INSTRUCTION MANUAL

OSCILLOSCOPE

MODEL 5530A

KIKUSUI ELCTRONICS CORPORATION

Power Requirements of this Product

Power requirements of this product have been changed and the relevant sections of the Operation Manual should be revised accordingly.
(Revision should be applied to items indicated by a check mark ☑.)

☐ Input voltage

The input voltage of this product is ________ VAC,
and the voltage range is ________ to ________ VAC. Use the product within this range only.

☐ Input fuse

The rating of this product's input fuse is ________A, ________VAC, and ________.

WARNING

- To avoid electrical shock, always disconnect the AC power cable or turn off the switch on the switchboard before attempting to check or replace the fuse.
- Use a fuse element having a shape, rating, and characteristics suitable for this product. The use of a fuse with a different rating or one that short circuits the fuse holder may result in fire, electric shock, or irreparable damage.

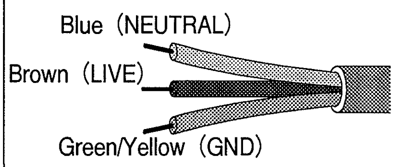
☐ AC power cable

The product is porvided with AC power cables described below. If the cable has no power plug, attach a power plug or crimp-style terminals to the cable in accordance with the wire colors specified in the drawing.

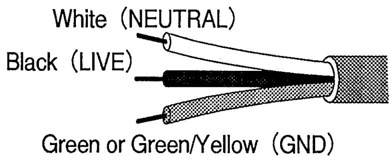
WARNING

- The attachment of a power plug or crimp-style terminals must be carried out by qualified personnel.

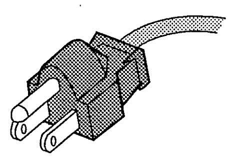
☐ Without a power plug



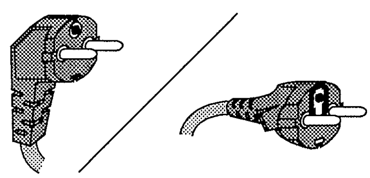
☐ Without a power plug



☐ Plugs for USA



☐ Plugs for Europe



☐ Provided by Kikusui agents

Kikusui agents can provide you with suitable AC power cable.
For further information, contact your Kikusui agent.

☐ Another Cable ________________________________

 Kikusui Part No. Z9-000-027 IB001681

KIKUSUI

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1. GENERAL

1.1 DESCRIPTION

Kikusui Model 5530A Oscilloscope is a wide-bandwidth dual-trace oscilloscope with a 6-inch rectangular dome-mesh post acceleration internal-graticule CRT. Its vertical channels have a maximum sensitivity of 1 mV (with 5 × MAG) and a bandwidth of DC to 35 MHz.

For triggering, both channels (CH1 and CH2) can select trigger signal sources mutually independently. The sweep circuit covers a wide sweep range of 0.5 sec/DIV to 0.2 μsec/DIV. The maximum sweep speed is 40 nsec/DIV (with 5 × MAG).

The circuits consist of IC's and components of premium quality. The 5530A is ideal for observation of signals of digital circuits as well as those of analog circuits.

1.2 FEATURES

o High acceleration voltage (12 kV):

The high acceleration voltage of the CRT ensures a bright trace for observation.

o Vertical delay circuit:

A delay line is provided in the vertical circuit, thereby enabling convenient observation of the rising edge of a high speed pulse signal, etc.

o Cardinal circuits with IC's:

The trigger circuit and time base circuit, which are cardinal circuits of the oscilloscope, employ IC's thereby ensuring smooth and stable triggering operation.

o Automatic CHOP/ALT sweep mode selection:

Sweep operation is automatically switched between CHOP mode and ALT mode depending on the sweep speed (being linked to the TIME/DIV switch -- for the chopping mode for sweep speed of 1 msec or slower and for the alternate mode for that of 0.5 msec or faster.)

o Maximum sweep speed of 40 nsec/DIV (with 5 × MAG):

This high sweep speed, together with the excellent performance of the trigger circuit, enables easy observation of high speed pulse signals.

o Bright trace at high sweep speed:

Even when operating at the highest sweep speed in the AUTO mode, the base line is clearly displayed if the input circuit is grounded. This feature is convenient for checking the zero level or slanted angle of the base line. The 5530A employs an improved AUTO trigger circuit which provides a bright, flickerless trace.

o Trace rotation coil:

The 5530A employs a trace rotation coil to adjust (rotate) the base line for leveling when it has become slanted by terrestrial magnetism.

