LBO-308PL/S
DUAL TRACE OSCILLOSCOPE
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1. GENERAL INFORMATION

1-1 Introduction

The model LBO-308S, shown in Figure 1-1, is a high-quality dual-trace, 20-MHz portable oscilloscope ideally suited for field service. It is an extremely compact, light-weight, general-purpose instrument, designed to provide accurate signal measurements for either bench or field service. The highly sensitive vertical amplifier provides calibrated deflection sensitivity from 2 mV/div to 10 V/div. The time base provides stable triggering over the full band-width of the vertical amplifier as well as calibrated sweep speeds from 0.2 sec/div to 0.5 μsec/div. A times 5 magnifier extends the maximum sweep speed to 0.1 μsec/div.

The instrument may be operated from either 117/234 volts AC, 11 to 30 volts DC, or from battery pack.

The model LBO-308 features a 3-inch rectangular 8 X 10 division CRT, mounted horizontally, with an internal graticule which provides for accurate and sharp displays at any viewing angle without parallax errors.

1-2 Specifications

Specifications for the model LBO-308PL/S oscilloscope are given in Table 1-1. Specifications for the model LP-16AX scope probe are given in Table 1-2.

Table 1-1
LBO-308PL/S SPECIFICATIONS

Vertical Amplifiers (Ch. 1 & 2)

Bandwidth (−3 dB)	
DC coupled	0 Hz to 20 MHz
AC coupled	2 Hz to 20 MHz
Risetime	17.5 nS
Deflection Coefficients	2 mV/div to 10 V/div in 12 calibrated steps; 1-2-5 sequence. Continuously variable between steps.
Accuracy	± 3% over 0-40°C
Input Impedance	1 megohm ± 2%, 35 pF ± 3 pF.
Maximum Input Voltage	600 V (DC plus AC peak).
Signal Delay	Leading edge displayed (308PL only)
Vertical Display Modes	CH-1 only, CH-2 only, CH-1 and CH-2 switched at 250 kHz rate for sweep speeds of 0.2 S/div to 0.5 mS/div, CH-1 and CH-2 alternately displayed for sweep speeds of 0.2 mS/div to 0.5 μs/div CH-1 and CH-2 added, CH-1 and CH-2 subtracted

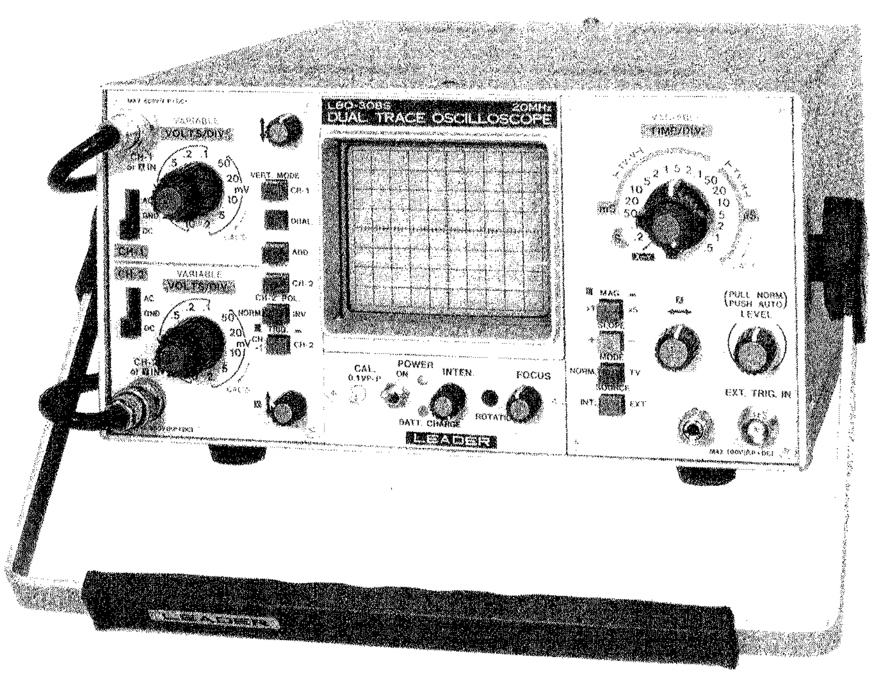


Figure 1-1. Model LBO-308 Dual Trace Oscilloscope

Horizontal Amplifier (X-Y Mode)

Bandwidth (−3 dB)	
DC coupled	0 Hz to 1 MHz
AC coupled	2 Hz to 1 MHz
Risetime	350 nS
X-Y Phase Difference	< 3° at 100 kHz (LBO-308S) < 3° at 30 kHz (LBO-308PL)
Deflection Coefficients	2 mV/div to 10 V/div in 12 calibrated steps; 1-2-5 sequence. Continuously variable between steps.
Accuracy	± 3% over 0-40°C
Input Impedance	1 megohm ± 2%, 35 pF ± 3 pF
Maximum Input Voltage	600 V (DC plus AC peak)

Time Base

Sweep Speeds	0.5 μS to 0.2 S/div in 18 calibrated steps; 1-2-5 sequence. Continuously variable between steps.
Magnifier	5X deflection increase at any TB setting. Extends fastest sweep speed to 0.1 μS/div.
Accuracy	± 3% unmagnified ± 5% magnified

Triggering

Sources	Channel 1, Channel 2, External
Modes	Auto, Normal
Coupling	Normal (AC), TV
Slope	+ and −
Sensitivity (Internal)	2 Hz to 20 MHz: 1 div
Sensitivity (External)	2 Hz to 20 MHz (NORM): 0.5 Vp-p 50 Hz to 20 MHz (AUTO): 0.4 Vp-p
Input Impedance	100 k-ohms, 47 pF
Maximum Input Voltage	100 V (DC plus AC peak)

Z-Axis Modulation

Level for Blanking	2 to 5 V peak pulse
Coupling	AC
Maximum Input Voltage	50 V (DC plus AC peak)
Input Impedance	10 k-ohms

Calibrator

Output Voltage	100 mV p-p ± 3%; positive-going, ground referenced
Frequency	Approximately 1 KHz
Waveform	Fast-rise square wave

CRT Display

Phosphor	P31 (P7 optional)
Accelerating Voltage	10 kV (LBO-308PL) 1.5 kV (LBO-308S)
Graticule	Internal 0.6 cm square divisions, 8 divisions high, 10 divisions wide. Central axes subdivided into fifths.
Front-panel Trace Adjustments	Intensity, Rotation, Focus

Physical & Environmental Data

Size (WxHxD)	9 1/2 x 4 5/8 x 12 5/8 inches 233 x 118 x 329 mm
Weight (No Battery Pack)	10.9 lbs. (5 kg)
Ambient Operating Temperature	0-40°C (32-104°F)
Vibration Tolerance	2 mm p-p displacement at 12-33 Hz
Shock Tolerance	30g, 2 shocks per axis

Power Requirements

AC Line Power	117 V ± 10% or 234 V ± 10% 50-60 Hz, 25 VA
DC Power (External or Battery Pack)	12 V 1500 mA to 30 V 500 mA

Supplied Accessories	Instruction Manual Two (2) LP-16AX probes AC Power Cable DC Power Cable Two (2) BNC post adapters Spare 0.3A slow-blow fuse LH-2008 Viewing Hood
Optional Accesories	LC-2215 Carrying Case LC-2006 Protective Front Cover LP-2054 Trchargeable Battery Pack (LBO-308S only)

Table 1-2
LP-16AX SPECIFICATIONS

10X Position

Input Impedance	10 megohms in parallel with 25 pF
Voltage Division Ratio	10:1 ± 2%
Bandwidth	DC-40 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 required to operate the LBO-308PL 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 applications.

2-1 Function of Controls, Connectors, and Indicators

Before turning this instrument on, familiarize yourself with the controls, connectors, indicators, and features described in this section. The descriptions given below 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).

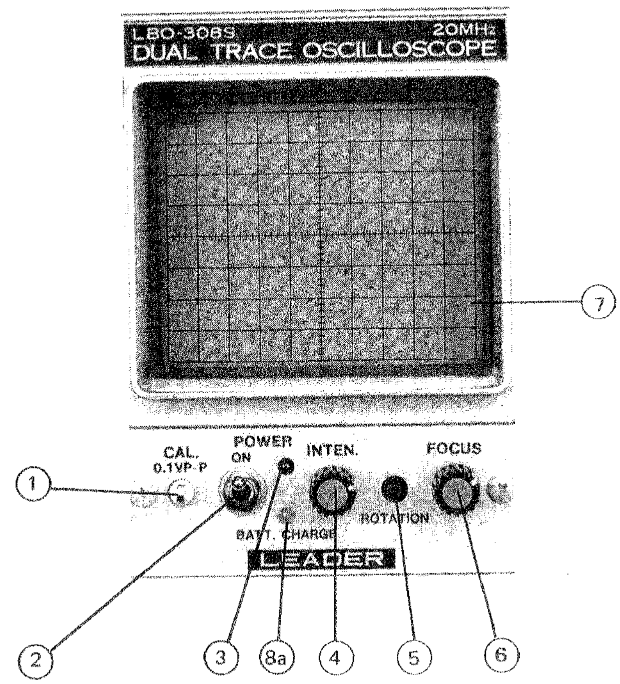


Figure 2-1. Display block

(1) CAL connector	Provides fast-rise square wave of precise amplitude for probe adjustment and vertical amplifier calibration.
(2) POWER switch	Turns instrument power on and off.
(3) POWER lamp	Lights when instrument is energized.
(4) INTEN control	To adjust the brightness of the CRT display. Clockwise rotation increases brightness.
(5) ROTATION control	Provides screwdriver adjustment of trace alignment with regard to the horizontal CRT graticule lines.
(6) FOCUS control	To attain maximum trace sharpness.
(7) CRT	Display device having a grid (graticule lines) inscribed on the inner CRT surface for parallax-free measurements. Blue filter provides good contrast and pleasing display.
(8a) BATT. CHARGE lamp (LBO-308S only)	Glows red when battery is charging; glows green when battery is fully charged.

2-1-2 Vertical Amplifier Block

Refer to Figure 2-2 for reference (8) to (16).

(8) Ch-1 or X-IN connector	For applying an input signal to verticle-amplifier channel 1, or the X-axis (horizontal) amplifier during X-Y operation.
(9) 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.
(10) VOLTS/DIV switches	To select the calibrated deflection factor of the input signals applied to the vertical amplifiers.
(11) VARIABLE controls	Provide continuously-variable adjustment of deflection factor between steps of the VOLTS/DIV switches. VOLTS/DIV calibration is accurate only when the VARIABLE control is in the detente or fully clockwise positions.
(12) 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.

(13) 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.

(14) 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.

(15) VERT 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.

DUAL pushbutton displays the input signals of both channels on the CRT when pressed. The simultaneous trace appearance is achieved by chopping the signals at sweep speeds of 0.25 to 0.5 mS per division, and alternately displaying signals at sweep speeds of 0.2 mS to 0.5 μs per division.

ADD pushbutton displays a single trace that is algebraic sum of the channel 1 and channel 2 input signals. This results in a differential display if the CH-2 POL switch is set to INV.

(16) CH-2 POL. switch
Inverts the polarity of the channel 2 signal when depressed.

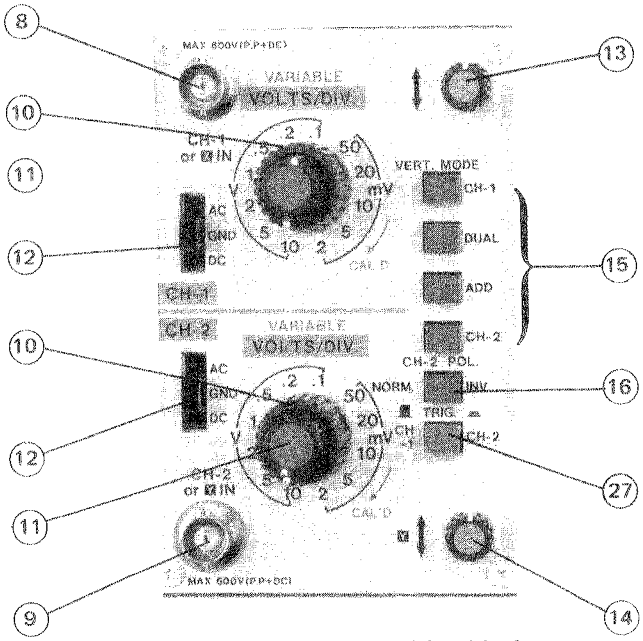


Figure 2-2. Vertical amplifier block

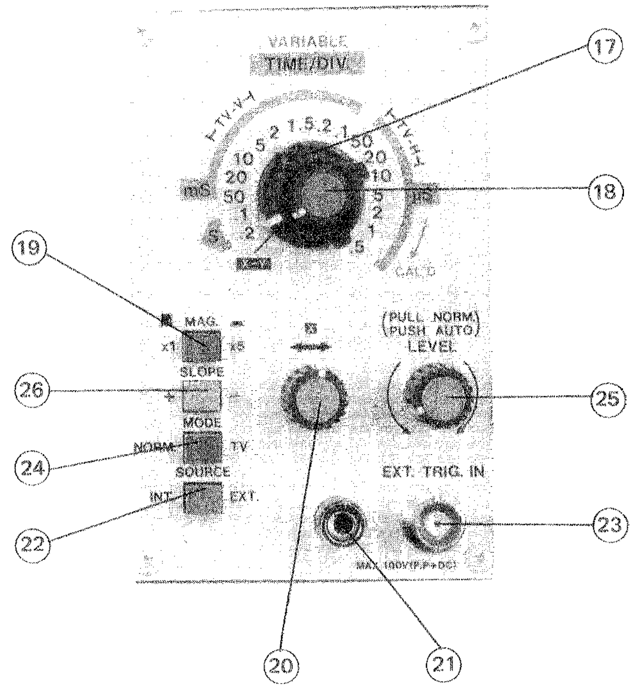


Figure 2-3. Sweep and trigger block

2-1-3 Sweep and Trigger Block

Refer to Figure 2-3 for references (17) to (26), and to Figure 2-2 for reference (27).

(17) TIME/DIV switch
To select either the calibrated sweep rate of the timebase, or X-Y operation.

(18) VARIABLE control
Provides continuously-variable adjustment of sweep rate between steps of the TIME/DIV switch. TIME/DIV calibrations are accurate only when the VARIABLE control is in the detente, or fully clockwise position.

(19) MAG switch
To expand the horizontal deflection by a factor of 5 when pressed in, thus increasing horizontal sweep speed by 5 times for X-Y operation. The effective timebase sweep rate is reduced by a factor of 5, making 0.1 μS per division the highest sweep speed available.

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

(21) Ground connector
Provides a convenient point to attach a separate ground lead to the oscilloscope.

(22)	SOURCE switch	To select the signal used for timebase triggering. INT (button out) position selects trigger signal from the vertical amplifier signals. EXT (button in) position uses the signals applied to the EXT TRIG IN connector to trigger the timebase.
(23)	EXT TRIG IN connector	For applying an external trigger signal to the oscilloscope.
(24)	MODE switch	To select the coupling mode for the signals applied to the trigger circuits. NORM (button out) position provides simple capacitive coupling, thus blocking any DC component of the trigger signal and attenuating AC signals below 20 Hz. TV (button in) position provides sync separation in accordance with the TIME/DIV switch setting. The vertical sync signal is selected for TIME/DIV switch settings of 0.1 mS and slower; the horizontal sync signal is selected for sweep speeds of 50 μS div and faster.
(25)	NORM/AUTO Trigger Mode switch (on LEVEL control)	To select the triggering mode. When depressed, sweep free runs and a baseline is displayed in the absence of signal. Automatically switches to triggered sweep when a signal of 50 Hz or higher is present and other trigger controls are properly set. When pulled, sweep occurs only when a trigger signal is present and other controls are properly set. No trace is visible in the absence of a trigger signal.
(25)	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 toward the negative peak of the trigger signal.
(26)	SLOPE switch	To sleect the positive or negative slope of the trigger signal for initiating sweep.
(27)	TRIG switch	To select the channel that will serve as the internal trigger signal source. CH-1 position (button out) selects channel 1 as the internal trigger-signal source. CH-2 position (button in) selects channel 2 as the internal trigger signal source.

2-1-4 Miscellaneous

Refer to Figure 2-4 for reference (28 to (37).

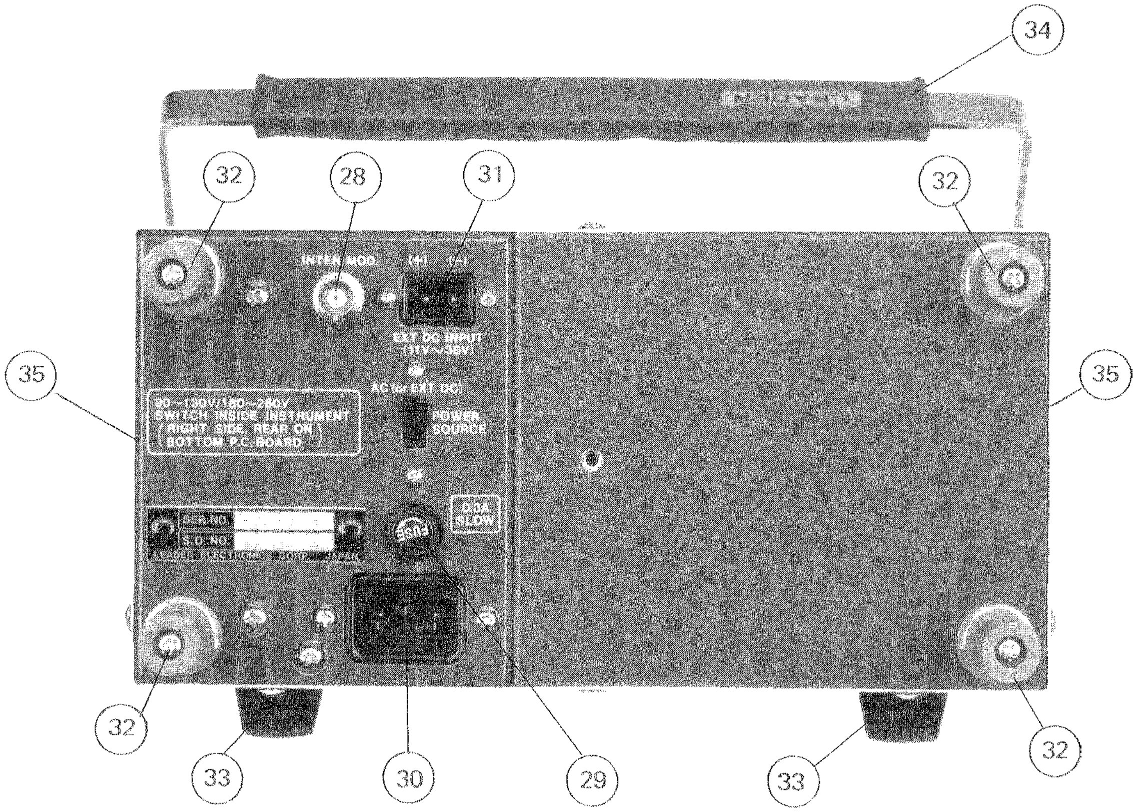
(28)	INTEN MOD connector	For applying signal to intensity modulate the CRT.
(29)	FUSE	Receptacle permits quick fuse replacement without opening case.
(30)	Power connector	Permits removal or replacement of AC power cord
(31)	EXT DC INPUT connector	For applying an external DC voltage to operate the instrument.
(32)	Cord Caddy	Provides a quick method of securing the power cord, and supports the oscilloscope for vertical operation.
(33)	Feet	Support the oscilloscope for shelf mounting.
(34)	Handle	Permits easy carrying, and serves as a tilt-stand for bench-top use.
(35)	Handle-position Lock	Permits handle to be rotated (relative to case) in 22.5° increments for carrying or case support.
(36)	POWER SOURCE switch (LBO-308S only)	To select either internal power (LP-2054 battery pack) or external power (AC line or external battery).
(37)	Rear plate (LBO-308S only)	Removeable plate for installation of internal battery pack.

2-2 Initial Operation

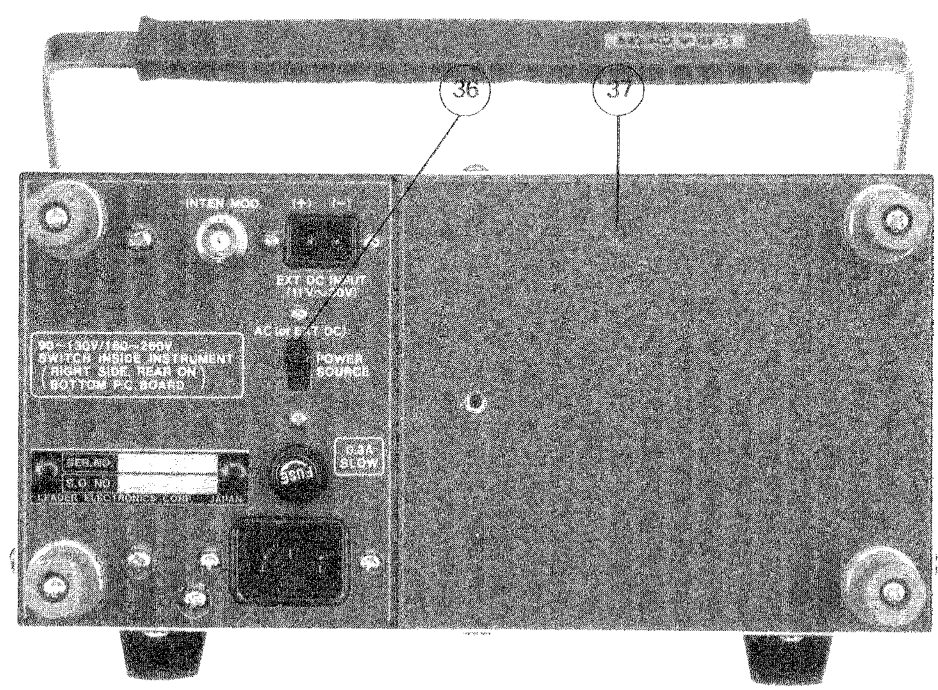
Before the instrument is put into use for the first time, perform the following procedures *in the order listed* to ensure satisfaction and prevent damage to the instrument.

2-2-1 Power Connections and Adjustments

AC Operation. The LBO-308PL is normally shipped wired for a nominally 117 VAC power source and will operate at line voltages of 90-130 VAC. A switch located within the instrument case allows the LBO-308PL to be operated from a 180-260 VAC power source. To convert to 180 V to 260 V operation, proceed as follows:



a. LBO-308PL/S common features



b. LBO-308S exclusive features

Figure 2-4. Rear panel and case features

CAUTION: Operation at voltages outside the stated ranges may result in imroper performance and/or damage to the instrument.

1. Remove the six screws (two on top and two each side) holding the top cover to the instrument frame, then lift off the cover and handle attached.

WARNING: Ensure the power cord is not pluged in.

2. The voltage-changeover switch is located in front of the power transformer, on the PC board. Slide the block switch handle towards the power transformer to the position marked "180V–260V".

3. Reinstall the instrument cover and six screws removed in Step. 1.

Once the LBO-308PL is set to operate on the local power-line voltage, insert the female end of the power cord into the Power connector (30) on the back panel.

The LBO-308S can be operated as described above after setting its back-panel POWER SOURCE switch (36) to AC.

DC Operation. The LBO-308PL may be set up to operate from a DC power source by simply inserting the supplied DC Power Cable into the EXT DC INPUT connector (31). This automatically disables the AC power circuitry and line cord, and allows power supplied to the [EXT DC INPUT] back-panel connector to energize the instrument. The POWER switch (2) on the front panel becomes functional in controlling the DC power input. This input power may be anywhere in the 12 V 1500 mA to 30 V 500 mA range.

The LBO-308S may also be operated as described above after setting its back-panel POWER SOURCE switch (36) to EXT DC.

LP-2054 Battery Pack. The LBO-308S only can be operated from an internal optional battery pack, the LP-2054. To install the LP-2054, proceed as follows:

1. Remove the Rear Plate (37) by unscrewing the two Cord Caddys (32) attached to this plate, and four screws.
2. Connect the battery pack to the connector on the end of the battery cable. Place this connector along the right edge of the battery pack and insert the pack into the space provided.
3. Replace the Rear Plate and Cord Caddys removed in Step 1. Be certain not to pinch the battery cable between Rear Plate and cabinet.

The LBO-308S will operate approximately 1 1/2 hours from a fully-charged LP-2054. This battery pack is recharged automatically when the LBO-308S is connected to an AC line. Give the LP-2054 its initial charge *after* performing all of the adjustments decribed in *AC Operation.* The BATT. CHARGE lamp (38) glows red while the battery pack is charging, and green when the charging is completed. When operation from the LP-2054 is desired, proceed as follows:

1. Disconnect the power cord from the AC line.
2. Disconnect the power cord from the Power Connector (30).
3. Set the POWER SOURCE switch (36) to BATTERY (INT).

2-2-2 Installation

The LBO-308PL/S will operate in either a horizontal or vertical position. It therefore, has features that allow easy placement on a bench top, riser shelf, or upright on the floor.

For bench-top mounting, it is advantageous to have the front of the instrument tilted upward for straight-on viewing. Press in the two Handle-position Locks (33) and simultaneously rotate the Handle (34) so it points below the case, then release the locks.

If the instrument is placed on a riser shelf above the work bench, rotate the Handle above the instrument and as far towards the back as possible. It is not necessary to lock it in this position.

If lack of working space requires that the instrument be placed on the floor, stand the LBO-308PL/S on end. The Cord Caddy (32) will act as legs to support the instrument. Rotate the Handle towards the back for clear access to the front-panel controls.

The LBO-308PL/S is designed to operate over a temperature range of 0°C to +40°C (32°F to 104°F) and a humidity range of 10 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.

AC/GND/DC switches (12)	AC
VOLTS/DIV switches (10)	50 mV
VARIABLE controls (11)	Fully CW
VERT MODE switches (15)	DUAL
Vertical Position controls (13) (14)	Index up
INTEN control (4)	Index up
FOCUS control (6)	Index up
CH-2 POL switch (16)	NORM
TIME/DIV switch (17)	.2 mS
VARIABLE control (18)	Fully CW
Horizontal Position control (20)	Index up
MAG switch (19)	X1
NORM/AUTO switch (25)	Index up
MODE switch (24)	NORM
SOURCE switch (22)	INT
TRIG switch (27)	CH-1
SLOPE switch (26)	+

2. Plug the power cord into a convenient AC receptacle and turn-on the POWER switch (2). Shortly, two traces should appear. If the traces are *extremely* bright, turn the INTEN control (4) counterclockwise. Otherwise, allow the instrument to 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 recommended is the standard practice of turning the intensity down if the scope is left unattended for any period of time.

3. Turn the INTEN control to adjust the brightness to the desired amount.
4. Adjust the FOCUS control (6) for a sharp trace.
5. Turn the CH-1 Vertical Position control (13) to move the CH-1 trace two divisions down from the top of the graticule grid. Turn the CH-2 Vertical Position control (14) to move the CH-2 trace two divisions up from the bottom of the graticule grid.
6. See if the traces are precisely parallel with the graticule lines. If they are not, adjust the ROTATION control (5) with a small screwdriver.
7. Turn the Horizontal Position control (20) to align the left edge of the traces with the left-most graticule line.
8. Connect the CH-1 or X-IN (8) and CH-2 or Y-IN (9) 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 (25) for a stable display.
9. Disconnect the vertical inputs from the calibrator output.

2-3 Basic Operating Procedures

The following paragraphs in this section describe how to operate the LBO-308PL beginning with the most elementary operating modes, and progressing to the less frequently-used and/or 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 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 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 kinds of connectors.

Scope probes are the most popular method of connecting the oscilloscope to circuitry. These probes are available with 1X attenuation (direct 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 picofarads. The reduction in input capacitance is the most important reason for using attenuator probes at high frequencies, where capacitance is the major factor in loading down a circuit and distorting the signal.

Dispite their high input impedance, attenuator probes do not pickup appreciable hum or noise. As was the case with coaxial cable, the outer conductor of the probe cable shields the central signal conductor. Scope probes, of any attenuation, are also quite convenient from a mechanical standpoint. Nearly all quality probes have a spring-loaded hook end that quickly and securely holds the probe to wiring and component leads. This hook can be removed to expose a needlepoint, excellent for use on the foil side of a pc board, or for quick 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 input connector of the oscilloscope. A coaxial cable matching characteristics impedance connects the signal source to the terminator. This techinque allows using cables 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 will appear in the displayed 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-308PL/S Ground connector (21) and the chassis or ground bus of the circuit under observation.

    WARNING: The LBO-308PL/S 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 the LBO-308PL/S or any other test equipment to "AC/DC", "hot chassis", or "transformerless" devices. Similarly, do NOT connect the LBO-308PL/S directly to the AC power line or any 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 internal triggering is the most elementary operating mode of the LBO-308PL. Use this mode when you wish to observe only a signal signal, and not be distracted by other traces on the CRT. Either channel can be used. However, channel 2 has a polarity-inverting switch, which adds additional flexibility to this channel.

The LBO-308PL is set up for single trace operation as follows:

1. Set the following controls 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 TRIG (27)) must match the channel selected (CH-1 or CH-2 VERT MODE (15)).

VARIABLE control (11)	Fully CW
AC/GND/DC switch (12)	AC
VERT MODE switches (15)	CH-1 (CH-2)
CH-2 POL switch (16)	NORM
TRIG switch (27)	CH-1 (CH-2)
VARIABLE control (18)	Fully CW
MAG switch (19)	X1
NORM/AUTO switch (25)	Pushed in
MODE switch (24)	NORM
SOURCE switch (22)	INT
POWER switch (2)	ON
INTEN control (4)	APS*
FOCUS control (6)	APS*
LEVEL control (25)	APS*
Horizontal Position control (20)	APS*

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

2. Use the corresponding Vertical Psoition control (13) or (14) to set the trace near mid screen.
3. Connect the signal to be observed to the corresponding input connector (8) or (9), and adjust the corresponding VOLTS/DIV switch (10) .so the displayed signal is totally on screen.

CAUTION: Do not apply a signal greater than 600 V (DC + AC peak)

4. Set the TIME/DIV switch (17) so the desired number of cycles of signal are displayed. For some measurements just 2 or 3 cycles are best, for other measurements 50-100 cycles (appearing as a solid band) works best. Adjust the LEVEL control if necessary for a stable display.
5. If the signal you wish to observe is so high in frequency that even the .5 μS position of the TIME/DIV switch results on too many cycles displayed, depress the MAG pushbutton (19). This increases the effective sweep speed by a factor of 5, so .5 μs/div becomes .1 μs/div.
6. If the signal you wish to observe is either DC or low enough in frequency that AC coupling attenuates or distorts the signal, flip the AC/GND/DC switch (12) to DC.

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

2-3-3 Triggering Alternatives

Triggering is often the most difficult operation to perform on an oscilloscope because of the many options available and the exacting requirements of certain signals. Internal trigger and the AUTO sweep mode, the trigger options selected for the single-trace operating procedure described in the previous paragraph, work well with most signals. However, for complex or otherwise difficult signals, other triggering control settings may be needed.

Trigger Mode Selection. Normally, the CRT beam is not swept horizontally across the face of the CRT until a sample of the signal being observed, or another signal harmonically related to it, triggers the timebase. This is the situation when the NORM trigger mode is selected by pulling the LEVEL knob (25). However, this trigger mode is inconvenient because no baseline appears on the CRT screen in the absence of an input signal, or if the trigger controls are improperly set. Since the absense of a trace can also be due to an improper-set vertical position control or VOLTS/DIV switch, much time can be wasted determining the cause. The AUTO trigger mode (LEVEL knob pushed in) 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 nonsynchronous dispaly when vertical signal is present but the trigger controls are inproperly set. This immediately indicates what is wrong. The only fault of AUTO operation is that signals below 50 Hz, or complex signals of any frequency, may not reliably trigger the timebase. Therefore, the usual practice is to leave the LEVEL knob if any signal (particular one below 50 Hz) fails to produce a stable display.

Trigger Source Options. The 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 (22) and TRIG (27) pushbuttons select the trigger source.

The SOURCE pushbutton selects either internal trigger (from CH-1 or CH-2) or an external trigger applied to the EXT TRIG IN connector (23).

CAUTION: Do not apply a signal greater than 600 V (DC + AC peak).

When internal trigger is selected, the TRIG pushbutton must also be used to select which channel will provide this internal trigger signal. The choice of channels remain even if the trigger channel is not dispalyed; the only requirement is that signal be appled to the trigger-source channel and the associated VOLTS/DIV switch be set provide sufficient signal amplitude (over 1 division).

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.

Using any trigger source not derived from the channel you are watching has the advantage that changes in the ampltiude of the signal under observation 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 further advantage that complex and/or noisy signals can be stably displayed providing the trigger signal is "clean".

Trigger Coupling Options. The normal trigger coupling mode is AC (i.e. a capacitor couples the trigger signal to the trigger circuits). Pressing the coupling MODE switch (24) inserts a TV sync separator into a trigger chain, so a clean trigger signal at either the vertical or horizontal repetition rate can be removed from a composite video signal. The setting of the TIME/DIV switch (17) determines whether vertical-rate (field) or horizontal-rate (line) sync pulses are passed to the trigger circuits. TIME/DIV switch settings of .2 S to .1 mS select the vertical-rate pulses; settings of .5 to 50 μS select the horizontal-rate pulses.

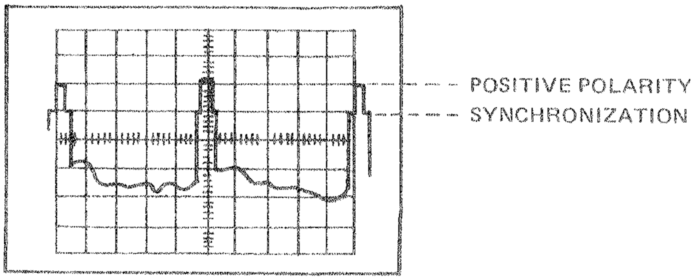
When TV coupling is selected, the SLOPE switch (26) must be matched to the polarity of the video signal. Leave the SLOPE pushbutton out (+ position) for positive-sync signals (Figure 2-5a), and depress it (– position) for negative-sync video signals (Figure 2-5b).

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-308PL has two controls that enable the operator to reliably achieve this condition. They are the LEVEL control (25) and the SLOPE switch (26).

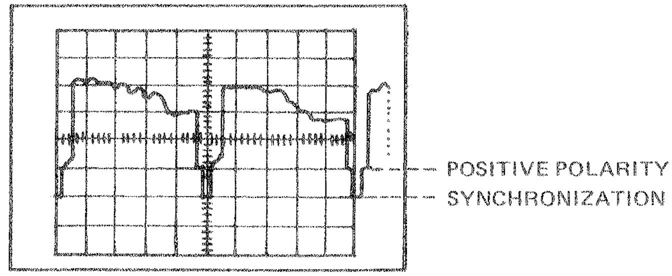
The SLOPE switch determines whether the sweep will begin on a positive-going or negative-going slope of the trigger signal (see Figure 2-6). In some cases the choice of slope is unimportant, in others it is vital to attaining a stable and/or jitter-free display. Always select the steepest and most stable slope or edge. For example, small changes in the amplitude of the sawtooth shown in Figure 2-6a 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 2-6b, 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 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 switch setting) yields a trace that has only the trailing-edge jitter of the original signal. If you are ever in doubt as to the best trigger slope, or have an unsatisfactory display, try both SLOPE switch settings for the most stable display.

The LEVEL control determines the point on the selected slope at which the timebase will be triggered. The effect of this control on the displayed trace is shown in Figure 2-7a. The arrow panel markings for this control refer to points more positive (clockwise) and more negative (counterclockwise) than the waveform's zero crossing. 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 negative trigger point, whereupon the display will free run (AUTO sweep mode) or disappear completely (NORM sweep mode). Try to trigger at the midpoint of slow-rise waveforms (such as sine and traingular waveforms), since these are usually the cleanest spots on these waveforms. As Figure 2-7b shows, triggering on a noisy area will cause instability in the display.

