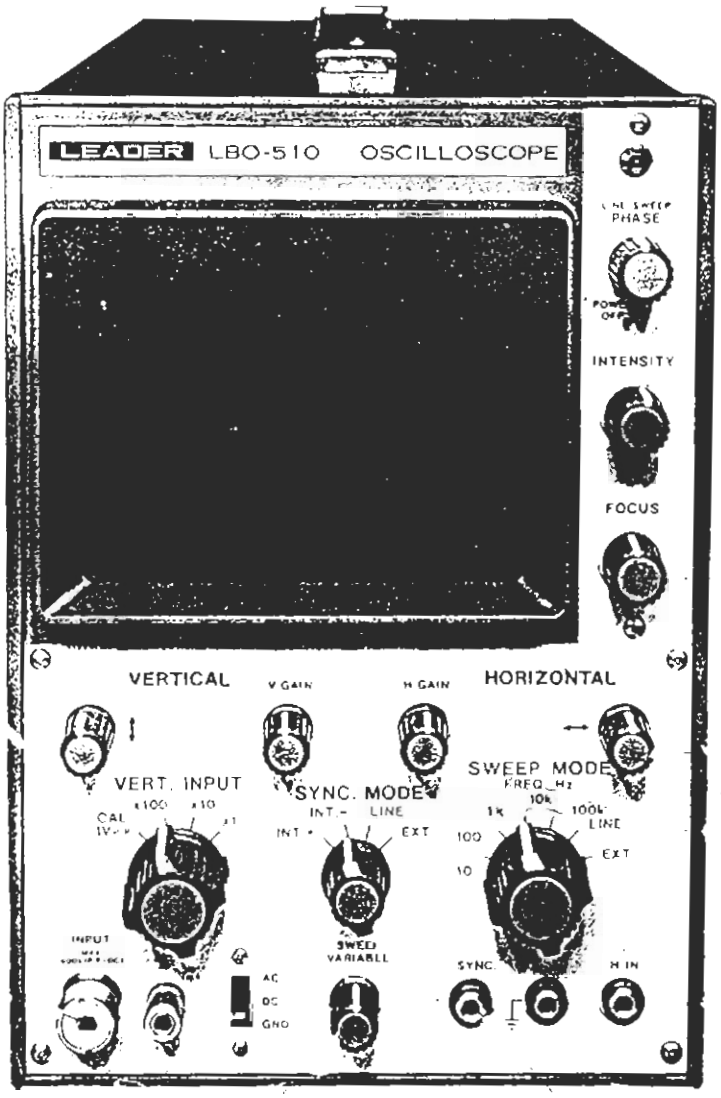
LBO-510

5" DC OSCILLOSCOPE

INSTRUCTION MANUAL



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MODEL LBO-510
OSCILLOSCOPE
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1. DESCRIPTION

1.1 General

LBO-510 is a compact general purpose 130mm (5") oscilloscope with wideband (DC to 4MHz) and high sensitivity (20mVp-p/cm) characteristics. It is designed for maximum usefulness in service shops, technical schools and laboratories. It features FET's in input circuits, DC-coupled amplifiers, phases (up to 140°) line frequency sweep and vertical calibration voltage. Return trace blanking is provided for clear waveform display.

1.2 Specifications

Vertical Axis	
Deflection Sensitivity	20mVp-p/cm or better.
Bandwidth, -3dB	DC: DC to 4MHz.
	AC: 2Hz to 4MHz.
Input Impedance	1MΩ: less than 40pF in shunt.
Input Control	X1, X10, X100, and fine adjuster.
Calibration Voltage	0.1Vp-p at line frequency.
Maximum Input Voltage	600V (p-p + DCV).
Horizontal Axis	
Deflection Sensitivity	300mVp-p/cm or better.
Bandwidth, -3dB	DC to 250kHz
Input Impedance	100kΩ: less than 40pF in shunt.
Maximum Input Voltage	100V (p-p + DCV).
Sweep Circuit	
Frequency	10Hz to 100kHz in four steps with fine adjuster.
Synchronization	Internal -, & +; external; line.
	Sensitivity: Internal, 1.5cm vertical amplitude.
	External, over 1Vp-p.
CRT Section	
Accelerating Voltage	Approx. 1500V.
Display Area	8 X 10cm, effective.
Z-Axis Modulation	Over 20Vp-p from external source.
Power Supply	100, 115 or 230V as specified, 50/60Hz; approx. 15VA.
Size and Weight	250 (H) X 180 (W) X 415 (D) mm; 7kg.
	10" X 7" X 16½; approx. 15 lbs.

Accessories, supplied

Test lead with banana plug	3 ea.
Instruction Manual	1 ea.

Option (separate order)

Low-capacitance probe	LP-15Y

2. CONTROLS AND CONNECTIONS

Before operating the LBO-510, especially for the first time, it is advisable for the user to become familiar with functions of various switches, controls, etc., described below.