1.3 COMPOSITION

The 5530A Oscilloscope comprises the following:

Main unit (oscilloscope unit) 1

Accessories	Code number	
960 BNC Probes (10:1, 1:1)	(89-03-0220)	2
942A Terminal Adaptor	(W4-986-011)	1
Fuse (slow blow, 1 A)	(99-02-0101)	1
Fuse (slow blow, 0.5 A)	(99-02-0100)	1
Instruction manual	( )	1

2. SPECIFICATIONS

Vertical Axes

Item	Specification	Remarks
Sensitivity	5 mV/DIV - 5 V/DIV, 1 mV/DIV - 1 V/DIV (Note)	1-2-5 sequence, 10 positions
Sensitivity accuracy	Better than ±3% of dial-indicated value when VARIABLE knob is in CAL'D position	±5% or better when 5 × MAG
Frequency bandwidth	DC: DC - 35 MHz AC: 2 Hz - 35 MHz DC: DC - 10 MHz (Note) AC: 2 Hz - 10 MHz (Note)	Within -3 dB; with reference to 8 DIV, 50 kHz
Continuously-variable adjustment of sensitivity	To 1/2.5 or less of dial-indicated value	
Rise time	10 nsec (35 MHz) 35 nsec (10 MHz) (Note)	
Input impedance	1 MΩ ±2% 25pF ±2 pF	Parallel
Input terminals	BNC receptacles	
Maximum allowable input voltage	400 V	DC + AC peak. AC frequency not higher than 1 kHz

(Note): When the POSITION knob is pulled out (in the 5 × MAG state)

Item	Specification	Remarks
Input coupling	AC and DC	
Base line shift caused by DC offset	Within 0.2 DIV at 5 mV/DIV range	When AC/DC/GND switch changed between DC and GND
Base line shift caused by range switching	Within 0.2 DIV at any range	With AC/DC/GND switch set at GND
Base line shift caused by 5 × MAG	Within 2 DIV when POSITION knob is pushed in or pulled out	With AC/DC/GND switch set at GND
Linearity	Vertical contraction or expansion is within ±0.2 DIV when signal with 4 DIV amplitude in screen center is moved to upper or lower limit of effective screen area.	Including linearity of CRT; at a frequency not higher than 100 kHz
Signal delay time	Approx. 120 nsec	With delay cable
Common mode rejection ratio	100:1 or higher, with 50 kHz sine wave	With accurately uniform sensitivities of CH1 and CH2

Item	Specification		Remarks
Intermodulation between channels	1000:1 or over, with 8 DIV reference at 100 kHz		With both CH1 and CH2 set at 5 mV/DIV range; in dual-trace operation with a signal for full screen deflection applied to one channel and with the other channel terminated with 50 ohms.
Polarity	Interted for channel 2 only		
Operation modes of vertical axis	CH1	Sincle-channel operation with CH1	
	CH2	Single-channel operation with CH2	
	DUAL (Automatically switched being linked to TIME/DIV switch)	ALT: CH1 and Ch2 are swept alternately.	ALT mode for 0.5 mS to 0.2 μS ranges
		CHOP: Signals of CH1 and CH2 are chopped at approx 200 kHz	CHOP mode for 0.5 S to 1 mS ranges
	ADD	CH1 + CH2	