The larger the amplitude of the trigger signal actually delivered 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 amplitude is proportional to the number of graticule

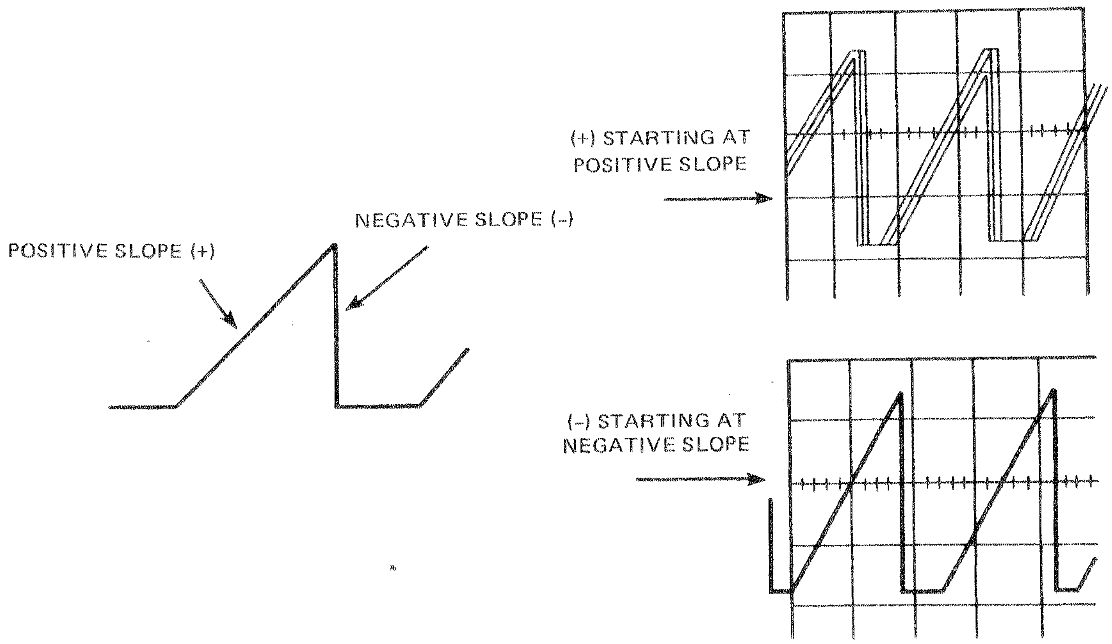


a. Position of SLOPE Switch (26): +

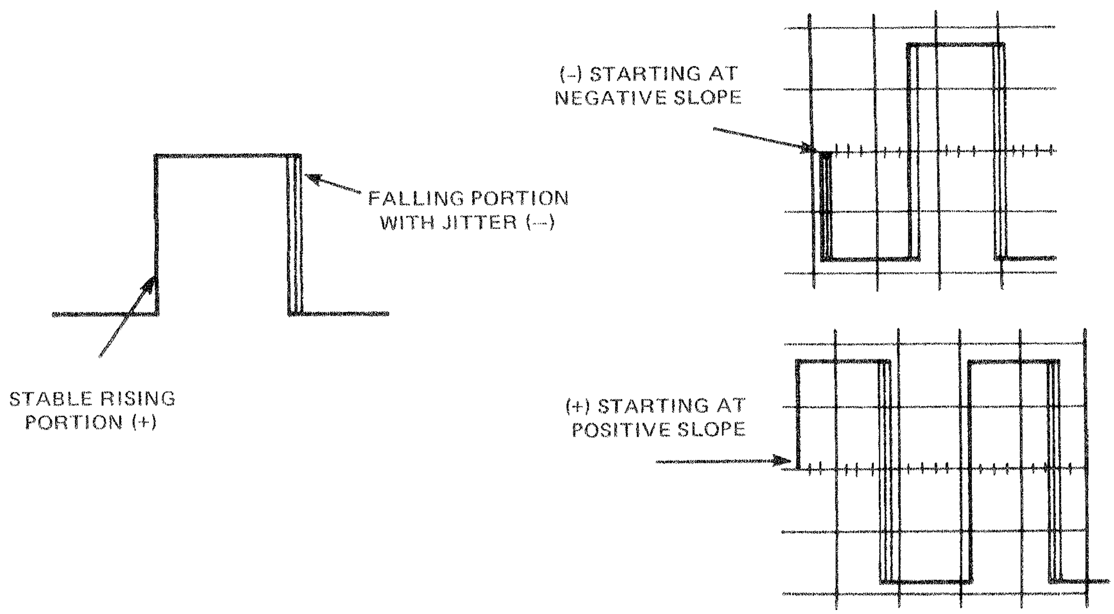


b. Position of SLOPE Switch (26): –

Figure 2-5. Matching the SLOPE switch setting to TV signal polarity



a. SAWTOOTH WAVEFORM



b. SQUARE WAVE

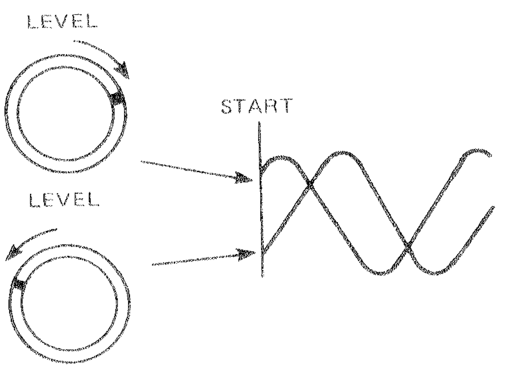
Figure 2-6. SLOPE switch setting

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.

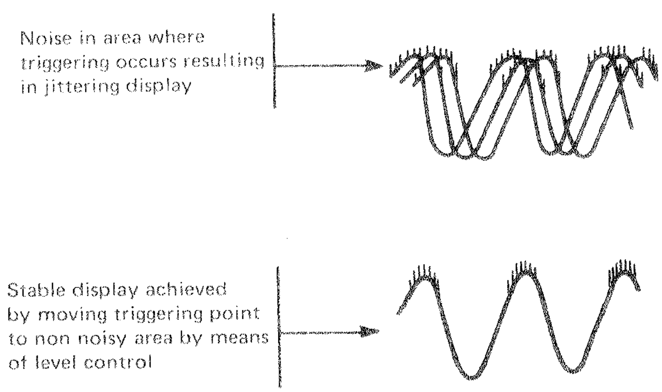
2-3-4 Probe Compensation and Use

The LP-16AX probes furnished with the LBO-308PL can be set for either low-capacitance operation (10X attenuation) or direct connection (1X attenuation). The selection is made by rotating the collar at the end of the probes main body (see Figure 2-8a) 1/2 turn. The appearance of a new attenuation indication as the collar click-stops into position shows the conversion is completed.

At either attenuation setting you have a choice of spring-loaded hook tip or needlepoint (see Figure 2-8b). 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 and permit attachment. Releasing the flange secures the hook to the hook to the circuit under observation. To expose the needle tip, unscrew the hook cover as shown.



a. Effect of LEVEL Control Adjustment on Triggering Starting Position



b. Elimination of Jittering Display by LEVEL Control Adjustment

Figure 2-7. LEVEL Control Adjustment

When 1X attenuation is selected, the probe simply operates as a section of a shielded cable. The signal source "sees" the 1 megohm input resistance of the LBO-308PL in parallel with its 35 pF input capacitance *and* the 200 pF or so cable capacitance of the probe. Because of this capacitance of this capacitance, 1X attenuation is generally used only at low frequencies and/or with low-impedance signal sources. Although many conditions (sources impedance, source capacitance, frequency, allowable error, etc.) are factors in attenuation choice, the impedance and frequency limits beyond which 1X operation of the LP-16AX 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 2-8c) that has a constant division ratio at all frequencies. Moreover, the signal source "sees" 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 1X attenuation. To do this, proceed as follows:

1. Connect a probe to the CH-1 or X-IN connector (8) and the CAL connector (1).

   NOTE: For best results, connect the probe ground lead to the other channel's input connector or the Ground connector (21).

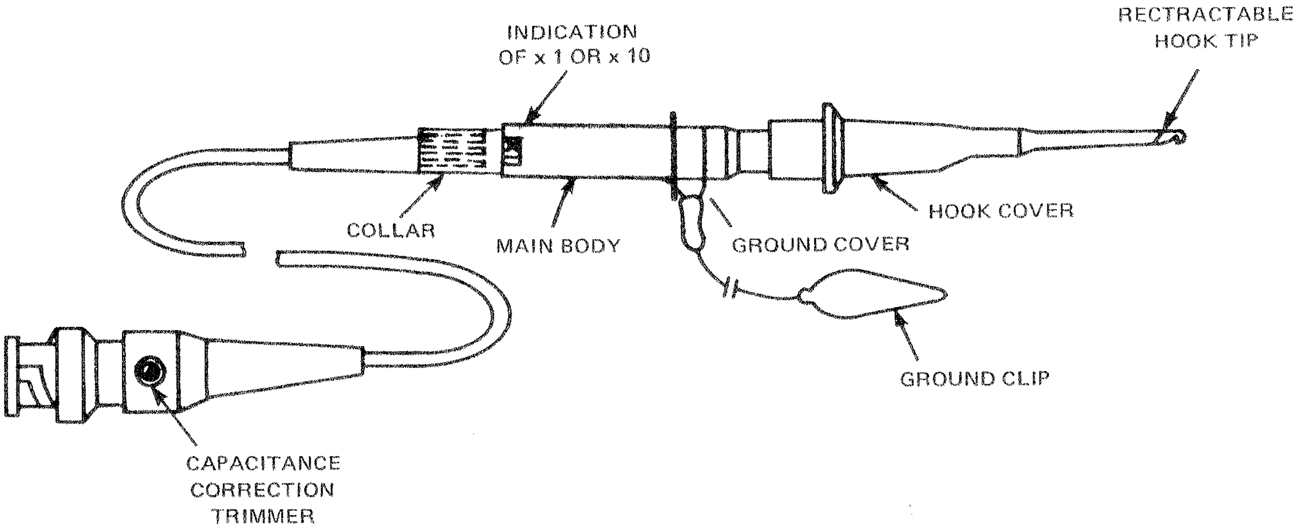
2. Set the channel 1 VOLTS/DIV switch (10) to 5 mV, and the TIME/DIV switch (17) to .2 mS.
3. Press the CH-1 VERT MODE pushbutton (15), and make sure the TRIG pushbutton (27) is out.
4. With a small screwdriver, adjust the capacitance-connection trimmer (Figure 2-8a) for a correctly-compensated square square wave (Figure 2.8d).
5. Press the CH-2 VERT MODE (15) and TRIG pushbuttons, and perform Steps 1, 2, and 4 for *channel* 2 with the *other* probe.

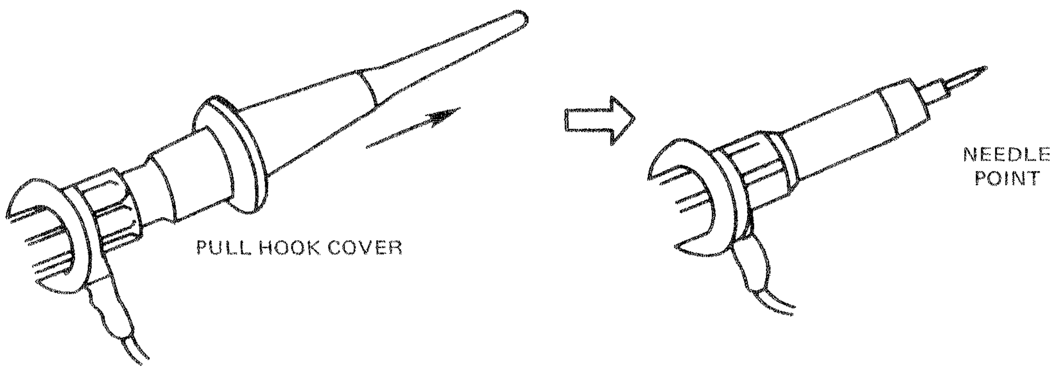
2-3-5 Dual-trace Operation

Dual-trace operation is the intended operating mode of the LBO-308PL. To set up the LBO-308PL for dual-trace operation, proceed as follows:

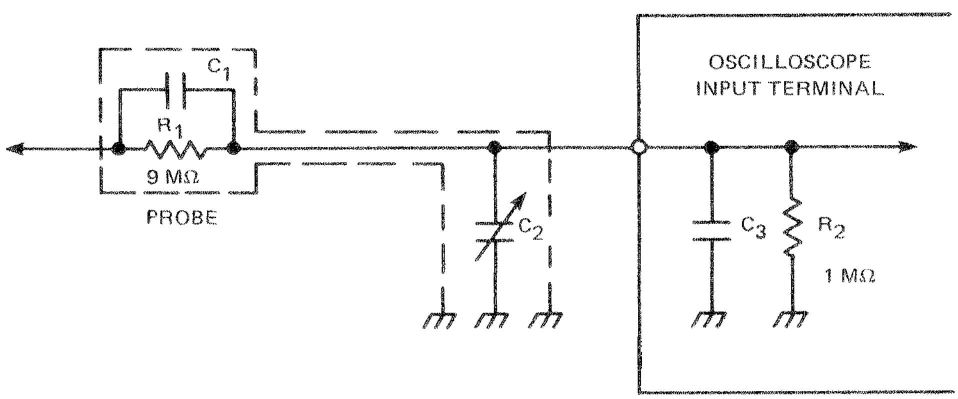
1. Set the following controls as indicated below. Any control not mentioned here or in the following steps can be neglected.

VARIABLE controls (11)	Fully CW
AC/GND/DC switches (12)	AC
VERT MODE switches (15)	DUAL
CH-2 POL switch (16)	NORM
TRIG switch (27)	CH-1 or CH-2*
VARIABLE control (18)	Fully CW
MAG switch (19)	X1

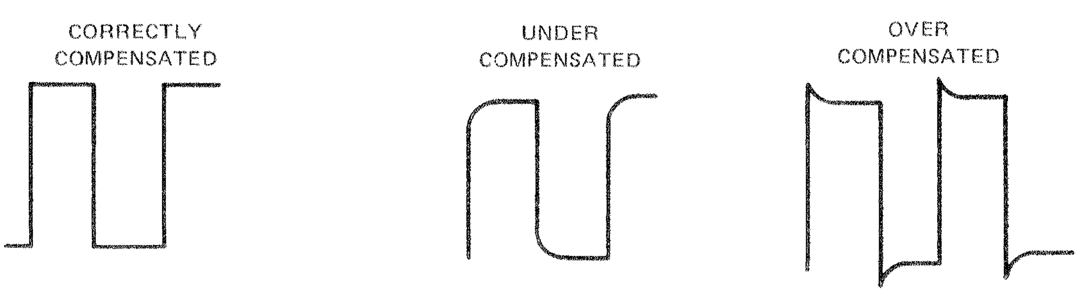




b. PROBE CONVERSION: HOOK TIP TO NEEDLE POINT



c. SCHEMATIC REPRESENTATION



d. EFFECTS OF PROBE COMPENSATION

Figure 2-8. Direct/Low Capacitance Probe LP-16AX

NORM/AUTO switch (25)	Pushed in
MODE switch (24)	NORM
SOURCE switch (22)	INT
POWER switch (2)	ON
INTEN control (4)	APS**
FOCUS control (6)	APS**
LEVEL control (25)	APS**
Horizontal Position control (20)	APS**

*See Step 5

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

2. Use the Vertical Position controls (13) and (14) 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.
3. Connect the signals to be observed to the CH-1 and CH-2 Input connectors (8) and (9), and adjust the VOLTS/DIV switches (10) so the displayed signals are totally on screen and clear of each other.

   CAUTION: Do not apply signals greater than 600 V (DC + AC peak).

4. Set the TIME/DIV switch (17) to display the desired number of cycles.
5. If both channels are handlling signals of the same frequency, trigger from the channel having the steepest-slope waveform. If the channels are carrying different but harmonically-related frequencies, trigger from channel carrying the lowest frequency. Adjust the LEVEL control (if necessary) after selecting the trigger channel.

   NOTE: If you disconnect the signal to the trigger-source channel, both traces will free run.

6. If the signals you wish to observe are so high in frequency that even the .5 μS position of the TIME/DIV switch results in too many cycles displayed, press in the MAG pushbutton (19). This increases the effective sweep speed by a factor of 5, so .5 μS/div becomes .1 μS/div.
7. If the signals you wish to observe are either DC or low frequency that AC coupling attenuates or distorts the signal, flip the AC/GND/DC switches (12) 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* bewteen the CH-1 and CH-2 signals.

To set up the LBO-308PL for additive operation, proceed as follows:

1. Set up for dual-trace operation per paragraph 2-3-5.
2. Make sure both VOLTS/DIV switches (10) are set to the position; and the VARIABLE controls (11) are click-stopped in their CAL'D positions. If the signal levels are very different, set both VOLTS/DIV switches to the position producing a large on-screen display of the *highest-amplitude* signal.
3. Trigger from the channel having the largest signal.
4. Press the ADD VERT MODE (15) pushbutton. The signal trace resulting is the algebraic sum of the CH-1 and CH-2 signals. Either or both of the vertical Position controls (13) and (14) 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 p-p amplitude of the resultant trace is very small, turn *both* VOLTS/DIV switches to increase the display height. Make sure both VOLTS/DIV controls are set to the same position.

To set up the LBO-308PL for differential operation, proceed follows:

1. Set up for dual-trace operation per paragraph 2-3-5.
2. Make sure both VOLTS/DIV switches are set to the same 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 biggest signal.
4. Press in the CH-2 POL pushbutton (16).
5. Press the ADD VERT MODE pushbutton (15). The signal trace resulting is the algebraic difference of the CH-1 and CH-2 signals. Either or both of the Vertical Position controls (13) and (14) 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 individual 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 small, turn *both* VOLTS/DIV switches to increase the display height. Make sure both VOLTS/DIV controls are set to the same position.

2-3-7 X-Y Operation

The internal timebase of the LBO-308PL is not utilized in X-Y operation; deflection in both the vertical *and* horizontal directions is via external signals. One of the vertical channels serves as the X-axis (horizontal) signal processor, so horizontal and vertical axes have identical control facilities.

All of the VERT MODE (15), TRIG (27), SLOPE (26), MODE (24), and SOURCE (22) pushbuttons, as well as the LEVEL control (25) are inoperative in the X-Y mode.

To set up the LBO-308PL for X-Y operation, proceed as follows:

1. Turn the TIME/DIV switch (17) fully counterclockwise to the X-Y position.

   CAUTION: Reduce the trace intensity, lest the undeflected spot may damage the CRT phosphor.

2. Apply the vertical signal to the CH-2 or Y-IN connector (9), and the horizontal signal to the CH-1 or X–IN connector (8). Once the trace is deflected, restore normal brightness.
3. Adjust the trace height with the CH-2 VOLTS/DIV switch (10), and the trace width the CH-1 VOLTS/DIV switch (10). The associated VARIABLE controls (11) can be if needed.

   NOTE: Further horizontal (X-axis) magnification is available from the MAG pushbutton (19), but is unlikely to be needed. Leave the MAG pushbutton out (X1 position) as a rule.

4. Adjust the trace position vertically (Y axis) with the CH-2 Vertical or Y Position control (14). Adjust the trace position horizontally (X axis) with the Horizontal or X Position control (20); the CH-1 Vertical Position control (13) has no effect during X-Y operation.
5. The vertical (Y-axis) signal can be inverted via the CH-2 POL switch (16).

2-3-8 Intensity Modulation

Intensity modulation, also known as Z-axis modulation, is a rarely-used 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 usually in conjunction with X-Y operation (described in paragraph 2-3-7).

To intensity modulate the CRT, simply connect the modulating signal to the INTEN MOD connector (28) on the back panel. Blanking occurs on the negative portion of the modulating signal, which is usually a pulse. To ensure blanking with pulses of all duty cycles, the required modulating signal amplitude is at least 3 volts peak-to-peak. Most TTL, ECL, and CMOS pulses are suitable. The *maximum* modulating signal amplitude is any case is 50 volts (DC + AC peak).

2-4 Measurement Applications

This section contains instructions for using your LBO-308PL 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 from each and every point on the waveform to a ground reference. When making either type of measurement, make sure that the VARIABLE controls (11) are click-stopped fully clockwise in their CAL'D positions.

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

1. Set up the LBO-308PL for the vertical mode desired per the instructions in 2-3 BASIC OPERATING PROCEDURES.
2. Adjust the TIME/DIV switch (17) for two or three cycles of waveform, and set the VOLTS/DIV switch (10) for the largest-possible totally on-screen display.
3. Use the appropriate Vertical Position control (13) or (14) to position the negative signal peaks on the nearest horizontal graticule line *below* the signal peaks, per Figure 2-9.
4. Use the Horizontal Position control (20) 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 peak with the central vertical graticule line. Multiply this number by the VOLTS/DIV switch setting to get the peak-to-peak voltage of the waveform. For example, if the VOLTS/DIV switch were set to 2V, the waveform shown in Figure 2-9 would be 11.2V p-p (5.6 div X 2V).

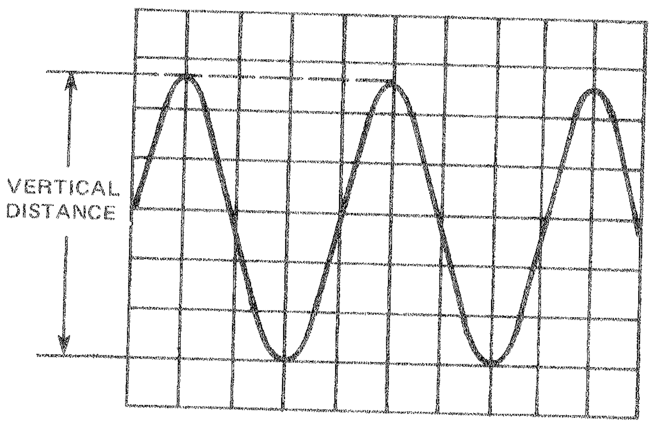


Figure 2-9. Peak-to-peak Voltage Measurement

6. If 10X attenuator probes are used, multiply the Step 5 voltage by 10 to get the correct p-p voltage.
7. If measuring a sine wave below 20 Hz, or a rectangular wave below 200 Hz, flip the AC/GND/DC switch to DC.

CAUTION: Make certain the waveform is not riding on a higher-amplitude DC voltage.

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

1. Set up the LBO-308PL for the vertical mode desired per instructions in 2-3 BASIC OPERATING PROCEDURES.
2. Adjust the TIME/DIV switch (17) for one complete cycle of waveform and set the VOLTS/DIV switch (10) for a trace amplitude of 4 to 6 divisions (see Figure 2-10).
3. Flip the AC/GND/DC switch (12) to GND.
4. Use the appropriate Vertical Position control (13) or (14) to set the base line on the central horizontal graticule line. However, if you know the signal voltage is wholly positive, use the bottom most graticule line. If you know the signal voltage is wholly negative, use the upper most graticule line.

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

5. Flip 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: Make certain the waveform is not riding on a high-amplitude DC voltage before flipping the AC/GND/DC switch.

6. Use the Horizontal Position control (20) to position any point of interest on the central vertical graticule line.

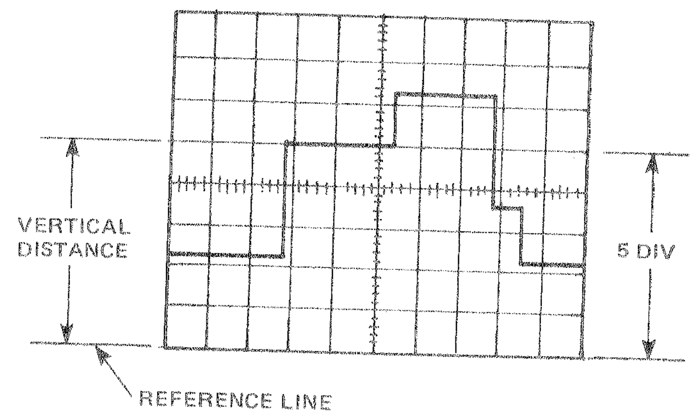


Figure 2-10. Instantaneous Voltage Measurement

This line 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 multipled by the VOLTS/DIV setting. In the example used for Figure 2-10, the voltage for a 0.5V/div scale is 2.5V (5.0 X .5V).

7. If 10X attenuator probes are used, multiply the Step 6 voltage by 10.

2-4-2 Differential Measurement Techniques

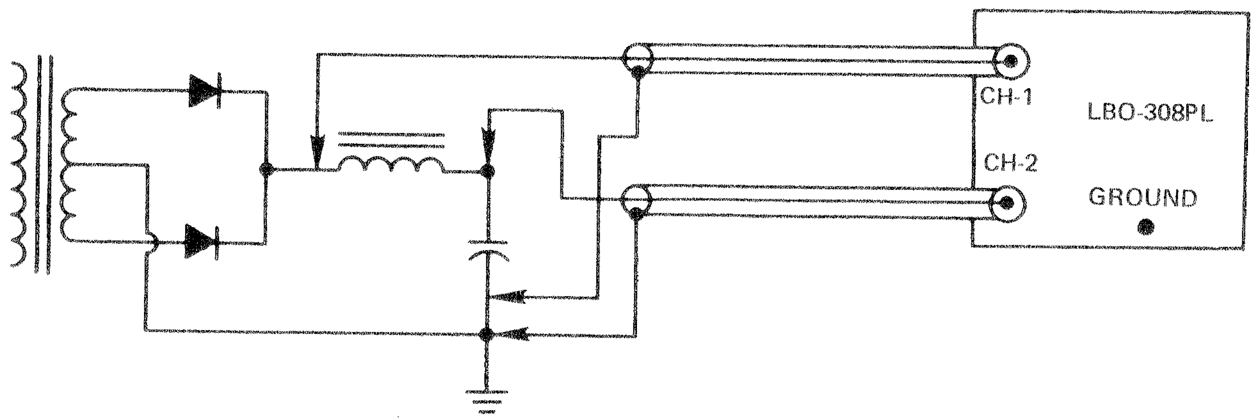
Differential measurement techniques allow direct measurement of the voltage drop across "floating" components both ends above ground), and measurement of very-small signals in electrically-noisy environments (such as exists near high-power AC machinery).

The control manipulations for differential operation were explained in paragraph *2-3-6 Additive and Differential Operation.* The techniques for making the physical connections are shown in Figure 2-11. Figure 2-11a shows the simple technique perferctly satisfactory 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 2-11b 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 or cable shields to the circuit under test avoids ground loops and EMI pickup.

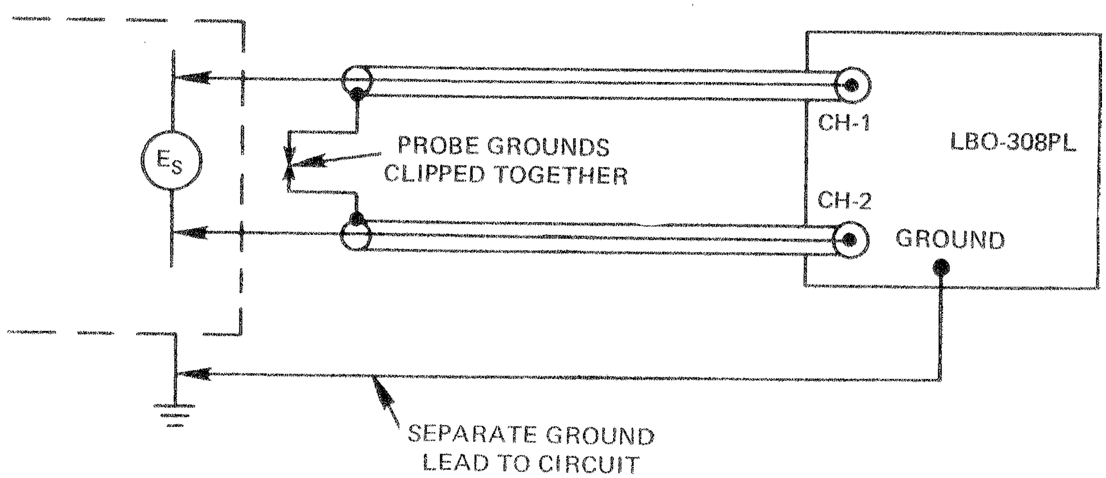
2-4-3 Time Interval Measurements

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

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.



a. HIGH-LEVEL SIGNAL CONNECTIONS



b. LOW-LEVEL TECHNIQUE

Figure 2-11. Connection Techniques for Differential Measurement.

1. Set up the LBO-308PL as described in *2-3-2 Single-trace Operation*.
2. Set the TIME/DIV switch (17) so the interval you wish to measure is totally on screen and as big as possible. Make certain the TIME/DIV VARIABLE control (18) is click-stopped fully clockwise in its CAL'D position. If it is not, any time interval measurements made under this condition will be inaccurate.
3. Use the Vertical Position control to position the trace so the central horizontal graticule line passes though the points on the waveform between which you want to make the measurement.
4. Use the Horizontal Position control (20) 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 TIME/DIV switch. If the MAG pushbutton (19) is pushed in, be certain to divide the TIME/DIV switch setting by 5.

Period, Pulse Width, and Duty Cycle. The basic technique described in the preceeding 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 2-12, 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 2-12a is 10 mS/div, so the period is 70 milliseconds in this example.

Pulse width is the distance bewteen 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 speed for this particular measurement. Increasing the sweep speed to 2 mS/div as in Figure 2-12b gives a large display, allowing more accurate measurement. An alternative technique useful for pulses less than a division wide is to press the MAG pushbutton (19), and reposition the pulse on screen with the coarse Horizontal Position control (20). 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 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).

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

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

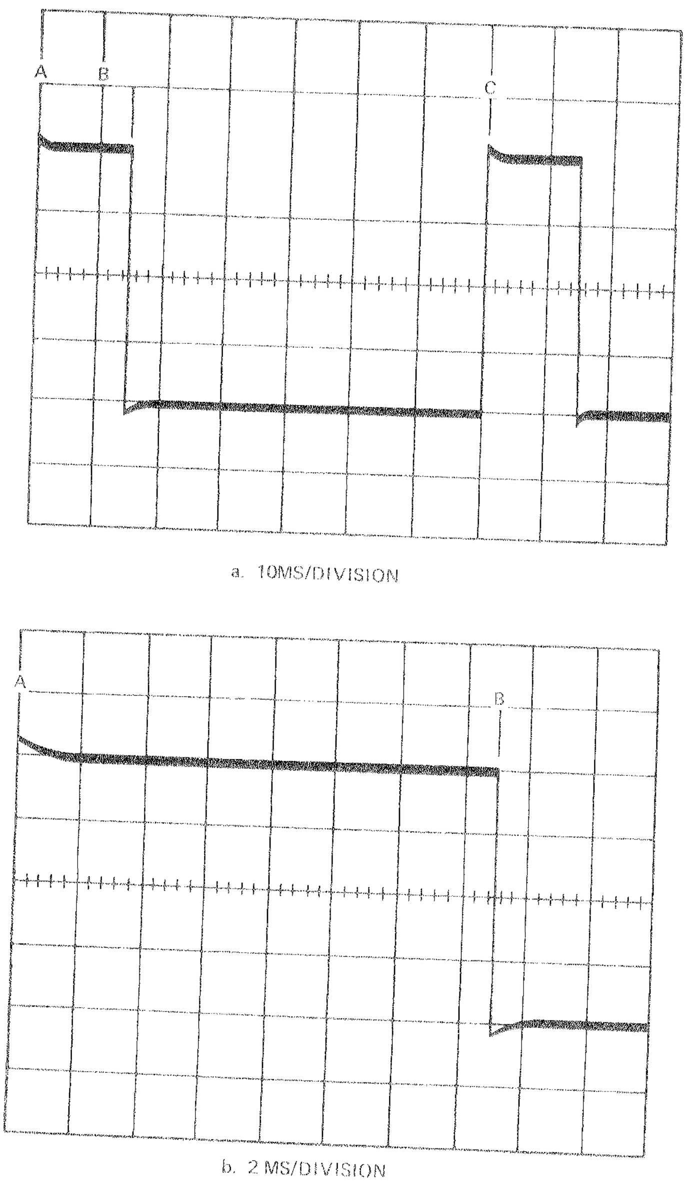


Figure 2-12. Time Interval Measurement

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 toh LBO-308PL as described in *2-3-5 Dual-trace Operation*, connecting one signal to the CH-1 Input connecting one signal to the CH-1 Input connector (8) and the other to the CH-2 Input connector (9).

   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 TRIG pushbutton (27) for the channel with the leading signal (CH-1 in the Figure 2-13 example), and make certain the SOURCE pushbutton (22) is out (INT position).

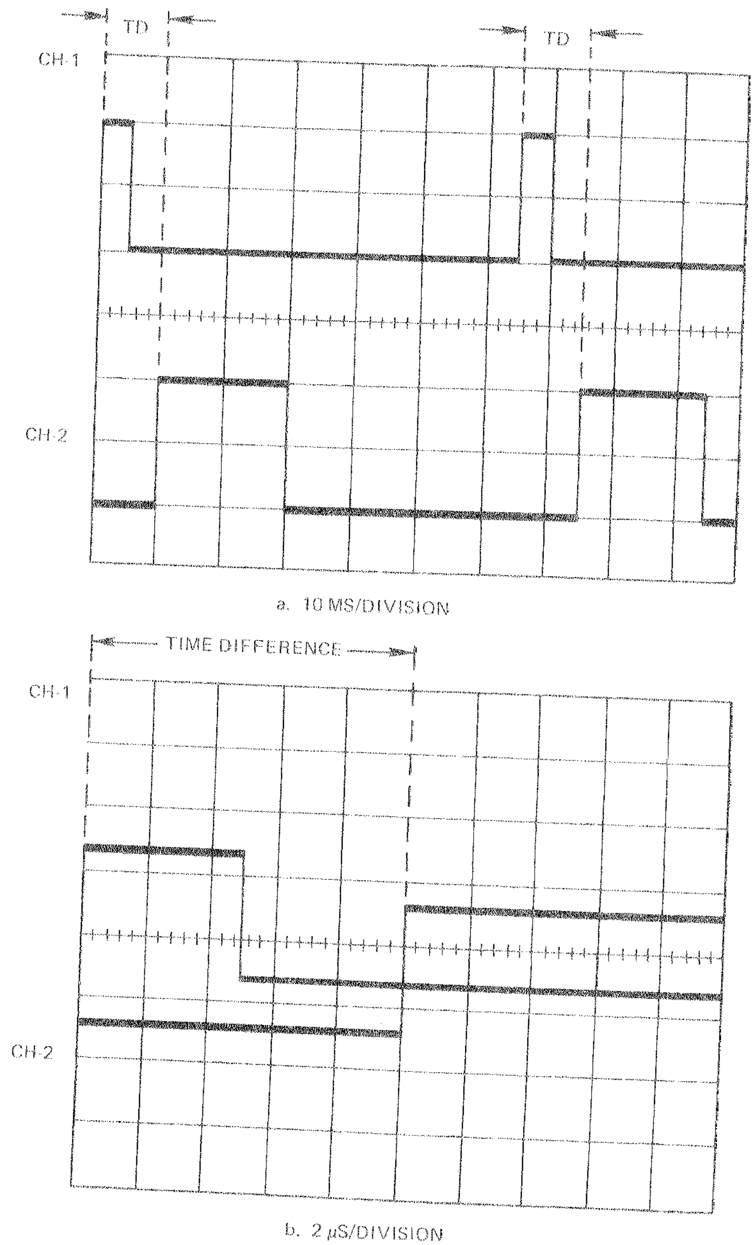


Figure 2-13. Measuring Lead and Lag Time

3. Use the TIME/DIV switch (17) to display the time difference as large as possible (Figure 2-13b). Make sure the VARIABLE timebase control is click-stopped fully clockwise in its CAL'D position.
4. Use the CH-1 Vertical Position control (13) to drop the bottom of channel 1 trace a little below the central horizontal graticule line, and the CH-2 Vertical Position control (14) to raise the top of the channel 2 trace a little above the line.
5. Use the Horizontal Position control (20) to align the left-most trace edge (channel 1 in this example) 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 bewteen the two signals, or the channel 2 signal may be said to be lagging the channel 1 signal, depending on the point of reference.
6. Count the number of horizontal divisions between the leading edges of the traces and multiply this number by setting of the TIME/DIV switch to determine the time difference. For example, the time difference in Figure 2-13b is 10 microseconds (5.0 div X 2 μS).

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 of signal-processing devices, the test setup shown in Figure 2-17 can be used.

Dual-trace Method. This method works with any type of waveform (sine, traiangle, 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 20 MHz.

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

1. Set up the LBO-308PL as described in *2-3-5 Dual-trace Operation*, connecting one signal to the CH-1 Input connector (8) and the other to the CH-2 Input connector (9).

   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 TRIG pushbutton (27) for the channel with the cleanest 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 VOLT/DIV switch (10) and VARIABLE control (11).
4. Use the LEVEL control (25) to ensure the trace crosses the central horizontal line at or near the beginning of the sweep. (See Figure 2-14).
5. Use the TIME/DIV switch (17), its VARIABLE control (18), and the horizontal Position control (20) 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 (10) and VARIABLE control (11) to adjust its amplitude to exactly 6 vertical divisions.
7. The horizontal distance bewteen corresponding points on the waveform is the phase difference. For example, in Figure 2-14 illustration the phase difference is 6 minor divisions, or 60°. You can now use the Horizontal control (20) to align one of the mid-cycle zero crossings with a graticule calibration to faciliate this measurement.
8. If the phase difference is less than 100° (two major divisions), press the MAG pushbutton (19), and use the Horizontal Position control (20) (if needed) to position the measurement area back on screen. With 5X magnification, each major horizontal division is 10°, and each minor division is 2°.

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. However, for maximum accuracy, measurements of small phase differences should be limited to below 100 kHz.

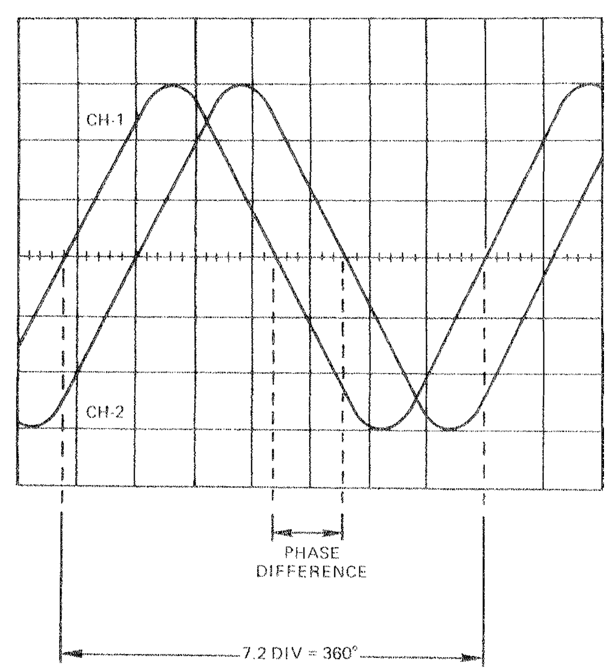


Figure 2-14. Dual-trace Method of Phase Measurement

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

1. Turn the TIME/DIV switch (17) fully counterclockwise to the X-Y position.

   CAUTION: Reduce the trace intensity, lest the undeflected spot damage the CRT phosphor.