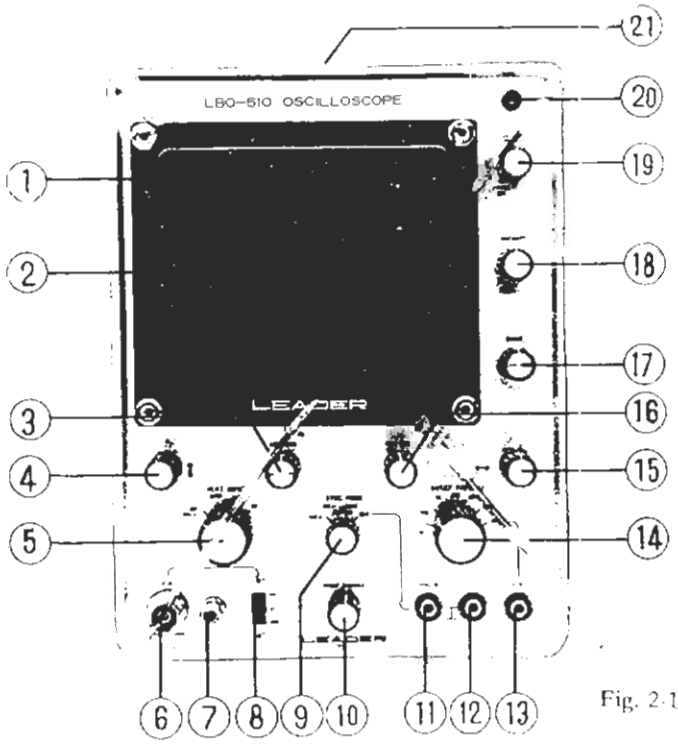


Fig. 2-1 Front Panel

2.1 Front Panel, see Fig. 2-1.

1.	Hood for CRT	Fastened with four thumbscrews.
2.	Graticule	Marked in 8 vertical and 10 horizontal divisions, each division = 1cm, with 5 minor (2mm) markings on center lines.
3.	VERT GAIN	For adjusting the vertical amplitude between range steps.
4.	⬍ Positioning	For positioning the trace vertically on the CRT screen.
5.	VERT INPUT	Three ranges, X1, X10 and X100, for vertical input control; CAL 0.1Vp-p setting for sensitivity calibration.
6.	V IN	Vertical input connector, UHF type.
7.	Ground terminal	

8.	AC-DC-GND	Switch for vertical amplifier input: AC to block out the DC component, DC for direct coupling, and GND to ground the amplifier input (input signal is at open circuit).
9.	SYNC MODE	Two settings for internal (+ and -); line frequency and external.
10.	SWEEP VARIABLE	For adjusting sweep frequency between steps of SWEEP FREQ Hz switch.
11.	SYNC IN	Socket for lead connection to external sync source.
12.	Ground socket	
13.	H IN	Socket for lead connection to external horizontal input signal.
14.	SWEEP FREQ Hz	Four steps to set sweep frequency range in 10Hz to 100kHz; at LINE for sweep at line frequency (phasing with PHASE control 19; at EXT for external horizontal input from 13.
15.	⟷ Positioning	For positioning the trace horizontally on the CRT screen.
16.	HOR GAIN	For adjusting the clarity of the CRT spot.
17.	FOCUS	For adjusting the clarity of the CRT spot.
18.	INTENSITY	For adjusting the brightness of the CRT spot.
19.	PHASE, POWER OFF	For adjusting the phase of the line frequency sweep; knob sets AC power at on when rotated clockwise and at off at full counterclockwise setting.
20.	Pilot lamp	Indicates when AC power is at on.
21.	Carrying handle	

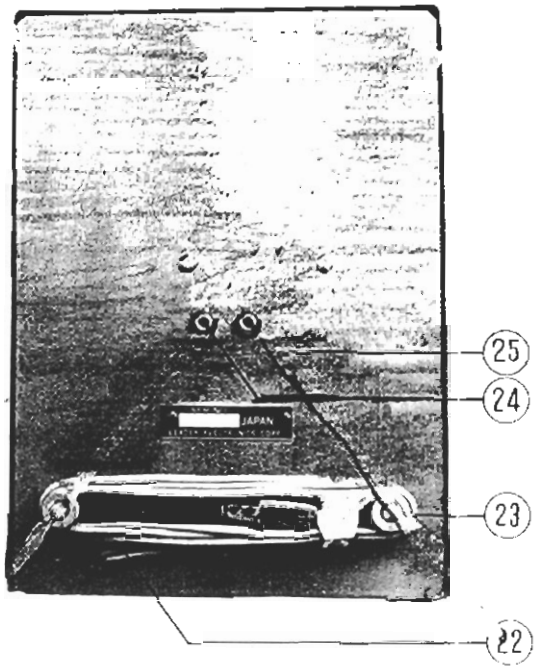


Fig. 2-2 Rear Panel

2.2 Rear Panel, see Fig. 2-2.

22. AC cord
23. Cord hooks — For AC cord storage.
24. INTEN MOD Z — Socket for lead connection to Z-axis modulating source.
25. Ground socket

3. OPERATION

3.1 Precautions in Operation

3.1.1 AC Line Voltage

The AC voltage for operation should be kept within ±10% of the rating as specified. If lower, proper performance will not be achieved. At higher voltages, internal power supplies may be damaged, especially when applied for long periods.

3.1.2 Maximum Input Voltages

Voltages applied to different input connectors must not exceed the values indicated in the chart below.