CH1 Signal Output

Item	Specification	Remarks
Output voltage	Approx. 20 mV/DIV into 1 MΩ load Approx. 10 mV/DIV into 50 Ω load	One division of deflection gives approx. output voltage.
Output resistance	Approx. 50 Ω	
Output frequency response	DC - 35 MHz, -3 dB	At 50 Ω terminated
Output DC level	Approx. 0 V	

Horizontal Axis

Item	Specification	Remarks
Sweep time	0.2 μsec/DIV - 0.5 sec/DIV	20 ranges, 1-2-5 sequence
Sweep time accuracy	±3% or better	VRIABLE knob in CAL'D position
Continuously variable adjustment of sweep time	Can be varied (made slower) to 2.5 times or over of dial-indicated value.	
Sweep magnification	5 times	
Sweep accuracy (when magnified)	0.5 sec/DIV - 1 μsec/DIV: ±3% 0.5 μsec/DIV, 0.2 μsec/DIV: ±5%	
Position shift caused by sweep magnification	Within ±1 DIV at CRT center	

Trigger Circuit

Item	Specification			Remarks
Trigger signal source	INT	CH1	Triggered with CH1 signal	
		CH2	Triggered with CH2 signal	
	EXT	Triggered with external signal		
	LINE	Triggered with AC line signal		
Coupling modes	DC, AC, HF REJ			
Polarity	"+" and "-"			
Internal trigger sensitivity	DC: DC - 10 MHz 0.5 DIV 10 MHz - 35 MHz 1 DIV AC: 5 Hz - 10 MHz 0.5 DIV 10 MHz - 35 MHz 1 DIV HF REJ: DC - 50 kHz 0.5 DIV			Amplitude on CRT
	DC: DC - 10 MHz 0.5 DIV AC: 5 Hz - 10 MHz 0.5 DIV HF REJ: DC - 50 kHz 0.5 DIV			When vertical axes "5 × MAG"
External trigger sensitivity	DC: DC - 10 MHz 0.1 V 10 MHz - 35 MHz 0.2 V AC: 5 Hz - 10 MHz 0.1 V 10 MHz - 35 MHz 0.2 V HF REJ: DC - 50 kHz 0.1 V			

Item	Specification	Remarks
AUTO	Satisfies the trigger sensitivity specification for repetitive signals of 20 Hz or over	When trigger signal is removed, sweep runs in AUTO (FREE RUN) mode.
NORM	Satisfies the trigger sensitivity specification	When trigger signal is removed, base line is blanked out and sweep is in STANDBY state.
SINGLE	Satisfies all of the above trigger specifications. When trigger signal is applied, sweep runs only once. When RESET button is pressed, sweep is in READY state.	Remains in READY state until the input signal is applied.
External trigger input impedance	Approx. 100 kΩ, 40 pF	
Input terminal	BNC receptacle	
Maximum allowable input voltage	100 Vp-p (DC + AC peak)	AC frequency not higher than 1 kHz

External Sweep Amplifier (XY Mode)

Item	Specification	Remarks
Mode	XY mode CH1 for X CH2 for Y	X: Horizontal axis Y: Vertical axis
Sensitivity	X: 5 mV/DIV - 5 V/DIV Y: 5 mV/DIV - 5 V/DIV	10 steps for both X and Y
Frequency bandwidth	X: DC - 2 MHz Y: DC - 35 MHz	Within -3 dB
Input impedance	Both X and Y axis: 1 MΩ ±2%, 25 pF ±2% (in parallel)	

Calibration Voltage

Item	Specification	Remarks
Waveform	Square wave	
Polarity	Positive	
Output voltage	1 Vp-p	
Output voltage accuracy	±3% or better	
Frequency	1 kHz ±25%	
Duty ratio	Within 45:55	
Rise time	Approx. 150 nsec	
Output terminal	Hook terminal	

Z Axis

Item	Specification	Remarks
Sensitivity	Intensity modulation discernible with 3 Vp-p input signal. (Trace becomes brighter with negative input.)	
Frequency bandwidth	DC - 1 MHz	
Input resistance	Approx. 10 kΩ	
Input terminals	BNC receptacle	Provided at instrument rear.

