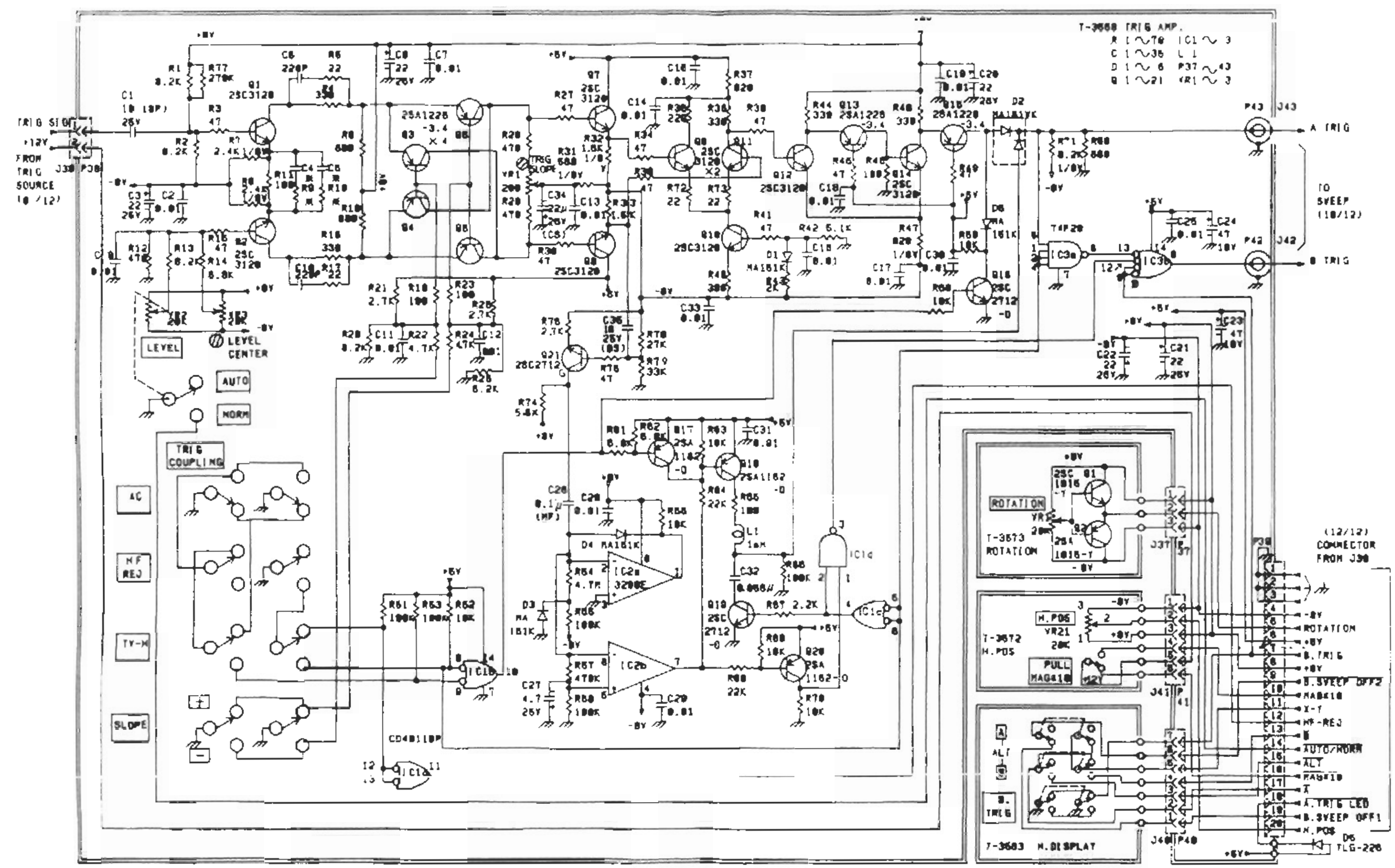


Fig. 4-10 LBO-325 Trigger Amplifier
(Schematic 9 of 12)