Connector	Max. Volts (p-p + DC)
V IN	600
H IN	100
INTEN	30
MOD Z	

Examples of maximum conditions are shown at "A" and "B" in Fig. 3-1.

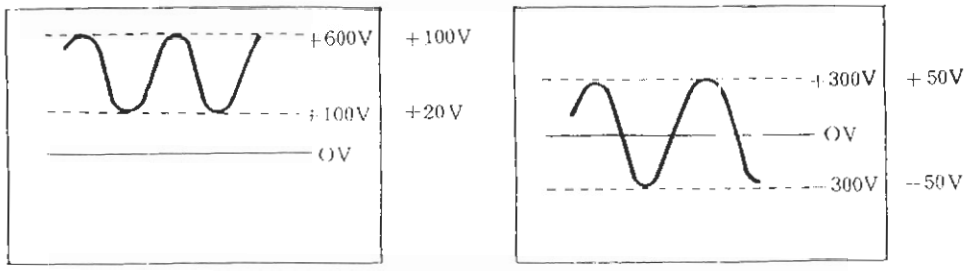


Fig. 3-1 Maximum voltages at V IN (H IN).

CAUTION: Do not connect to the flyback circuit in TV sets.

3.1.3 Prevention of "Ion burns"

When the CRT beam is concentrated in a spot on the screen, there will be possibility of burning the particular portion. The INTENSITY control should always be adjusted to extinguish the spot during standby periods, or the spot must be kept in motion with the sweep frequency.

3.1.4 Influence of Strong Magnetic Fields

The LBO-510 should be operated in locations where local magnetic field is not present; there will be a distorted display of waveforms. Keep the "gun type" soldering irons away from the scope.

3.2 Preparation

A. Control Settings:

INTENSITY	Near fully clockwise.
FOCUS	
↕ (vertical)	at midposition.
↔ (horizontal)	
VERT GAIN	Fully counterclockwise.
HOR GAIN	Fully clockwise.
VERT INPUT	X100.
SYNC MODE	INT +.
AC -DC GND	AC
SWEEP FREQ Hz	10-100k.
SWEEP VARIABLE	any setting.

B. Connections:

1. Remove AC cord off the standoffs at back of cabinet. Connect the plug to the AC line.
2. Test lead or low capacitance probe to V IN connector.
3. Test lead to V IN ground.

C. Adjustments:

1. Rotate PHASE knob clockwise to turn on the AC power switch.
2. Adjust INTENSITY and FOCUS controls for clear trace.

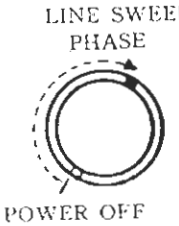


Fig. 3-2 Turning on AC power

3.3 Waveform Observation

3.3.1 General

1. Connect the leads from V IN to test point of circuit under examination.
2. AC–DC –GND switch settings -
   - AC: For AC input, or to pick out the AC component when there is superposed DC voltage in the input signal.
   - DC: Generally used when only the AC signal is under examination or for DC voltage measurements.

   GND: used during vercical calibration only (See Sect 3.5)
3. Set VERT INPUT switch at X100, X10, or X1 and adjust VERT GAIN control for suitable trace amplitude.
4. Set HOR. GAIN control for suitable trace width.
5. Set SWEEP FREQ switch at 10-100, etc., and adjust SWEEP VARIABLE control as required for the waveform display.

6. Adjust the spot positioning controls to position the trace as required on the graticule.

3.3.2 Use of SYNC MODE switch

As long as the trace amplitude is 1.5cm or more, the sweep will be synchronized and the trace will "stop". This occurs when the sweep frequency is the same or at a submultiple of the input frequency.

A. INT + or INT -:

1. For sine waves, either setting can be used.
2. For irregular waveforms, the setting will depend on which peak the synchronization is desired.

B. LINE:

This setting is used when the input frequency is related to the AC line frequency 50, 100, 150Hz .... etc. (60, 120, 180Hz .... etc.)

C. EXT:

For synchronizing the sweep with an external source; the input is connected to SYNC IN socket. Input voltage should be approximately 1Vp-p; higher voltages must be lowered with use of a voltage divider.

3.3.3 External Sweep Operation

1. Set SWEEP FREQ Hz switch at EXT.
2. Connect the external sweep input to H IN socket. NOTE: Do not apply more than 100Vp-p (p-p + DCV). A blocking capacitor of suitable value must be used when only the AC component is to be utilized.
3. Adjust HOR. GAIN control for desired sweep width.

3.3.4 Use of Line Frequency Sweep

The LINE setting of SWEEP FREQ switch is used when it is desired to phase the input signal at line frequency, such as the horizontal output from certain types of TV, FM, or AM sweep generators.

The LINE SWEEP PHASE control is used in the phasing. Reference should be made to operating instructions of the sweep generator in use.

3.4 Intensity Modulation

Frequency markers, timing pulses and other signals can be applied on the trace with connection from sweep generators, etc., to INTEN MOD socket; on the rear panel. Approximately 20Vp-p input is required.

3.5 Voltage Measurements

3.5.1 Applications

When comparing the performance of amplifiers, tuners, etc., it is convenient to determine the response in terms of voltage. After calibration, DC voltages and within limits, DC voltage superposed on the AC component can be measured.