CRT Circuit

Item	Specification	Remarks
Type	6-inch rectangular, mesh type, post acceleration CRT	
Phosphor	P31	
Acceleration voltage	Approx. 10.3 kV/1.7 kV	Approx. 12 kV in total
Effective CRT screen size	8 × 10 DIV	1 DIV ≅ 9.5 mm (0.37 in.)
Alignment of trace with graticule	Electrically adjustable with rotation coil	

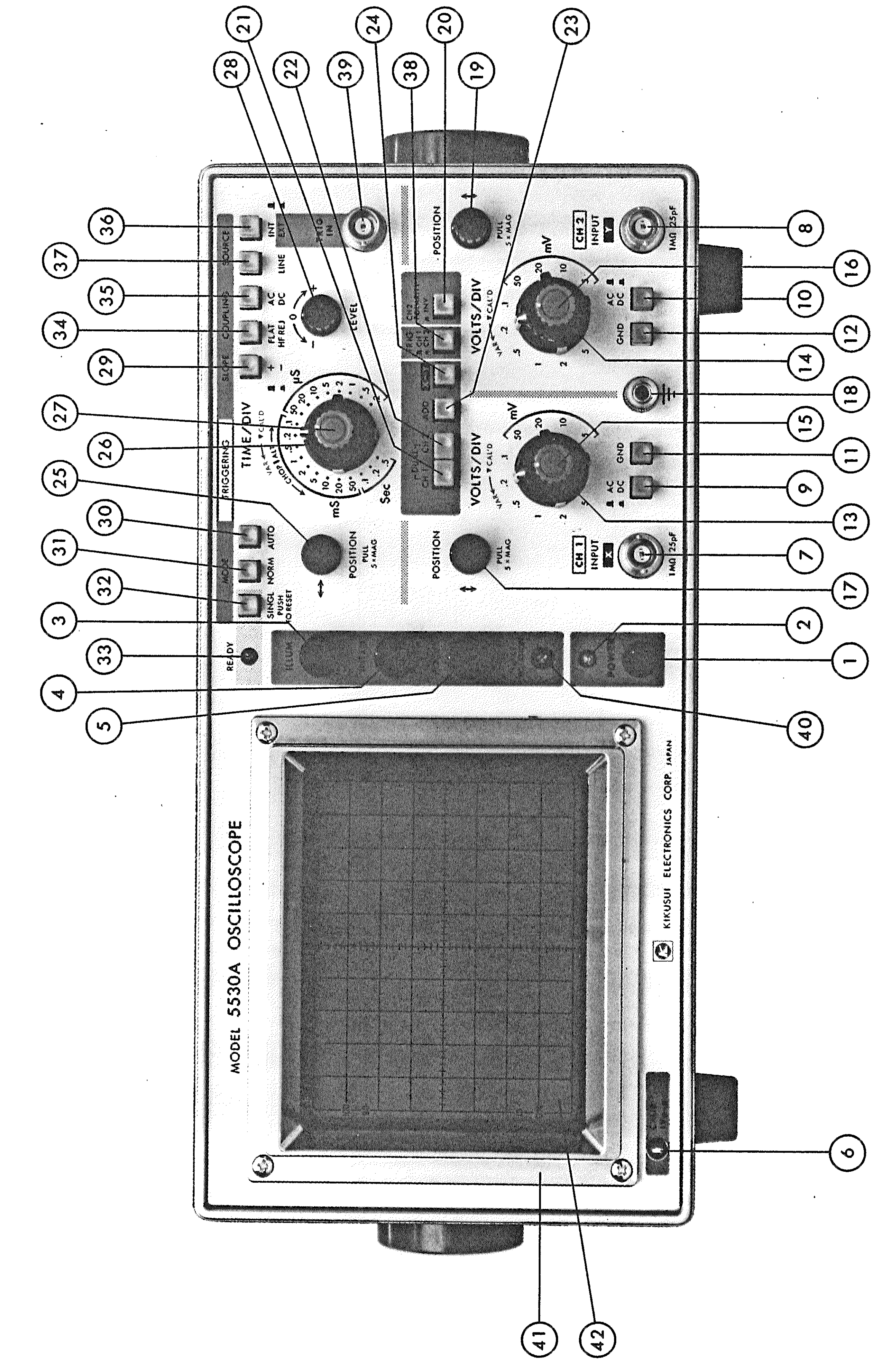
Item	Specification	Remarks
Unblanking	With G1	
Illumination	Continuously variable	