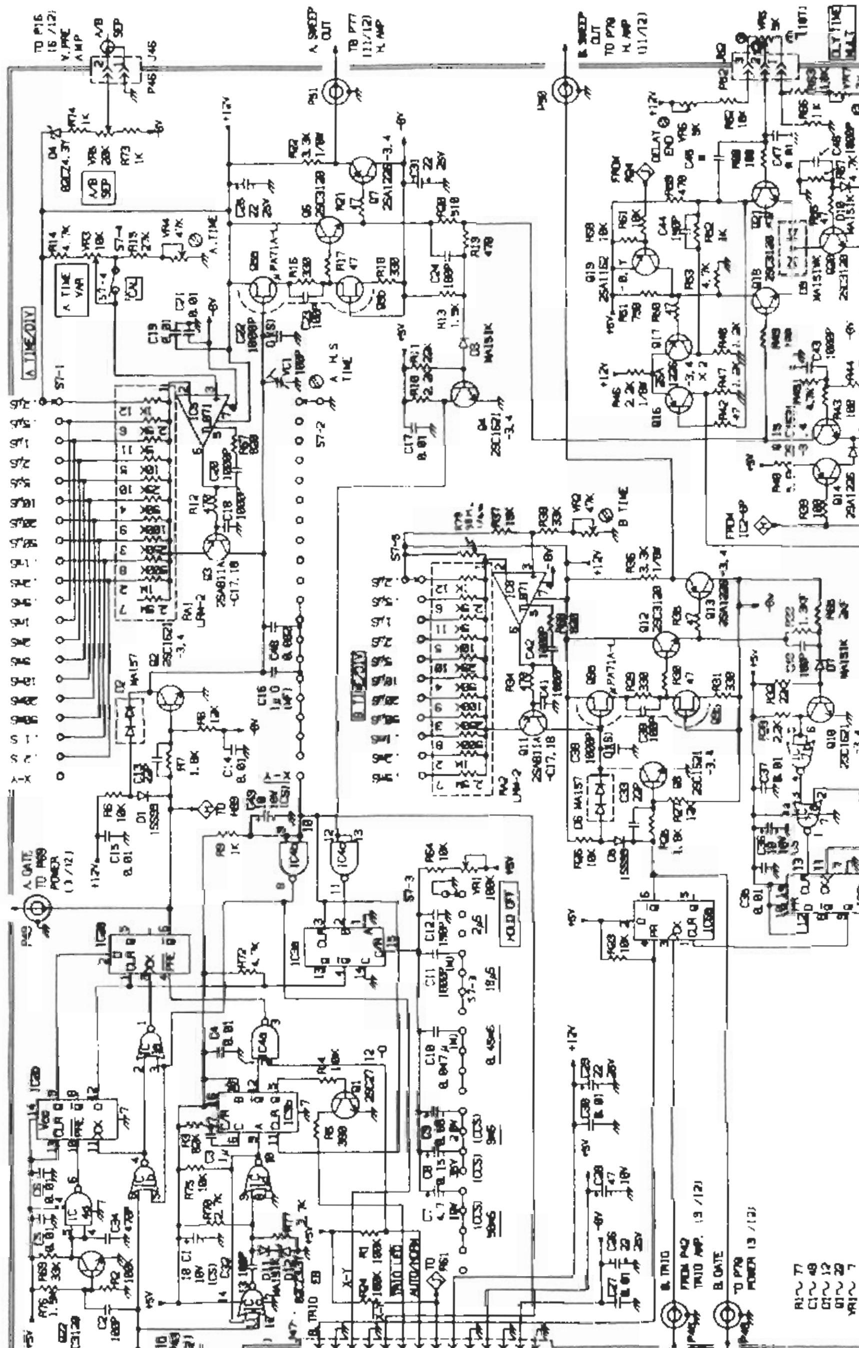


Fig. 4-11 LBO-325 Sweep (Schematic 10 of 12)