2. Make certain the CH-2 POL switch (16) is out. This will introduce a 180° error if pushed in.
3. Connect one signal to the CH-1 or X IN Input connector (8), and the other signal to the CH-2 or Y Input connector (9).
4. Center the trace vertically with the CH-2 Vertical Position control (14), and adjust the CH-2 VOLTS/DIV switch (10) and VARIABLE control (11) for a trace height of exactly 6 divisions.
5. Adjust the CH-1 VOLTS/DIV control (10) for the largest possible on-screen display.
6. *Precisely* center the trace horizontally with the Horizonal or X Position control (20).
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 θ) 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 Figure 2-15a pattern is 2.0. Dividing this by 6 yields .334, whose are sine is 19.5 degrees.
9. The simple formula in Figure 2-15a works for angles less than 90°. For angles over 90° (leftward tilt), add 90° to the angle found in Step 7. Figure 2-15b 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 2-16 nomograph. Simply lay a ruler on the monograph so its 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

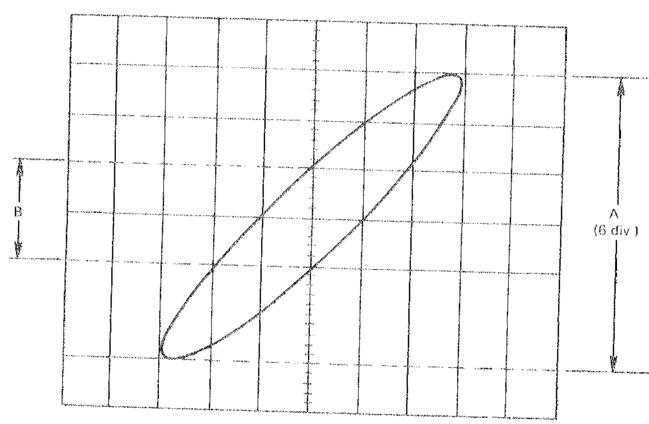
The dual-trace feature of the LBO-308PL offers a quick method of checking for distortion caused by a signal-processing device (such as an amplifier). To do this, proceed as follows:

1. Connect the output of a signal generator (of frequency suitable to the device under test) to the CH-1 Input connector (8) and the input of the device under test (DUT).
2. Connect the CH-2 Input connect (9) to the output of the device or its load (see Figure 2-17).
3. Increase the signal to the DUT until the channel 2 trace or an RMS AC voltmeter indicates the desired output level.
4. If the DUT has reversed the phase, press the CH-2 POL pushbutton (16).
5. Superimpose the two traces with the Vertical Positioning controls (13) and (14), and use the VARIABLE VOLTS/DIV control (11) of the *largest* trace to achieve the best trace match.
6. Any *uniform horizontal* displacement of the traces 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 Measurements

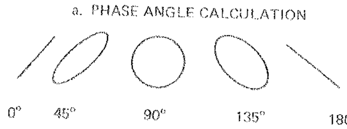
When a precise determination of frequency is needed, a frequency counter is obviously the first choice. However, an oscilloscope can be used in either of two ways to measure frequency when a counter is not available, or modulation and/or noise makes the counter unusable.

Reciprocal Method. Frequency is the reciprocal of period. Simply measure the period "t" of the unknown signal as instructed in *2-4-3 Time Interval 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/k key. Period in seconds (S) yields frequency in hertz (Hz); period in milloseconds (mS) yields frequency in kilohertz (kHz); period in microseconds (μS) yields frequency in megahertz (MHz). The accuracy of this technique is limited by the timebase calibration accuracy (see Table of Specifications).



θ = arc sine $\frac{B}{A}$ θ = arc sine $\frac{\text{Step 7 divs}}{6}$

a. PHASE ANGLE CALCULATION



b. LISSAJOUS PATTERNS OF VARIOUS PHASE ANGLES

Figure 2-15. Lissajous Method of Phase Measurement

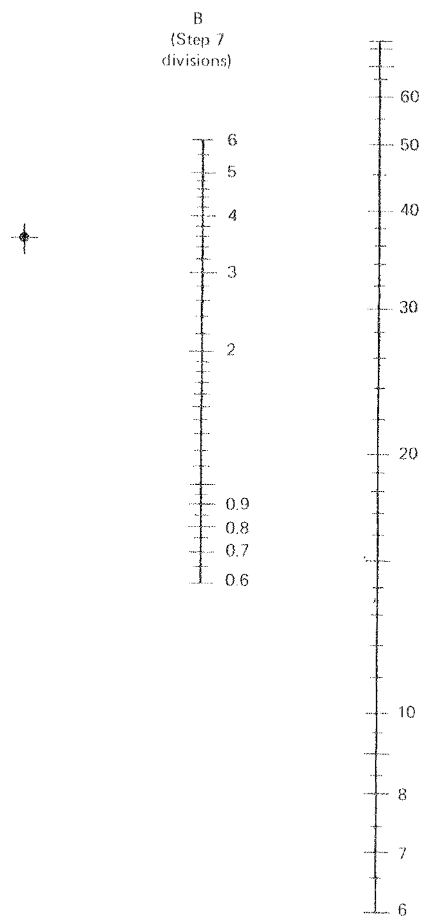


Figure 2-16. Phase Angle Nomograph

Comparison Method. In the frequency-comparison or frequency-ratio method, the unknown frequency is compared to a known frequency (from a calibrated signal generator). The two signals are fed to the oscilloscope operating in its X-Y mode, and the signal generator frequency is varied until a recognizable Lissajous pattern appears. The pattern shape indicates the ratio between the two frequencies. When generator frequency is multiplied by this ratio, the unknown frequency will be determined. This method is usable for frequencies up to 1 MHz.

To measure frequency by the comparison method, proceed as follows:

1. Set up the LBO-308PL for X-Y operation (apragraph 2-3-7).
2. Connect the output of a signal generator having accurate frequency calibration to the CH-1 or X IN connector (8).
3. Adjust the CH-1 VOLTS/DIV switch (10) for about 6 divisions horizontal deflection.
4. Connect the signal with the unknown frequency to the CH-2 or Y IN connector (9).
5. Adjust the CH-2 VOLTS/DIV switch (10) for about 6 divisions vertical deflection.
6. Vary the frequency of the signal generator until the scope display resembles a circle, an ellipse, or a diagonal line. When this occurs the unknown frequency is the same as the signal generator frequency (which can be read from its dial). The accuracy of this technique depends on the signal generator's calibration accuracy.

NOTE: While many other ratios are theoretically possible, drift in either signal frequency makes more complex Lissajous patterns nearly impossible to read.

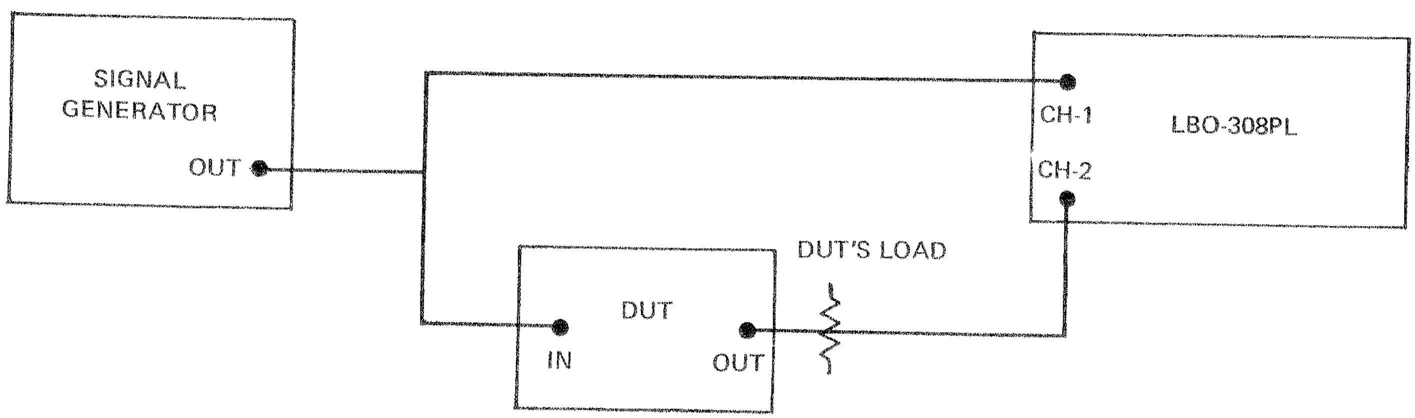


Figure 2-17. Test Setup for Distortion Comparison and Phase Measurement.

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, 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 Input connector (8), and set the AC/GND/DC switch (12) to AC.
2. Adjust the TIME/DIV switch (17) to display 1 1/2 - 2 cycles of the pulse. Make certain the associated VARIABLE control (18) is click-stopped fully clockwise in its CAL'D position.
3. Adjust the CH-1 VOLTS/DIV switch (10) to make the peak-to-peak pulse amplitude exceed 6 major graticule divisions.
4. Rotate the CH-1 VARIABLE control (11) to reduce the peak-to-peak pulse amplitude to *exactly* 6 major divisions. While doing this, use the CH-1Vertical Position control to place the positive pulse peak one graticule line down from the topmost line, and the negative pulse peak one graticule line up from the bottommost line. (See Figure 2-18a).
5. Use the Horizontal Position control (20) to shift the trace so a leading edge passes through the intersection of the central vertical graticule line and the 10% point (3 *minor* divisions up from the negative pulse peak).
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), press the MAG pushbutton (19) and reposition the trace as in Step 5. (See Figure 2-18b).
7. Count the number of horizontal divisions between the central vertical graticule line (10% point) and the intersection of the trace with the 90% line (3 *minor* divisions down from the positive pulse peak).
8. Multiply the number of divisions counted in Step 7 by the setting of the TIME/DIV switch to find the mesured risetime. If 5X magnification was used, divide the TIME/DIV setting by 5. For example, if the timebase setting in Figure 2-18b were .5 μS/div (.1 μS/div magnified), the risetime would be 0.2 μS (0.5 μS X 2 div 1 ÷ 5 = 0.2).
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 17.5 nanosecond transition time of the LBO-308PL. This error is negligible if the measured rise and fall times are 60 nS or longer.

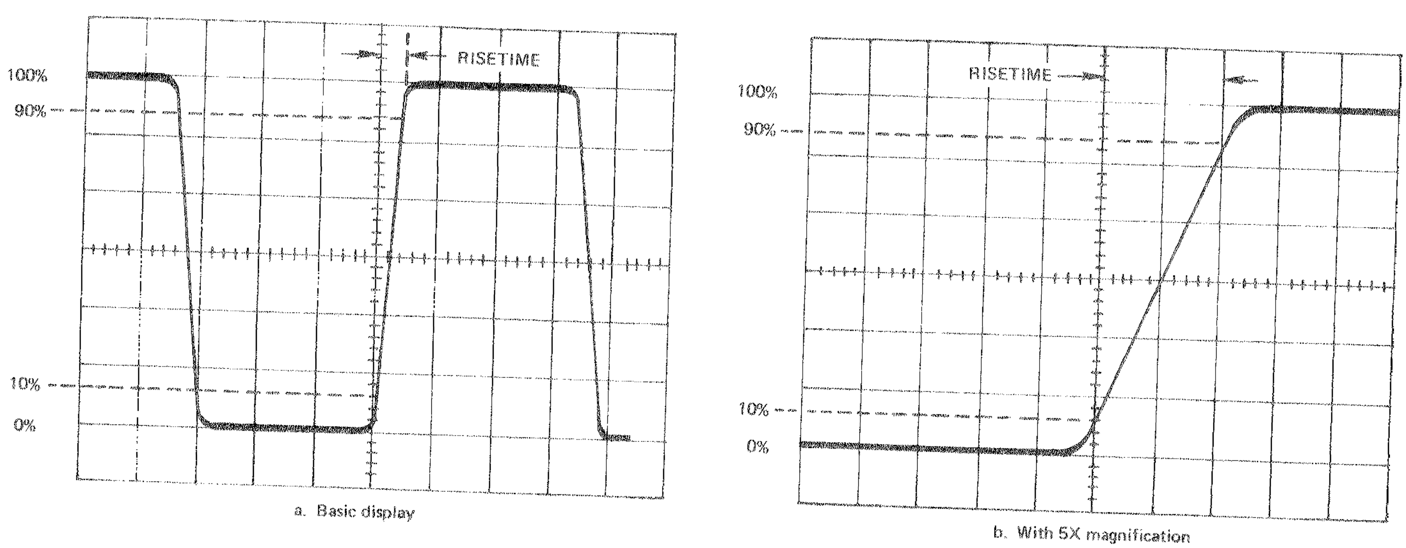


Figure 2-18. Risetime Measurement

3. PERFORMANCE CHECK

3-1 Introduction

Performance checks allow the basic performance specifications of the oscilloscope to be verified and should be used to determine acceptability of newly purchased or recently calibrated equipment. Performance checks should also be performed at least once every six months to assure that the instrument is operating properly. These checks do not require access to the interior of the instrument and are performed without removal of the instrument covers and without adjusting any internal controls. If after completing performance checks some specifications are not met, appropriate adjustments should be performed by a qualified serviceman.

3-2 Test Equipment Required

Test equipment required for performance checks is listed in Table 3-1. The test equipment specifications stated in Table 3-1 are the minimum necessary to obtain accurate results.

Table 3-1
Test Equipment Required

Description	Minimum Specifications
Amplitude Calibrator	Output signal 1 kHz square wave Signal amplitude 20 mV to 20 V p-p Accuracy ± 0.5%
Sine-wave Generator (Constant Amplitude)	Frequency 50 kHz to above 30 MHz Accuracy ± 3%
Oscillator	Frequency 10 Hz to 50 kHz Accuracy ± 3%
Time-mark Generator	Marker outputs 100 nsec to 0.5 sec Accuracy ± 0.5%
TV Source	Composite sync output at least 100 mV or composite video output at least 230 mV.
Cable (2)	50-ohm, 44-in cable BNC connectors
Cable (2)	50-ohm, 12-in cable BNC connectors
T Connector	BNC Tee adapter
BNC Adapter	BNC female to BNC female
Termination	50-ohm termination BNC connectors
Alignment Tool	Low-capacitance tool for variable capacitor adjustment
Screwdriver	For variable resistor adjustment

3-3 Preliminary Procedure

Use the following preliminary procedure to put the oscilloscope into an operating mode before proceeding with the performance checks.

3-3-1 Equipment Preparation

Set the POWER SOURCE switch in the rear of the instrument for the power source being used. If using AC, connect the AC cable between the AC Connector of the instrument and the power source. If using external DC, connect the DC cable between the EXT DC INPUT Connector of the instrument and the power source. Turn POWER ON switch on oscilloscope front panel ON. The POWER ON lamp should light. Connect all required test equipment to an appropriate power source and turn it on.

NOTE

To ensure the oscilloscope is operating within specifications, allow a 30-minute warmup period before starting performance checks.

3-3-2 Initial Control Settings

a. The initial front panel control settings to be used for each performance check are listed below. Any variations from these settings, required for a particular performance check, are stated in the applicable procedure. In each procedure the user will also be reminded to return the front-panel controls to their initial settings upon completion of a particular performance check. Initially set the front panel controls as follows:

INTEN. and FOCUS controls as required.

Vertical Amplifier Controls

VERT. MODE switch	CH-1
CH-2 POL. switch	NORM.
Vertical position controls (both)	Midrange
VOLTS/DIV. switches (both)	.1 V
VARIABLE controls (both)	CAL'D (clockwise)
CH-1 AC/GND/DC switch	DC
CH-2 AC/GND/DC switch	GND

Sweep and Trigger Circuit Controls

TIME/DIV. switch	.2 mS
VARIABLE control	CAL'D (clockwise)
MAG. switch	x1
Horizontal position control	Midrange
SLOPE switch	+
MODE switch	NORM.
SOURCE switch	INT.
TRIG. CH-1/CH-2 switch	CH-1
LEVEL control	Midrange, adjusted for stable display
NORM/AUTO switch	Push AUTO

b. A baseline trace should be visible on the CRT graticule. Adjust INTEN. and FOCUS controls for a low intensity, well-defined trace.

c. The baseline trace should be parallel with the horizontal graticule lines. If not, adjust front panel ROTATION screwdriver adjustment to align trace with the horizontal graticule lines.

d. Proceed with performance checks after allowing for warmup period.

3-4 Deflection Accuracy

The deflection accuracy is checked by applying a voltage-calibrated signal to the input of the instrument. The signal displayed on the CRT is then compared against the voltage standard.

3-4-1 Equipment Required

Amplitude calibrator
50-ohm BNC cables (3 required)
BNC T connector
BNC adapter

3-4-2 CH-1 and CH-2 Deflection Accuracy

a. Connect equipment as shown in Figure 3-1.

b. Set CH-1 VOLTS/DIV. switch to 20 mV position.

c. Adjust amplitude calibrator for a 0 volt output.

d. Set trace to bottom horizontal graticule line by means of CH-1 vertical positioning control.

e. Adjust amplitude calibrator for a 100 mV output.

f. Observe vertical deflection on the CRT display. It should be between 4.85 and 5.15 divisions.

g. Check vertical deflection accuracy for all settings of VOLTS/DIV. switch as specified in Table 3-2.

h. Set: CH-1 AC/GND/DC switch to GND
CH-2 AC/GND/DC switch to DC
VERT. MODE switch to CH-2
TRIG. CH-1/CH-2 switch to CH-2

Table 3-2
Deflection Accuracy

VOLTS/DIV Switch Setting	Amplitude Calibrator Output	Vertical Deflection (Divisions)
2 mV	10 mV	4.85 to 5.15
5 mV	20 mV	3.88 to 4.12
10 mV	50 mV	4.85 to 5.15
20 mV	0.1 V	4.85 to 5.15
50 mV	0.2 V	3.88 to 4.12
.1 V	0.5 V	4.85 to 5.15
.2 V	1 V	4.85 to 5.15
.5 V	2 V	3.88 to 4.12
1 V	5 V	4.85 to 5.15
2 V	10 V	4.85 to 5.15
5 V	20 V	3.88 to 4.12
10 V	50 V	4.85 to 5.15

i. Repeat steps b through g for CH-2.

j. Adjust amplitude calibrator for a 100 mV output.

k. Set CH-1 and CH-2 VOLTS/DIV. switches to 20 mV.

l. Observe vertical deflection between 4.85 and 5.15 divisions on the CRT display. Turn CH-2 VARIABLE control fully counterclockwise and observe vertical deflection reduce to less than 2 divisions.

m. Set: CH-1 AC/GND/DC switch to DC
CH-2 AC/GND/DC switch to GND
VERT. MODE switch to CH-1
TRIG. CH-1/CH-2 switch to CH-1

n. Observe vertical deflection between 4.85 and 5.15 divisions on the CRT display. Turn CH-1 VARIABLE control fully counterclockwise and observe vertical deflection reduce to less than 2 divisions.

o. Return both VARIABLE controls fully clockwise to the CAL'D positions.

3-4-3 X-Axis Gain

a. Adjust amplitude calibrator for a 500 mV output.

b. Set: CH-1 VOLTS/DIV. switch to .1 V
TIME/DIV. switch to X-Y
INTEN. control for visible display

c. Observe horizontal deflection, shown as dots, between 4.85 and 5.15 divisions on the CRT display. Adjust X and Y position controls as needed to view beginning and end of display.

d. Disconnect test equipment and return all oscilloscope front-panel controls to their initial settings.

3-5 Bandwidth

The bandwidth is checked by applying a 50-kHz reference signal to the input of the instrument and adjusting its amplitude for a 5-division display. The frequency of the signal generator is then increased to 20 MHz, while maintaining the amplitude output constant. Displayed amplitude on the CRT must be 3.5 divisions or greater.

3-5-1 Equipment Required

Sine-wave generator (constant amplitude)
50-ohm BNC cable
50-ohm BNC termination

3-5-2 CH-1 and CH-2 Bandwidth

a. Connect equipment as shown in Figure 3-2.

b. Set: Both VOLTS/DIV. switches to 5 mV
Both AC/GND/DC switches to DC
TIME/DIV. switch to 10 μS
All position switches as required

c. Set sine-wave generator frequency to 50 kHz and adjust its output signal amplitude for a 5-division display on the CRT.

d. Adjust frequency of constant amplitude sine-wave generator to 20 MHz.

e. Observe that display amplitude on the CRT is at least 3.5 divisions.

f. Set VERT. MODE switch to CH-2.

g. Disconnect the sine-wave generator from CH-1 input connector and connect it to CH-2 input connector.

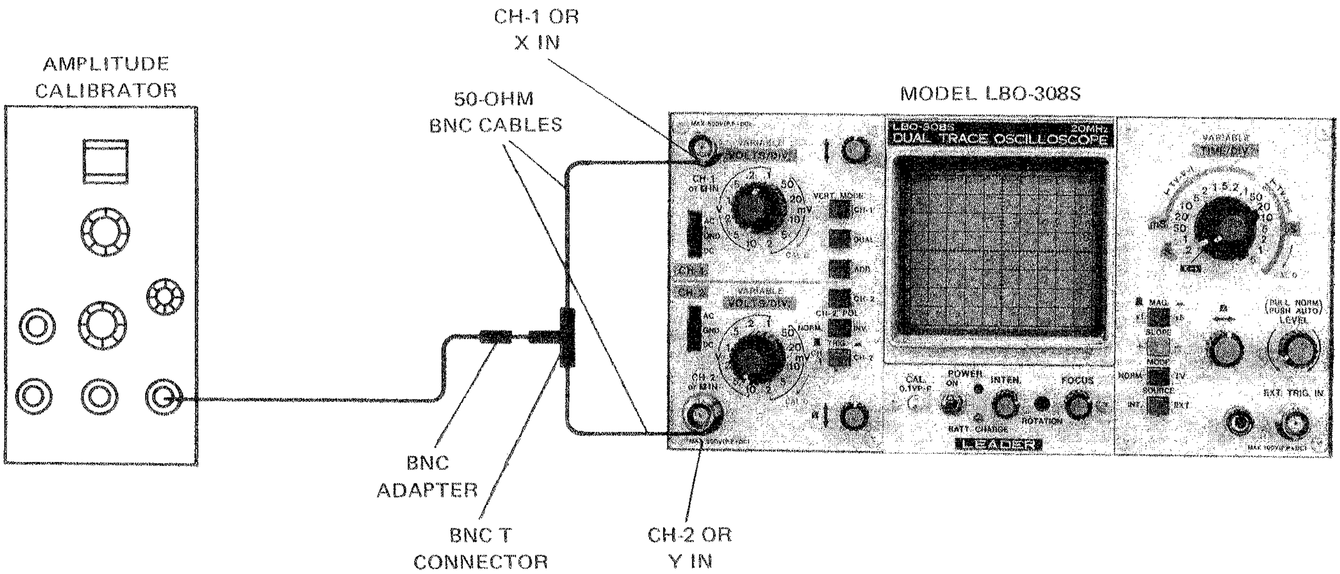


Figure 3-1. Deflection Accuracy Test Setup

h. Set sine-wave generator to 50-kHz reference frequency and adjust its output signal amplitude for a 5-division display on the CRT.

i. Adjust frequency of sine-wave generator to 20 MHz.

j. Observe that display amplitude on the CRT is at least 3.5 divisions.

3-5-3 X-Axis Bandwidth

a. Set: CH-1 AC/GND/DC switch to AC
CH-2 AC/GND/DC switch to GND
CH-1 VOLTS/DIV. switch to 20 mV
TIME/DIV. switch to X-Y

b. Connect the sine-wave generator to the CH-1 input, using the 50-ohm cable without the 50-ohm termination.

c. Set sine-wave generator to 50-kHz reference frequency and adjust its output signal amplitude for a 5-division display on the CRT.

d. Adjust frequency of sine-wave generator to 1 MHz.

e. Observe that display amplitude on the CRT is at least 3.5 divisions.

f. Disconnect test equipment and return all oscilloscope front-panel controls to their initial settings.

3-6 Triggering

Triggering cabability of the oscilloscope is verified by checking stability of the CRT display for various triggering modes in accordance with the instrument's specifications.

3-6-1 Equipment Required

Oscillator
Sine-wave generator
50-ohm BNC cables (3 required)
50-ohm BNC termination
BNC T connector
BNC adapter

3-6-2 50-Hz Triggering

a. Connect equipment as shown in Figure 3-3.

b. Set CH-1 VOLTS/DIV. switch to .5 V.

c. Set oscillator frequency to 50 Hz and adjust output signal amplitude for a 1 division display on the CRT.

d. Adjust TIME/DIV. switch for a convenient sine-wave display.

e. Check for stable display on the CRT for both the + and − positions of the SLOPE switch and both the AUTO and NORM. positions of the NORM/AUTO switch. If necessary, adjust the LEVEL control as required.

f. Set SOURCE switch to EXT.

g. Readjust output signal amplitude of oscillator for a 1 division display on the CRT.

h. Repeat step e above.

3-6-3 20-MHz Triggering

a. Disconnect oscillator from test setup and replace it with sine-wave generator as shown in Figure 3-4.

b. Set SOURCE switch to INT.

c. Set sine-wave generator frequency to 20 MHz and adjust output signal amplitude for a 1 division display on the CRT.

d. Adjust TIME/DIV. switch for a convenient sine-wave display.

e. Check for stable display on the CRT for both the + and − positions of the SLOPE switch and both the AUTO and NORM. positions of the NORM/AUTO switch. If necessary, adjust the LEVEL control as required.

f. Set SOURCE switch to EXT.

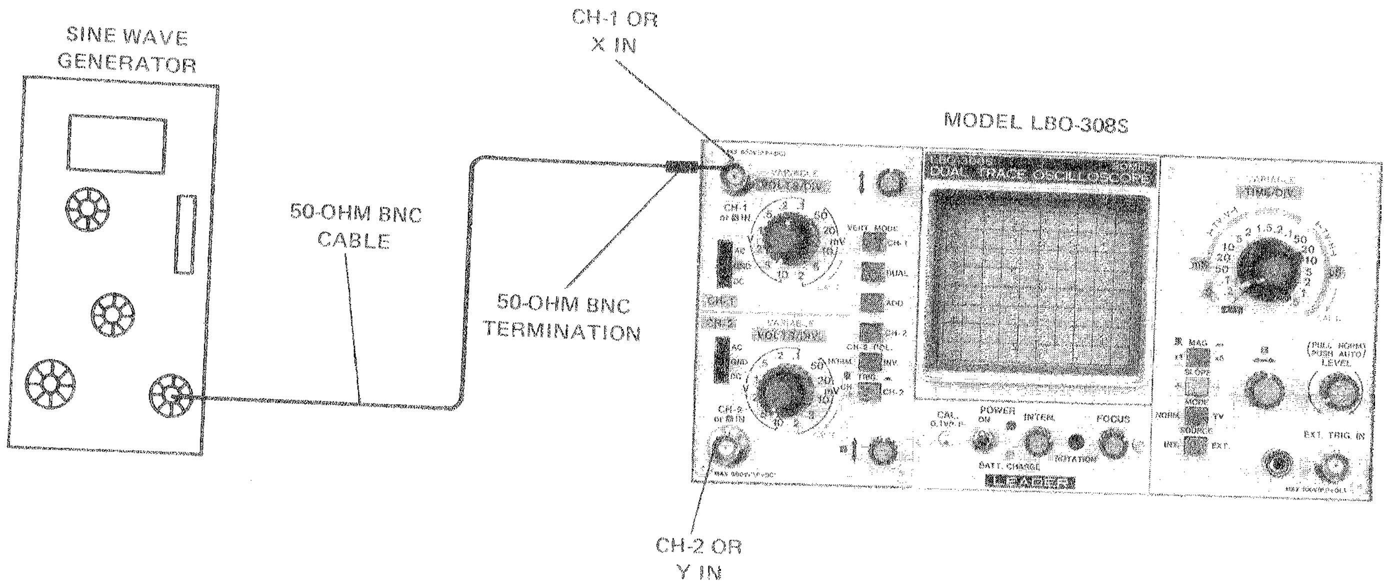


Figure 3-2. Bandwidth Test Setup

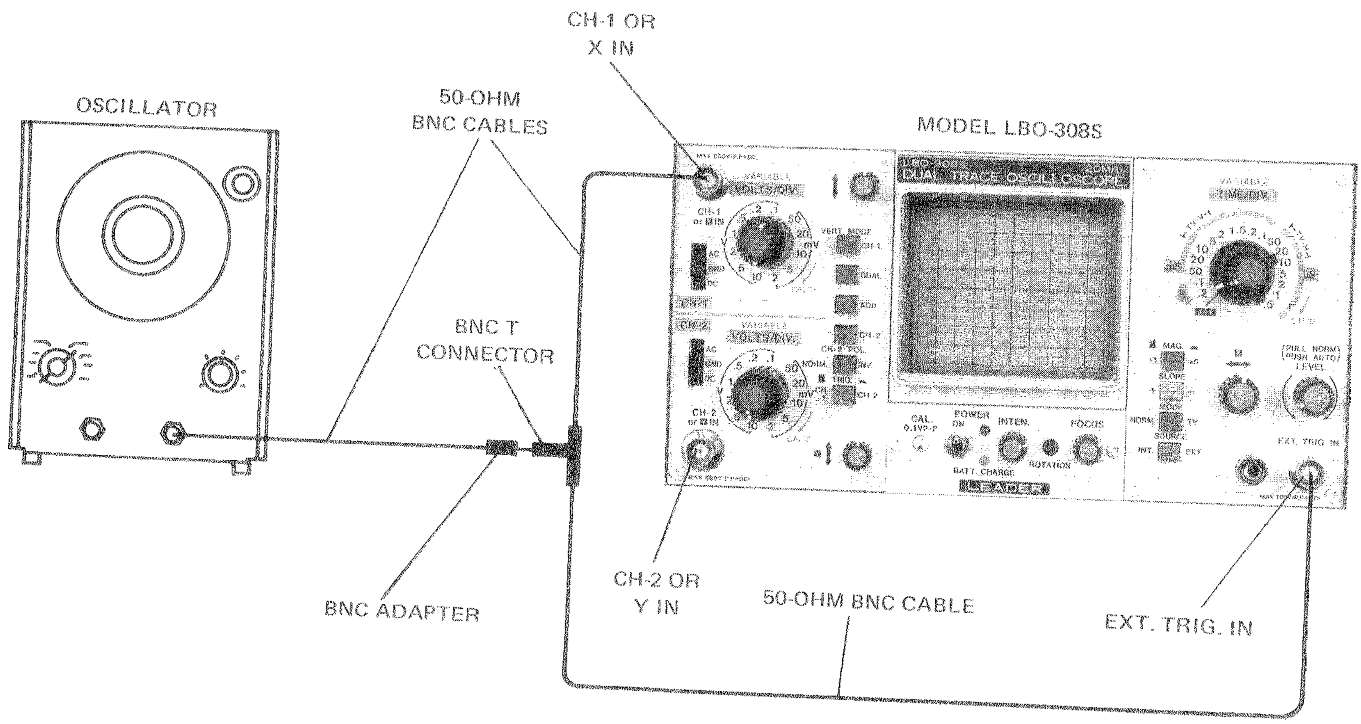


Figure 3-3. 50-Hz Triggering Test Setup

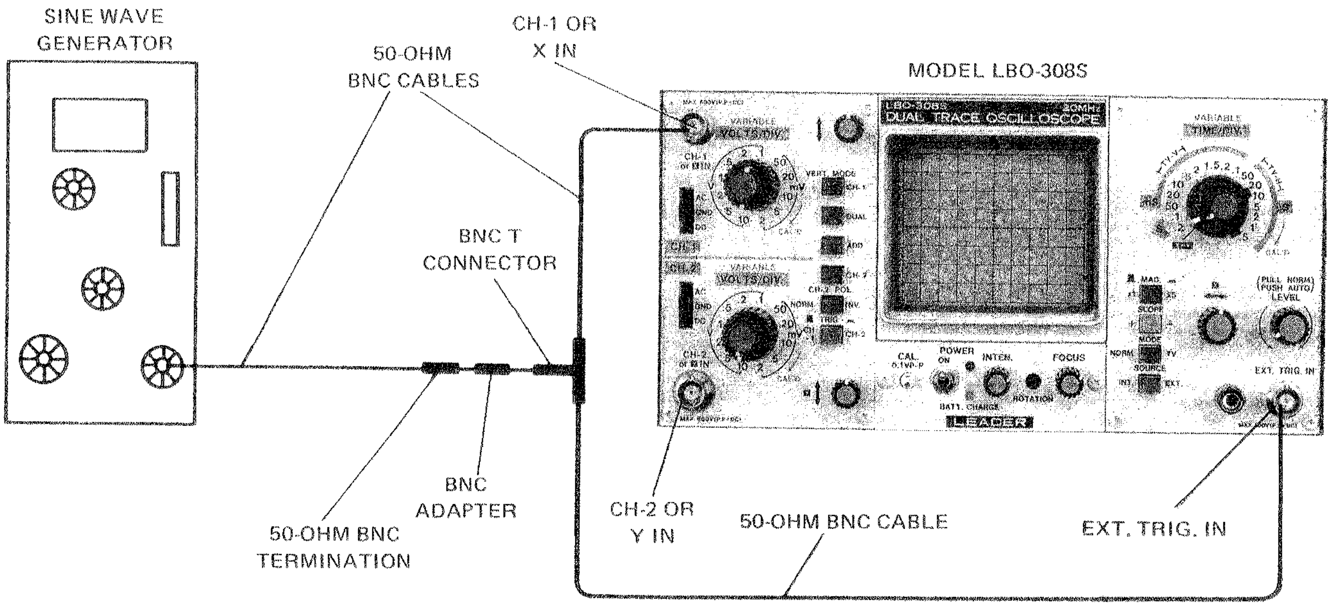


Figure 3-4. 20 MHz Triggering Test Setup

g. Readjust output signal amplitude for a 1 division display on the CRT.

h. Repeat step e above.

3-6-4 Z-Axis Modulation

a. Set: CH-1 VOLTS/DIV. switch to 1 V
TIME/DIV. switch to .1 mS
SOURCE switch to INT.
NORM/AUTO switch to AUTO

b. Set sine-wave generator frequency to 50-kHz and adjust output-signal amplitude for a 5 division display on the CRT.

c. Disconnect 50-ohm BNC cable from EXT. TRIG. IN connector and connect it to INTEN MOD. input connector at the rear of the instrument.

d. Check that trace modulation on CRT is noticeable at manual viewing intensity. If necessary, adjust LEVEL control to obtain stable display.

e. Disconnect test equipment and return all oscilloscope front-panel controls to their initial settings.

3-7 Sweep Time Accuracy

Sweep time accuracy of the oscilloscope is verified by comparing the instrument's time base with a time-mark generator.

3-7-1 Equipment Required

Time-mark generator
50-ohm BNC cables (3 required)
BNC T connector
BNC adapter

3-7-2 Sweep Time Accuracy

a. Connect equipment as shown in Figure 3-5.

b. Set: CH-1 VOLTS/DIV. switch to .2 V
NORM/AUTO switch to NORM.

c. Check sweep accuracy for each position of the TIME/DIV. switch in accordance with Table 3-3. Observe the number of markers/division indicated on Table 3-3 and verify that the accuracy is within ± 0.3 division over the entire ten divisions on the CRT.

Table 3-3
Sweep Time Accuracy

TIME/DIV Switch Setting	Time-Mark Generator Output	CRT Display (Markers/ Division)
.5 μS	0.5 μS	1
1 μS	1 μS	1
2 μS	1 μS	2
5 μS	5 μS	1
10 μS	10 μS	1
20 μS	10 μS	2
50 μS	50 μS	1
.1 mS	0.1 mS	1
.2 mS	0.1 mS	2
.5 mS	0.5 mS	1
1 mS	1 mS	1
2 mS	1 mS	2
5 mS	5 mS	1
10 mS	10 mS	1
20 mS	10 mS	2
50 mS	50 mS	1
.1 S	0.1 S	1
.2 S	0.1 S	2

3-7-3 Magnified Sweep Accuracy

a. Set: MAG. switch to x5
TIME/DIV. switch to .5 μS

b. Set time-mark generator to 200 nanoseconds and adjust CH-1 VOLTS/DIV. switch as necessary for a visible display.

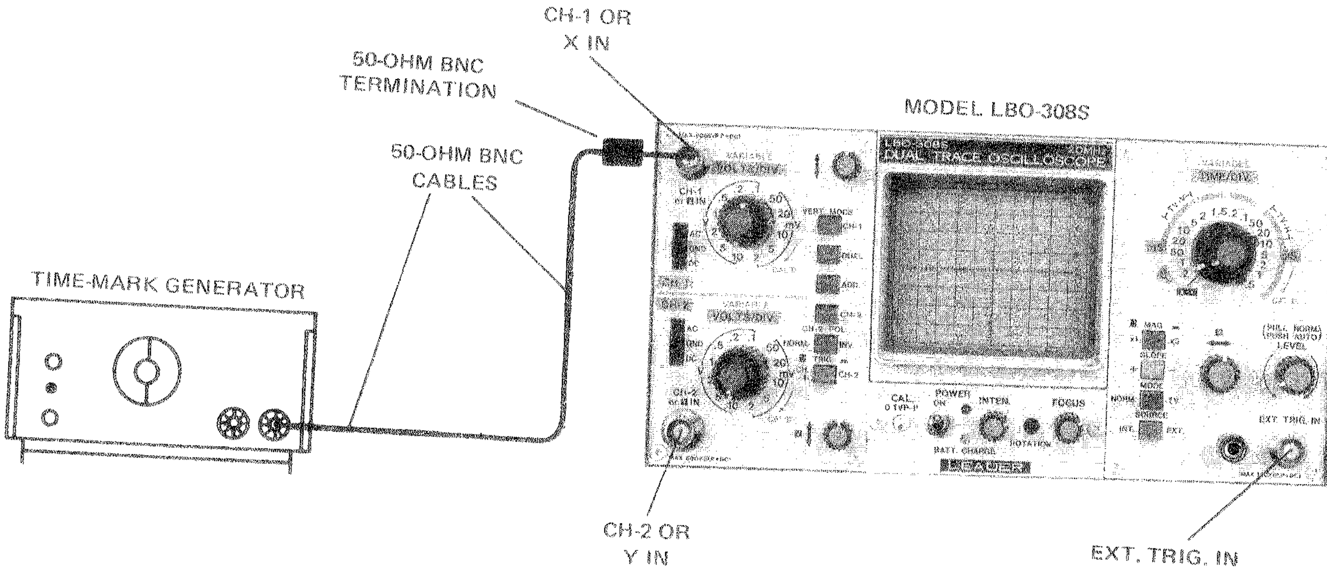


Figure 3-5. Sweep Time Accuracy Test Setup

c. Check magnified sweep accuracy for each position of the TIME/DIV. switch listed in Table 3-4. Observe the number of divisions between markers indicated in Table 3-4 and verify that the accuracy is within ± 0.5 division over the entire ten divisions on the CRT.