Power Requirements

Item	Specification	Remarks
AC line voltage ranges	100 V, 115 V, 215 V, 230 V, ±10%	Voltage ranges are selectable at instrument rear.
Frequency	50/60 Hz	
Power consumption	Approx. 52 VA	

Mechanical Specifications

Item	Specification	Remarks
External dimensions	370 W × 165 H × 525 D mm (14.57 W × 6.50 H × 20.67 D in.)	With handle in the portable state
	370 W × 165 H × 460 D mm (14.57 W × 6.50 H × 18.11 D in.)	Maximum dimension
	370 W × (190) H × 460 D mm (14.57 W × 7.48 H × 18.11 D in.)	With handle on case top
	310 W × 150 H × 400 D mm (12.20 W × 5.91 H × 15.75 D in.)	Case only
Weight	Approx. 9.5 kg (21 lbs)	Main unit only



MODEL 5530A OSCILLOSCOPE
KIKUSUI ELECTRONICS CORP. JAPAN
TRIGGERING
MODE
SINGL PUSH TO RESET
NORM
AUTO
SLOPE
COUPLING
SOURCE
INT
EXT
LINE
AC
DC
FLAT
HF REJ
LEVEL
TRIG IN
TIME/DIV
CHOP
VAR
CAL'D
μS
mS
Sec
POSITION
PULL 5×MAG
VOLTS/DIV
mV
ADD
INV
GND
CH 1 INPUT X
CH 2 INPUT Y
1MΩ 25pF
READY
ILLUM
POWER

Figure 3-1

3. EXPLANATION OF PANEL SWITCHES AND CONTROLS

3.1 EXPLANATION OF FRONT PANEL (See Figure 3-1.)

The switches, controls and lamps on the front panel are explained in this section. Of the double-knob controls, the items for the black knob are indicated with black letters and those for the red knob with red letters on the panel.

①	POWER	Main power switch of the instrument. The depressed state is power on. When it is pressed again, the power is turned off.
②	Power lamp	Power indicator lamp (LED)
③	ILLUMI	To adjust illumination of graticule (brighter with clockwise rotation).
④	INTEN	Controls the brightness of the spot or trace.
⑤	FOCUS	To focus the spot or trace to the sharpest image, in conjunction with the internal ASTIG control potentiometer.
⑥	CALIB (1 Vp-p)	Generates a pulse signal of 1 Vp-p, approx. 1 kHz, for oscilloscope sensitivity calibration and probe phase characteristics adjustment. The signal is delivered through the chip terminal on the panel.
Vertical Amplifiers		The functions of controls and terminals of CH1 and CH2 are identical. Explanations on items of CH1 are directly applicable to those of CH2.

(7) CH1 (X) (8) CH2 (Y)	Input terminals for vertical axes (and also for X-Y operation). The terminals are BNC receptacles, which can be used also when the probe is used.
(9), (10) AC, DC	Pushbutton switch to select input coupling. The depressed state is for DC-coupling and the popped-up state is for AC-coupling. With AC-coupling, DC component of input signal is blocked and AC component alone is displayed. With DC-coupling, all components are displayed.
(11), (12) GND	When this pushbutton switch is depressed, the vertical amplifier input is disconnected from the BNC receptacle and it is connected to the ground, thereby indicating the zero input voltage level on the CRT.
(13), (14) VOLTS/DIV	The black knob selects vertical sensitivity from 5 mV/DIV to 5 V/DIV in 10 ranges. The range values are for 1 DIV vertical diflection with the VARIABLE (red) knob set in the CAL'D (extreme clockwise) position.
(15) (16) ▼CAL'D VAR	Continuously-variable adjustment of vertical sensitivity. When turned to the extreme counterclockwise position, the sensitivity is reduced by approximately 1/2.5. The extreme clockwise position is the calibrated position.
(17) (19) POSITION ↕	Vertical positioning of the spot or trace. As this knob is turned clockwise, the spot or trace moves upward.