3.5.2 Voltage Calibration

1. Switch settings:

   VERT INPUT at CAL 0.1Vp-p.

   AC-DC-GND at GND.

   SWEEP FREQ at 10-100.

2. Adjustments:

   SWEEP VARIABLE for a two-cycle trace.

   VERT GAIN for trace amplitude at 5cm, peak to peak, see Fig. 3-3.

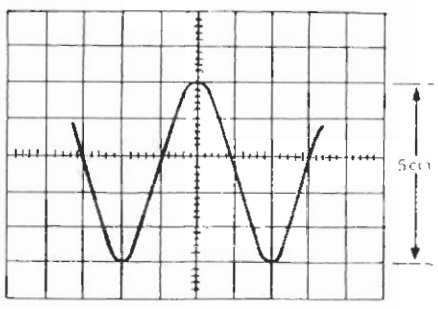


Fig. 3-3 Vert amplitude calibration

   Adjust vertical positioning if necessary.

   Do not touch VERT GAIN control after this adjustment; this is important.

3. Under conditions in step 2 above, 1cm vertically represents 20mVp-p (0.02Vp-p). At VERT X1, 1cm = 20mV; at X10 and X100 respectively, the sensitivity is 0.2Vp-p and 2Vp-p.

4. At other calibrating amplitudes, different sentivities can be obtained as shown in CHART 3-1.

CHART 3-1 Vertical Sensitivities

Calibrating Amplitude, peak-to-pack at 0.1Vp-p	Vp-p per cm		
	X1	X10	X100
5 cm	20mV	0.2V	2.0V
2 cm	50mV	0.5V	5.0V
1 cm	100mV	1.0V	10.0V

NOTES: 1. For good accuracy, the AC line voltage must be at the rated value.

2. The Vrms value for sine waves only is Vp-p/2.83, or 0.353Vp-p.

3.5.3 AC Voltage Measurements

1. After calibration, set AC-DC-GND switch at AC.
2. Set the VERT INPUT switch to place the waveform peaks within upper and lower lines on the graticule.
3. Note the distance between the peaks.

4. The peak-to-peak voltage is given by -
(Distance in cm) X (Vp-p/cm) X Multiplier = Vp-p.
Example: (See Fig. 3-4).

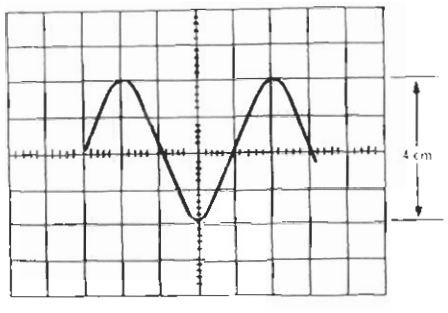


Fig. 3-4 Vp-p measurement.

Distance	4cm
Vp-p/cm	20mVp-p (sensitivity calibration).
Multiplier	X1 (VERT INPUT setting).
Voltage	(4 X 20mVp-p X 1) = 0.08 Vp-p.

3.5.4 DC Voltage Measurements

The scope can be used as a DC voltmeter with high input resistance.

1. After calibration, set AC-DC-GND switch at GND. The sweep controls are not adjusted.
2. Adjust vertical positioning to set the trace on center horizontal line for 0V, see dashed line in Fig. 3-5 (actually the trace is continuous).

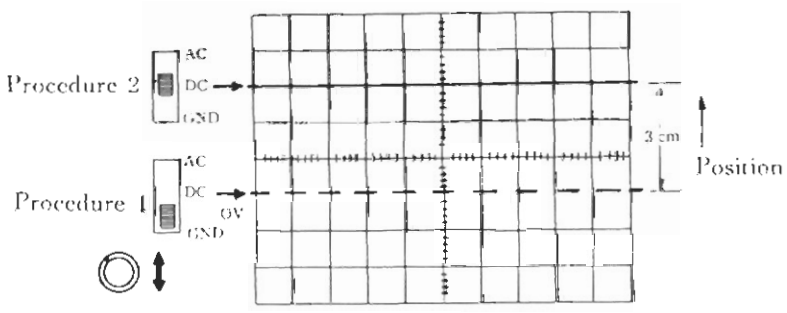


Fig. 3-5 DC voltage measurement.

3. Set AC-DC-GND switch at DC.
4. Connect VERT IN leads to voltage under measurement.
The trace will move up for +V and down for -V.
5. Set VERT GAIN switch so that the trace position is below upper line or above lower line.
The voltage range is then ±0.08V at 20mVp-p calibration with VERT INPUT switch at X1.
At X10 and X100 respectively, the range will be ±0.8V and ±8.0V.
At other Vp-p/cm sensitivities, (see Sect. 3.5.2), refer to CHART 3-2.

CHART 3-2 DC Voltage Ranges

Calibration: Vp-p/cm	Full Range DC Voltages (0V at center line)		
	X1	X10	X100
20mV	±0.08V	±0.8V	±8.0V
50mV	±0.20V	±0.8V	±20.0V
100mV	±0.4V	±4.0V	±40.0V

NOTE: By positioning the 0V reference below or above the center line, it is possible to widen the measuring ranges. For example, if set at the lowest line, the range will be 0 to +0.16V, etc., and vice versa.