Table 3-4
Magnified Sweep Time Accuracy

TIME/DIV Switch Setting	Time-Mark Generator Output	CRT Display (Divisions/ Marker)
.5 μS	200 nanoseconds	2
1 μS	200 nanoseconds	1
10 μS	2 microsecond	1
.5 mS	100 microseconds	1

3-8 TV Triggering

A vertical sync signal (TV field) and a horizontal sync signal TV line from a TV source are used to check the TV sync separator triggering circuit in the oscilloscope.

3-8-1 Equipment Required

TV source
50-ohm BNC cables (3 required)
BNC T connector
BNC adapter

3-8-2 TV Sync Triggering

a. Connect test equipment as shown in Figure 3-6.

b. Set: TIME/DIV. switch to 5 mS
CH-1 VOLTS/DIV. switch to 1 V
MODE switch to TV

c. Adjust TV source for 1 division of composite sync signal (about 2.3 divisions of composite video signal) on the CRT screen.

d. Adjust SLOPE switch and LEVEL control as needed to trigger display as illustrated on page 10, Figure 2-5.

e. Check CRT screen and readjust LEVEL control as needed for stable display. (Display triggers on TV field.)

f. Switch NORM/AUTO switch to NORM. and check CRT screen for continued stable display. Return NORM/AUTO switch to AUTO.

g. Set TIME/DIV. switch to 20 μS and check CRT screen for stable display (display now triggers on TV line).

h. Switch NORM/AUTO switch to NORM. and check CRT screen for continued stable display. Return NORM/AUTO switch to AUTO.

3-9 X-Y Mode Phase Difference

The phase difference in the X-Y mode of operation is measured by applying a 100-kHz signal to the CH-1 (X IN) and CH-2 (Y IN) input connectors and measuring the phase angle between them.

3-9-1 Equipment Required

Sine-wave generator
50-ohm BNC cables (3 required)
BNC T connector
BNC adapter

3-9-2 Phase Measurement

a. Connect test equipment as shown in Figure 3-7.

b. Set: Both VOLTS/DIV. switches to .5 V
Both AC/GND/DC switches to DC
TIME/DIV. switch to X-Y

c. Set sine-wave generator frequency to 100 kHz and adjust its output amplitude for a display of 8 divisions on the CRT.

d. Check that phase angle on CRT display is equal or less than 0.42 division, as shown in Figure 3-8.

e. Disconnect test equipment and return all front-panel oscilloscope controls to their initial settings.

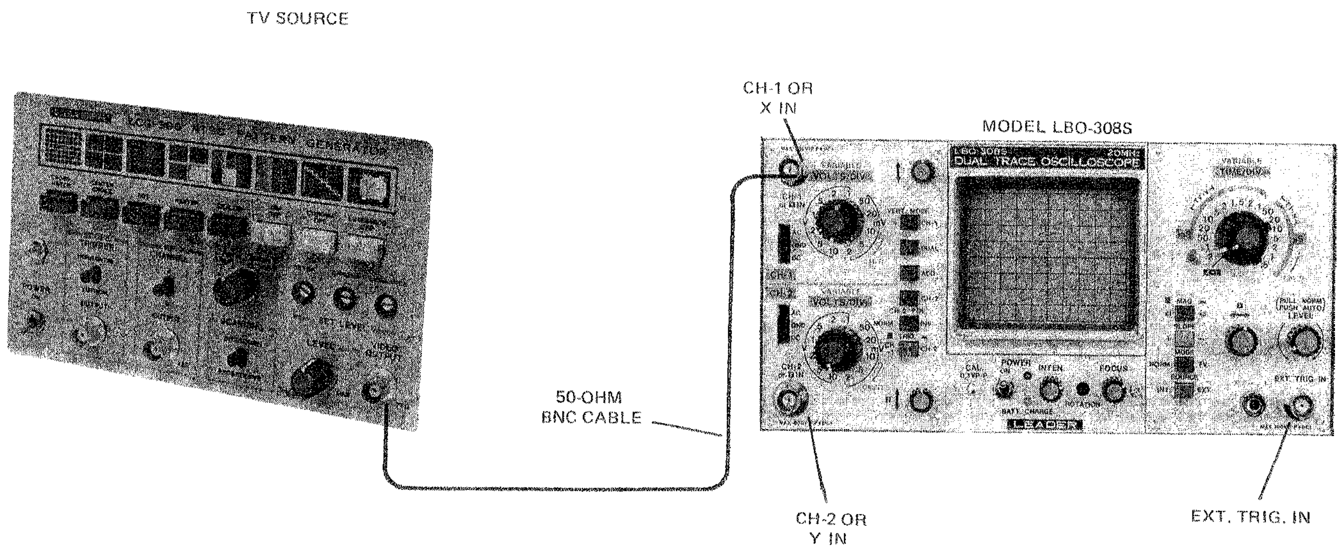


Figure 3-6. TV Sync Triggering Test Setup

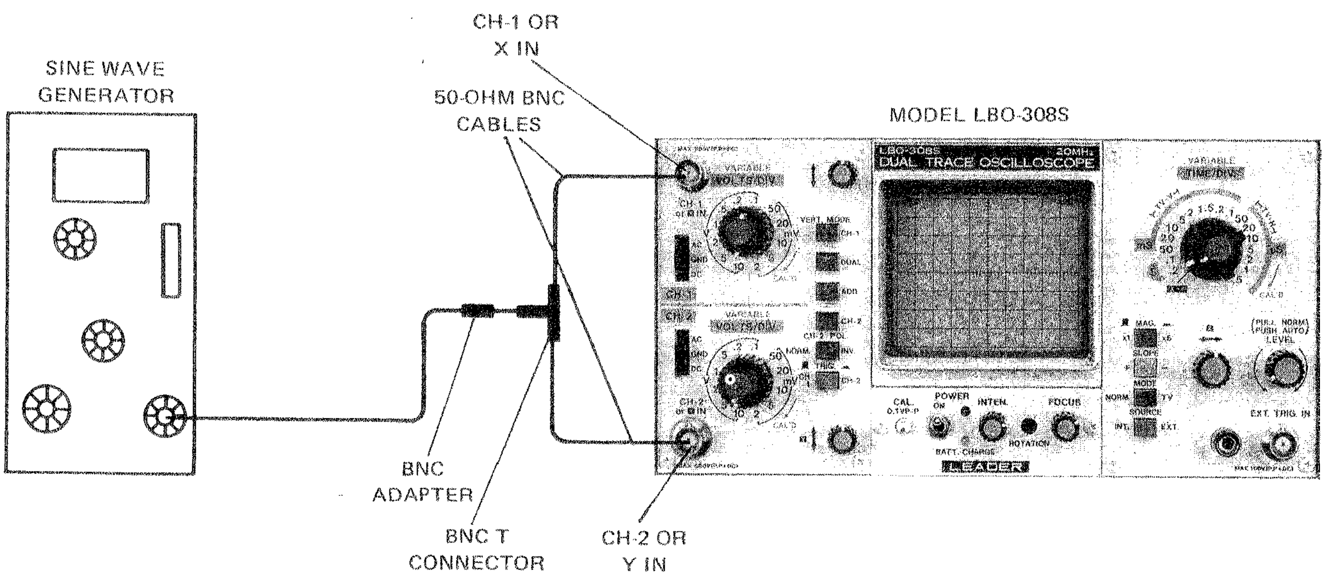


Figure 3-7. Phase Measurement Test Setup

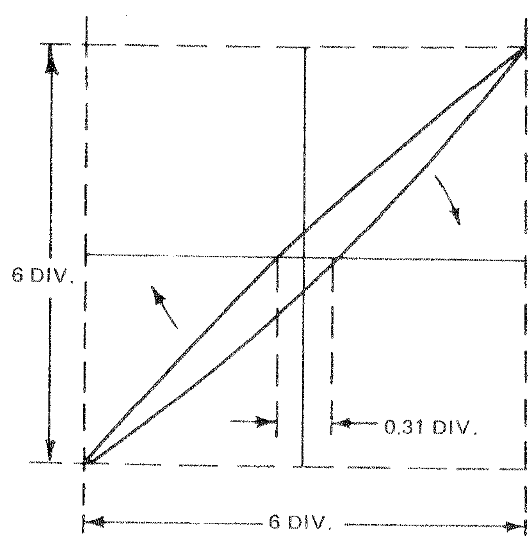


Figure 3-8. X-Y Phase Measurement

4. ADJUSTMENT AND CALIBRATION PROCEDURES

This section contains adjustment and calibration procedures that must be performed in a properly-equipped service shop by a qualified technician. The procedures are appliciable to both the LBO-308PL and LBO-308S unless otherwise stated.

4-1 Preparation

4-1-1 Test Equipment and Tools

Test equipment and tools needed for the adjustment and calibration procedures described in this section are listed in Table 4-1.

4-2-1 Disassembly

Most of the procedures in this section require removal of the top and/or bottom covers.

> WARNING: Do not remove the instrument covers unless you are fully qualified to service oscilloscopes.

The bottom cover on the 308PL is held in place by four screws and 308S by 5, all on the bottom of the instrument case. The top cover is held in place by six screws, two on top and two on each side.

4-1-3 Warmup and Preliminary Set-up

Set the LBO-308PL controls as specified in paragraph *3-3-2 Initial Control Settings* until instructed otherwise in the following procedures. Turn on the LBO-308PL and required test equipment. Because the scope covers are removed, allow for a long warmup time, at least one hour.

TEST EQUIPMENT AND TOOLS

Description	Minimum Pertinent Specifications
Amplitude calibrator	10 mV + 0.5% and 200 mV + 0.5% steps 1 kHz square wave
Signal generator	0.5 MHz–25 MHz constant amplitude, 3% frequency accuracy, 50 ohms, low-distortion sine wave
Function generator	1 kHz sine wave, 1% max. distortion 1 kHz–200 kHz square wave, 50 nS risetime, < 5% overshoot, 50 ohms output impedance
Pulse generator*	Negative pulse polarity, 1 kHz 3 V p-p, 50 ohms output impedance
Dual-trace oscilloscope	DC–20 kHz vertical bandwidth, .5 μS-100 nS/div sweep speed
Scope probes	10X attenuation 10 megohms, low capacitance
Time-mark generator	10 uS–50 mS, ± 0.5% accuracy
DC voltmeter	10 V–1500 V full scale, 1% accuracy, 20 k-ohms or higher
Regulated power supply	5–15 V, 2A
Thermometer	120°F full scale
Alignment tools	Nonconductive, 2 mm and 3 mm blade widths
Screwdrivers	No. 1 and No. 2 Phillips
Feed-thru termination	50 ohms ± 2%
BNC T fitting	Female-Male-Female
BNC–BNC cables	24" and 48"
Resistor	500Ω 1W

*Not needed if function generator has DC offset control.

4-2 Power Supply

4-2-1 Voltage Checks and Adjustments

Most of the supply voltages are set by fixed resistors or regulators. These are simply checked for conformance to the voltage tolerance specified in Table 4-2. To perform the voltage checks and adjustments, proceed as follows:

1. Remove the bottom cover (paragraph 4-1-2).
2. Remove the protective plastic shield from the bottom DC board by removing the four screws that secure it to the frame.
3. In turn, connect a high-accuracy DC voltmeter from each test point specified in Table 4-2 to chassis ground. Check that each voltage measured is within tolerance. If the voltages measured at TP1 and/or TP8 are outside the permissible range, adjust the indicated trimmer pot for the proper voltage.

> WARNING: Do NOT use a metallic screwdriver to make the –1400 V adjustment.

TABLE 4-2
SUPPLY VOLTAGE TEST POINTS & ADJUSTMENTS

Test Point	Adjust	Voltage	Tol.	Permissible Range
TP1	VR102	+10	±0.5%	+9.95 to +10.05
TP2	—	+20	±10%	+18 to +20
TP3	—	+5	±5%	+4.75 to +5.25
TP4	—	–8	±3.5%	–7.7 to –8.3
TP5	—	+12	±4%	+11.5 to +12.5
TP6	—	+100	±10%	+90 to +110
TP7	—	+150	±10%	+135 to +165
TP8	VR108	–1400	±1%	–1386 to –1414
TP11	—	+5	±5%	+4.75 to 5.25

4-2-2 Battery Lower-Limit Adjustment

To limit the amount of load current drawn during battery operation, the scope is designed to cease functioning when the battery voltage drops below 11 volts. To ensure this operation, proceed as follows:

1. Remove the bottom cover and plastic shield.
2. Insert the battery cable into the EXT DC INPUT connector on the back panel of the scope. If this is a model 308S, also set the POWER SOURCE switch (36) to AC (or EXT DC).
3. Connect the battery cable to a regulated power supply set at 12 volts.
4. Flip the POWER switch (2) to ON, and give it a few minutes of additional warmup. Observe that the scope works properly.
5. Slowly reduce the output voltage of the power supply. The LBO-308PL should continue working properly when the voltage is as low as 11.0 volts. As the voltage is reduced still further, the scope traces will shift position, change in width, and then disappear. The POWER lamp (3) will also flicker.
6. Adjust LOW BATT trimmer VR101 on T-1988B-P so the scope malfunctions when the DC input voltage is 10.5 volts.
7. If testing is complete, replace the plastic shield and bottom cover.

4-2-3 Charge Rate Adjustment

This procedure sets the charge rate for the internal battery. It is applicable only to an LBO-308S equipped with an LP-2054 Battery Pack.

1. Remove the bottom cover and plastic shield if it has not been done previously.
2. Set the POWER SOURCE switch (36) to AC (or EXT DC).
3. Disconnect the battery, and connect a 500 ohm 1W resistor across J-106-1 and J-106-2 (located at end of battery cable).
4. Check the air temperature in the vicinity of the battery pack with a thermometer.
5. Connect a DC voltmeter across the resistor of Step 3.
6. Adjust FC ADJ trimmer pot VR103 on T-988B-P until the meter indicates the voltage appropriate for the temperature measured in Step 4. Table 4-3 shows voltages appropriate for various room temperatures.

Table 4-3
TP12 VOLTAGE VS. TEMPERATURE

Temperatures	TP12 Voltage
100°F	13.8 V
90	14.0
80	14.2
70	14.5
60	14.8

7. If testing is complete, replace the plastic shield and bottom cover.

4-3 Display Circuits

Many of the adjustments in this section are affected by the preceeding adjustments, or themselves affect the following adjustments. Therefore, if any of them are in need of adjustment, perform all of the CRT adjustments in the order listed.

4-3-1 Blanking Circuits

To set up the blanking circuits, proceed as follows:

1. Remove the bottom cover and plastic shield, if it has not been done previously.
2. Set the TIME/DIV switch (17) at .2 mS.
3. Set the time/division switch of the test oscilloscope at 1 mS, and its vertical amplifier scale factor at 1 volt/division. Set its base line on the bottom horizontal graticule line, and use DC input coupling and a 10X scope.
4. Connect the test oscilloscope probe to TP9 (T-1988B-P) (see Figure 4-1), and adjust BLANKING trimmer pot VR111 (T-1988B-P) so the positive peak of the TP9 signal is at + 60 volts (see Figure 4-1a).

   NOTE: If problems in adjusting the INTEN control (next procedure) arise, the positive peak of the TP9 voltage can be reduced to + 50 V.

5. Change the TIME/DIV switch to 0.5 μS, and the test oscilloscope time/division switch to 5 μS.
6. Adjust trimmer VC101 (on T-1988B-P) for minimum overshoot and undershoot of the TP9 waveform (see Figure 4-1b).
7. Replace the plastic shield.

4-3-2 Intensity Range Adjustment

To adjust the operating range of the INTEN control, proceed as follows:

1. Adjust the INTEN control (4) so its index mark points in the direction shown in Figure 4-1c.
2. Set the TIME/DIV switch (17) to .2 mS.
3. Adjust INTEN trimmer pot VR110 on T-1988B-P so the trace is barely visible.

4-3-3 Geometry Adjustment

For a low-distortion CRT display, proceed as follows:

1. Connect the CH-1 Input connect (8) to the time-mark generator output, and adjust the generator for 0.1 mS output.
2. Set the TIME/DIV switch (17) to .1 mS, and adjust the CH-1 VOLTS/DIV switch (10) so the marker display overscans the screen.
3. Use the Horizontal Position control (20) to align the markers with the vertical graticule lines.

4. Adjust GEOMETRY trimmer pot VR105 on T-1988B-P for minimum curvature of the vertical markers. Adjust the FOCUS control (6) as needed while doing this. Ignore changes in Marker spacing at this time but be certain to perform paragraph 4-5-1 before returning the LBO-308PL to service.

4-3-4 Astigmatism Adjustment

For sharpest trace, proceed as follows:

1. Connect the CH-1 Input connector (8) to the sine wave generator.
2. Apply sufficient signal amplitude for about 6 divisions vertical deflection, and adjust the generator frequency to display about 2 cycles.
3. Simultaneously adjust the front panel FOCUS control (6) and ASTIG trimmer pot VR106 on T-1988B-P for *sharpest and most uniform* trace thickness.
4. When the trace appears satisfactorily sharp, check the adjustment by turning the FOCUS control to defocus the trace. If the trimmer pot VR106 is properly set, the blurred trace will have uniform thickness and evenly-distributed intensity.

4-3-5 Z-axis Modulation Check

To ensure that the intensity modulation circuits of the LBO-308PL are functioning, proceed as follows:

1. Set the TIME/DIV switch (17) to 1 mS, and CH-1 VOLTS/DIV switch (10) to 1 V.
2. Set the pulse generator frequency to 1 kHz, the pulse width anywhere between 25% and 50% duty cycle, and the *negative* output amplitude to 3 V p-p into a 50-ohm termination. If you are using a function generator equipped with DC offset, set the positive pulse peak at zero volt DC, as measured with the test oscilloscope.
3. Connect the CH-1 Input Connector (8) and INTEN MOD connector (28) to the generator output. The LBO-308PL scope trace should now appear as a broken line, with blanking occuring on the portion of the trace corresponding to the negative pulse peak.

NOTE: Make certain the LEVEL control is adjusted for a stable display.

4. Disconnect the pulse generator from the LBO-308PL/S.

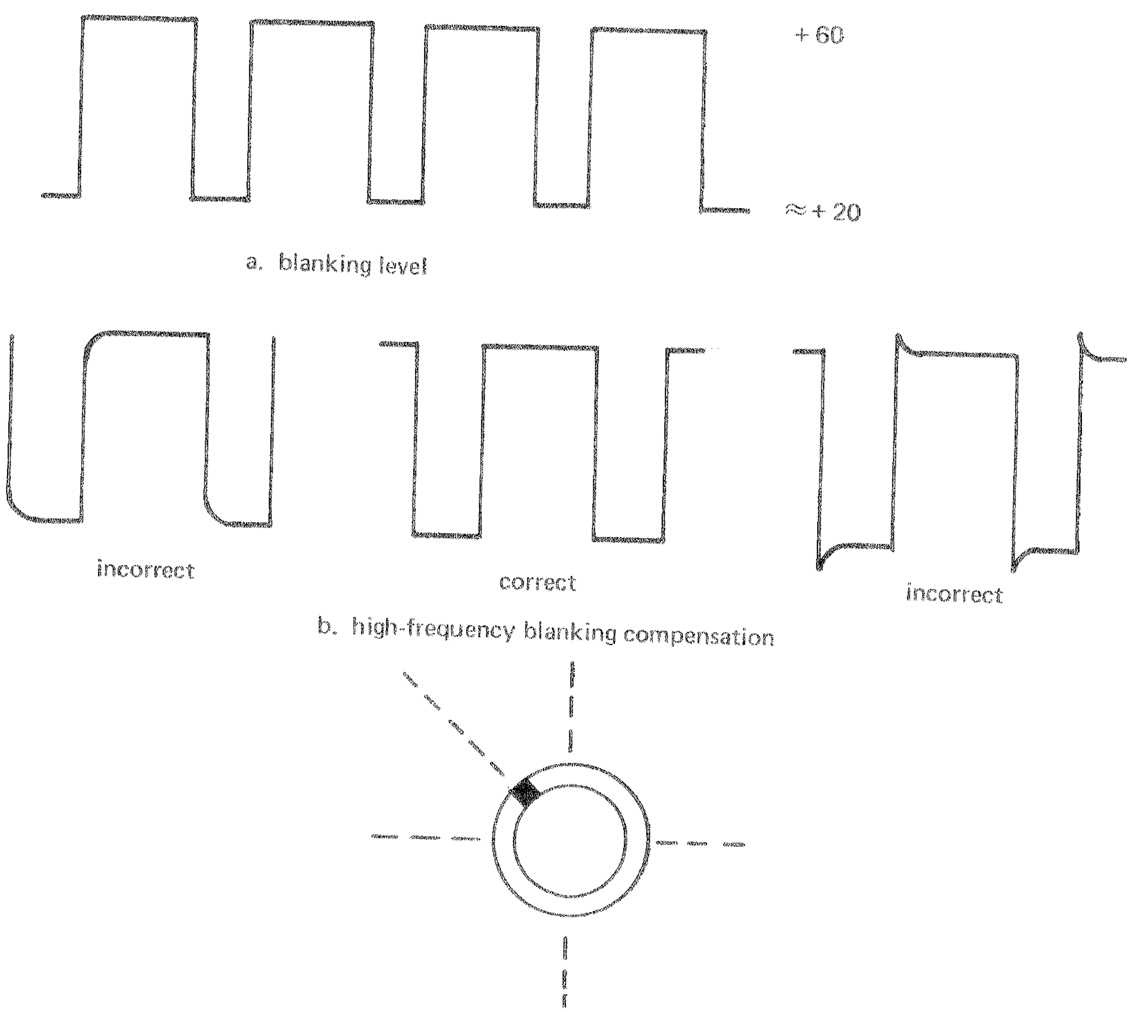


Figure 4-1 CRT Adjustments

4-4 Vertical Amplifier

Many of the adjustments in this section are affected by the preceeding adjustments, or themselves affect the following adjustments. Therefore, if any of the DC adjustments (4-4-1, 4-4-2, 4-4-3) must be performed, perform all of them in the order listed. Similarily, procedures involving the input attenuators (4-4-6 and 4-4-7) should alsobe performed as a group. If any of the other AC adjustments must be made, it is best to perform 4-4-4 to 4-4-8 as a group.

4-4-1 Step Attenuator Balance Adjustment

For minimal trace shift when the VOLTS/DIV switches are turned, proceed as follows:

1. Perform paragraph *4-2-1 Voltage Checks and Adjustments* if you have not already done so.
2. Remove the top cover.
3. Press the CH-1 VERT MODE pushbutton (15), set both VOLTS/DIV switches (10) to 20 mV, and both AC/GND/DC switches (12) to GND.
4. Place the trace on the central horizontal graticule line by means of the CH-1 Vertical Position control (13).
5. Rotate the CH-1 VOLTS/DIV switch to 5 mV.
6. Adjust Step Bal trimmer pot VR201 on T-1994C-R (308S) or T-2203-1 (308PL) to return the trace to the central horizontal graticule line.
7. Repeat Steps 4 to 6 until little, if any, trace shift occurs when the CH-1 VOLTS/DIV switch setting is changed from 20 mV to 5 mV.
8. Press the CH-2 VERT MODE pushbutton (15).
9. Perform Steps 4 to 7 for CH-2, adjusting Step Bal trimmer pot VR301on T-1994C–R (308S) or T-2203-1 (308PL) for minimum trace shift.

4-4-2 Balance Adjustment

For minimal trace shift when the VARIABLE controls are rotated, proceed as follows:

1. Rotate both VARIABLE controls (11) fully *counter*-clockwise.
2. Position the trace near mid screen by means of the CH-2 Vertical Position control (14).
3. Rotate the CH-2 VARIABLE control fully clockwise. Adjust DC Bal trimmer pot VR302 on T-1994C-R (308S) or T-2203-1 (308PL) to a position that produces no trace shift as the CH-2 VARIABLE control is rotated from one extreme to another.
4. Press the CH-1 VERT MODE pushbutton (15).
5. Position the trace near mid screen by means of the CH-1 Vertical Position control (13).
6. Rotate the CH-1 VARIABLE control fully clockwise. Adjust DC Bal trimmer pot VR202 on T-1994C-R (308S) or T-2203-1 (308PL) to a position that produces no trace shift as the CH-1 VARIABLE control is rotated from one extreme to another.
7. Turn both VARIABLE controls clockwise until click-stopped in their CAL'D position.

4-4-3 ADD Balance Adjustment

To minimize trace shift when switching to the ADD mode, proceed as follows:

1. Press the DUAL VERT MODE pushbutton (15).
2. Position the CH-1 and CH-2 traces on the central horizontal graticule line by means of the Vertical Position controls (13) and (14).
3. Press the ADD VERT MODE pushbutton (15), and note the amount of trace shift.
4. Adjust ADD Bal trimmer pot VR405 on T-1994C-R (308S) or T-2203-1 (308PL) for minimum trace shift while alternately pressing the DUAL and ADD VERT MODE pushbuttons.

4-4-4 Output Amplifier Adjustments

Impedance Matching. To impedance match the delay line in the LBO-308PL, proceed as follows:

NOTE: This procedure is not applicable to the LBO-308S.

1. Press the CH-1 VERT MODE pushbutton (15), set the AC/GND/DC switches (12) to DC, and set the TIME/DIV switch (17) to .5 μS.
2. Connect the CH-1 Input connection (8) to the square-wave generator output, and set the generator output frequency at 200 kHz.
3. Set the CH-1 VOLTS/DIV switch at 10 mV, and adjust the generator output level for 5-6 divisions display height.
4. Adjust trimmer pot VR401 (T-2203-1) for a perfectly flat top to the square wave. When mismatched, an abberation appears about 0.4 μS after the leading edges of the square wave (see Figure 4-2b).
5. Disconnect the LBO-308PL from the square-wave generator.

Bias Adjustment. To adjust the output amplifier bias in the LBO-308S, proceed as follows:

NOTE: This procedure is not applicable to the LBO-308PL.

1. Press the CH-1 VERT MODE pushbutton (15), and set the AC/GND/DC switches (12) to DC.
2. Connect the CH-1 Input connector (8) to the output of a sine-wave generator set to 1 kHz.
3. Connect both channels of a dual-trace oscilloscope to the collectors of Q401 and Q402 (T-1994C-1) through 10X scope probes.
4. Adjust the CH-1 VOLTS/DIV switch (10) and the generator output for 4 V p-p indication on the test oscilloscope.

5. Adjust Limit Adj trimmer pot VR401 for equal limiting (see Figure 4-2c).
6. Disconnect the sine-wave generator from the LBO-308S.

4-4-5 Gain Calibration

For accurate voltage indication, proceed as follows:

1. Set both VOLTS/DIV switches (10) to 2 mV, and make sure their VARIABLE controls (11) are click-stopped fully clockwise at CAL'D.
2. Set the TIME/DIV switch (17) to .2 mS.
3. Perform paragraph *4-2-1 Voltage Checks and Adjustments* if you have not already done so.
4. Connect the CH-1 Input connector (8) to the output of an amplitude calibrator set for 10 mV.
5. Adjust Gain trimmer pot VR206 on T-1994C-1 (308S) or T-2203-1 (308PL) for a display height of exactly 5 Divisions.
6. Press the CH-2 VERT MODE pushbutton (15), and transfer the amplitude calibrator to the CH-2 Input connector (9).
7. Adjust Gain trimmer pot VR306 on T-1994C-1 (308S) or T-2203-1 (308PL) for display height of exactly 5 divisions.

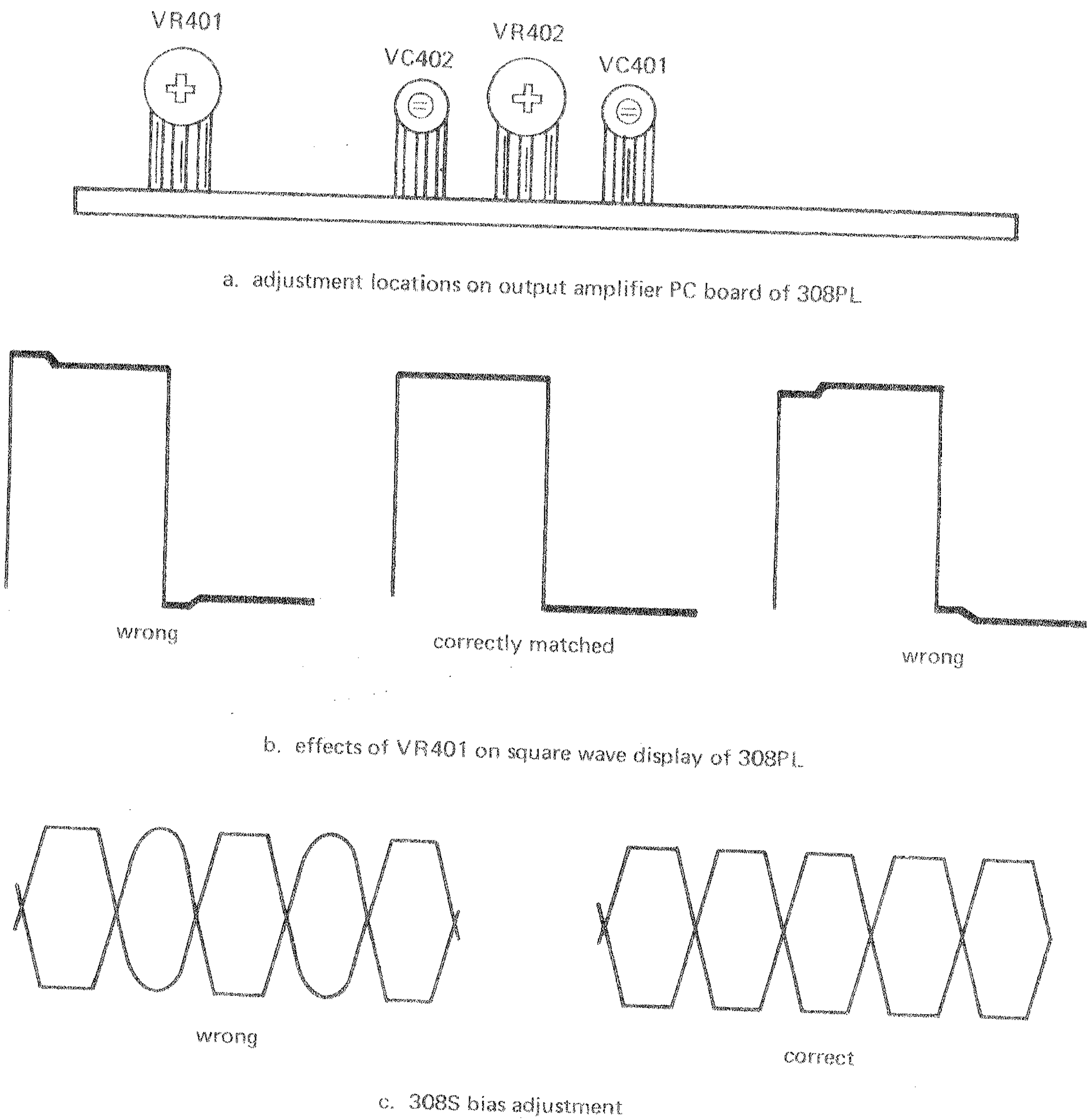


Figure 4-2. Output Amplifier Adjustments

4-4-6 Step Response and Frequency Check

For flattest frequency response and best high-frequency pulse reproduction, proceed as follows:

1. Connect CH-2 Input connector (9) to the output of a square-wave generator set at 200 kHz. Be sure to use 50-ohm cable and 50-ohm feed-thru termination on the CH-2 Input connector.
2. Set both VOLTS/DIV switches (10) to 5 mV, and adjust the generator output for a display height of about 4 divisions.
3. Set the TIME/DIV switch (17) to .5 μS.
4. Adjust trimmer capacitors VC301 on the side PC board T-1994C-1 (308S) or T-2203-1 (308PL) and trimmers VC401, VC402, and VR402) on the output amplifier board T-1994C-1 (308S) or T-2204-P (308PL) (see Figure 4-2a) for minimum abberations (overshoot, undershoot, ringing, etc.) on the displayed square wave.
5. Press the CH-1 VERT MODE pushbutton (15), and transfer the terminated cable to the CH-1 Input connector (8).
6. Adjust trimmer capacitor VC201 on the side PC board T-1994C-1 (308S) or T-2203-1 (308PL) for minimum abberations on the displayed square wave.
7. Disconnect the termination cable *from the square-wave generator*, and connect it to the output of a sine wave (signal) generator.
8. Set the generator frequency to 0.5 MHz, and adjust its output level for a display exactly 7 divisions high.
9. Increase the signal generator frequency, while making sure its output level remains constant, until the display height decreases to 5 divisions. The generator frequency at this point should be 20 MHz or higher.

4-5 Timebase

Many of the adjustments in this section are affected by the following adjustments. Therefore, if any of them are in need of adjustments, perform *all* of the timebase adjustments and calibration procedures in the order listed.

4-5-1 TIME/DIV Calibration

To calibrate the timebase, adjust the horizontal amplifier gain as follows:

1. Perform paragraph *4-2-1 Voltage Checks and Adjustments* if you have not already done so.
2. Set the TIME/DIV switch (17) to 50 mS, and make certain its VARIABLE control (18) is click-stopped fully CW.
3. Connect the CH-1 Input connector (8) to the output of a time-mark generator set to 50 mS.
4. Use the Horizontal Position control (20) to set the first marker (start of trace) on the left-most vertical graticule line.
5. Adjust WIDTH trimmer pot VR509 on T-1990B-1 to place a marker on each vertical graticule line. If necessary, simultaneously adjust BIAS trimmer pot VR511 on T-1990-1 to improve the sweep linearity so all markers can aligned with a graticule line.
6. Change the time-mark generator to 10 μS, and set the TIME/DIV switch at 10 μS.
7. Adjust trimmer capacitor VC501 on T-1990B-1 to place a marker on each vertical graticule line.
8. Set the TIME/DIV switch to 50 μS, and press in the MAG switch (19).
9. Adjust MAG trimmer pot VR510 to place a marker on each vertical graticule line.
10. Release the MAG switch (X1).

4-5-2 Horizontal Position Centering

To enable the Horizontal Position control to function properly, proceed as follows:

1. Make sure the LEVEL knob is pushed in.
2. Turn the Horizontal Position control (20) so its index mark is aligned with the X stenciling. This sets the control in the middle of its mechanical range.
3. Adjust horizontal POS trimmer pot VR508 on T-1990B-1 to put the start of the trace at the left-most graticule line.

4-5-3 Sweep Length Adjustment

To adjust the sweep for the proper amount of overscan, proceed as follows:

1. Set the time mark generator to 50 μS.
2. Use the Horizontal Position control (20) to shift the 3rd marker to the left-most vertical graticule line.
3. Adjust LENGTH trimmer pot VR505 on T-1990B-1 so the trace ends at the right-most vertical graticule line.
4. Disconnect the time-mark generator from the LBO-308PL/S.

4-6 Trigger Circuit

4-6-1 LEVEL Balance Adjustment

To adjust the trigger circuits so triggering occurs at the same relative point regardless of polarity, proceed as follows:

1. Connect the CH-1 Input connector (8) to the output of a sine-wave generator.
2. Set the TIME/DIV switch (17) to .2 mS and the sine wave generator frequency to 1 kHz.
3. Adjust the generator output amplitude for *exactly* 4 divisions trace height, and precisely center the waveform about the central horizontal graticule line (i.e., two divisions above, two divisions below).
4. Adjust the LEVEL control (25) so the trace begins exactly on the central horizontal graticule line.

5. Press in the SLOPE switch (26). If the trace no longer starts on the central horizontal graticule line, TRIG (LEVEL BAL) trimmer pot VR504 on T-1990B-1 must be adjusted. Carefully adjust this pot while changing trigger polarity with the SLOPE switch. After each adjustment of VR504 on T-1990B-1, use the LEVEL control (if needed) to set the trigger point back on the central graticule line. Continue this way until sweep begins on the central horizontal graticule line regardless of the SLOPE switch setting.