(18) GND ⏚	This terminal is electrically connected to the instrument chassis and panel (both CH1 and CH2).
(20) CH2 POLARITY INV	Pushbutton switch to invert (180°) the phase of CH2 signal. The depressed state is for phase inversion.

The above functions are the same for both CH1 and CH2, except that of CH2 POLARITY.

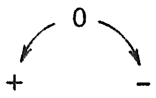
Mode selector of vertical axes	4-gang pushbutton switches to select modes of CH1 and CH2 axes as follows:
(21) CH1	The instrument operates as a single-channel oscilloscope with CH1 alone.
(22) CH2	The instrument operates as a single-channel oscilloscope with CH2 alone.
(21) (22) DUAL CH1 CH2	If both CH1 and CH2 pushbuttons are depressed at the same time, the instrument operates as a dual-channel oscilloscope with both CH1 and CH2 channels, in the CHOP or ALT mode being automatically selected by the TIME/DIV switches (in the CHOP mode for 0.5 S/DIV to 1 mS/DIV or in the ALT mode for 0.5 mS/DIV to 0.2 μS/DIV).
(23) ADD	For measurement of algebraic sum (addition) or difference (subtraction) of amplitudes of CH1 and CH2 signals. For subtraction, press the POLARITY button (20) of CH2.

24	X-Y	The instrument operates as an X-Y scope with external sweep amplifier. CH1 is for X axis (horizontal axis) and CH2 for Y axis (vertical axis). The frequency bandwidth of the X axis becomes DC to 2 MHz, -3 dB.

Horizontal Amplifier

25	←→ POSITION	For horizontal positioning of the spot or trace, which moves rightward as this knob is turned clockwise.
	PULL 5 × MAG	If you pull out this knob which is in common with the POSITION knob, the horizontal sweep is magnified by 5 times with the center of screen as the center of magnification. No magnification occurs when in the X-Y mode.
26	TIME/DIV	The black dial selects sweep time covering from 0.5 sec/DIV to 0.2 μsec/DIV in 20 ranges. The values indicated by the dial are time per one scale division of horizontal sweep when the red VARIABLE knob 27 is set in the extreme clockwise position (CAL'D position).
27	▼ CAL'D VAR	This red knob is for continuously-variable adjustment of sweep time. The value indicated by the TIME/DIV dial can be made slower to 1/2.5 or more. When this knob is set in the CAL'D position, the sweep is calibrated to the value indicated by the TIME/DIV dial.

(28) LEVEL



Controls the trigger level (the starting point of sweep) on the trigger signal. As this knob is turned clockwise, the trigger level moves in the "+" direction; as the knob is turned counterclockwise, the level moves in the "-" direction.

(29) ⎍ +
⊔ -

Selects the triggering slope.

⎍ Triggering is effected when the trigger signal crosses the trigger level in positive-going direction.

⊔ Triggering is effected when the trigger signal crosses the trigger level in negative-going direction.

(30) AUTO

When this pushbutton is pressed, the horizontal sweep runs in the FREE RUN mode. A bright trace is displayed on the screen when no input signal is applied. Triggering is effected if the input signal frequency is 20 Hz or over and signal amplitude is 5 mm or over on the screen. (If the trigger level is within the range of the input signal, the sweep is synchronized; if it is not within the range, the sweep runs in the AUTO mode).

(31) NORM

When no input signal is applied, the time base is in a standby state and is not swept. The sweep is synchronized to the input signal only when the trigger level is within the peak-to-peak range of the input signal.