3.5.5 DC Superposed on AC

1. The voltage sensitivity is set as given in Sect. 3.5.4.
2. An example with sine wave is shown in Fig. 3-6.

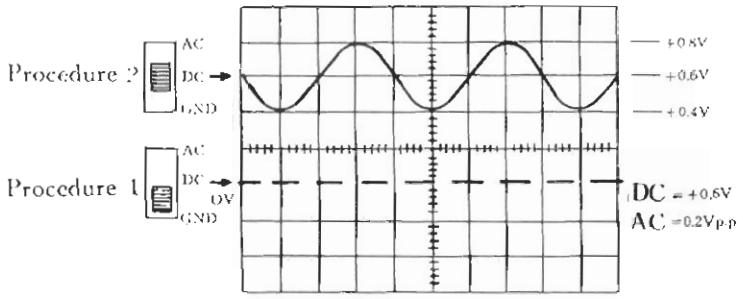


Fig. 3-6 Simultaneous DC and AC measurement.

3. When the AC voltage is high compared with DC voltage, each must be measured separately.

3.5.6 Use of Probe, LPB-10Y

When the low-capacitance probe, LPB-10Y, is used, the voltage sensitivity is lowered by a factor of 10. The voltage, AC or DC, as measured must be multiplied by 10.

3.6 Other Applications

Typical uses of the LBO-510 other than for waveform display and voltage measurements are given below.

3.6.1 Frequency Comparison

Unknown frequencies under test can be compared with a standard, or known, frequency by the lissajous pattern method.

1. Connect the unknown frequency to V IN.
   Adjust vertical controls for suitable amplitude.
2. Connect the standard, or reference, frequency to H IN.
   Set SWEEP FREQ switch at EXT.
   Adjust HOR. GAIN for suitable width.

3. Adjust the known, or unknown, frequency for a clearly defined single or multiple loop pattern.
4. The frequency is calculated from the following relation:

$$F_u = F_s \frac{N_x}{N_y}$$

where F_s = standard frequency (horizontal input)
F_u = unknown frequency (vertical input)
N_x = number of loops on upper line.
N_y = number of loops on left line.

The pattern for $F_u = F_s$ X3 is shown in Fig. 3-7.

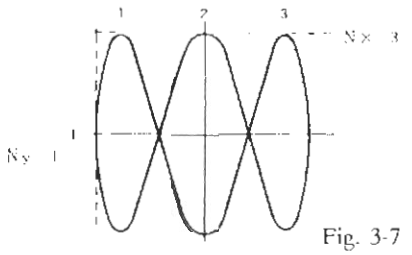


Fig. 3-7 Frequency comparison.

Examples:

A. Use of line frequency as standard.
   1. Set SWEEP FREQ at LINE: AC-DC-GND switch at AC.
   2. Connect a variable audio oscillator to V IN.
   3. Adjust the generator frequency control.
      At 50, 100, 150Hz .... (or 60, 120, 180Hz ....), the pattern with 1, 2, 3 .... loops will be displayed: these are at multiples of the line frequency.

B. Use of 1kHz standard.
   When a 1kHz standard is used (horizontal input), the same patterns will be displayed at 1, 2, 3 .... kHz. At submultiples, namely, 500, 333, 250, 200Hz .... etc., the patterns will be rotated by 90° but the same formula is used in calculation.

3.6.2 Phase Determination

The phase angle of a given frequency at different points in a circuit can be determined by connections to V IN and H IN sockets. The upper frequency limit is approximately 10kHz.

1. Set the SWEEP FREQ switch at EXT.
2. Adjust the gain controls for suitable height and width.
3. Referring to Fig. 3-8, the phase angle is calculated from the following relation:

$\sin \theta = A/B$, or $\theta = \sin^{-1} A/B$.

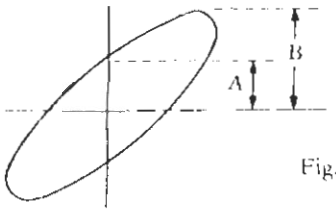


Fig. 3-8 Phase angle measurement.

3.6.3 Amplitude Modulation Measurement

Two methods will be given for determination of amplitude modulation of carrier frequencies up to 4MHz.

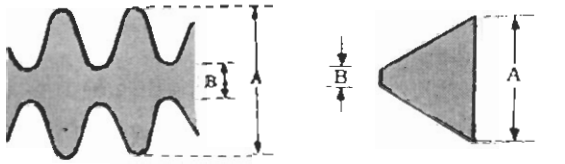
The signal input to V IN may be obtained from a pickup coil loosely coupled to a radio transmitter, or direct from a signal generator (at least 1Vrms will be required). Care must be exercised when making the transmitter measurements.

Depth of modulation, m, is calculated from the relation.

$$m = \frac{A - B}{A + B} \times 100\%$$

A. Envelope method.

Adjust sweep controls for a two-cycle display, see "A" in Fig. 3-9. (NOTE: A signal from the audio source to SYNC IN, with SYNC MODE switch at EXT, can be used in synchronizing the sweep).



A: Envelope method B: Trapezoid method

Fig. 3-9 AM measurements.

B. Trapezoid method.

1. Set SWEEP FREQ switch at EXT.
2. Connect a part of the audio modulation source to H IN.
3. Adjust HOR GAIN for suitable width.