4-6-2 Trigger Sensitivity Checks

After adjusting the LEVEL balance, check trigger sensitivity as follows:

1. Change the TIME/DIV switch (17) setting to .5 mS, and pull the LEVEL knob (25) for NORM.
2. Make sure the MODE switch (24) is out (NORM), and the SOURCE switch (22) is out (INT).
3. Reduce the amplitude of the sine-wave signal being fed to CH-1 until the display is exactly one division high. If the display disappears make sure it can be restored by adjusting the LEVEL control.
4. Push in the LEVEL knob and check that the display remains stable. If it free runs, make sure it can be locked by adjusting the LEVEL control.
5. Switch the signal input to the CH-2 Input connector (9), and set the CH-2 VOLTS/DIV switch (10) to the same setting as CH-1.
6. Press the CH-2 VERT MODE pushbutton (15) and TRIG switch (27). If the display free runs, make sure it can be locked by adjusting the LEVEL control.
7. Set the CH-2 VOLTS/DIV switch to .1V and adjust the sine wave output level for 4 divisions trace height (400 mV p-p). Feed this signal to the EXT TRIG IN connector (23), as well as to CH-2. (Use a T-fitting.)
8. Press the SOURCE pushbutton (22) in (EXT). If the display free runs, make sure it can be locked by adjusting the LEVEL control.
9. Press the SOURCE pushbutton again to release it (INT).
10. Disconnect the sine-wave generator from the oscilloscope.

4-7 X-Y Circuitry

To calibrate the X-axis output amplifier and adjust its positioning circuits, proceed as follows:

1. Perform paragraphs *4-2-1 Voltage Checks and Adjustments* and *4-4-4 Gain Calibration* if you have not already done so.
2. Connect the CH-1 or X IN connector (8) to an amplitude calibrator set for 100 mV p-p output.
3. Set the CH-1 VOLTS/DIV switch (10) to 20 mV, the TIME/DIV switch (17) to X-Y.
4. Adjust X-Y gain trimmer pot VR403 on T-1994C-1 (308S) or T-2203-1 (308PL), for exactly 5 divisions spacing between the bright dots.
5. Remove the input signal from the CH-1 or X IN connector.
6. Turn the Horizontal or X Position control (20) so its index mark is aligned with the X panel mark.
7. Adjust X-Y CENTER trimmer pot VR404 on T-1994C-1 (308S) or T-2203-1 (308PL), to place the bright dot on the central vertical graticule line.
8. These adjustments are somewhat interactive, so repeat Steps 2 through 7 until both adjustment criteria are met.

4-8 Calibrator

To ensure the LBO-308PL/S calibrator waveform amplitude and symmetry are correct, proceed as follows:

1. Perform paragraphs *4-2-1 Voltage Checks and Adjustments* and *4-4-4 Gain Calibration* if you have not already done so.
2. Set the CH-2 VOLTS/DIV switch (10) to 20 mV, and the TIME/DIV switch (17) to .2 mS.
3. Connect the CAL connector (1) to the CH-2 Input connector (9).
4. Adjust CAL trimmer pot VR503 on T-1990B-1 for a display height of 5 divisions.
5. Use the Horizontal Position control (20) to set the start if the trace precisely on the left-most graticule line.
6. Set the TIME/DIV switch and its VARIABLE control (18) so *one cycle* of calibrator waveform fills exactly 10 horizontal divisions. Adjust symmetry pot VR502 on T-1990B-1 for mark/space ratio of 5 divisions each.
7. Restore the timebase VARIABLE control to its CAL'D position.

5. REPLACEMENT PARTS LIST

SCH. No. S	SCH. No. PL	Symbol No.	Description			
			RESISTORS			
1/3	1/7	R101	Carbon film ¼W		220k	±5%
1/3	1/7	R102	Carbon film ¼W		68k	±5%
1/3	1/7	R103	Carbon film ¼W		4.7k	±5%
1/3	1/7	R104	Carbon film ¼W		4.7k	±5%
1/3	1/7	R105	Carbon film ¼W		120k	±5%
1/3	1/7	R106	Carbon film ¼W		2.2M	±5%
1/3	1/7	R107	Carbon film ¼W		27k	±5%
	1/3	*R108	Carbon film ¼W		330Ω	±5%
	1/7	**R108	Carbon film ¼W		470Ω	±5%
	1/3	*R109	Carbon film ¼W		330Ω	±5%
	1/7	**R109	Carbon film ¼W		470Ω	±5%
	1/3	*R110	Carbon film ¼W		10Ω	±5%
1/3	1/7	R111	Carbon film ¼W		180Ω	±5%
1/3	1/7	R112	Carbon film ¼W		47k	±5%
1/3	1/7	R113	Carbon film ¼W		100k	±5%
1/3	1/7	R114	Carbon film ¼W		10k	±5%
1/3	1/7	R115	Carbon film ¼W		2.2M	±5%
1/3	1/7	R116	Carbon film ¼W		2.2M	±5%
1/3	1/7	R117	Carbon film ¼W		22k	±5%
1/3	1/7	R118	Carbon film ¼W		150k	±5%
	1/3	*R119	Carbon film ¼W		10k	±5%
	1/7	**R119	Carbon film ¼W		6.8k	±5%
1/3	1/7	R120	Carbon film ¼W		4.7k	±5%
1/3	1/7	R121	Carbon film ¼W		100Ω	±5%
1/3	1/7	R122	Carbon film ¼W		560Ω	±5%
1/3	1/7	R123	Carbon film ¼W		180Ω	±5%
1/3	1/7	R124	Carbon film ¼W		47Ω	±5%
1/3	1/7	R125	Carbon film ¼W		4.7k	±5%
1/3	1/7	R126	Carbon film ¼W		100k	±5%
1/3	1/7	R127	Carbon film ¼W		22k	±5%
1/3	1/7	R128	Carbon film ¼W		100k	±5%
1/3	1/7	R129	Carbon film ¼W		1k	±5%
	1/3	*R130	Carbon film 1W		10Ω	±5%
	1/3	*R131	Carbon film ¼W		1k	±5%
	1/3	*R132	Carbon film ¼W		10k	±5%
	1/3	*R133	Carbon film ¼W		22k	±5%
	1/3	*R134	Carbon film ¼W		22k	±5%
	1/3	*R135	Carbon film ¼W		47k	±5%
	1/3	*R136	Carbon film ¼W		22k	±5%
1/3	1/7	R137	W.W. ½W		0.33Ω	±10%
1/3	1/7	R138	Carbon film ¼W		1k	±5%
	1/3	*R139	Carbon film ¼W		1k	±5%
1/3	1/7	R140	Carbon film ¼W		22k	±5%
1/3	1/7	R141	Carbon film ¼W		1k	±5%
	1/3	*R142	Carbon film ¼W		5.6k	±5%
1/3	1/7	R143	Carbon film ¼W		1M	±5%
1/3	1/7	R144	Metal film ¼W		47k	±1%
	1/3	*R145	Metal film ½W		10M	±5%
	1/7	**R145	Metal glaze ½W		10M	±5%
1/3	1/7	R146	Carbon film ¼W		22k	±5%

*(LBO-308S only) **(LBO-308PL only)

SCH. No. S	SCH. No. PL	Symbol No.	Description			
			RESISTORS			
1/3	1/7	R147	Carbon film ¼W		1k	±5%
1/3	1/7	R148	Carbon film ¼W		220k	±5%
1/3	1/7	R149	Carbon film ¼W		47k	±5%
	1/3	*R150	Metal film ½W		500k	±1%
	1/7	**R150	Metal glaze ½W		1.8M	±5%
	1/3	*R151	Metal film 1W		10M	±5%
	1/7	**R151	Metal glaze 1W		8.2M	±5%
1/3	1/7	R152	Metal film ¼W		75k	±1%
	1/3	*R153	Metal film ¼W		22M	±5%
	1/7	**R153	Metal glaze ¼W		22M	±5%
	1/3	*R154	Metal film ¼W		22M	±5%
	1/7	**R154	Metal glaze ¼W		22M	±5%
1/3	1/7	R155	Metal film ¼W		100k	±1%
	1/3	*R156	Carbon film ¼W		120k	±5%
	1/7	**R156	Carbon film ¼W		68k	±5%
1/3	1/7	R157	Carbon film ¼W		470k	±5%
1/3	1/7	R158	Carbon film ¼W		220k	±5%
1/3	1/7	R159	Carbon film ¼W		100Ω	±5%
1/3	1/7	R160	Carbon film ¼W		22Ω	±5%
1/3	1/7	R161	Carbon film ¼W		1k	±5%
1/3	1/7	R162	Carbon film ¼W		180Ω	±5%
1/3	1/7	R163	Carbon film ¼W		120k	±5%
1/3	1/7	R164	Carbon film ¼W		22Ω	±5%
1/3	1/7	R165	Carbon film ¼W		22Ω	±5%
	1/3	*R166	Metal film ¼W		9.1k	±1%
1/3	1/7	R167	Carbon film ¼W		10k	±5%
1/3	1/7	R168	Carbon film ¼W		180Ω	±5%
1/3	1/7	R169	Carbon film ¼W		10k	±5%
1/3	1/7	R170	Carbon film ¼W		22k	±5%
1/3	1/7	R171	Carbon film ¼W		1k	±5%
1/3	1/7	R172	Carbon film ¼W		3.9k	±5%
1/3	1/7	R173	Carbon film ¼W		33k	±5%
1/3	1/7	R174	Carbon film ¼W		47k	±5%
	1/3	*R175	Carbon film ¼W		100Ω	±5%
2/3	2/7	R201	Carbon film ¼W		1k	±5%
2/3	2/7	R202	Carbon film ¼W		100k	±5%
2/3	2/7	R203	Metal film ½W		1M	±1%
2/3	2/7	R204	Carbon film ¼W		680Ω	±5%
2/3	2/7	R205	Carbon film ¼W		100Ω	±5%
2/3	2/7	R206	Carbon film ¼W		680Ω	±5%
2/3	2/7	R207	Carbon film ¼W		10k	±5%
2/3	2/7	R208	Carbon film ¼W		100Ω	±5%
2/3	2/7	R209	Carbon film ¼W		100Ω	±5%
2/3	2/7	R210	Carbon film ¼W		100Ω	±5%
2/3	2/7	R211	Carbon film ¼W		4.7k	±5%
2/3	2/7	R212	Carbon film ¼W		4.7k	±5%
2/3	2/7	R213	Carbon film ¼W		100Ω	±5%
2/3	2/7	R214	Carbon film ¼W		100Ω	±5%
2/3	2/7	R215	Metal film ¼W		1.8k	±1%

SCH. No.		Symbol No.	Description			
S	PL		RESISTORS			
2/3	2/7	R216	Metal film	¼W	1.8k	±1%
2/3	2/7	R217	Carbon film	¼W	100Ω	±5%
2/3	2/7	R218	Metal film	¼W	1.5k	±0.5%
2/3	2/7	R219	Metal film	¼W	310Ω	±0.5%
2/3	2/7	R220	Metal film	¼W	1k	±0.5%
2/3	2/7	R221	Carbon film	¼W	3.9k	±5%
2/3	2/7	R222	Carbon film	¼W	8.2k	±5%
2/3	2/7	R223	Metal film	¼W	750Ω	±1%
2/3	2/7	R224	Carbon film	¼W	220Ω	±5%
2/3	2/7	R225	Carbon film	¼W	100Ω	±5%
	2/3	*R226	Metal film	¼W	750Ω	±1%
	2/7	**R226	Metal film	¼W	235Ω	±1%
2/3	2/7	R227	Carbon film	¼W	220Ω	±5%
2/3	2/7	R228	Carbon film	¼W	6.8k	±5%
2/3	2/7	R229	Carbon film	¼W	6.8k	±5%
2/3	2/7	R230	Carbon film	¼W	560Ω	±5%
2/3	2/7	R231	Metal film	¼W	104Ω	±0.5%
2/3	2/7	R232	Metal film	¼W	300Ω	±0.5%
2/3	2/7	R233	Metal film	¼W	1k	±1%
2/3	2/7	R234	Metal film	¼W	1k	±1%
2/3	2/7	R235	Carbon film	¼W	220Ω	±5%
2/3	2/7	R236	Carbon film	¼W	470Ω	±5%
2/3	2/7	R237	Carbon film	¼W	470Ω	±5%
2/3	2/7	R238	Carbon film	¼W	220Ω	±5%
2/3	2/7	R239	Carbon film	¼W	2.7k	±5%
2/3	2/7	R240	Carbon film	¼W	2.7k	±5%
2/3	2/7	R241	Carbon film	¼W	100Ω	±5%
2/3	2/7	R242	Carbon film	¼W	22Ω	±5%
2/3	2/7	R243	Carbon film	¼W	390Ω	±5%
2/3	2/7	R244	Carbon film	¼W	100Ω	±5%
2/3	2/7	R245	Carbon film	¼W	390Ω	±5%
2/3	2/7	R246	Carbon film	¼W	100Ω	±5%
	2/3	*R247	Carbon film	¼W	100Ω	±5%
	2/7	**R247	Carbon film	¼W	4.7k	±5%
	2/3	*R248	Carbon film	¼W	4.7k	±5%
	2/7	**R248	Carbon film	¼W	2.2k	±5%
2/3	2/7	R249	Carbon film	¼W	22Ω	±5%
2/3	2/7	R250	Carbon film	¼W	270Ω	±5%
2/3	4/7	R251	Carbon film	¼W	56Ω	±5%
2/3	4/7	R252	Carbon film	¼W	2.2k	±5%
2/3	4/7	R253	Carbon film	¼W	220Ω	±5%
	2/3	*R254	Carbon film	¼W	5.6k	±5%
	4/7	**R254	Carbon film	¼W	2.2k	±5%
2/3	4/7	R255	Carbon film	¼W	680Ω	±5%
2/3	4/7	R256	Carbon film	¼W	4.7k	±5%
2/3	3/7	R301	Carbon film	¼W	1k	±5%
2/3	3/7	R302	Carbon film	¼W	100k	±5%
2/3	3/7	R303	Metal film	½W	1M	±1%
2/3	3/7	R304	Carbon film	¼W	680Ω	±5%
2/3	3/7	R305	Carbon film	¼W	100Ω	±5%
2/3	3/7	R306	Carbon film	¼W	680Ω	±5%
2/3	3/7	R307	Carbon film	¼W	10k	±5%
2/3	3/7	R308	Carbon film	¼W	100Ω	±5%
2/3	3/7	R309	Carbon film	¼W	100Ω	±5%
2/3	3/7	R310	Carbon film	¼W	8.2k	±5%

SCH. No.		Symbol No.	Description			
S	PL		RESISTORS			
2/3	3/7	R311	Carbon film	¼W	3.9k	±5%
2/3	3/7	R312	Carbon film	¼W	100Ω	±5%
2/3	3/7	R313	Carbon film	¼W	4.7k	±5%
2/3	3/7	R314	Carbon film	¼W	4.7k	±5%
2/3	3/7	R315	Carbon film	¼W	100Ω	±5%
2/3	3/7	R316	Carbon film	¼W	8.2k	±5%
2/3	3/7	R317	Carbon film	¼W	3.9k	±5%
2/3	3/7	R318	Carbon film	¼W	100Ω	±5%
2/3	3/7	R319	Metal film	¼W	1.8k	±1%
2/3	3/7	R320	Metal film	¼W	1.8k	±1%
2/3	3/7	R321	Carbon film	¼W	100Ω	±5%
2/3	3/7	R322	Metal film	¼W	1.5k	±0.5%
2/3	3/7	R323	Metal film	¼W	310Ω	±0.5%
2/3	3/7	R324	Metal film	¼W	1k	±0.5%
2/3	3/7	R325	Metal film	¼W	750Ω	±1%
2/3	3/7	R326	Carbon film	¼W	220Ω	±5%
2/3	3/7	R327	Carbon film	¼W	100Ω	±5%
2/3	3/7	R328	Metal film	¼W	750Ω	±1%
2/3	3/7	R329	Carbon film	¼W	220Ω	±5%
2/3	3/7	R330	Carbon film	¼W	6.8k	±5%
2/3	3/7	R331	Carbon film	¼W	6.8k	±5%
2/3	3/7	R332	Carbon film	¼W	560Ω	±5%
2/3	3/7	R333	Metal film	¼W	104Ω	±0.5%
2/3	3/7	R334	Metal film	¼W	300Ω	±0.5%
2/3	3/7	R335	Metal film	¼W	1k	±1%
2/3	3/7	R336	Metal film	¼W	1k	±1%
2/3	3/7	R337	Carbon film	¼W	8.2k	±5%
2/3	3/7	R338	Carbon film	¼W	8.2k	±5%
2/3	3/7	R339	Carbon film	¼W	270Ω	±5%
2/3	3/7	R340	Carbon film	¼W	220Ω	±5%
2/3	3/7	R341	Carbon film	¼W	470Ω	±5%
2/3	3/7	R342	Carbon film	¼W	470Ω	±5%
2/3	3/7	R343	Carbon film	¼W	220Ω	±5%
2/3	3/7	R344	Carbon film	¼W	2.7k	±5%
2/3	3/7	R345	Carbon film	¼W	2.7k	±5%
2/3	3/7	R346	Carbon film	¼W	100Ω	±5%
2/3	3/7	R347	Carbon film	¼W	390Ω	±5%
2/3	3/7	R348	Carbon film	¼W	100Ω	±5%
2/3	3/7	R349	Carbon film	¼W	390Ω	±5%
2/3	3/7	R350	Carbon film	¼W	100Ω	±5%
	2/3	*R351	Carbon film	¼W	150Ω	±5%
	3/7	**R351	Carbon film	¼W	4.7k	±5%
	2/3	*R352	Carbon film	¼W	4.7k	±5%
	3/7	**R352	Carbon film	¼W	2.2k	±5%
2/3	3/7	R353	Carbon film	¼W	22Ω	±5%
2/3	3/7	R354	Carbon film	¼W	22Ω	±5%
2/3	4/7	R355	Carbon film	¼W	56Ω	±5%
2/3	4/7	R356	Carbon film	¼W	680Ω	±5%
2/3	4/7	R357	Carbon film	¼W	220Ω	±5%
2/3	4/7	R358	Carbon film	¼W	2.2k	±5%
	2/3	*R359	Carbon film	¼W	5.6k	±5%
	4/7	**R359	Carbon film	¼W	2.2k	±5%
2/3	4/7	R360	Carbon film	¼W	4.7k	±5%

(LBO-308S only)** *(LBO-308PL only)**

SCH. No. S	SCH. No. PL	Symbol No.	Description		
			RESISTORS		
2/3	4/7	R401	Carbon film ¼W	220Ω	±5%
2/3	4/7	R402	Carbon film ¼W	220Ω	±5%
	2/3	*R403	Carbon film ¼W	220Ω	±5%
	4/7	**R403	Carbon film ¼W	330Ω	±5%
2/3		R404	Carbon film ¼W	1k	±5%
	2/3	*R405	Carbon film ¼W	1k	±5%
	4/7	**R405	Carbon film ¼W	1.2k	±5%
	2/3	*R406	Metal film ¼W	4.7k	±1%
	4/7	**R406	Carbon film ¼W	560Ω	±5%
	2/3	*R407	Carbon film ¼W	4.7k	±5%
	4/7	**R407	Carbon film ¼W	33Ω	±5%
	2/3	*R408	Carbon film ¼W	1.2k	±5%
	4/7	**R408	Carbon film ¼W	33Ω	±5%
	2/3	*R409	Carbon film ¼W	220Ω	±5%
	4/7	**R409	Metal film ¼W	75Ω	±1%
	2/3	*R410	Carbon film ¼W	2.7k	±5%
	4/7	**R410	Carbon film ¼W	560Ω	±5%
	2/3	*R411	Carbon film ¼W	2.7k	±5%
	4/7	**R411	Carbon film ¼W	1.2k	±5%
	2/3	*R412	Carbon film ¼W	22Ω	±5%
	4/7	**R412	Carbon film ¼W	1k	±5%
	2/3	*R413	Carbon film ¼W	4.7k	±5%
	4/7	**R413	Carbon film ¼W	33Ω	±5%
	2/3	*R414	Carbon film ¼W	1k	±5%
	4/7	**R414	Carbon film ¼W	33Ω	±5%
	2/3	*R415	Carbon film ¼W	100Ω	±5%
	4/7	**R415	Metal film ¼W	75Ω	±1%
	2/3	*R416	Carbon film ¼W	100k	±5%
	5/7	**R416	Carbon film ¼W	68Ω	±5%
	2/3	*R417	Carbon film ¼W	100k	±5%
	5/7	**R417	Carbon film ¼W	100Ω	±5%
	2/3	*R418	Carbon film ¼W	22Ω	±5%
	5/7	**R418	Carbon film ¼W	100Ω	±5%
	2/3	*R419	Carbon film ¼W	4.7k	±5%
	5/7	**R419	Carbon film ¼W	1.5k	±5%
	2/3	*R420	Carbon film ¼W	1k	±5%
	5/7	**R420	Carbon film ¼W	1.5k	±5%
2/3		*R421	Carbon film ¼W	100Ω	±5%
2/3		*R422	Carbon film ¼W	100Ω	±5%
	2/3	*R423	Carbon film ¼W	68k	±5%
	5/7	**R423	Metal film ¼W	1.3k	±1%
	2/3	*R424	Carbon film ¼W	82k	±5%
	5/7	**R424	Metal film ¼W	1.3k	±1%
	2/3	*R425	Carbon film ¼W	100Ω	±5%
	5/7	**R425	Metal film ¼W	5.1k	±1%
	2/3	*R426	Carbon film ¼W	68k	±5%
	5/7	**R426	Carbon film ¼W	100Ω	±5%
2/3		*R427	Carbon film ¼W	100Ω	±5%
	2/3	*R428	Carbon film ¼W	220Ω	±5%
	5/7	**R428	Carbon film ¼W	100Ω	±5%
2/3		*R429	Carbon film ¼W	100Ω	±5%
2/3		*R430	Carbon film ¼W	100Ω	±5%
	2/3	*R431	Carbon film ¼W	680Ω	±5%
	5/7	**R431	Metal film 2W	8.2k	±5%
	2/3	*R432	Carbon film ¼W	100Ω	±5%

SCH. No. S	SCH. No. PL	Symbol No.	Description		
			RESISTORS		
	5/7	**R432	Metal film 2W	8.2k	±5%
2/3	4/7	*R433	Carbon film ¼W	47Ω	±5%
2/3	4/7	*R434	Carbon film ¼W	4.7k	±5%
2/3	4/7	*R435	Carbon film ¼W	4.7k	±5%
2/3	4/7	*R436	Carbon film ¼W	1.8k	±5%
2/3	4/7	*R437	Carbon film ¼W	4.7k	±5%
2/3	4/7	*R438	Carbon film ¼W	47Ω	±5%
2/3	4/7	*R439	Carbon film ¼W	4.7k	±5%
2/3	4/7	*R440	Carbon film ¼W	100Ω	±5%
2/3	4/7	*R441	Carbon film ¼W	100Ω	±5%
2/3	4/7	*R442	Carbon film ¼W	680Ω	±5%
2/3	4/7	*R443	Carbon film ¼W	100Ω	±5%
2/3	4/7	*R444	Carbon film ¼W	100Ω	±5%
2/3	4/7	*R445	Carbon film ¼W	220Ω	±5%
2/3	4/7	R446	Carbon film ¼W	1.5k	±5%
2/3	4/7	R447	Carbon film ¼W	1.5k	±5%
2/3	4/7	R448	Carbon film ¼W	100k	±5%
2/3	4/7	R449	Carbon film ¼W	100k	±5%
2/3	4/7	R450	Carbon film ¼W	3.3k	±5%
2/3	4/7	R451	Carbon film ¼W	56Ω	±5%
2/3	4/7	R452	Carbon film ¼W	82k	±5%
2/3	4/7	R453	Carbon film ¼W	33k	±5%
2/3	4/7	R454	Carbon film ¼W	33k	±5%
2/3	4/7	R455	Carbon film ¼W	56Ω	±5%
2/3	4/7	R456	Carbon film ¼W	1k	±5%
2/3	4/7	R457	Carbon film ¼W	56Ω	±5%
2/3	4/7	R458	Carbon film ¼W	560Ω	±5%
2/3	4/7	R459	Carbon film ¼W	560Ω	±5%
2/3	4/7	R460	Carbon film ¼W	2.2k	±5%
2/3	4/7	R461	Carbon film ¼W	2.2k	±5%
2/3	4/7	R462	Carbon film ¼W	220Ω	±5%
2/3	4/7	R463	Carbon film ¼W	2.2k	±5%
2/3	4/7	R464	Carbon film ¼W	2.2k	±5%
2/3	4/7	R465	Carbon film ¼W	100k	±5%
2/3	4/7	R466	Carbon film ¼W	100k	±5%
2/3	4/7	R467	Carbon film ¼W	100k	±5%
2/3	4/7	R468	Carbon film ¼W	100k	±5%
2/3	4/7	R469	Carbon film ¼W	100k	±5%
2/3	4/7	R470	Carbon film ¼W	10k	±5%
2/3	4/7	R471	Carbon film ¼W	100k	±5%
2/3	4/7	R472	Carbon film ¼W	220k	±5%
2/3	4/7	R473	Carbon film ¼W	100k	±5%
2/3	4/7	R474	Carbon film ¼W	100k	±5%
2/3	4/7	R475	Carbon film ¼W	220k	±5%
2/3	5/7	*R476	Carbon film ¼W	10Ω	±5%
2/3	5/7	*R477	Carbon film ¼W	100Ω	±5%
2/3	5/7	*R478	Carbon film ¼W	1.2k	±5%
2/3	4/7	*R479	Carbon film ¼W	100k	±5%
2/3		*R480	Carbon film ¼W	330Ω	±5%
2/3		*R481	Carbon film ¼W	330Ω	±5%
	4/7	**R482	Carbon film ¼W	100Ω	±5%

(LBO-308S only)** *(LBO-308PL only)**

SCH. No. S	SCH. No. PL	Symbol No.	Description		
			RESISTORS		
3/3	6/7	R501	Carbon film ¼W	100k	±5%
3/3	6/7	R502	Carbon film ¼W	120k	±5%
3/3	6/7	R503	Carbon film ¼W	22k	±5%
3/3	6/7	R504	Carbon film ¼W	2.2k	±5%
3/3	6/7	R505	Carbon film ¼W	100Ω	±5%
3/3	6/7	R506	Carbon film ¼W	22k	±5%
3/3	6/7	R507	Carbon film ¼W	1k	±5%
3/3	6/7	R508	Carbon film ¼W	330Ω	±5%
3/3	7/7	R509	Carbon film ¼W	1M	±5%
3/3	7/7	R510	Carbon film ¼W	220k	±5%
3/3	7/7	R511	Carbon film ¼W	100k	±5%
3/3	7/7	R512	Carbon film ¼W	10k	±5%
3/3	7/7	R513	Carbon film ¼W	100Ω	±5%
3/3	6/7	R514	Carbon film ¼W	100Ω	±5%
3/3	6/7	R515	Carbon film ¼W	10k	±5%
3/3	6/7	R516	Carbon film ¼W	1k	±5%
3/3	6/7	R517	Carbon film ¼W	4.7k	±5%
3/3	6/7	R518	Carbon film ¼W	12k	±5%
3/3	6/7	R519	Carbon film ¼W	1k	±5%
3/3	6/7	R520	Carbon film ¼W	56k	±5%
3/3	6/7	R521	Carbon film ¼W	1k	±5%
3/3	6/7	R522	Carbon film ¼W	100k	±5%
3/3	6/7	R523	Carbon film ¼W	100k	±5%
3/3	6/7	R524	Carbon film ¼W	100k	±5%
3/3	6/7	R525	Carbon film ¼W	100k	±5%
3/3	6/7	R526	Carbon film ¼W	100k	±5%
3/3	6/7	R527	Carbon film ¼W	100k	±5%
3/3	6/7	R528	Carbon film ¼W	100k	±5%
3/3	6/7	R529	Carbon film ¼W	100Ω	±5%
3/3	6/7	R530	Carbon film ¼W	100k	±5%
3/3	6/7	R531	Carbon film ¼W	5.6k	±5%
3/3	6/7	R532	Carbon film ¼W	6.8k	±5%
3/3	6/7	R533	Carbon film ¼W	15k	±5%
3/3	6/7	R534	Carbon film ¼W	22k	±5%
3/3	6/7	R535	Carbon film ¼W	100k	±5%
3/3	6/7	R536	Carbon film ¼W	10k	±5%
3/3	6/7	R537	Carbon film ¼W	68k	±5%
3/3	6/7	R538	Carbon film ¼W	10k	±5%
3/3	6/7	R539	Carbon film ¼W	2.2k	±5%
3/3	6/7	R540	Carbon film ¼W	100k	±5%
3/3	6/7	R541	Carbon film ¼W	15k	±5%
3/3	6/7	R542	Carbon film ¼W	4.7k	±5%
3/3	6/7	R543	Carbon film ¼W	56k	±5%
3/3	6/7	R544	Carbon film ¼W	2.2M	±5%
	3/3	*R545	Carbon film ¼W	180k	±5%
	6/7	**R545	Carbon film ¼W	47k	±5%
	3/3	*R546	Carbon film ¼W	5.6k	±5%
	6/7	**R546	Carbon film ¼W	3.3k	±5%
3/3	6/7	R547	Carbon film ¼W	4.7k	±5%
3/3	6/7	R548	Carbon film ¼W	2.2k	±5%
3/3	6/7	R549	Carbon film ¼W	1M	±5%
	6/7	R550			
3/3	6/7	R551	Carbon film ¼W	22k	±5%
3/3	6/7	R552	Carbon film ¼W	1k	±5%
	3/3	*R553	Carbon film ¼W	4.7k	±5%

*(LBO-308S only) **(LBO-308PL only)

SCH. No. S	SCH. No. PL	Symbol No.	Description		
			RESISTORS		
	6/7	**R553	Carbon film ¼W	3.9k	±5%
3/3	6/7	R554	Carbon film ¼W	100Ω	±5%
3/3	6/7	R555	Carbon film ¼W	4.7k	±5%
3/3	6/7	R556	Carbon film ¼W	120k	±5%
3/3	6/7	R557	Carbon film ¼W	100k	±5%
	3/3	*R558	Metal film ¼W	4.1M	±5%
	6/7	**R558	Metal glaze ¼W	4.1M	±1%
3/3	6/7	R559	Metal film ¼W	2M	±1%
3/3	6/7	R560	Metal film ¼W	1M	±1%
3/3	6/7	R561	Metal film ¼W	400k	±1%
3/3	6/7	R562	Metal film ¼W	200k	±1%
	3/3	*R563	Metal film ¼W	100k	±1%
	6/7	**R563	Metal film ¼W	98k	±1%
3/3	6/7	R564	Carbon film ¼W	33k	±5%
3/3	6/7	R565	Carbon film ¼W	47Ω	±5%
3/3	6/7	R566	Carbon film ¼W	10Ω	±5%
3/3	6/7	R567	Carbon film ¼W	22Ω	±5%
3/3	6/7	R568	Carbon film ¼W	10k	±5%
3/3	6/7	R569	Carbon film ¼W	2.7k	±5%
	3/3	*R570	Carbon film ¼W	1.2k	±5%
	7/7	**R570	Carbon film ¼W	1.5k	±5%
	3/3	*R571	Carbon film ¼W	1k	±5%
	7/7	**R571	Carbon film ¼W	560Ω	±5%
3/3	7/7	R572	Carbon film ¼W	56Ω	±5%
3/3	7/7	R573	Carbon film ¼W	56Ω	±5%
	3/3	*R574	Carbon film ¼W	15k	±5%
	7/7	**R574	Carbon film ¼W	6.8k	±5%
3/3	7/7	R575	Carbon film ¼W	5.6k	±5%
	3/3	*R576	Carbon film ¼W	100Ω	±5%
	7/7	**R576	Carbon film ¼W	47Ω	±5%
3/3	7/7	R577	Carbon film ¼W	1k	±5%
3/3	7/7	R578	Carbon film ¼W	5.6k	±5%
3/3	7/7	R579	Carbon film ¼W	6.8k	±5%
3/3	7/7	R580	Carbon film ¼W	22Ω	±5%
3/3	7/7	R581	Carbon film ¼W	22Ω	±5%
3/3	7/7	R582	Carbon film ¼W	220Ω	±5%
3/3	7/7	R583	Carbon film ¼W	220Ω	±5%
	3/3	*R584	Carbon film ¼W	470Ω	±5%
	7/7	**R584	Carbon film ¼W	1k	±5%
3/3	7/7	R585	Carbon film ¼W	56Ω	±5%
3/3	7/7	R586	Carbon film ¼W	22Ω	±5%
3/3	7/7	R587	Carbon film ¼W	22Ω	±5%
3/3	7/7	R588	Carbon film ¼W	22Ω	±5%
3/3	7/7	R589	Carbon film ¼W	22Ω	±5%
3/3	7/7	R590	Metal film 2W	15k	±5%
3/3	7/7	R591	Metal film 2W	15k	±5%
	7/7	**R592	Carbon film ¼W	330Ω	±5%
	7/7	**R593	Carbon film ¼W	18k	±5%
	7/7	**R594	Carbon film ¼W	3.3k	±5%

SCH. No. S	SCH. No. PL	Symbol No.	Description			
			VARIABLE RESISTORS			
1/3	1/7	VR101	Metal glaze	½W	10k	
1/3	1/7	VR102	Metal glaze	½W	1k	
1/3	1/3	*VR103	Metal glaze	½W	10k	
	1/3	*VR104	Metal glaze	0.5W	50kB	
	1/7	**VR104	Metal glaze	½W	10k	
1/3	1/7	VR105	Metal glaze	½W	1M	
1/3	1/7	VR106	Metal glaze	½W	1M	
1/3	1/7	VR107	Metal film	½W	2M (insulated shaft)	
1/3	1/3	*VR108	Metal glaze	½W	22k	
	1/3	*VR109	Carbon film	0.1W	50k	
	1/7	**VR109	Carbon film	0.1W	50kB	
1/3	1/7	VR110	Metal glaze	½W	220k	
1/3	1/7	VR111	Metal glaze	½W	10k	
	1/7	**VR112	Metal glaze	½W.	1M	
2/3	2/7	VR201	Metal glaze	½W	22k	
2/3	2/7	VR202	Metal glaze	½W	100Ω	
2/3	2/7	VR203	Carbon film	½W	300ΩC	w/S202
2/3	2/7	VR204	Carbon film	½W	1kC	w/S202
2/3	2/7	VR205	Carbon film	0.1W	500ΩB	
2/3	2/7	VR206	Metal glaze	½W	1k	
2/3	3/7	VR301	Metal glaze	½W	22k	
2/3	3/7	VR302	Metal glaze	½W	100Ω	
	2/3	*VR303	Carbon film	½W	300ΩC	w/S303
	3/7	**VR303	Carbon film	½W	300Ω	(S302
	2/3	*VR304	Carbon film	½W	1kC	w/S303
	3/7	**VR304	Carbon film	½W	1kC	(S302
2/3	3/7	VR305	Carbon film	0.1W	500ΩB	
2/3	3/7	VR306	Metal glaze	½W	1k	
	2/3	*VR401	Metal glaze	½W	1kB	
	3/7	**VR401	Metal glaze	½W	220Ω	
	2/3	*VR402	Metal glaze	½W	220k	
	3/7	**VR402	Metal glaze	½W	22k	
	2/3	*VR403	Metal glaze	½W	4.7k	
	3/7	**VR403	Metal glaze	½W	10k	
	2/3	*VR404				
	3/7	**VR404	Metal glaze	½W	3.3k	
	2/3	*VR405	Metal glaze	½W	330Ω	
	3/7	**VR405	Metal glaze	½W	470Ω	
	3/3	*VR501	Carbon film	½W	20kB	w/S501
	7/7	**VR501	Carbon film	½W	20kB	w/S505
3/3	7/7	VR502	Metal glaze	½W	100k	
	3/3	*VR503	Metal glaze	½W	470ΩB	
	7/7	**VR503	Metal glaze	½W	470Ω	
3/3	7/7	VR504	Metal glaze	½W	47k	
3/3	7/7	VR505	Metal glaze	½W	4.7k	
3/3	7/7	VR506	Carbon film	½W	10k	w/S506
3/3	7/7	VR507	Carbon film	½W	20kB	
3/3	7/7	VR508	Metal glaze	½W	470Ω	
3/3	7/7	VR509	Metal glaze	½W	10k	
	3/3	*VR510	Metal glaze	½W	220Ω	
	7/7	**VR510	Metal glaze	½W	220	
3/3		**VR511	Metal glaze	½W	100	

SCH. No. S	SCH. No. PL	Symbol No.	Description			
			CAPACITORS			
1/3	1/7	C101	Mica	500V	47pF	±10%
1/3	1/7	C102	Mica	50V	220pF	±10%
1/3	1/7	C103	Mica	50V	150pF	±10%
1/3	1/7	C104	Mica	500V	10pF	±10%
	1/3	*C105	Electrolytic	35V	4.7μF	
	1/7	**C105	Electrolytic	35V	4.7μF	±20%
	1/3	*C106	Electrolytic	25V	1μF	
	1/7	**C106	Electrolytic	25V	1μF	±20%
	1/3	*C107	Electrolytic	50V	47μB	
	1/7	**C107	Electrolytic	50V	47μFB	
	1/3	*C108	Plastic film		0.1μF	±10%
	1/7	**C108	Plastic film	50V	0.1μF	±10%
	1/3	*C109	Electrolytic	25V	1μF	
	1/7	**C109	Electrolytic	25V	1μF	±20%
	1/3	*C110	Electrolytic	50V	220μC	
	1/7	**C110	Electrolytic	50V	220μFC	
	1/3	*C111	Plastic film		0.1μF	±10%
	1/7	**C111	Plastic film	50V	0.1μF	±10%
	1/3	*C112	Electrolytic	25V	1μF	
	1/7	**C112	Electrolytic	25V	1μF	±20%
	1/3	*C113	Electrolytic	50V	220μC	
	1/7	**C113	Electrolytic	50V	220μFC	
	1/3	*C114	Electrolytic	25V	470μF	
	1/7	**C114	Electrolytic	25V	470μFE	
	1/3	*C115	Electrolytic	25V	33μF	
	1/7	**C115	Electrolytic	25V	33μFE	
	1/3	*C116	Electrolytic	25V	1μF	
	1/7	**C116	Electrolytic	25V	1μF	±20%
	1/3	*C117	Ceramic	50V	0.1μF	
	1/7	**C117	Ceramic	50V	0.1μF	±10%
1/3	1/7	C118	Mica	50V	220pF	±10%
	1/3	*C119	Electrolytic	50V	2200μF	
	1/7	**C119	Electrolytic	50V	2200μFSL	
1/3		*C120	Electrolytic	25V	1μF	
1/3		*C121	Electrolytic	25V	1μF	
	1/3	*C122	Ceramic	50V	0.01μF	
	1/7	**C122	Ceramic	50V	0.01μF	±10%
	1/3	*C123	Electrolytic	50V	33μF	
	1/7	**C123	Electrolytic	50V	33μFE	
1/3		*C124	Electrolytic	25V	1μF	
	1/3	*C125	Ceramic	50V	0.01μF	
	1/7	**C125	Ceramic	50V	0.01μF	±10%
1/3	1/7	C126	Ceramic	500V	0.01μF	
1/3	1/7	C127	Ceramic	1kV	0.01μF	
	1/3	*C128	Plastic film	600V	0.022μF	±10%
	1/3	**C128	Plastic film	630V	0.022μF	±10%
1/3	1/7	C129	Ceramic	1kV	0.01μF	
	1/3	*C130	Plastic film	600V	0.1μF	±20%
	1/7	**C130	Plastic film	630V	0.1μF	±20%
1/3	1/7	C131	Ceramic	2kV	0.01μF	
1/3	1/7	C132	Ceramic	2kV	0.01μF	
1/3	1/7	C133	Ceramic	2kV	220pF	±10%
	1/3	*C134	Electrolytic	25V	1μF	
	1/7	**C134	Electrolytic	25V	1μF	±20%
1/3	1/7	C135	Ceramic	50V	0.01μF	