(32)	SINGLE	Pushbutton switch for the single sweep (one-shot sweep) operation. When this button is pressed, the AUTO and NORM push-buttons are reset to the undepressed state and the SINGLE pushbutton also is automatically reset.
	PUSH TO RESET	Used in conjunction with the SINGLE push-button to reset the single sweep circuit to the READY state after one sweep operation is over.
(33)	READY	This lamp (LED) lights to indicate that the single sweep circuit is in the READY state.
(34)	⎍ FLAT _⊓_ HF REJ	Selects filtering of the trigger signal. When in the FLAT state, the CH1, CH2 or EXT trigger source signal is directly fed to the trigger circuit. When in the HF REJ (high frequency reject) state, a low pass filter of approximately 50 kHz is connected in the trigger input circuit in order to eliminate signal components or noise components of higher than 50 kHz.
(35)	⎍ AC _⊓_ DC	Selects between AC-coupling and DC-coupling for trigger input circuit. When in AC-coupling, the DC component of trigger signal is cut off and triggering is done with the AC component alone. When in DC-coupling, triggering is done with overall input signal including the DC component.

36	INT	Triggering is done with internal signal CH1 or CH2 as selected by INT TRIG selector switch 38.
	EXT	Triggering is done with an external signal applied through EXT TRIG IN terminal 39.
37	LINE	When this button is pressed, triggering is done with the AC line frequency for observation of signals related to the line frequency. If the triggering polarity does not conform with that selected by the ± polarity selector 29, insert the AC plug in the reverse polarity into the line receptacle.
38	TRIG CH1 CH2	Selects the CH1 or CH2 signal for the INT trigger source signal when in the DUAL or ADD mode. The undepressed state is for CH1 and the depressed state is for CH2 as the trigger signal.
39	TRIG IN	When INT/EXT pushbutton 39 is in the depressed state, the external signal applied to this terminal is used as the trigger signal.
40	TRACE ROTATION	This semi-fixed potentiometer is to correct slanting of the horizontal base line which may be caused by terrestrial magnetism, etc.
41	Camera mount	This bezel is a camera mount which enables to install a camera in one-touch operation.
42	Graticule	Graticule with adjustable illumination.