4. CIRCUIT DESCRIPTION

4.1 General

In this section the circuits which compose the LBO-510 will be briefly described. Reference will be made to the functional block and schematic diagrams.

4.2 Vertical Amplifier

The signal under examination is connected to V Input. The AC-DC-GND switch inserts a blocking capacitor for AC signals. At GND, the input signal is cut off. For attenuation of the input, two frequency-compensated attenuators are used at X10 and X100 positions of VERT INPUT switch.

The amplifier consists of a source follower, Q203, Self-balancing stage, Q204-Q205 for

pushpull output and an emitter follower with Q206-Q207. The deflection amplifier stage is made up with Q208-Q209 (high voltage transistors).

Vertical gain is controlled with VR204 which adjusts the feedback in the Q204-Q205 stage. Spot positioning is done with VR204 which adjusts the base bias voltage on Q206-Q207 and in turn will vary the DC voltage to produce the required static deflection.

Two diode-connected transistors, Q201-Q202, are connected across the input of Q203 for overload protection.

4.3 Horizontal Circuits

4.3.1 Sweep Frequency Generator

A modified multivibrator circuit (run-down type) is used in generating the sweep frequency voltage, from 10Hz to over 100kHz. in four steps. Intermediate frequencies are set with SWEEP VARIABLE control, VR302, which adjusts the time constant of the sawtooth waveform output.

For synchronizing the sweep frequency, inputs, + and -, are derived from the vertical deflection amplifier stage. The sweep is automatically synchronized when there is sufficient voltage to produce about 1.5cm trace amplitude. Line frequency synchronizing is done with a stepped-down voltage from the power transformer.

4.3.2 Horizontal Amplifier

Inputs from the sweep generator, external sweep source, and phased line frequency circuit are selected with the SWEEP FREQ Hz switch. The amplifier consists of a source follower, Q304 (with overload protector D302), and a self-balancing amplifier, Q305-Q306, for pushpull output to the horizontal CRT deflection plates.

4.4 Power Supplies and CRT circuit

The operating voltages are given in CHART 4-1.

CHART 4-1 Operating Voltages

Voltages	Use	Rectifiers, etc.
−1200V (approx.)	CRT accel.	D107, D108 (doubler)
+200V	Final amp.: astigmatism	D101, D104
+8V	Amplifiers	D102, D103;
−15V	and sweep ckt	D105, D106
6.3VAC	CRT heater	
30VAC	Cal. 0.1Vp-p and phase circuits	

A simplified schematic for the CRT gun circuit is shown in Fig. 4-1.

To blank the return trace during the sweep operation, the negative-going voltage of the sawtooth waveform is amplified in the blanking circuit, Q307-Q308-Q309. The output is applied to the cathode of the CRT.

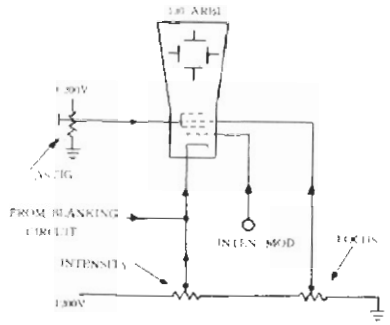


Fig. 4-1 CRT gun circuit (simplified).

5. MAINTENANCE

5.1 General

After a long period of use, it may be necessary to make minor adjustments and/or replacement of components. In this section, direction are given for checking and adjustments.

5.2 Exposing the Chassis

IMPORT: When checking with the AC power turned on, extreme care must be taken not to come into contact with the high voltage in the CRT circuit.

1. Disconnect AC plug from the AC line.
2. Referring to Fig. 5-1, remove four screws as shown for covers on each side, and take off the covers.

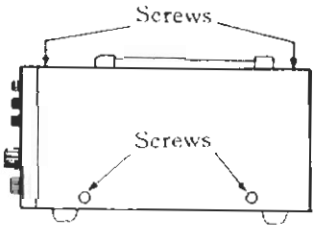


Fig. 5-1 Removal of covers (right side shwon).

5.3 Location of Adjusters

Adjusters on the printed circuit board are shown in Fig. 5-2.

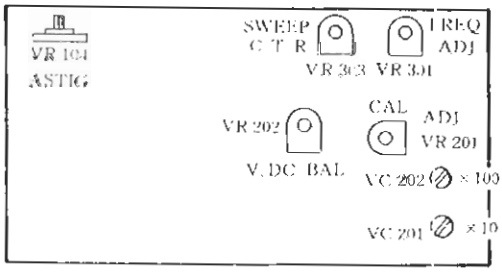


Fig. 5-2 Location of adjusters on PCB.

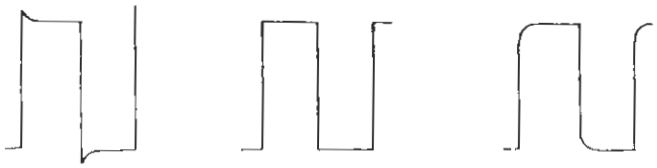
5.4 Vertical Amplifier Balancing

When there is a pronounced shift in the display as VERT GAIN control is adjusted, the following steps are taken. (NOTE: A slight amount of shift can be usually tolerated since it can be compensated with the positioning control without affecting the sensitivity.)