(LBO-308S only)** *(LBO-308PL only)**

SCH. No. S	SCH. No. PL	Symbol No.	Description: CAPACITORS			
1/3	1/7	C136	Ceramic	2kV	0.01μF	
1/3	1/7	C137	Ceramic	2kV	0.01μF	
1/3	1/7	C138	Ceramic	2kV	0.01μF	
1/3	1/7	C139	Ceramic	500V	0.01μF	
	1/3	*C140	Electrolytic	280V	1μF	
	1/7	**C140	Electrolytic	250V	1μFB	
1/3	1/7	C141	Electrolytic	25V	1μF	
	1/3	*C142	Electrolytic	160V	10μFM	
	1/7	**C142	Electrolytic	160V	10μFB	
1/3	1/7	C143	Electrolytic	250V	2.2μF	
	1/3	*C144	Electrolytic	150V	10μF	
	1/7	**C144	Electrolytic	160V	10μFB	
1/3	1/7	C145	Electrolytic	160V	10μF	
	1/3	*C146	Electrolytic	16V	220μF	
	1/7	**C146	Electrolytic	16V	220μFE	
	1/3	*C147	Electrolytic	25V	1μF	
	1/7	**C147	Electrolytic	25V	1μFM	
1/3	1/7	C148	Ceramic	500V	0.01μF	
	1/3	*C149	Ceramic	50V	0.1μF	
	1/7	**C149	Ceramic	50V	0.1μF	±10%
1/3	1/7	C150	Solid	500V	0.75pF	±10%
1/3	1/7	*C151	Mica	500V	10pF	±10%
	1/3	*C152	Ceramic	50V	0.1μF	
	1/7	**C152	Ceramic	50V	0.1μF	±10%
	1/3	*C153	Electrolytic	25V	1μF	
	1/7	**C153	Electrolytic	25V	1μFM	
	1/3	*C154	Electrolytic	25V	1μF	
	1/7	**C154	Electrolytic	25V	1μFM	
	1/3	*C155	Electrolytic	50V	3.3μF	
	1/7	**C155	Electrolytic	50V	3.3μFM	
	1/7	**C156	Ceramic	50V	0.047μF	±10%
	1/7	**C157	Plastic film	200V	0.1μF	±10%
	1/7	**C158	Ceramic	500V	0.001μF	
2/3	2/7	C201	Plastic film	630V	0.1μF	±20%
2/3	2/7	C202	Plastic film	50V	0.01μF	±10%
2/3	2/7	C203	Plastic film	630V	0.01μF	±20%
2/3	2/7	C204	Mica	50V	220pF	±10%
2/3	2/7	C205	Ceramic	50V	0.01μF	
	2/3	*C206	Electrolytic	10V	10μF	
	2/7	**C206	Electrolytic	10V	10μF	±20%
2/3	2/7	C207	Ceramic	50V	0.01μF	
2/3	2/7	C208	Ceramic	50V	0.01μF	
	2/3	*C209	Electrolytic	10V	10μF	
	2/7	**C209	Electrolytic	10V	10μF	±20%
	2/3	*C210	Mica	500V	1pF	±10%
	2/7	**C210	Mica	500V	3pF	±10%
2/3	2/7	C211	Mica	500V	27pF	±10%
2/3	2/7	C212	Mica	500V	7pF	±10%
	2/3	*C213	Mica	50V	47pF	±10%
	2/7	**C213	Mica	50V	56pF	±10%
	2/3	*C214	Mica	500V	15pF	±10%
	2/7	**C214	Mica	50V	18pF	±10%
2/3	2/7	C215	Ceramic	50V	0.01μF	

SCH. No. S	SCH. No. PL	Symbol No.	Description: CAPACITORS			
	2/3	*C216	Electrolytic	16V	10μ	
	2/7	**C216	Electrolytic	16V	10μF	±20%
2/3		*C217	Mica	500V	22pF	±10%
	2/3	*C218	Mica	500V	39pF	±10%
	2/7	**C218	Mica	50V	18pF	±10%
2/3	2/7	C219	Mica	50V	47pF	±10%
	4/7	**C219	Mica	50V	47pF	±10%
	2/7	**C220	Electrolytic	25V	1μF	±20%
	2/7	**C221	Electrolytic	25V	1μF	±20%
	4/7	**C222	Mica	50V	100pF	±10%
	2/7	**C223				
	2/7	**C224				
	2/7	**C225				
	2/7	**C226	Ceramic	50V	0.01μF	
2/3	3/7	C301	Plastic film	630V	0.1μF	±20%
	2/3	*C302	Plastic film		0.01μF	±10%
	3/7	**C302	Plastic film	50V	0.01μF	±10%
2/3	3/7	C303	Plastic film	630V	0.01μF	±20%
2/3	3/7	C304	Mica	50V	220pF	±10%
2/3	3/7	C305	Ceramic	50V	0.01μF	
	2/3	*C306	Electrolytic	10V	10μF	
	3/7	**C306	Electrolytic	10V	10μF	±20%
2/3	3/7	C307	Ceramic	50V	0.01μF	
2/3	3/7	*C308	Ceramic	50V	0.01μF	
2/3	3/7	C309	Ceramic	50V	0.01μF	
	2/3	*C310	Electrolytic	10V	10μF	
	3/7	**C310	Electrolytic	10V	10μF	±20%
	2/3	*C311	Mica	500V	7pF	±10%
	3/7	**C311	Mica	500V	5pF	±10%
	2/3	*C312	Mica	500V	39pF	±10%
	3/7	**C312	Mica	500V	33pF	±10%
	2/3	*C313	Mica	500V	15pF	±10%
	3/7	**C313	Mica	500V	10pF	±10%
2/3	3/7	C314	Mica	50V	56pF	±10%
	2/3	*C315	Mica	500V	15pF	±10%
	3/7	**C315	Mica	50V	18pF	±10%
2/3	3/7	C316	Ceramic	50V	0.01μF	
	2/3	*C317	Electrolytic	16V	10μ	
	3/7	**C317	Electrolytic	16V	10μF	±20%
2/3	3/7	C318	Ceramic	50V	0.01μF	
2/3	3/7	C319	Ceramic	50V	0.01μF	
2/3	3/7	*C320	Mica	500V	22pF	±10%
2/3	2/3	*C321	Mica	500V	39pF	±10%
	3/7	**C321	Mica	50V	18pF	±10%
	2/3	*C322	Mica	50V	47pF	±10%
	4/7	**C322	Mica	50V	47pF	±10%
2/3	3/7	C323	Ceramic	50V	0.01μF	
	3/7	C324	Ceramic	50V	0.01μF	
	4/7	**C325	Mica	50V	100pF	±10%
2/3	4/7	C401	Ceramic	50V	0.01μF	
	2/3	*C402	Electrolytic	16V	1μF	
	5/7	**C402	Mica	50V	27pF	±10%
2/3	5/7	*C403	Electrolytic	16V	1μF	
	2/3	*C404	Electrolytic	16V	10μF	

(LBO-308S only)** *(LBO-308PL only)**

SCH. No. S	SCH. No. PL	Symbol No.	Description			
			CAPACITORS			
	5/7	**C404	Electrolytic	250V	4.7µF	
	2/3	*C405	Electrolytic	10V	10µF	
	5/7	**C405	Ceramic	50V	0.01µF	
	2/3	*C406	Electrolytic	25V	1µF	
	5/7	**C406	Electrolytic	16V	33µF	
	2/3	*C407	Ceramic	500V	0.01µF	
	5/7	**C407	Ceramic	50V	0.01µF	
	2/3	*C408	Mica	50V	160pF	±10%
	5/7	**C408	Electrolytic	16V	33µF	
2/3		C409	Mica	50V	100pF	±10%
2/3		C410	Ceramic	500V	0.01µF	
2/3		C411	Ceramic	50V	0.01µF	
2/3		C412	Ceramic	50V	0.01µF	
2/3		C413	Ceramic	500V	0.01µF	
2/3		C414	Ceramic	500V	0.01µF	
2/3		C415	Mica	50V	100pF	±10%
2/3		C416	Mica	50V	150pF	±10%
2/3		C417	Ceramic	50V	0.01µF	
2/3		C418	Electrolytic	16V	10µF	
2/3		C419				
2/3	4/7	C420	Ceramic	50V	0.01µF	
2/3	4/7	C421	Ceramic	50V	0.01µF	
2/3	4/7	C422	Ceramic	50V	0.01µF	
2/3	4/7	C423	Electrolytic	25V	1µF	
2/3	4/7	C424	Mica	50V	47pF	±10%
2/3	4/7	C425	Mica	50V	47pF	±10%
2/3	4/7	C426	Ceramic	50V	0.01µF	
2/3	4/7	C427	Ceramic	50V	0.01µF	
2/3	2/3	*C428	Ceramic	500V	0.01µF	
	4/7	**C428	Electrolytic	10V	10µF	±20%
	2/3	*C429	Electrolytic	16V	4.7µF	
	4/7	**C429	Electrolytic	16V	4.7µF	±20%
	2/3	*C430	Electrolytic	16V	4.7µF	
	4/7	**C430	Electrolytic	16V	4.7µF	±20%
	2/3	*C431	Electrolytic	10V	10µF	
	4/7	**C431	Electrolytic	10V	10µF	±20%
2/3	4/7	C432	Ceramic	50V	0.01µF	
	3/3	*C501	Electrolytic	16V	4.7µF	
	6/7	**C501	Electrolytic	16V	4.7µF	±20%
	3/3	*C502	Electrolytic	16V	4.7µF	
	6/7	**C502	Electrolytic	16V	4.7µF	±20%
3/3	6/7	C503	Mica	500V	5pF	±10%
3/3	6/7	C504	Ceramic	50V	0.01µF	
	3/3	*C505	Electrolytic	10V	10µF	
	6/7	**C505	Electrolytic	10V	10µF	±20%
3/3	6/7	C506	Ceramic	50V	0.01µF	
3/3	6/7	C507	Ceramic	50V	0.01µF	
3/3	6/7	C508	Ceramic	50V	0.1µF	
	3/3	*C509	Electrolytic	10V	10µF	
	7/7	**C509	Electrolytic	10V	10µF	±20%
	3/3	*C510	Plastic film		0.0047µF	±10%
	7/7	**C510	Plastic film	50V	0.0047µF	±10%

SCH. No. S	SCH. No. PL	Symbol No.	Description			
			CAPACITORS			
3/3	5/7	C511	Mica	50V	220pF	±10%
3/3	5/7	C512	Ceramic	50V	0.01µF	
	3/3	C513	Electrolytic	10V	10µF	
	6/7	C513	Electrolytic	10V	10µF	±20%
3/3	6/7	C514	Mica	500V	3pF	±10%
	3/3	*C515	Electrolytic	25V	1µF	
	6/7	**C515	Electrolytic	25V	1µ	±20%
	3/3	*C516	Electrolytic	25V	1µF	
	6/7	**C516	Electrolytic	25V	1µ	±20%
	3/3	*C517	Electrolytic	25V	0.01µF	
	6/7	**C517	Electrolytic	25V	1µ	±20%
3/3	6/7	C518	Plastic film		0.01µF	±10%
	6/7	C518	Plastic film	50V	0.01µF	±10%
	3/3	*C519	Electrolytic	25V	1µF	
	6/7	**C519	Electrolytic	25V	1µ	±20%
3/3	6/7	C520	Ceramic	50V	0.01µF	
	3/3	*C521	Plastic film		0.001µF	±10%
	6/7	**C521	Plastic film	50V	0.001µF	±10%
	3/3	*C522	Electrolytic	6.3V	47µF	
	6/7	**C522	Electrolytic	6.3V	47µF	
	3/3	*C523	Plastic film		0.0047µF	±10%
	6/7	**C523	Plastic film	50V	0.0047µF	±10%
	3/3	*C524	Electrolytic	25V	1µF	
	6/7	**C524	Electrolytic	25V	1µF	±20%
3/3	6/7	C525	Ceramic	50V	0.01µF	
3/3	6/7	C526	Electrolytic	10V	10µF	
3/3	6/7	**C527	Mica	500V	270pF	±10%
3/3	6/7	C528	Ceramic	50V	0.01µF	
	3/3	*C529	Plastic film		0.022µF	±10%
	6/7	**C529	Plastic film	50V	0.022µF	±10%
	3/3	*C530	Plastic film		1µF	± 2%
	6/7	**C530	Plastic film	250V	1µF	± 2%
		*C531				
	6/7	**C531				
	3/3	*C532	Plastic film		0.01µF	± 2%
	6/7	**C532	Plastic film	100V	0.01µF	± 2%
3/3	6/7	C533	Mica	500V	47pF	±10%
	3/3	*C534	Mica	500V	5pF	±10%
	6/7	**C534	Mica	50V	39pF	±10%
		*C535				
	6/7	**C535				
	3/3	*C536	Electrolytic	10V	33µF	
	6/7	**C536	Electrolytic	10V	33µF	±20%
	3/3	*C537	Electrolytic	16V	22µF	
	6/7	**C537	Electrolytic	16V	22µF	±20%
3/3	6/7	C538	Ceramic	500V	0.01µF	
3/3	6/7	C539	Ceramic	50V	0.01µF	
	3/3	*C540	Electrolytic	16V	22µF	
	6/7	**C540	Electrolytic	16V	22µF	±20%
3/3	7/7	C541	Mica	50V	47pF	±10%
3/3	7/7	C542	Ceramic	50V	0.01µF	
	3/3	*C543	Plastic film		1800pF	±10%
	7/7	**C543	Plastic film	50V	3900pF	±10%
	3/3	*C544	Plastic film		470pF	±10%
	7/7	**C544	Plastic film	50V	330pF	±10%

(LBO-308S only)** *(LBO-308PL only)**

CAPACITORS

SCH. No. S	SCH. No. PL	Symbol No.	Description		Value	Tolerance
3/3		C545	Ceramic	500V	0.001µF	
3/3	6/7	C546	Ceramic	50V	0.01µF	
3/3	6/7	C547	Electrolytic	250V	4.7µF	
	7/7	**C548				
	7/7	**C549	Electrolytic	16V	33µF	±20%
	6/7	C550	Mica	500V	5pF	±10%
1/7		C601	Ceramic	2kV	0.0022µF	
1/7		C602	Ceramic	2kV	0.0022µF	
1/7		C603	Ceramic	2kV	0.0022µF	
1/7		C604	Ceramic	2kV	0.0022µF	
1/7		C605	Ceramic	2kV	0.0022µF	
1/7		C606	Ceramic	2kV	0.0022µF	
1/7		C607	Ceramic	2kV	0.0022µF	
1/7		C608	Ceramic	2kV	0.0022µF	
1/7		C609	Ceramic	2kV	0.0022µF	
1/7		C610	Ceramic	2kV	0.0022µF	
1/7		C611	Ceramic	2kV	0.0022µF	
1/7		C612	Ceramic	2kV	0.0022µF	
1/7		C613	Ceramic	2kV	0.0022µF	
1/7		C614	Ceramic	2kV	0.0022µF	
1/7		C615	Ceramic	2kV	0.0022µF	
1/7		C616	Ceramic	2kV	0.0022µF	
1/7		C617	Ceramic	2kV	0.0022µF	
1/7		C618	Ceramic	2kV	0.0022µF	
1/7		C619	Ceramic	2kV	0.0022µF	
1/7		C620	Ceramic	2kV	0.0022µF	
1/7		C621	Ceramic	2kV	0.0022µF	
1/7		C622	Ceramic	2kV	0.0022µF	

VARIABLE CAPACITORS

SCH. No. S	SCH. No. PL	Symbol No.	Description		Value
1/3	1/7	VC101	Ceramic	500V	10pF
2/3	2/3	*VC201	Ceramic	500V	201F
	1/7	**VC201	Ceramic	500V	20pF
2/3	3/7	VC301	Ceramic	500V	20pF
2/3	5/7	VC401	Ceramic	500V	20pF
2/3	5/7	VC402	Ceramic	500V	20pF
3/3	6/7	VC501	Ceramic	500V	40pF
3/3		VC502	Ceramic	500V	20pF

TRANSISTORS

SCH. No. S	SCH. No. PL	Symbol No.	Description	
1/3		Q101	NPN	2SC1318-R/S (50V)
	1/7	Q101	NPN (50V, 400mW)	2SC1318-R-S
1/3		Q102	NPN	2SC1318-R/S (50V)
	1/7	Q102	NPN (50V, 400mW)	2SC1318-R-S
1/3		Q103	NPN	2SC1173-Y (30V)
	1/7	Q103	NPN (30V, 10W)	2SC1173-Y
1/3		Q104	NPN	2SC1173-Y (30V)
	1/7	Q104	NPN (30V, 10W)	2SC1173-Y
1/3		Q105	PNP	2SA1015-GR (–50V)
	1/7	Q105	PNP (–50V, 400 mW)	2SA1015-GR

*(LBO-308S only) **(LBO-308PL only)

TRANSISTORS

SCH. No. S	SCH. No. PL	Symbol No.	Description	
1/3		Q106	NPN	2SC1815-Y (50V)
	1/7	Q106	NPN (50V, 400mW)	2SC1815-Y
1/3		Q107	PNP	2SA886-Q (–40V)
	1/7	Q107	PNP (–40V, 1.2W)	2SA886-Q
1/3		Q108	PNP	2SA1015-GR (–50V)
	1/7	Q108	PNP (–50V, 400mW)	2SA1018-GR
1/3		Q109	NPN	2SC1815-Y (50V)
	1/7	Q109	NPN (50V, 400mW)	2SC1815-Y
1/3		Q110	NPN	2SC1846-Q (35V)
1/3		Q111	NPN	2SC1815-Y (50V)
1/3		Q112	NPN	2SC1815-Y (50V)
1/3		Q113	PNP	2SA1015-GR (–50V)
1/3		Q114	J-FET	2SK30A-GR (50V)
1/3		Q115	J-FET	2SK30A-GR (50V)
1/3		Q116	NPN	2SC1815-Y (50V)
	1/7	Q116	NPN (50V, 400mW)	2SC1815-Y
1/3		Q117	NPN	2SD880-O (60V)
	1/7	Q117	NPN (60V, 30W)	2SC880-O
1/3		Q118	NPN	2SC1318-R/S (50V)
	1/7	Q118	NPN (50, 400mW)	2SC1318-R-S
1/3		Q119	NPN	2SC1815-Y (50V)
1/3		Q120	NPN	2SC1815-Y (50V)
1/3		Q121	NPN	2SC1815-Y (50V)
1/3		Q122	PNP	2SA1015-Y (–50V)
1/3		Q123	NPN	2SC1279S-E (160V)
	1/7	Q123	NPN (160V, 250mW)	2SC1279S-E
1/3		Q124	NPN	2SD470-B (700V)
	1/3	*Q125	NPN	2SC983-Y (150V)
	1/7	**Q125	NPN (150V, 800mW)	2SC2229-Y
	1/3	*Q126	NPN	2SC983-Y (150V)
	1/7	**Q126	NPN (150V, 800mW)	2SC2229-Y
1/3		Q127	NPN	2SC1815-Y (50V)
	1/7	Q127	NPN (50V, 400mW)	2SC1815-Y
1/3		Q128	PNP	2SA1015-GR (–50V)
	1/7	Q128	PNP (–50V, 400 mW)	2SA1015-GR
2/3		Q201	NPN	2SC1815-O/Y (50V)
	2/7	Q201	NPN (50V, 400mW)	2SC1815-O-Y
2/3		Q202	NPN	2SC1815-O/Y (50V)
	2/7	Q202	NPN (50V, 400mW)	2SC1815-O-Y
2/3		Q203	Dual J-FET	IMF3958 (40V)
	2/7	Q203	Dual J-FET (–40V)	IMF3958
2/3		Q204	Quad NPN	MPQ918 (20V)
	2/7	Q204	NPN (20V, 300mW)	MPQ918
2/3		Q205	NPN	2SC1215 (20V)
	2/7	Q205	NPN (20V, 200mW)	2SC1215
2/3		Q206	NPN	2SC1215 (20V)
	2/7	Q206	NPN (20V, 200mW)	2SC1215
2/3		Q207	NPN	2SC1215 (20V)
	2/7	Q207	NPN (20V, 200mW)	2SC1215
2/3		Q208	PNP	2SA1015-GR (–50V)
	2/7	Q208	PNP (–50V, 400mW)	2SA1015-GR
2/3		Q209	NPN	2SC1215 (20V)
	2/7	Q209	NPN (20V, 200mW)	2SC1215
	2/3	*Q210	PNP	2SA1015-GR (–50V)
	2/7	**Q210	PNP (–50V, 400mW)	2SA1015-GR

SCH. No. S	SCH. No. PL	Symbol No.	Description	
			TRANSISTORS	
2/3		Q211	NPN	2SC1215 (20V)
	2/7	Q211	NPN (20V, 200mW)	2SC1215
2/3		Q212	NPN	2SC1215 (20V)
	2/7	Q212	NPN (20V, 200mW)	2SC1215
2/3		Q213	NPN	2SC1215 (20V)
	2/7	Q213	NPN (20V, 200mW)	2SC1215
2/3		Q214	NPN	2SC1215 (20V)
	2/7	Q214	NPN (20V, 200mW)	2SC1215
2/3		Q215	NPN	2SC1215 (20V)
	4/7	Q215	NPN (20V, 200mW)	2SC1215
2/3		Q216	PNP	2SA1015-GR (−50V)
	4/7	Q216	PNP (−50V, 400mW)	2SA1015-GR
2/3		Q301	NPN	2SC1815-O/Y (50V)
	3/7	Q301	NPN (50V, 400 mW)	2SC1815-O-Y
2/3		Q302	NPN	2SC1815-O/Y (50V)
	3/7	Q302	NPN (50V, 400mW)	2SC1815-O-Y
2/3		Q303	Dual J-FET	IMF3958 (40V
	3/7	Q303	Dual J-FET (−40V)	IMF3958
	2/3	*Q304	Quad NPN	MPQ918 (20V)
	3/7	**Q304	NPN (20V, 300mW)	MPQ918
2/3		Q305	NPN	2SC1215 (20V)
	3/7	Q305	NPN (20V, 200mW)	2SC1215
2/3		Q306	NPN	2SC1215 (20V)
	3/7	Q306	NPN (20V, 200mW)	2SC1215
2/3		Q307	NPN	2SC1215 (20V)
	3/7	Q307	NPN (20V, 200mW)	2SC1215
2/3		Q308	NPN	2SC1215 (20V)
	3/7	Q308	NPN (20V, 200mW)	2SC1215
2/3		Q309	NPN	2SC1215 (20V)
	3/7	Q309	NPN (20V, 200mW)	2SC1215
2/3		Q310	PNP	2SA1015-GR (−50V)
	3/7	Q310	PNP (−50V, 400mW)	2SA1015-GR
2/3		Q311	NPN	2SC1215 (20V)
	3/7	Q311	NPN (20V, 200mW)	2SC1215
2/3		Q312	PNP	2SA1015-GR (50V)
	3/7	Q312	PNP (−50V, 400mW)	2SA1015-GR
2/3		Q313	NPN	2SC1215 (20V)
	3/7	Q313	NPN (20V, 200mW)	2SC1215
2/3		Q314	NPN	2SC1215 (20V)
	3/7	Q314	NPN (20V, 200mW)	2SC1215
2/3		Q315	NPN	2SC1215 (20V)
	3/7	Q315	NPN (20V, 200mW)	2SC1215
2/3		Q316	NPN	2SC1215 (20V)
	3/7	Q316	NPN (20V, 200mW)	2SC1215
2/3		Q317	NPN	2SC1215 (20V)
	4/7	Q317	NPN (20V, 200mW)	2SC1215
2/3		Q318	PNP	2SA1015-GR (−50V)
	4/7	Q318	PNP (−50V, 400mW)	2SA1015-GR
2/3		Q401	NPN	2SC1215 (20V)
	4/7	Q401	NPN (20V, 200mW)	2SC1215
2/3		Q402	NPN	2SC1215 (20V)
	4/7	Q402	NPN (20V, 200mW)	2SC1215
	2/3	*Q403	NPN	2SC1215 (20V)

*(LBO-308S only) **(LBO-308PL only)

SCH. No. S	SCH. No. PL	Symbol No.	Description	
			TRANSISTORS	
	4/7	**Q403	PNP (−50V, 400mW)	2SA1015-Y
	2/3	*Q404	PNP	2SA1015-GR (−50V)
	4/7	**Q404	PNP (−50V, 400mW)	2SA1015-Y
	2/3	*Q405	PNP	2SA1015-GR (−50V)
	4/7	**Q405	PNP (−50V, 400mW)	2SA1015-Y
	2/3	*Q406	PNP	2SA1015-GR (−50V)
	4/7	**Q406	NPN (50V, 400mW)	2SC1815-Y
	2/3	*Q407	NPN	2SC1215 (20V)
	4/7	**Q407	NPN (50V, 400mW)	2SC1815-Y
	2/3	*Q408	NPN	2SC1628-Y (150V)
	4/7	**Q408	PNP (−50V, 400mW)	2SA1015-Y
	2/3	*Q409	PNP	2SA818-Y (−150V)
	5/7	**Q409	PNP (−50V, 400mW)	2SA1015-GR
	2/3	*Q410	NPN	2SC1215 (20V)
	5/7	**Q410	PNP (−50V, 400mW)	2SA1015-GR
	2/3	*Q411	PNP	2SA1015-GR (−50V)
	5/7	**Q411	NPN (20V, 200mW)	2SC1215
	2/3	*Q412	PNP	2SA1015-GR (−50V)
	5/7	**Q412	NPN (20V, 200mW)	2SC1215
	2/3	*Q413	NPN	2SC1215 (20V)
	5/7	**Q413	NPN (150V, 1W)	2SC1953-R-Q
	2/3	*Q414	NPN	2SC1628-Y (150V)
	5/7	**Q414	NPN (150V, 1W)	2SC1953-R-Q
	2/3	*Q415	PNP	2SA818-Y (−150V)
	5/7	**Q415	NPN (20V, 200mW)	2SC1215
2/3	4/7	Q416	NPN	2SC1215 (20V)
2/3	4/7	Q417	NPN	2SC1215 (20V)
	2/3	Q418	NPN	2SC1815-O/Y (50V)
	4/7	Q418	NPN (50V, 400mW)	2SC1815-O-Y
	4/7	Q419	NPN (50V, 400mW)	2SC1815-O-Y
	4/7	Q420	NPN (50V, 400mW)	2SC1815-O-Y
	2/3	Q421	PNP	2SA1015-GR (−50V)
	4/7	Q421	PNO (−50V, 400mW)	2SA1015-GR
	2/3	Q422	NPN	2SC1215 (20V)
	4/7	Q422	NPN (20V, 200mW)	2SC1215
	2/3	Q423	NPN	2SC1815-O/Y (50V)
	4/7	Q423	NPN (50V, 400mW)	2SC1815-O-Y
	2/3	Q424	NPN	2SC1815-O/Y (50V)
	4/7	Q424	NPN (50V, 400mW)	2SC1815-O-Y
	3/3	Q501	NPN	2SC1815-O/Y (50V)
	6/7	Q501	NPN (50V, 400mW)	2SC1815-O·Y
	3/3	Q502	NPN	2SC1815-O/Y (50V)
	6/7	Q502	NPN (50V, 400mW)	2SC1815-O·Y
	3/3	Q503	NPN	2SC1215 (20V)
	6/7	Q503	NPN (20V, 200mW)	2SC1215
3/3		Q504	PNP	2SA1015-GR (−50V)
	6/7	Q504	PNP (−50V, 400mW)	2SA1015-GR
3/3		Q505	PNP	2SA1015-GR (−50V)
	6/7	Q505	PNP (−50V, 400mW)	2SA1015-GR
3/3		Q506	NPN	2SC1815-O/Y (50V)
	6/7	Q506	NPN (50V, 400mW)	2SC1815-O·Y
3/3		Q507	NPN	2SC1815-O/Y (50V)
	6/7	Q507	NPN (50V, 400mW)	2SC1815-O·Y
3/3		Q508	NPN	2SC1215 (20V)

SCH. No.		Symbol No.	Description	
S	PL		**TRANSISTORS**	
	6/7	Q508	NPN (20V, 200mW)	2SC1215
3/3		Q509	NPN	2SC752-O (15V)
	6/7	Q509	NPN (15V, 400mW)	2SC752-O
3/3		Q510	PNP	2SA1015-GR (−50V)
	6/7	Q510	PNP (−50V, 400mW)	2SA1015-GR
3/3		Q511	PNP	2SA1015-GR (−50V)
	6/7	Q511	PNP (−50V, 400mW)	2SA1015-GR
3/3		Q512	NPN	2SC1815-O/Y (50V)
	6/7	Q512	NPN (50V, 400mW)	2SC1815-O•Y
3/3		Q513	PNP	2SA1015-GR (−50V)
	6/7	Q513	PNP (−50V, 400mW)	2SA1015-GR
3/3		Q514	NPN	2SC1815-O/Y (50V)
	6/7	Q514	NPN (50V, 400mW)	2SC1815-O•Y
3/3		Q515	PNP	2SA1015-GR (−50V)
	7/7	Q515	PNP (−50V, 400mW)	2SA1015-GR
3/3		Q516	PNP	2SA1015-GR (−50V)
	7/7	Q516	PNP (−50V, 400mW)	2SA1015-GR
3/3		Q517	NPN	2SC1815-O/Y (50V)
	7/7	Q517	NPN (50V, 400mW)	2SC1815-O•Y
3/3		Q518	NPN	2SC1815-O/Y (50V)
	7/7	Q518	NPN (50V, 400mW)	2SC1815-O•Y
3/3		Q519	NPN	2SC1815-O/Y (50V)
	7/7	Q519	NPN (50V, 400mW)	2SC1815-O•Y
	3/3	*Q520	NPN	2SC983-O (150V)
	7/7	**Q520	NPN (150V, 800mW)	2SC2229-O
	3/3	*Q521	NPN	2SC983-O (150V)
	7/7	**Q521	NPN (150V, 800mW)	2SC2229-O
			DIODES	
1/3		D101	Det	1S1588 (35V)
	1/7	D101	Det (35V, 120mA)	1S1588
1/3		D102	Det	1S1588 (35V)
	1/7	D102	Det (35V, 120mA)	1S1588
1/3		D103	Det	1S1588 (35V)
	1/7	D103	Det (35V, 120mA)	1S1588
1/3		D104	Det	1S1588 (35V)
	1/7	D104	Det (35V, 120mA)	1S1588
	1/3	*D105	Det	RAIZN (200V, 1A)
	1/7	**D105	Rect (200V, 1A)	1DZ61
	1/3	*D106	Zener	RD8.2EB (8.2V, 400mW)
	1/7	**D106	Zener (6.8V, 400mV)	RD6.8EB
1/3		D107	Rect	1S1834 (400V, 1A)
	1/7	D107	Rect (400V, 1A)	1S1834
1/3		D108	Det	1S1588 (35V)
	1/7	D108	Det (35V, 120mA)	1S1588
1/3		D109	Det	1S1588 (35V)
	1/7	D109	Det (35V, 120mA)	1S1588
1/3		D110	Zener	RD6.2EB (6.2V, 400mW)
	1/7	D110	Zener (6.2V, 400mW)	RD6.2EB
1/3	1/3	*D111	Det	RAIZN (200V, 1A)
1/3		D112	Bridge Rect	W-02 (200V, 1.5A)
	1/7	D112	Bridge Rect (200V, 1.5A)	W-02
	1/3	*D113	Zener	02BZ2.2 (2.2V, 250mW)
	1/3	*D114	Det	1S1588 (35V)

*(LBO-308S only) **(LBO-308PL only)

SCH. No.		Symbol No.	Description	
S	PL		**DIODES**	
	1/3	*D115	Det	1S1588 (35V)
	1/3	*D116	Zener	02BZ2.2 (2.2V, 250mW)
	1/3	*D117	Zener	RD8.2EB (8.2V, 400mW)
	1/3	*D118	Det	1S1588 (35V)
1/3		D119	Det	1S1588 (35V)
	1/7	D119	Det (35V, 120mA)	1S1588
	1/3	*D120	Zener	RD12EB (12V, 400mW)
1/3		D121	Rect	SF-1 (1500V, 30mA)
	1/7	D121	Rect (1500V, 30mA)	SF-1
1/3		D122	Rect	SF-1 (1500V, 30mA)
	1/7	D122	Rect (1500V, 30mA)	SF-1
1/3		D123	Rect	SF-1 (1500V, 30mA)
	1/7	D123	Rect (1500V, 30mA)	SF-1
1/3		D124	Det	1S1588 (35V)
	1/7	D124	Det (35V, 120mA)	1S1588
1/3		D125	Rect	1S2463 (320V, 100mA)
	1/7	D125	Rect (320V, 100mA)	1S2463
1/3		D126	Rect	1S2463 (320V, 100mA)
	1/7	D126	Rect (320V, 100mA)	1S2463
1/3		D127	Rect	1S2463 (320V, 100mA)
	1/7	D127	Rect (320V, 100mA)	1S2463
1/3		D128	Rect	1S2463 (320V, 100mA)
	1/7	D128	Rect (320V, 100mA)	1S2463
1/3		D129	Rect	1S2463 (320V, 100mA)
	1/7	D129	Rect (320V, 100mA)	1S2463
1/3		D130	Zener	RD5-1EB (5.1V, 400mW)
	1/7	D130	Zener (5.1V, 400mW)	RD5.1EB
1/3		D131	Rect	1S2463 (320V, 100mA)
	1/7	D131	Rect (320V, 100mA)	1S2463
1/3		D132	Rect	1S2463 (320V, 100mA)
	1/7	D132	Rect (320V, 100mA)	1S2463
1/3		D133	Rect	1S2463 (320V, 100mA)
	1/7	D133	Rect (320V, 100mA)	1S2463
1/3		D134	Rect	1S2463 (320V, 100mA)
	1/7	D134	Rect (320V, 100mA)	1S2463
1/3		D135	Det	1S1588 (35V)
	1/7	D135	Det (35V, 120mA)	1S1588
1/3		D136	Det	1S1588 (35V)
	1/7	D136	Det (35V, 120mA)	1S1588
1/3		D137	Zener	RD3.9EB (3.9V, 400mW)
	1/7	D137	Zener (3.9V, 400mW)	RD3.9EB
1/3	1/3	*D138	LED	SLP-520D (Red/Green)
1/3	1/7	D139	LED	SLP-24B (Red)
	1/3	*D140	Rect	1DZ61 (200V, 1A)
	1/7	**D140	Rect (200V, 1A)	1DZ61
2/3		D201	Zener	RD5.1EB (5.1V, 400mW)
	2/7	D201	Zener (5.1V, 400mW)	RD5.1EB
2/3		D202	Zener	RD5.1EB (5.1V, 400mW)
	2/7	D202	Zener (5.1V, 400mW)	RD5.1EB
2/3		D203	Det	1S1588 (35V)
	2/7	D203	Det (35V, 120mA)	1S1588
2/3		D204	Det	1S1588 (35V)
	4/7	D204	Det (35V, 120mA)	1S1588
2/3		D205	Det	1S1588 (35V)
	4/7	D205	Det (35V, 120mA)	1S1588