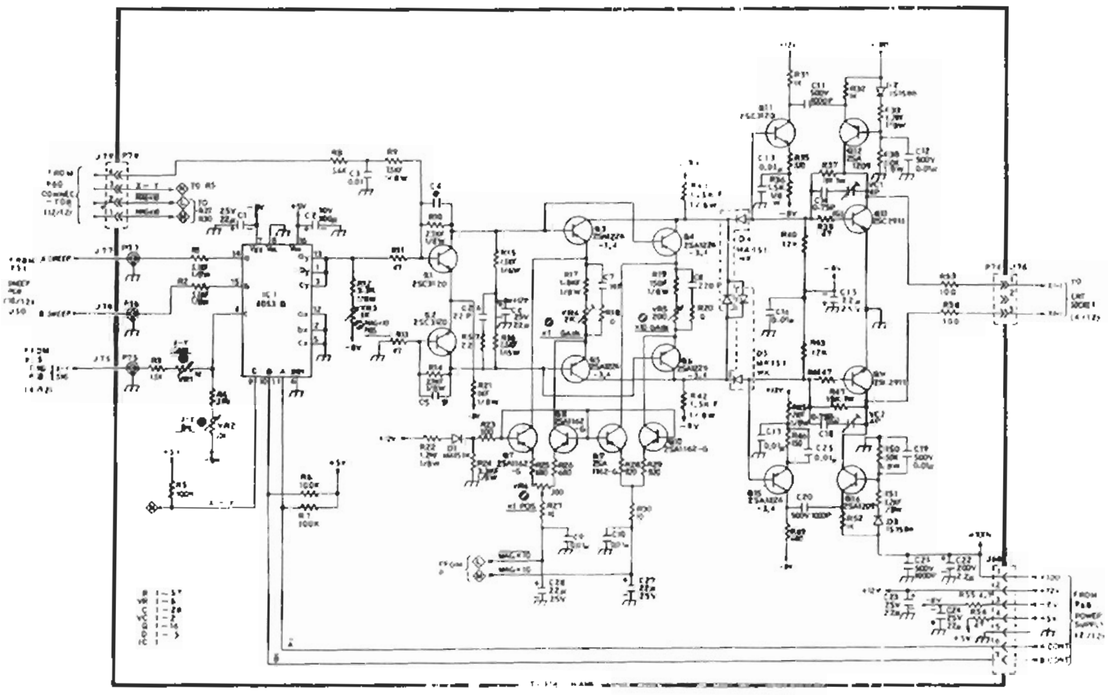


Fig. 4-12 LBO-325 Horizontal Amplifier
(Schematic 11 of 12)

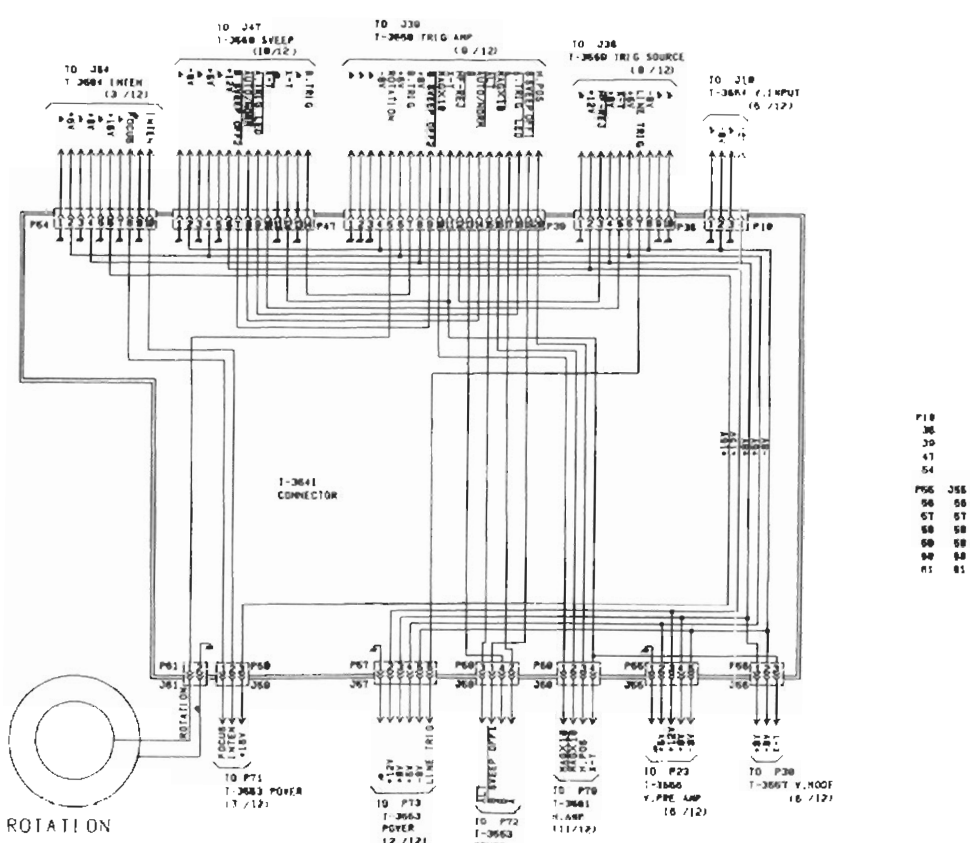


Fig. 4-13 LBO-325 Connector
(Schematic 12 of 12)

LEADER INSTRUMENTS CORP.

TWO YEAR WARRANTY POLICY

Leader Instruments Corporation warrants its products* to be free from defects in materials and workmanship for a period of two years from the date of purchase. Its obligation under this warranty is limited to repairing or replacing, at its own sole option, any such defective products. Products must be returned to a Leader Service Center with transportation charges prepaid and must be accompanied by a brief description of the problem encountered and date and place of purchase. This warranty does not apply to equipment which has been damaged by accident, negligence or mis-application or has been altered or modified in any way. This warranty applies only to the original purchaser who must have properly registered the product within 10 days of purchase.

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*Excluded are accessories and instrument carts which are covered under a separate warranty.