1. Control settings:
   AC-DC-GND switch at GND.
   VERT INPUT at X100
   VERT GAIN at fully counterclockwise.
   HOR GAIN at fully counterclockwise.
2. Adjustments:
   Set vertical positioning for spot at middle horizontal line. Rotate VERT GAIN to fully clockwise. There should be no vertical shift for proper condition.
3. If any shift occurs, adjust V DC BAL, VR202, using a small screw driver, to return the spot to original position.
4. Repeat process of rotating VERT GAIN back and forth and adjusting VR202 until there is no spot movement, or a minimum condition.

5.5 Vertical Attenuator Frequency Compensation

1. Set the scope controls for waveform observation.
2. Set AC-DC-GND switch at DC.
3. Connect a 1kHz square wave (overshoot and sag less than 1%) to V IN.
4. The waveform display at VERT INPUT, X10 and X100, should be as shown at "B" in Fig. 5-3.



A: Improper B: Proper C: Improper

Fig. 5-3 Attenuator frequency compensation

5. If not, adjust trimmers VC201 and VC202 respectively at X10 and X100 settings of VERT INPUT.

5.6 Upper Limit of Sweep Frequency

This adjustment is required only when a single wave of ≥ 110kHz input is not properly displayed.

1. Control settings:
   SWEEP FREQ Hz switch at 100k range.
   SWEEP VARIABLE at fully clockwise.

2. Connect a 110kHz sine wave signal input to V IN.
3. Adjust FREQ ADJ, VR301, for the single wave display.

5.7 Sweep Centering

1. Control settings:
   AC-DC-GND switch at GND.
   HOR GAIN at fully counterclockwise.
   Horizontal positioning for spot at middle vertical line.
   SWEEP FREQ Hz switch at 10-100.
2. Adjustments:
   HOR GAIN for sweep to cover about 8cm. Under this condition, the trace length each side of middle line should be within about 10% at four frequency settings of the switch.
   If not, adjust SWEEP CTR, VR303, for best average conditions.

5.8 Calibration Voltage, 0.1Vp-p

1. Connect AC plug to the AC line voltage at value specified for the scope.
2. Set VERT INPUT switch at X1.
3. Connect to V IN a voltage at 0.1Vp-p from a square wave generator at 50 to 1000Hz. (If a sine wave is used, adjust the voltage to 0.0353Vrms.)
4. Adjust VERT GAIN control for trace amplitude of 5cm. Do not touch this control after this step.
5. Set VERT INPUT switch at CAL 0.1Vp-p.
   The trace amplitude should be 5cm. If not, then adjust CAL ADJ, VR301, for proper amplitude.

5.8 Astigmatism

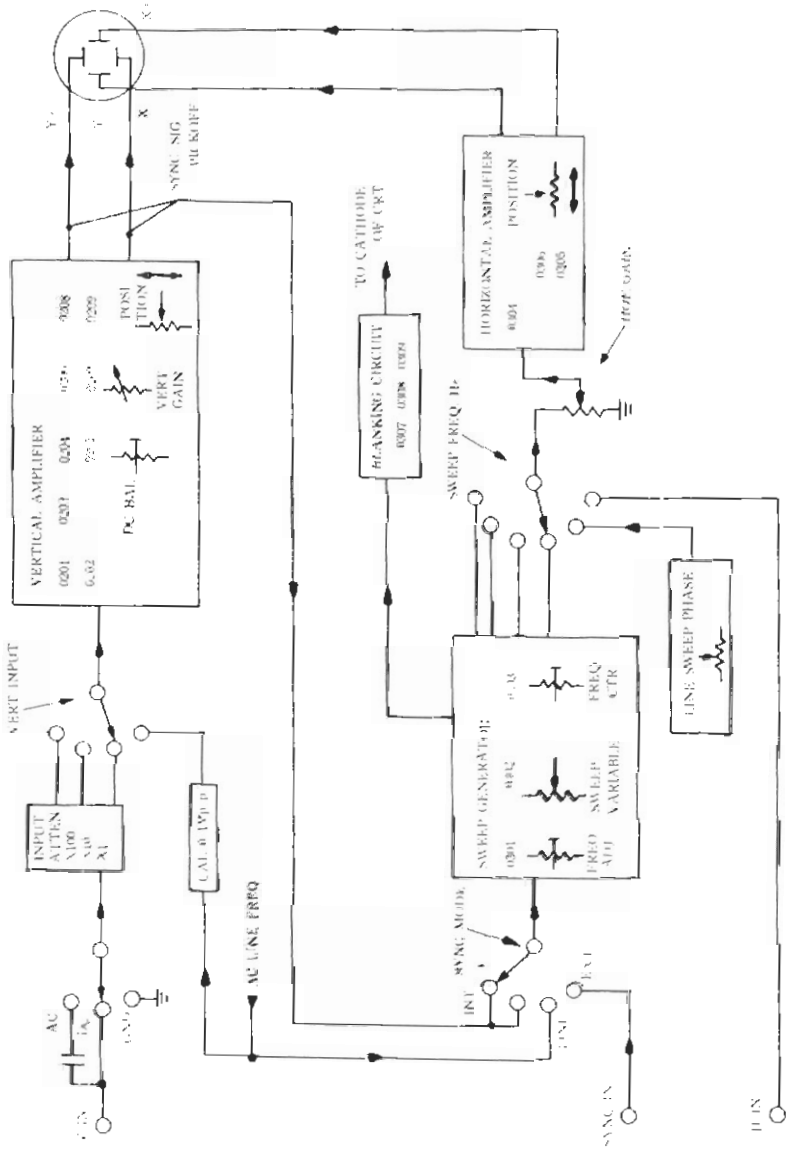
This adjustment is required only when the CRT has been replaced.