SCH. No. S	SCH. No. PL	Symbol No.	Description	
			DIODES	
2/3		D206	Det	1S1588 (35V)
	4/7	D206	Det (35V, 120mA)	1S1588
2/3		D207	Det	1S1588 (35V)
	4/7	D207	Det (35V, 120mA)	1S1588
	4/7	D208	Zener (3V, 400mW)	RD3.0EB
2/3		D301	Zener	RD5.1EB (5.1V, 400mW)
	3/7	D301	Zener (5.1V, 400mW)	RD5.1EB
2/3		D302	Zener	RD5.1EB (5.1V, 400mW)
	3/7	D302	Zener (5.1V, 400mW)	RD5.1EB
2/3		D303	Det	1S1588 (35V)
	3/7			
	3/7	D303	Det (35V, 120mA)	1S1588
2/3		D304	Det	1S1588 (35V)
	4/7	D304	Det (35V, 120mA)	1S1588
2/3		D305	Det	1S1588 (35V)
	4/7	D305	Det (35V, 120mA)	1S1588
2/3		D306	Det	1S1588 (35V)
	4/7	D306	Det (35V, 120mA)	1S1588
2/3		D307	Det	1S1588 (35V)
	4/7	D307	Det (35V, 120mA)	1S1588
	4/7	**D308	Zener (3V, 400mW)	RD3.0EB
	4/7	D401	Det (35V, 120mA)	1S1588
	4/7	D402	Det (35V, 120mA)	1S1588
	4/7	D403	Det (35V, 120mA)	1S1588
	4/7	D404	Det (35V, 120mA)	1S1588
	4/7	D405	Det (35V, 120mA)	1S1588
	4/7	D406	Det (35V, 120mA)	1S1588
	4/7	D407		
	4/7	D408		
	4/7	D409		
	4/7	D410	Det (35V, 120mA)	1S1588
	4/7	D411	Det (35V, 120mA)	1S1588
	4/7	D412	Det (35V, 120mA)	1S1588
	4/7	D413	Det (35V, 120mA)	1S1588
	4/7	D414	Det (35V, 120mA)	1S1588
	4/7	D415	Det (35V, 120mA)	1S1588
	6/7	D501	Det (45V, 50mA)	1N60
	6/7	D502	Zener (2.2V, 250mW)	02BX2.2
	6/7	D503	Det (45V, 50mA)	1N60
	6/7	D504	Det (45V, 50mA)	1N60
	6/7	D505	Det (35V, 120mA)	1S1588
	6/7	D506	Det (35V, 120mA)	1S1588
	6/7	D507	Det (35V, 120mA)	1S1588
	6/7	D508	Det (35V, 120mA)	1S1588
	6/7	D508	Det (35V, 120mA)	1S1588
	6/7	D509	Det (35V, 120mA)	1S1588
	6/7	D510	Det (35V, 120mA)	1S1588
	6/7	D511	Det (35V, 120mA)	1S1588
	6/7	D512	Det (35V, 120mA)	1S1588
	6/7	D513	Det (35V, 120mA)	1S1588
	6/7	D514	Det (35V, 120mA)	1S1588
	6/7	D515	Det (35V, 120mA)	1S1588
	6/7	D516	Zener (5.1V, 400mW)	RD5.1EB
	7/7	D517	Det (35V, 120mA)	1S1588
	7/7	D518	Det (35V, 120mA)	1S1588
	6/7	D519	Det (35V, 120mA)	1S1588

*(LBO-308S only) **(LBO-308PL only)

SCH. No. S	SCH. No. PL	Symbol No.	Description		
			Ic		
1/3	1/7	Ic101	C.MOS CD4011CN		(Un Buffer)
1/3	1/7	Ic102	C.MOS CD4011CN		(Un Buffer)
1/3	1/7	Ic103	C.MOS CD4011CN		(Un Buffer)
1/3	1/7	Ic104	C.MOS CD4011CN		(Un Buffer)
1/3	1/7	Ic105	Regulator 78L05A	5V 100mA	
1/3	1/7	Ic106	Regulator 78M12	12V 500mA	
1/3	1/7	Ic107	Regulator 78L05A	5V 100mA	
1/3	1/7	Ic108	Regulator 78M08	8V 500mA	
2/3		Ic401	C.MOS CD4001BE		
	4/7	Ic401	C.MOS CD4001BE		Buffer
2/3	4/7	Ic402	C.MOS CD4011CN		(Un Buffer)
2/3	4/7	Ic403	C.MOS CD4011CN		(Un Buffer)
2/3		Ic404	C.MOS CD4066BE		
	4/7	Ic404	C.MOS CD4066BE		Buffer
2/3		Ic405	TTL 74LS76		
	4/7	Ic405	TTL 74LS76N		
3/3	6/7	Ic501	Amplifier AN606		
3/3	7/7	Ic502	C.MOS CD4011CN		(Un Buffer)
3/3	6/7	Ic503	TTL SN74LS00N		
3/3		Ic504	C.MOS CD4066BE		
	6/7	Ic504	C.MOS CD4066BE		Buffer
3/3		Ic505	C.MOS CD4066BE		
	6/7	Ic505	C.MOS CD4066BE		Buffer
	3/3	*Ic506	C.MOS MC145720BP		
	6/7	**Ic506	C.MOS MC14572UBP		
3/3		Ic507	C.MOS CD4066BE		
	7/7	Ic507	C.MOS CD4066BE		Buffer
3/3	6/7	Ic508	TTL SN74LS76		
3/3	6/7	Ic509	C.MOS CD4011CN		(Un Buffer)
			SWITCHES		
1/3	1/7	S101	Toggle ST-1206-NP		DPDT
1/3	1/7	S102	Switch		
1/3	1/7	S103	Slide S-2500		DPDT
1/3	1/7	S104	Slide SDS-202N-8		DPDT
2/3	2/7	S201	Slide SSB-023-(2)		Tri PDT
2/3	2/7	S202	Rotary V ATT		
2/3	3/7	S301	Slide SSB-023-(2)		Tri PDT
2/3	3/7	S302	Rotary V ATT		
2/3		S401	Push		
	4/7	S401	Push (SUB6-1)		V. Mode
2/3		S402	Push		
	4/7	S402	Push (SUB6-1)		V. Mode
2/3		S403	Push		
	4/7	S403	Push (SUB6-1)		V. Mode
2/3		S404	Push		
	4/7	S404	Push (SUB6-1)		V. Mode
2/3		S405	Push		
	4/7	S405	Push (SUB6-1)		V. Mode
2/3		S406	Push		
	4/7	S406	Push (SUB6-1)		V. Mode

SCH. No.		Symbol No.	Description		
S	PL		**SWITCHES**		
3/3	3/3	*S501	Push		
	7/7	**S501	Push SUB4-1	Trig. Mode	
	3/3	*S502	Push		
	7/7	**S502	Push SUB4-1	Trig. Mode	
3/3	3/3	S503	Push		
	3/3	*S504	Push		
	7/7	**S504	Push SUB4-1	Trig. Mode	
	3/3	*S505	Push		
	7/7	**S505	Pull-Push	S21P/RV3-6-19	
3/3	7/7	S506	Rotary TIME		
			TRANSFORMERS & COIL		
1/3	1/7	L101	Micro Inductor	47μH	±10%
1/3	1/7	L102	Troidal Choke	125μH 2A	
1/3	1/7	L103	El Choke	800μH 1A	
1/3		L104	Micro Inductor	100μH	±10%
	1/7	L104	Micro Inductor 100μH	100μH	±10%
1/3		L105	Micro Inductor	470μH	±10%
	1/7	L105	Micro Inductor 470μH	470μH	±10%
1/3		L106	Micro Inductor	470μH	±10%
	1/7	L106	Micro Inductor 470μH	470μH	±10%
1/3		L107	Micro Inductor	4.7μH	±10%
	1/7	L107	Micro Inductor 4.7μH	4.7μH	±10%
1/3		L108			
	1/7	L108	Coil	L-616	
2/3	4/7	L401	Choke	1μH	±10%
2/3	4/7	L402	Choke	1μH	±10%
2/3	4/7	L403	Micro Inductor	47μH	±10%
2/3	4/7	L404	Micro Inductor	47μH	±10%
2/3	4/7	L405	Micro Inductor	47μH	±10%
2/3	4/7	L406	Micro Inductor	2.2μH	±10%
2/3	4/7	L407	Micro Inductor	2.2μH	±10%
	4/7	L408	Delay Line (2 tons)	V-51	
3/3	6/7	L501	Micro Inductor	47μH	±10%
	7/7	L501	Micro Inductor	47μH	±10%
3/3	6/7	L502	Micro Inductor	47μH	±10%
3/3	6/7	L503	Micro Inductor	47μH	±10%
3/3	6/7	L504	Micro Inductor	47μH	±10%
3/3	6/7	L506	Micro Inductor	47μH	±10%
1/3	1/7	T101	Driver Transformer	(TJ-405A)	
1/3	1/7	T102	Out Put Transformer	(TJ-406B)	
	1/7	PT101	Power Transformer	(J-415)	
	1/7	PT102			
1/3		PT401	Power Transformer	(J-415)	

SCH. No.		Symbol No.	Description	
S	PL		**PRINTED CIRCUIT BOARDS**	
1/	1/3	*	POWER	T-1988
	1/7	**	POWER	T-1988B
	1/3	*	POWER SW	T-1989
	1/7	**	POWER SW	T-1989B
	3/3	*	TRIG. H. AMP	T-1990
	1/7	**	HIGH VOLTAGE MULTIPLIER	T-2365A
	3/3	*	TRIG. MODE	T-1991
	2/7	**	V. PREAMP	T-2203
	2/3	*	V. INPUT SW	T-1993
	2/7	**	V. INPUT SW	T-1993A
	2/3	*	V. AMP	T-1994
	2/3	*	V. MODE	T-1995
	2/7	**	V. MODE	T-1995A
	3/7	**		T-2203
	3/7	**		T-1993A
	3/7	**		T-1995A
	4/7	**		T-2203
	4/7	**		T-1995A
	5/7	**	V. FINAL AMP	T-2204
	6/7	**	TRIG. SWEEP	T-1990B
	6/7	**	TRIG. MODE	T-1991A
	7/7	**	H. AMP	T-1990B
			FUSE & LAMP	
1/3		*F101		
	1/7	F101	SLOW BLOW 0.3A	
2/3		*F102		
	1/7	F102	SLOW BLOW 2A	
			TERMINALS & CONNECTORS	
1/3		J116		
2/3		J201		
2/3		J301		
3/3		J514		
1/3		P102		
			TUBES	
1/3		V101	Neon	
	1/7	V101	Neon (AC, 75V)	NE38B
1/3		V102	Neon	
	1/7	V102	Neon (AC, 75V)	NE38B
1/3		V103	CRT	95FB31
	1/7	V103	CRT	95JB31
	1/7	V104	Neon (AC, 75V)	NE38B

(LBO-308S only)** *(LBO-308PL only)**

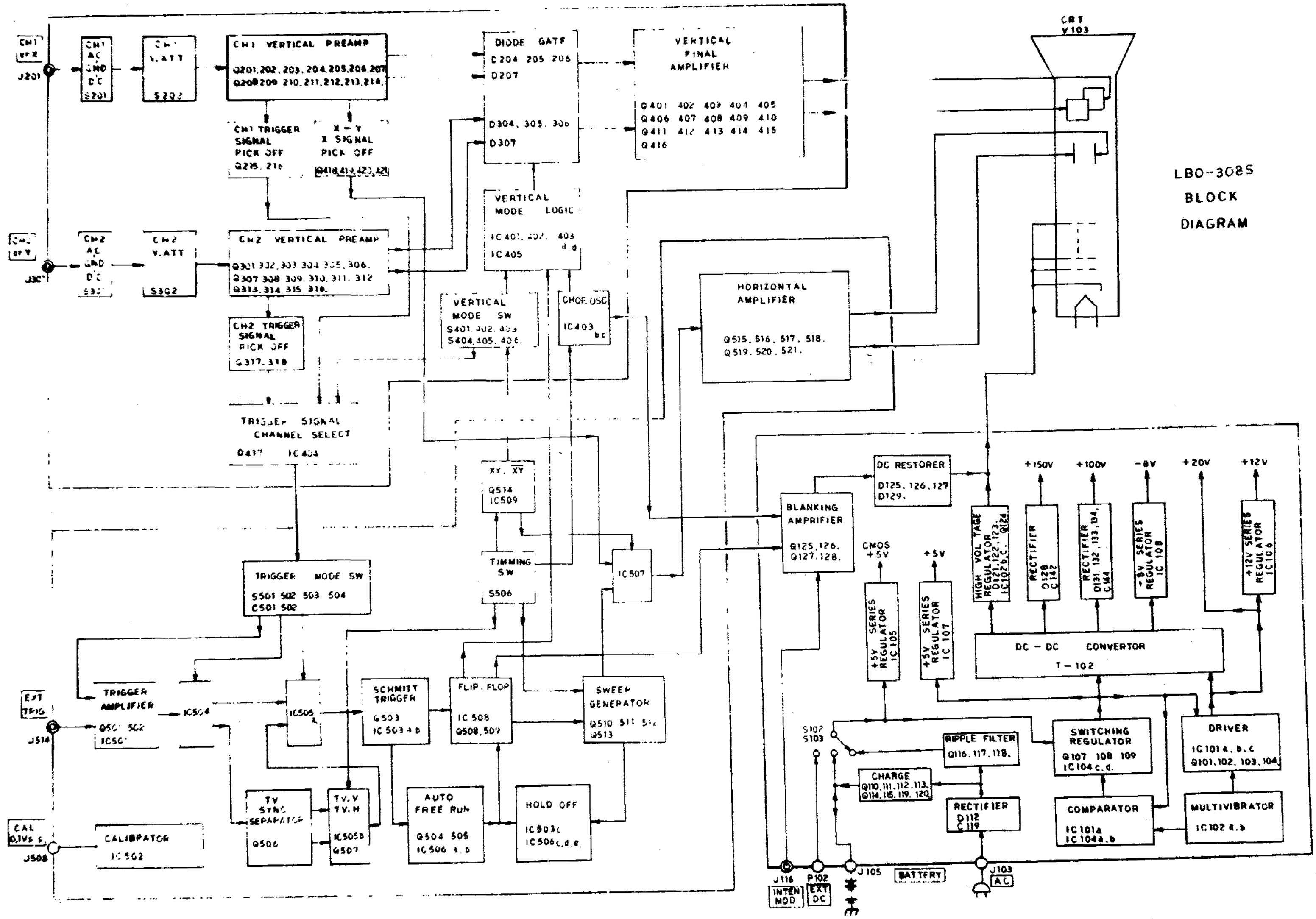


Figure 6-1. LBO-308S Block Diagram

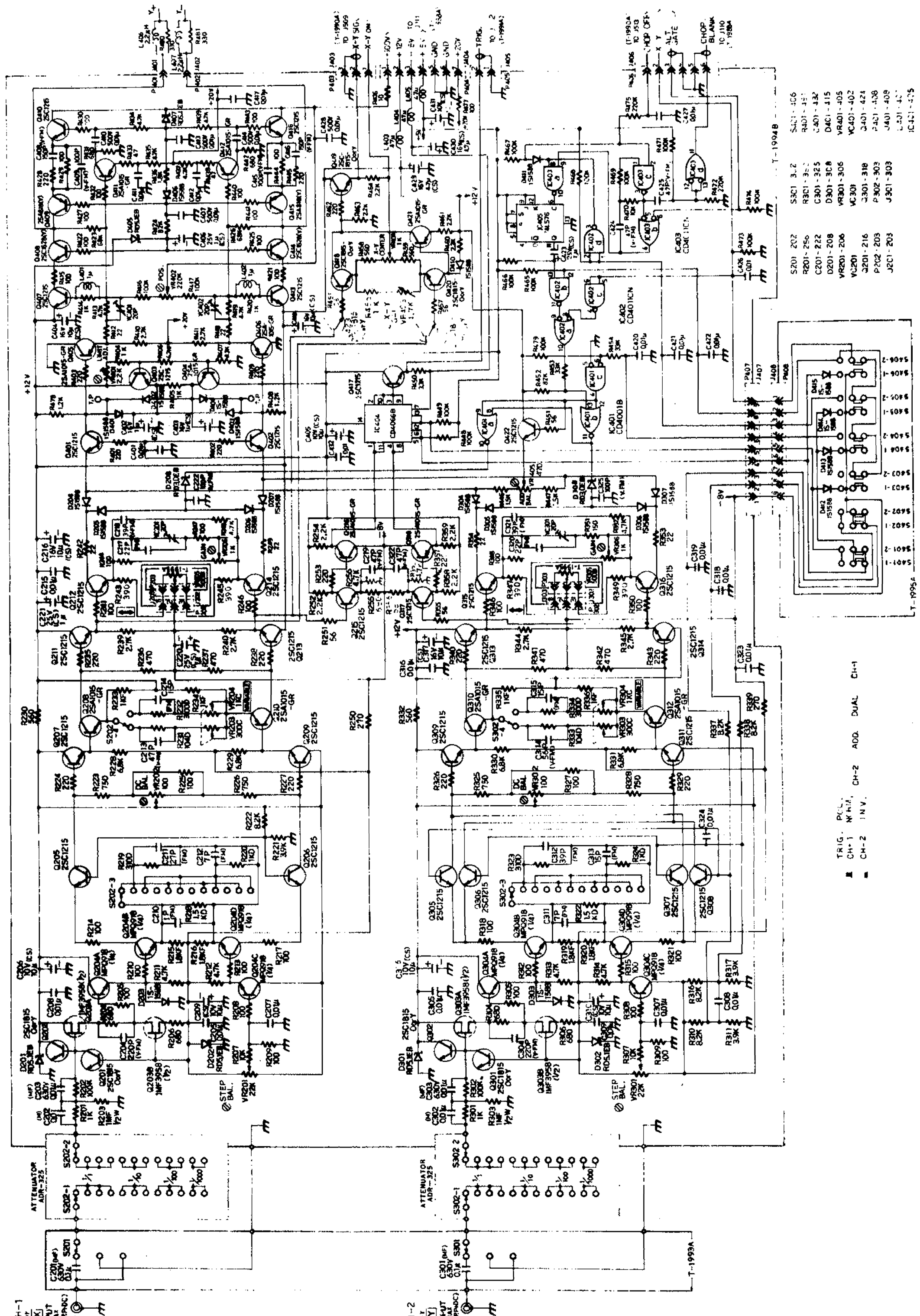


Figure 6-2. LBO-308S Vertical Amplifier

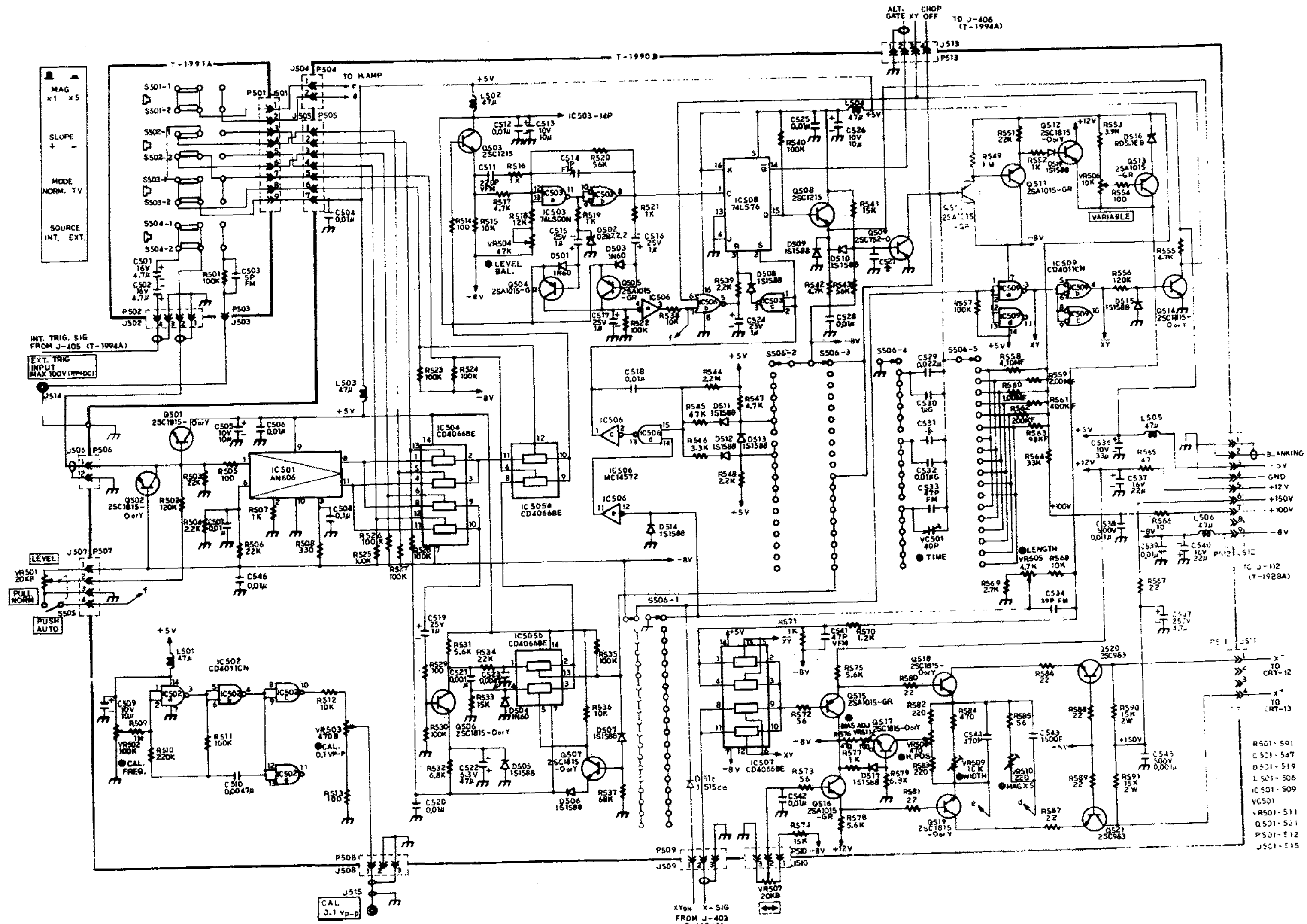


Figure 6-3. LBO-308S Trigger Sweep H. Amplifier Circuit

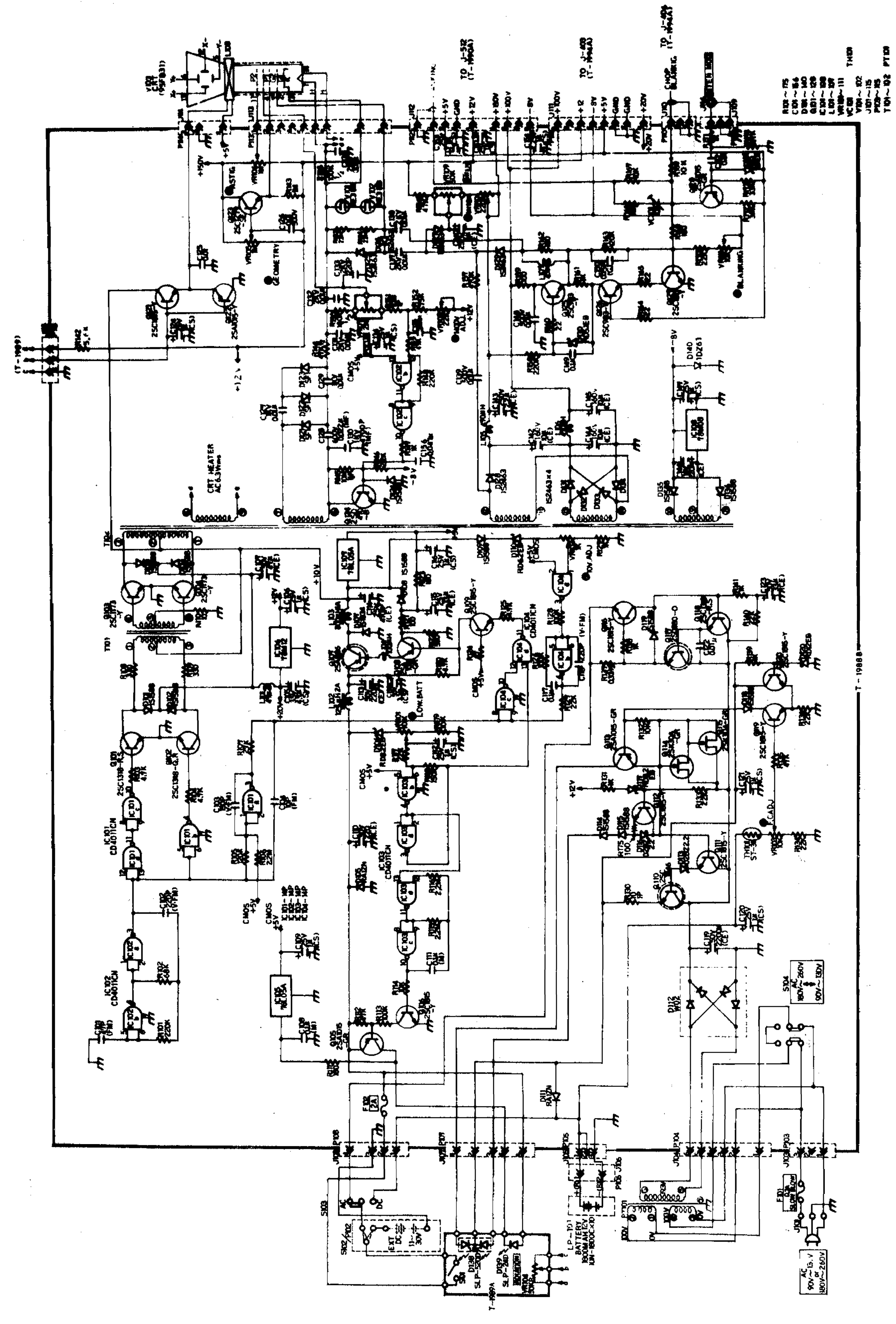


Figure 6-4. LBO-308S Power Supply T-1998B

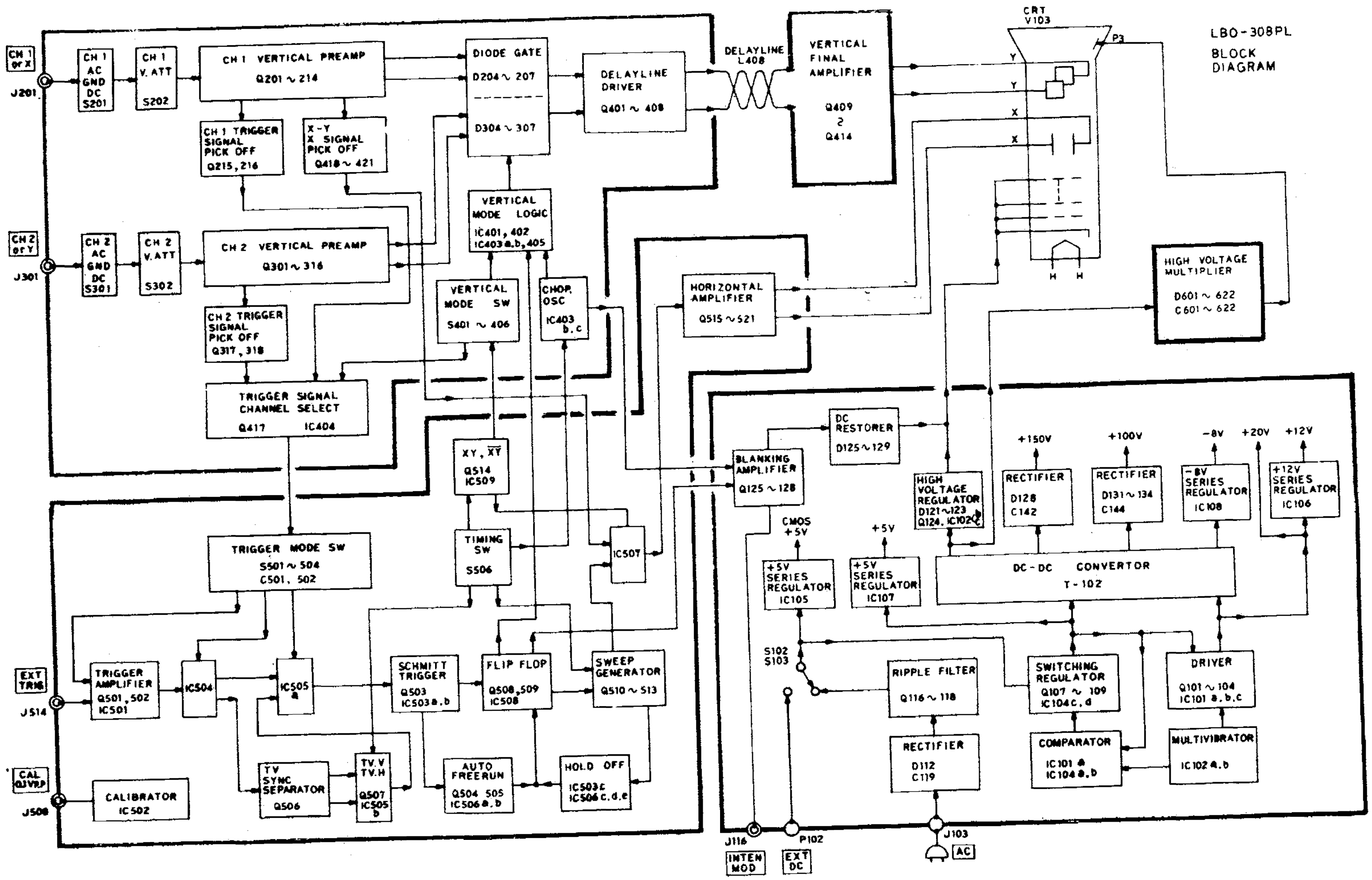


Figure 6-5. LBO-308PL Block Diagram

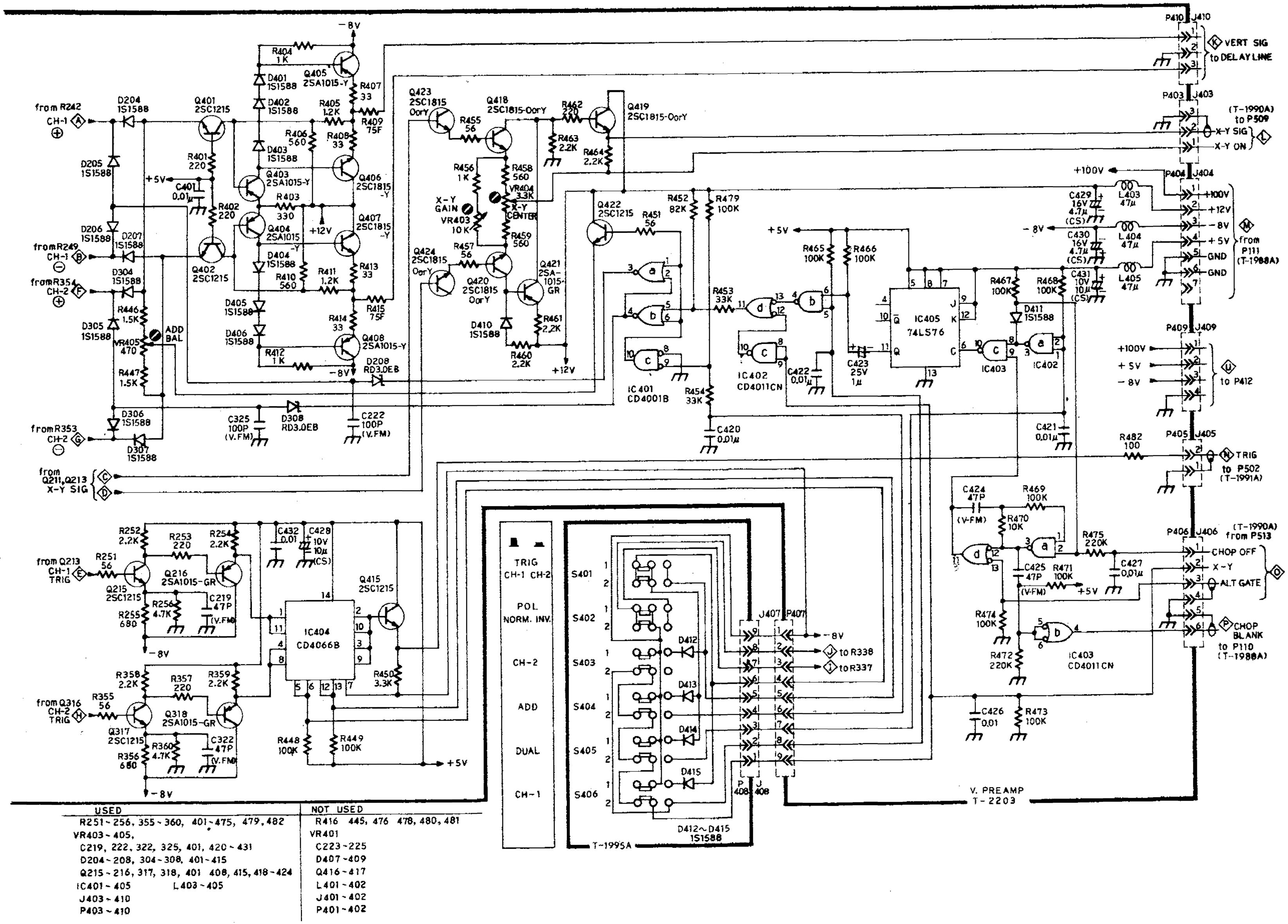


Figure 6-6. LBO-308PL Vertical Mode and Pre-Amp, T-2203, T-1995A.

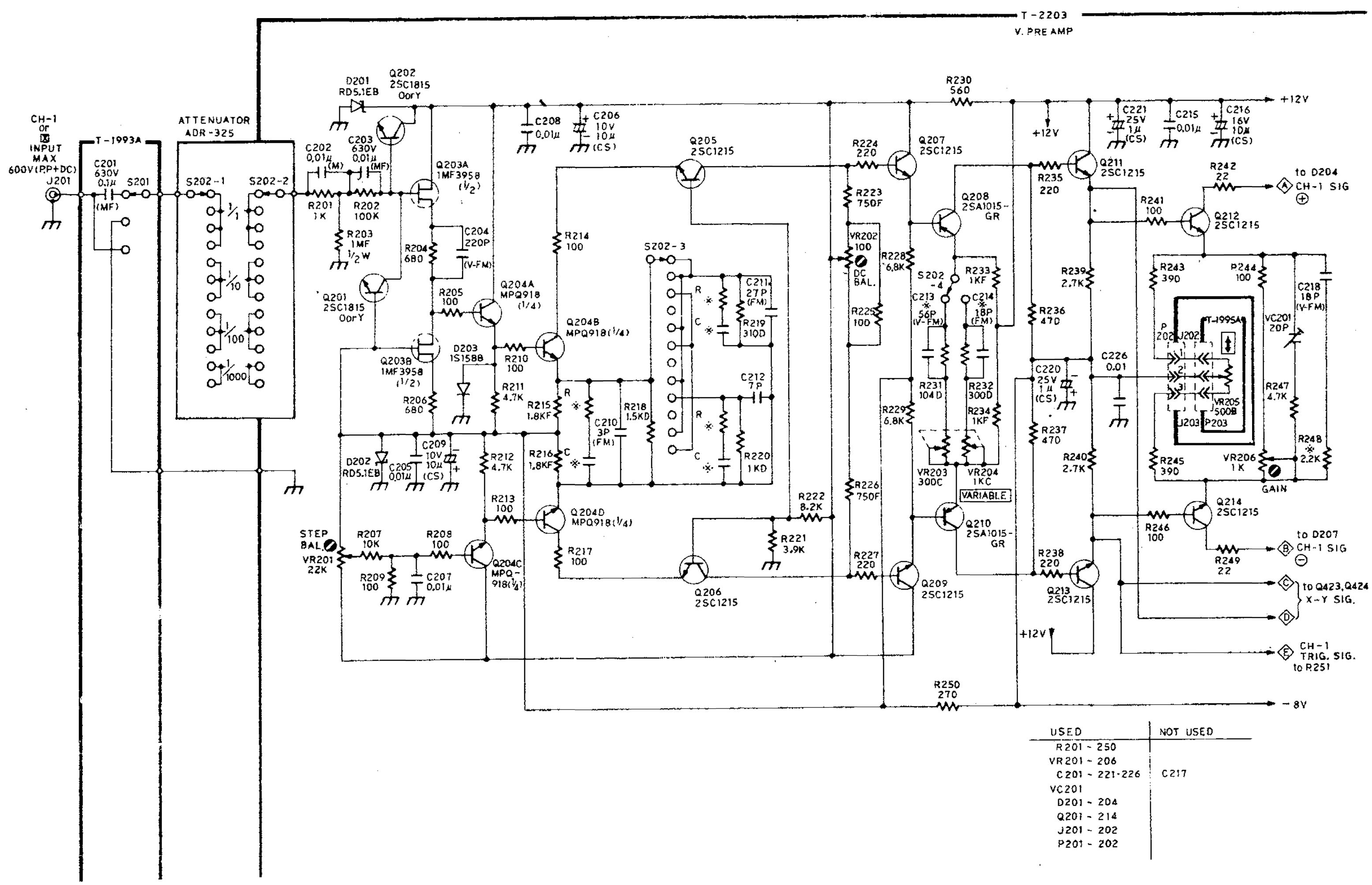
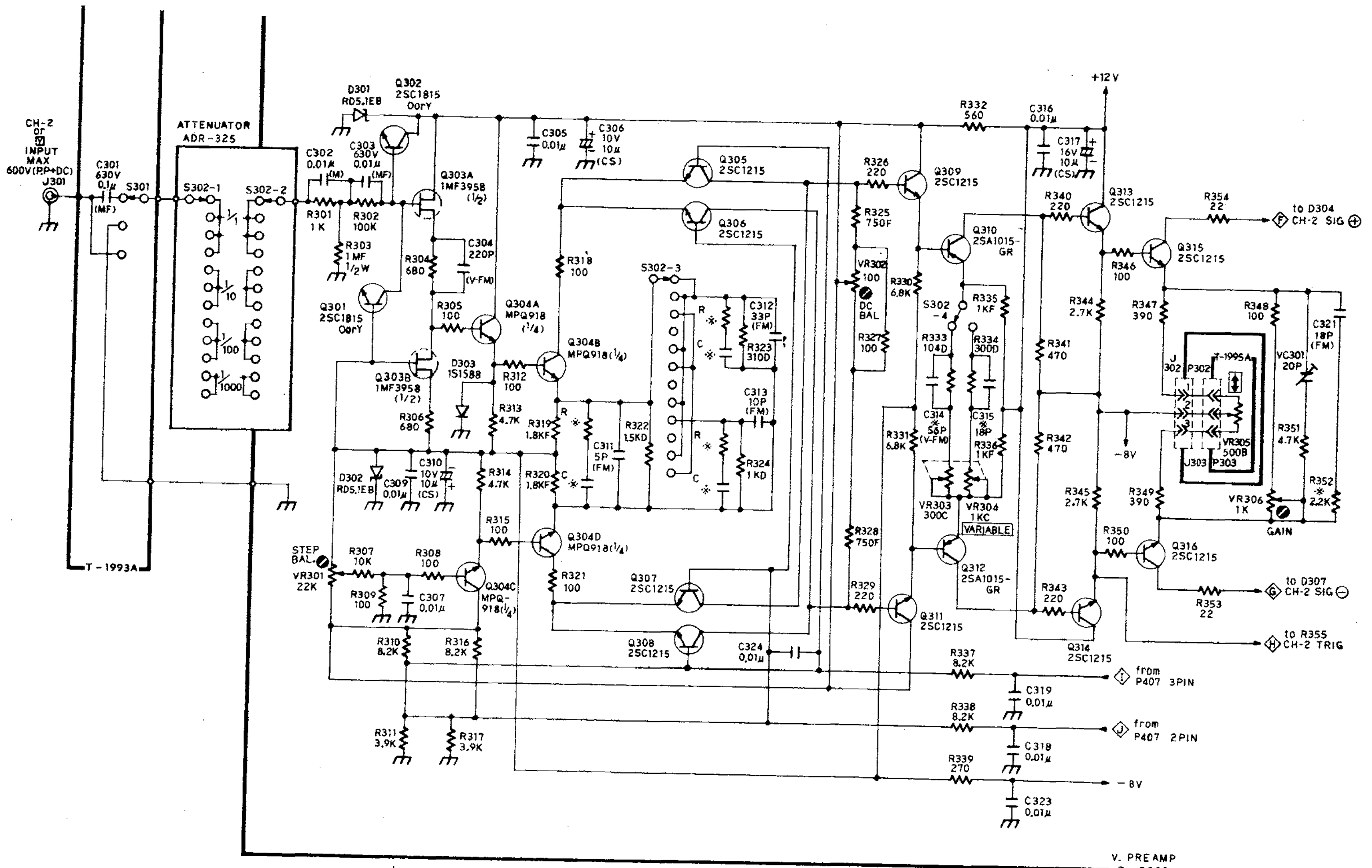
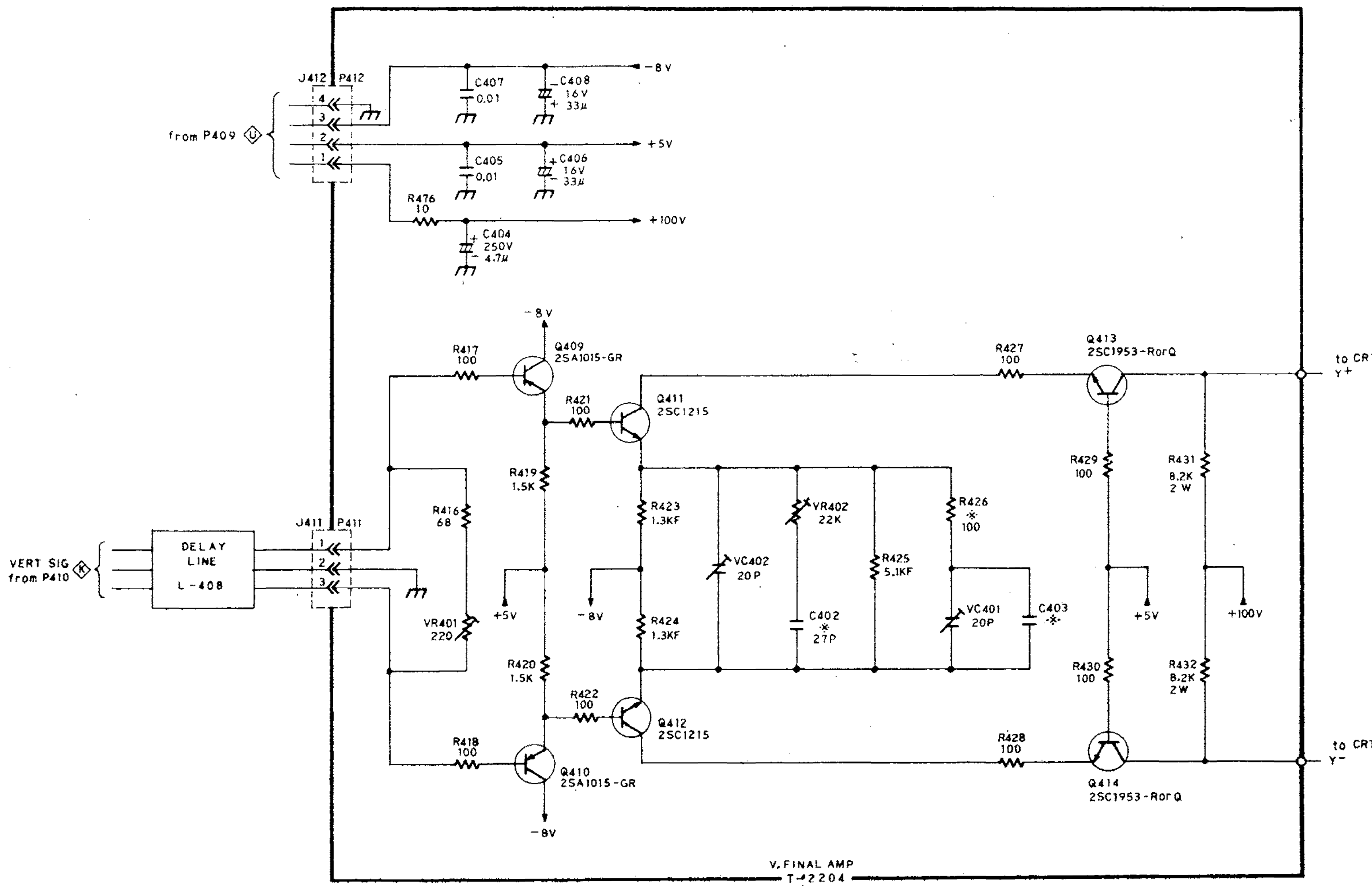


Figure 6-7. LBO-308PL CH-1 Vertical Pre-Amp. T-2203



USED	NOT USED
R301 - 354	
VR301 - 306	
C302 - 324	C308, 320
VC301	
D301 - 303	
Q301 - 316	
J301 - 302	
P301 - 302	

Figure 6-8. LBO-308PL CH-2 Vertical Pre-Amp. T-2203



USED	NOT USED
R416 ~ 432	
VR401 ~ 402	
C402 ~ 408	
VC401 ~ 402	
Q409 ~ 414	
J411 ~ 412	
P411 ~ 412	

Figure 6-9. LBO-308PL Final Vertical Amp. T-2204

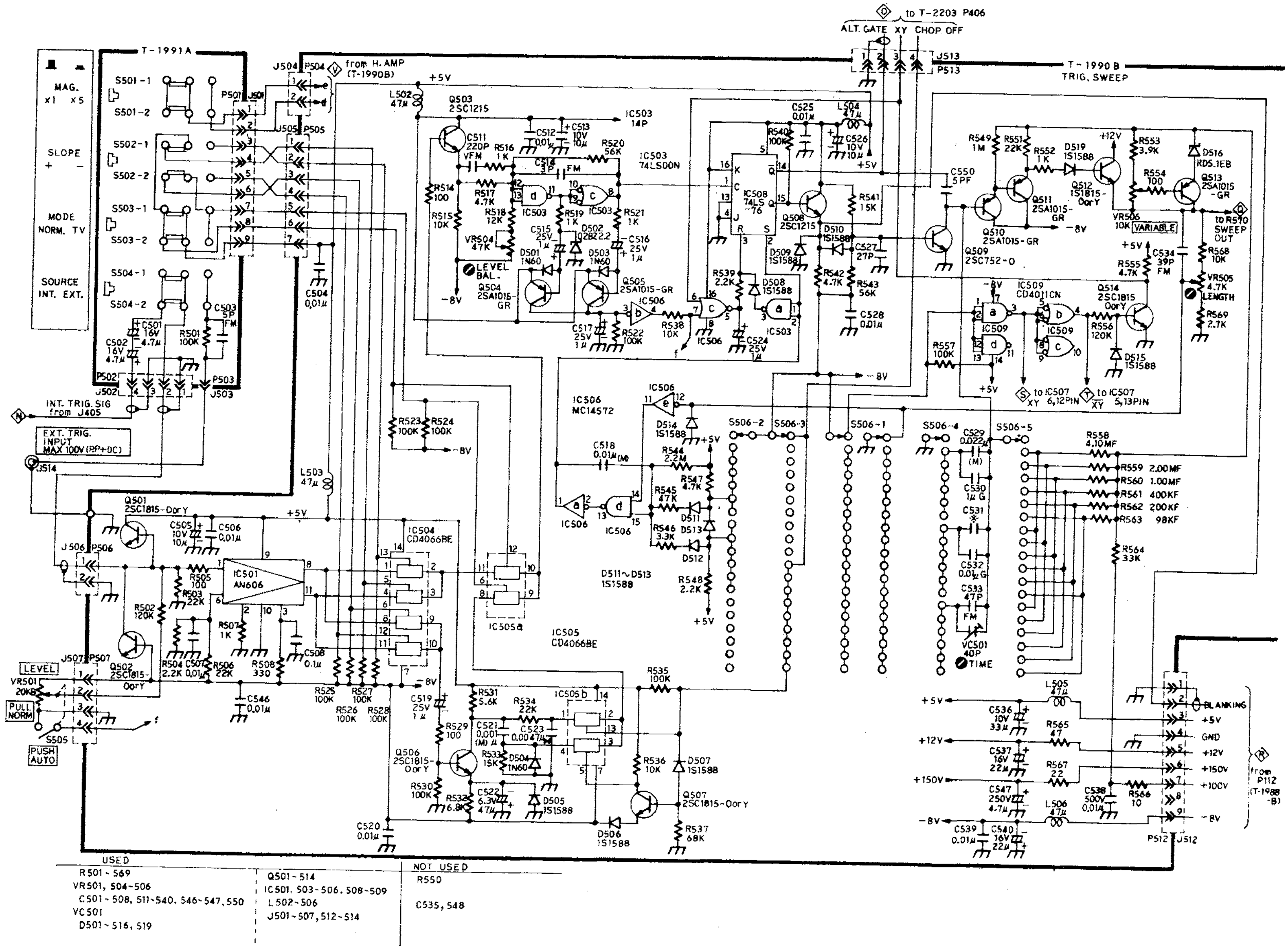


Figure 6-10. LBO-308PL Sweep Trigger and Horizontal Amp. T-1990B

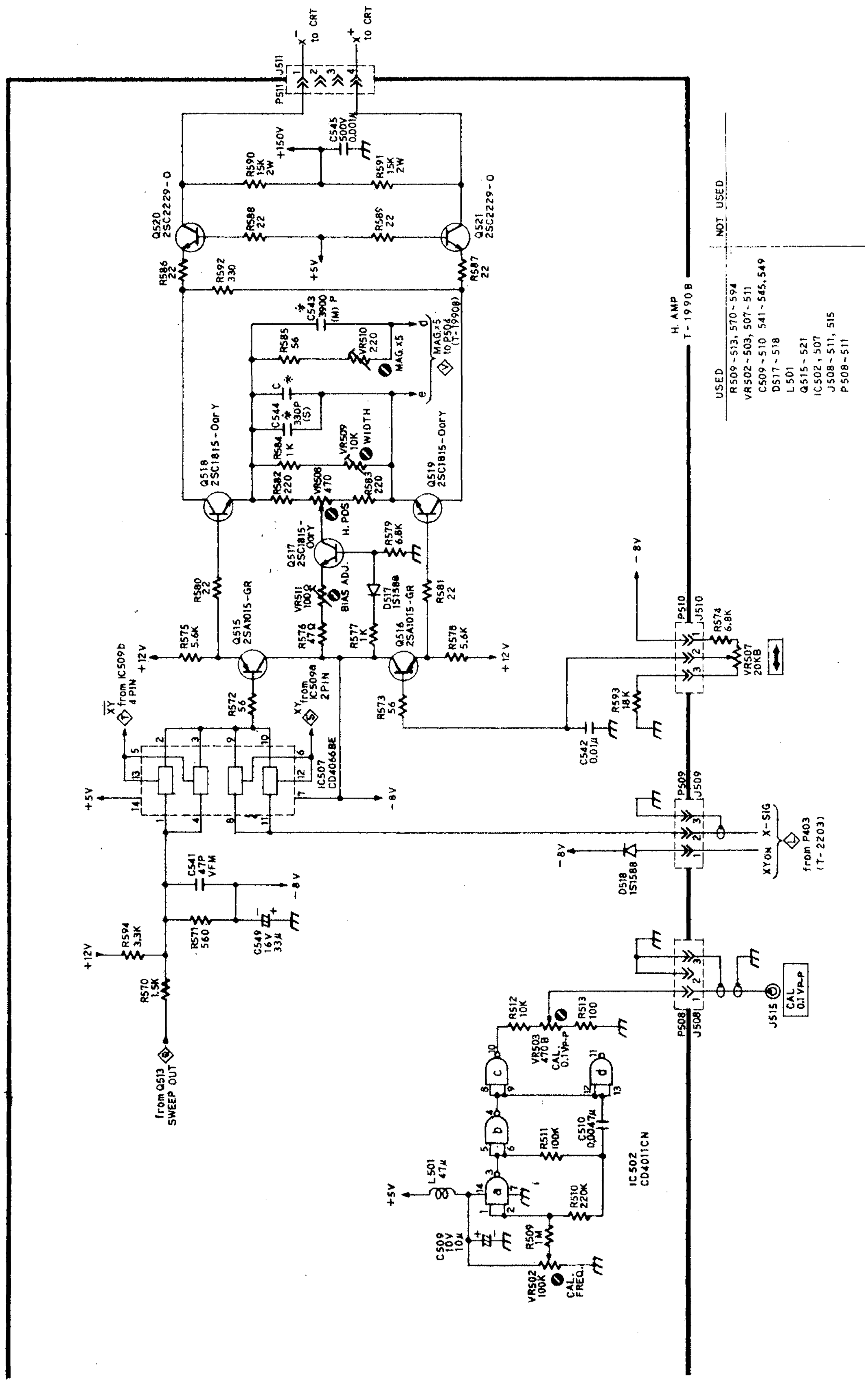


Figure 6-11. LBO-308PL Horizontal Amp. and Calibrator T-1990B

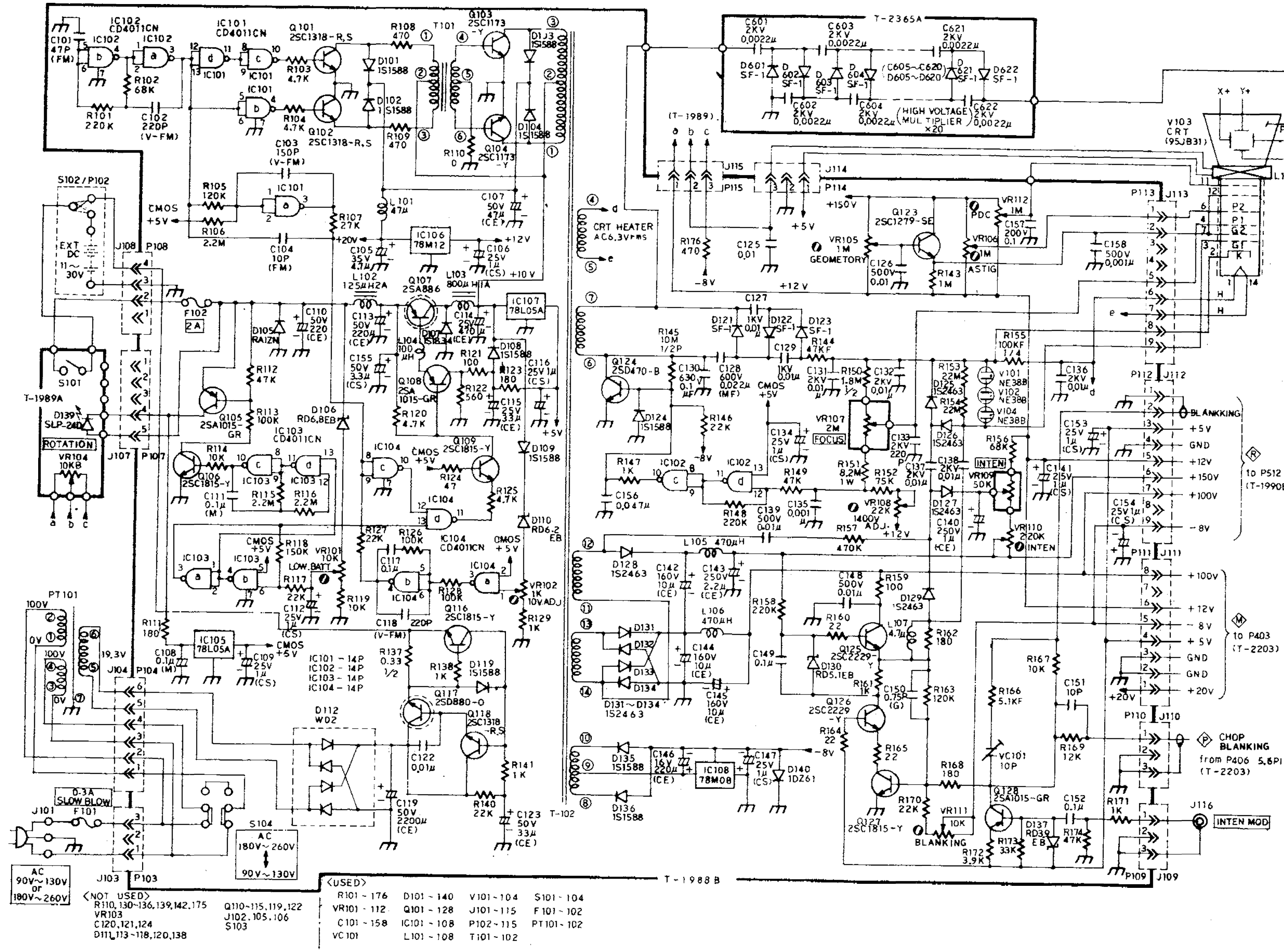


Figure 6-12. LBO-308PL Power Supply T-1988B

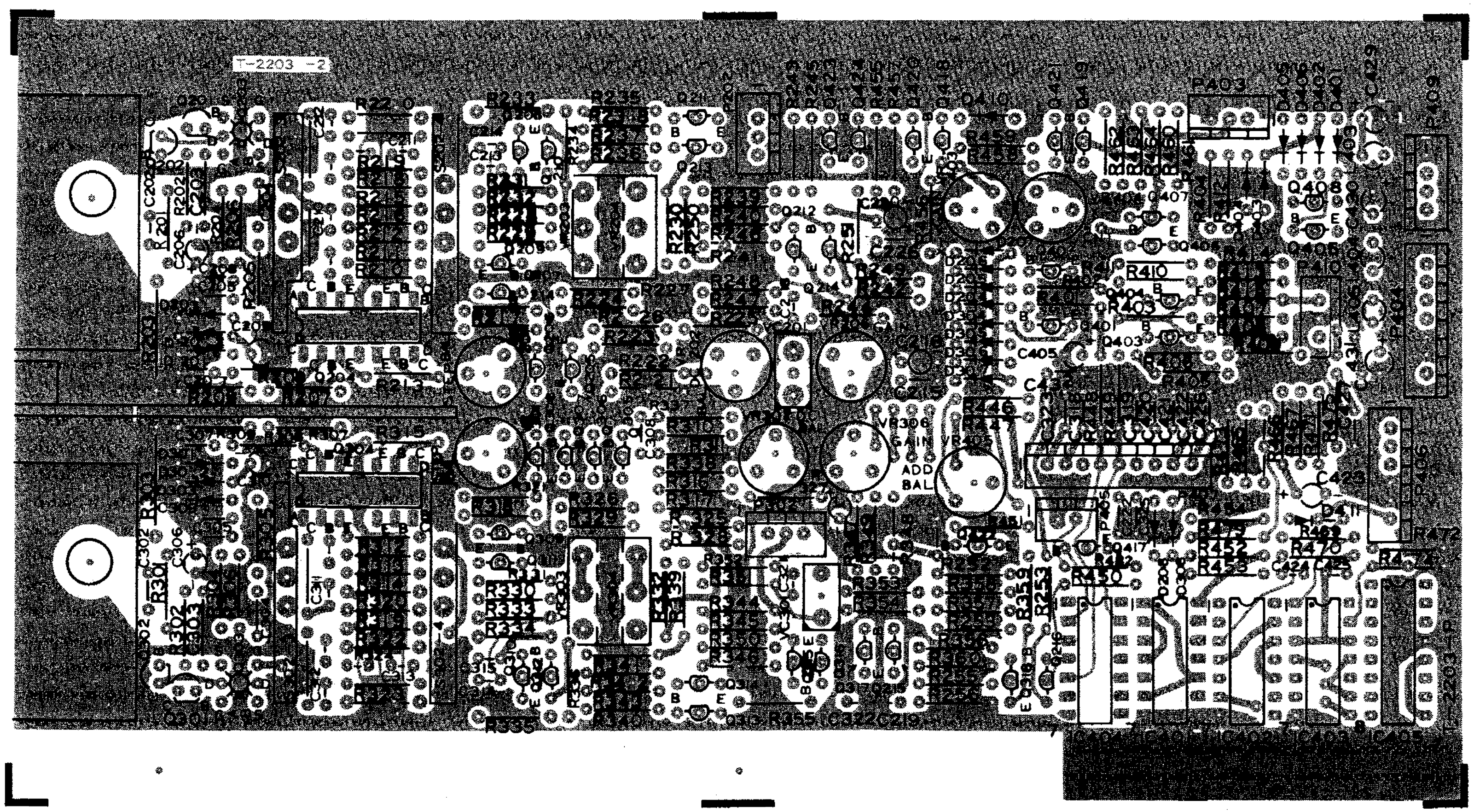


Figure 6-13. LBO-308PL Vertical Pre-Amp. P.C. Board T-2203-2

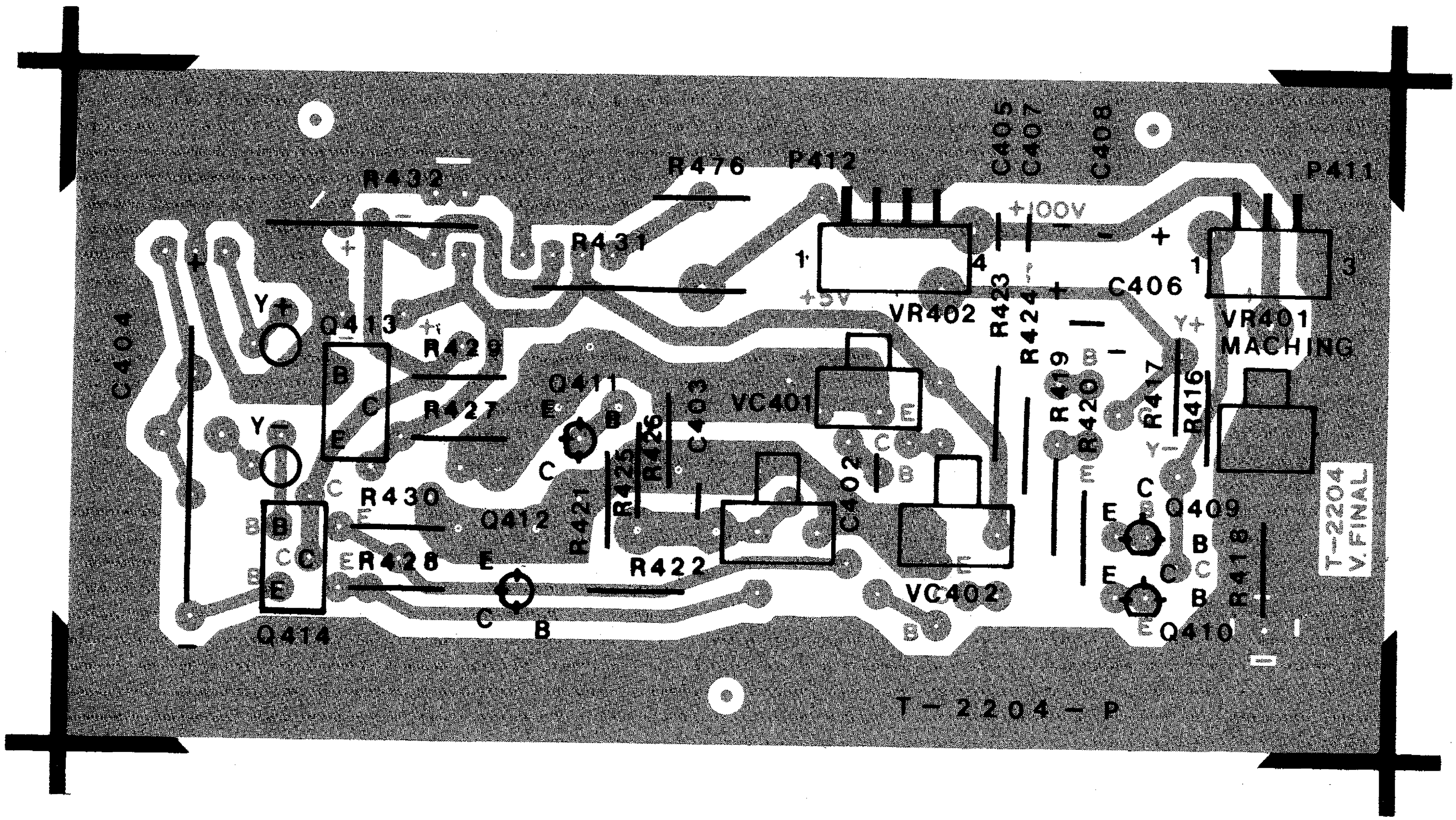


Figure 6-14 LBO-308PL Final Vertical Amp. P. C. Board T-2204

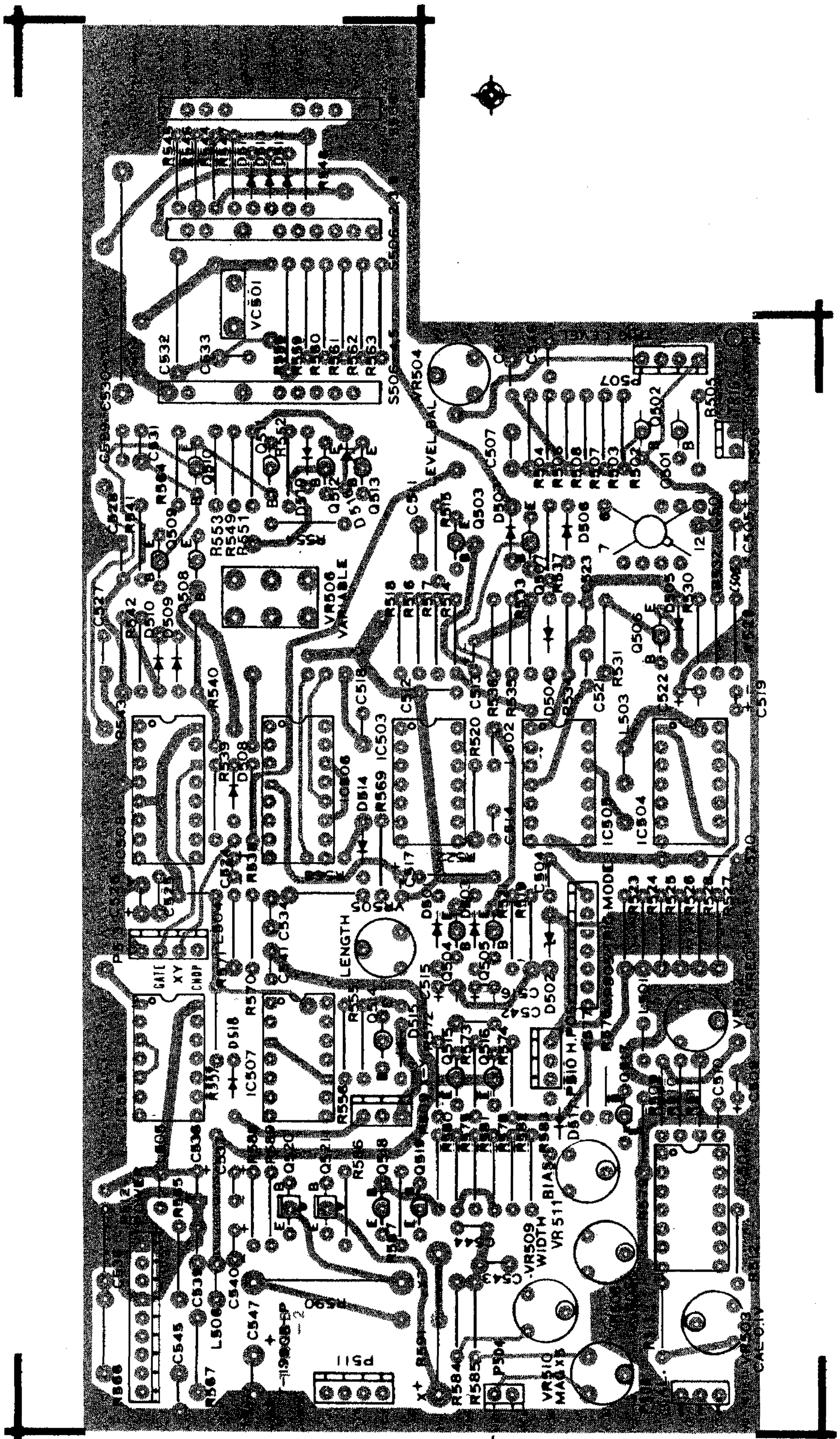


Figure 6-15. LBO-308PL Sweep Trigger Horizontal Amp. P. C. Board T-1990B-2

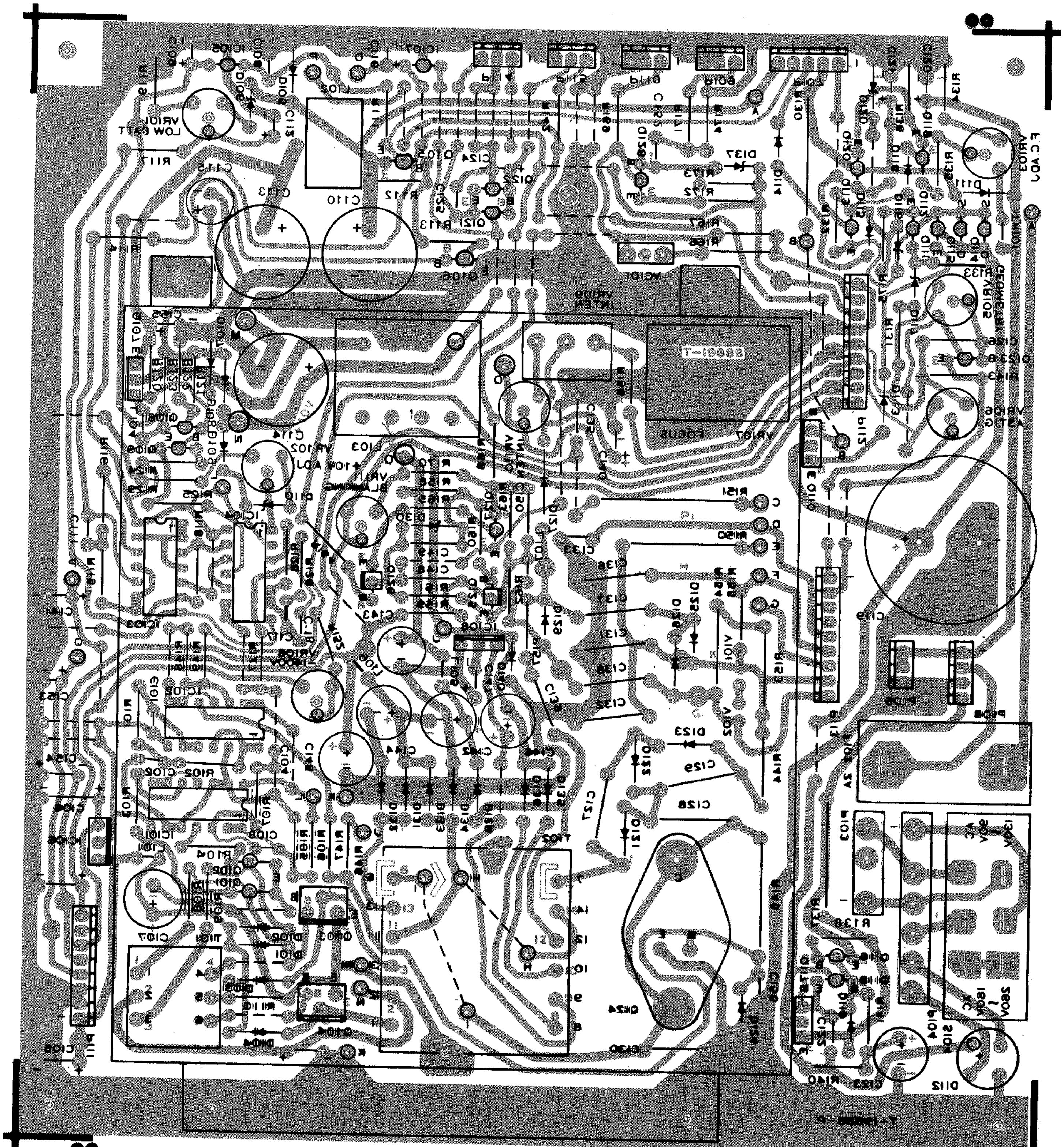


Figure 6-16. LBO-308PL Power Supply P. C. Board T-1988B

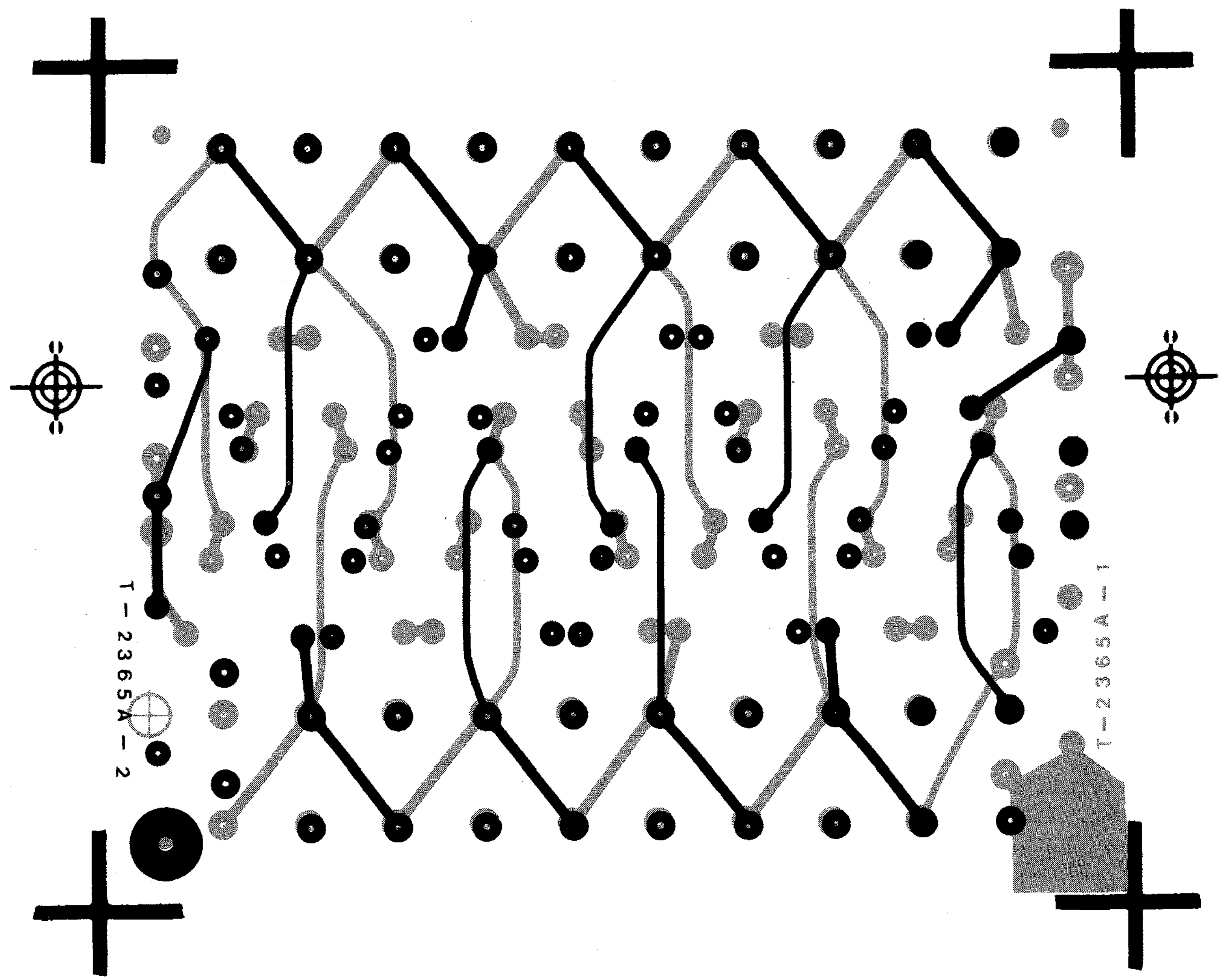


Figure 6-17. LBO-308PL High Voltage Power Supply P. C. Board T-2365A-2