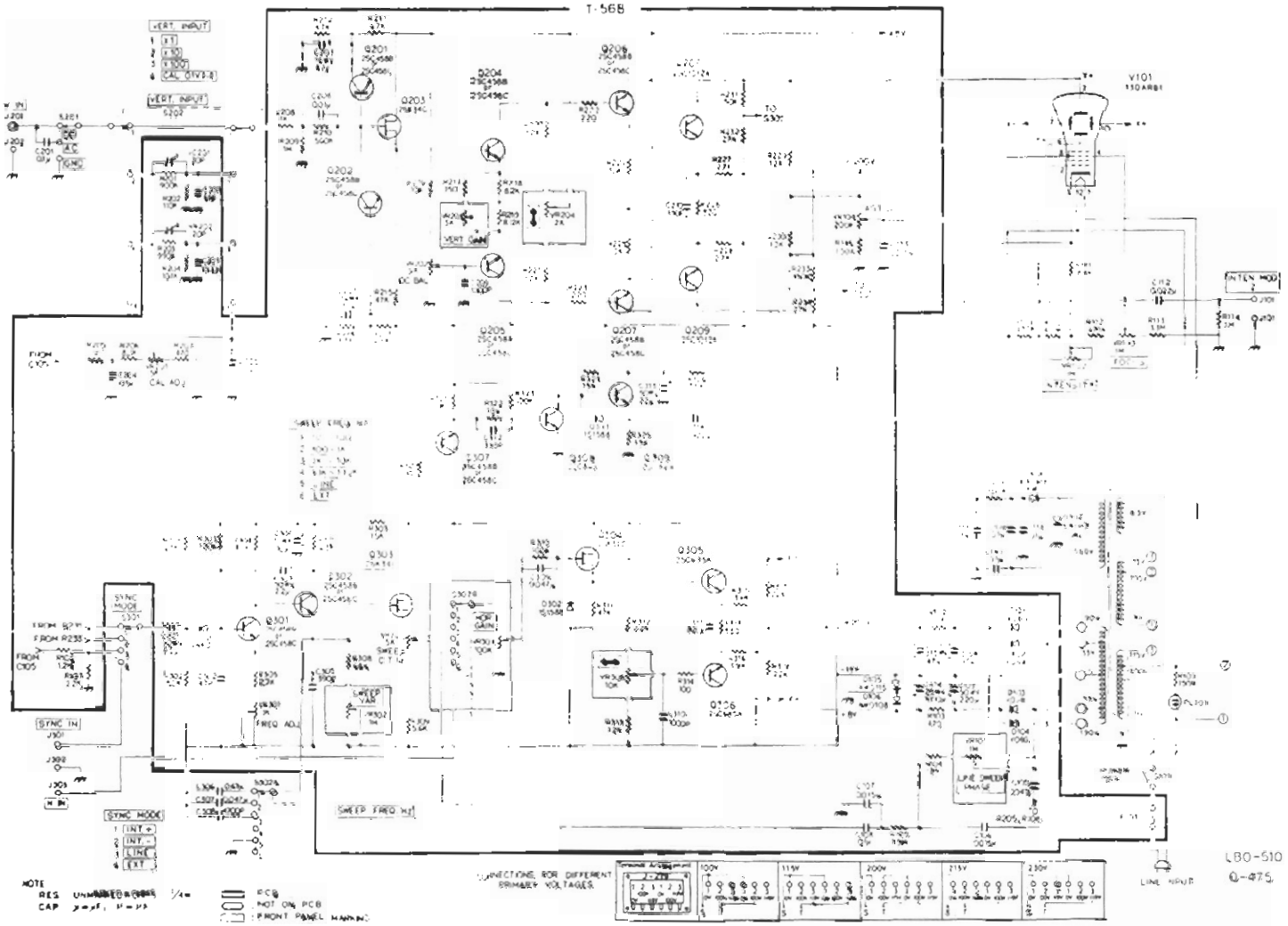
1. Control settings:
   VERT INPUT at CAL 0.1Vp-p.
   SWEEP FREQ Hz at LINE.
2. Adjust LINE SWEEP PHASE control for a circular pattern; adjust FOCUS control for a clear trace. The trace should be uniform in width around the circle. If not, adjust ASTIG, VR104.

5.10 Fuse Replacement

The rating of the AC line fuse depends on the AC voltage used in operation; use 0.5A for 100-115V or 0.3A for 200-230V. If the fuse blows after replacement, check the power supply circuits for defective parts, such as rectifiers and filter capacitors.

FUNCTIONAL BLOCK DIAGRAM: LBO-510




T-568
VERT. INPUT
SYNC IN
SYNC MODE
SWEEP FREQ ADJ
V101
LINE INPUT
LBO-510
0-475