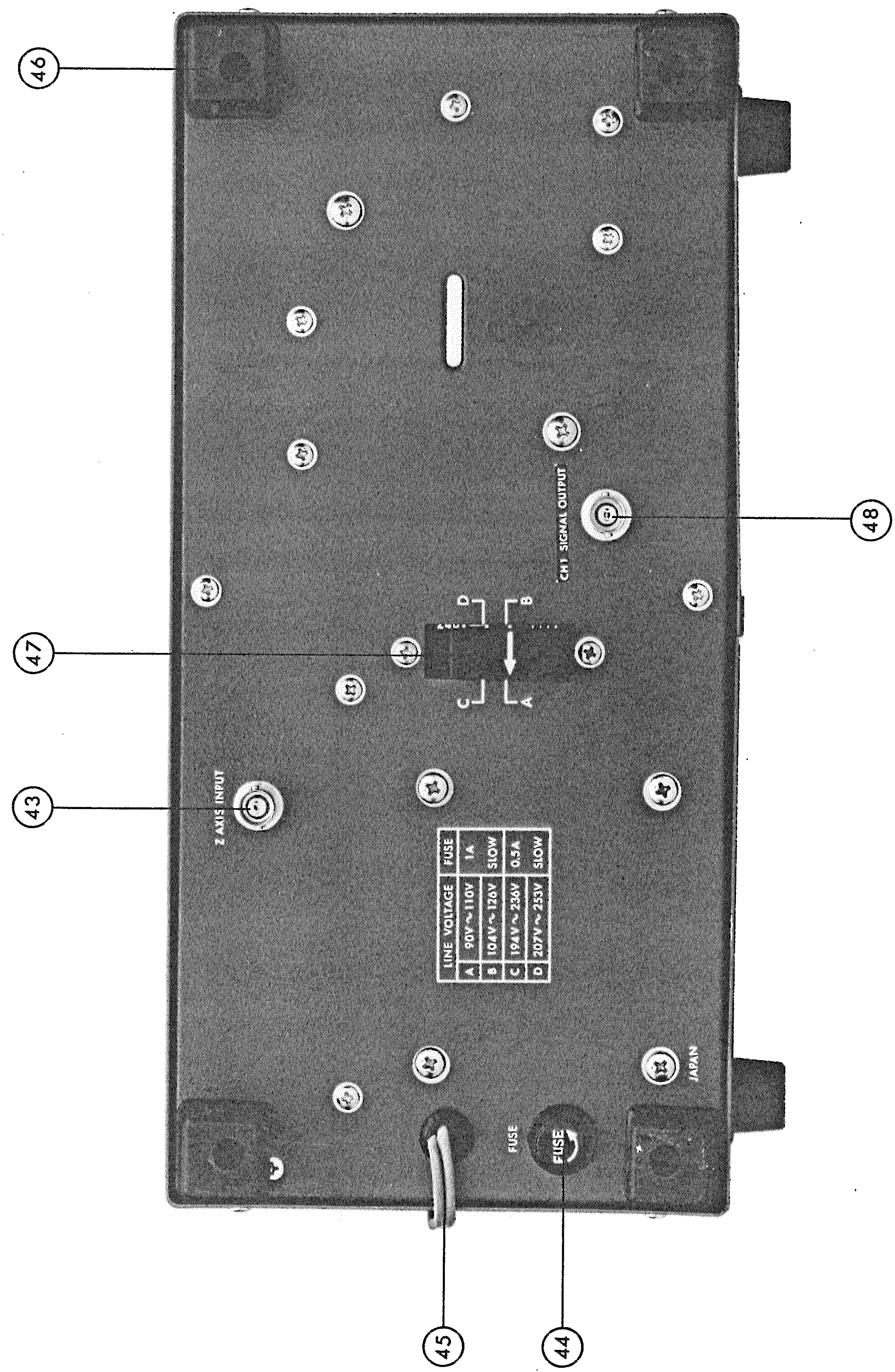


Figure 3-2

3.2 EXPLANATION OF REAR PANEL (See Figure 3-2.)

The items mounted on the rear panel are Z-AXIS INPUT terminal (binding post terminals), a fuse holder, a power cord, a voltage selector connector, etc.

43	Z-AXIS INPUT	Input terminal for the external intensity modulation signal.
44	FUSE	Fuse holder for slow blow fuse. To replace the fuse, remove the cap by turning it counter-clockwise.
45	Power cord	AC power cord of the instrument. Connect the cord to an AC line receptacle of the correct voltage.
46	Cord hunger	Used to take up the power cord when the instrument is not in used. Also used as stud (four studs) when the instrument is operated in the laid down attitude.
47	Line voltage selector	Selects the AC line voltage on which the instrument is to be operated.
48	CH1 SIGNAL OUTPUT	This output terminal provides CH1 signal which is fed to a frequency counter, etc.

3.3 PRECAUTIONS IN OPERATING THE OSCILLOSCOPE

AC line voltage:

The oscilloscope normally operates on an AC line power of nominal voltage ±10%. Note that the oscilloscope may not operate normally or may be damaged if the voltage is not within this range.

Environments:

Ambient temperature and humidity: The ambient temperature specification of this oscilloscope is 0°C to 40°C (32°F to 104°F). Note that mal-functioning and life shortening may result if the oscilloscope is used or stored in high-temperature high-humidity atmosphere for a long period.

Electromagnetic or electrostatic field: The measuring accuracy may be degraded if the oscilloscope is placed in a strong electromagnetic or electrostatic field.

Protection of CRT screen:

Note that the CRT screen may be damaged if the trace intensity is abnormally high or a stationary spot is left for a long period.

Maximum allowable voltages of input terminals:

The maximum allowable input voltages of the input terminals and probe are as shown in the following table. Note that the input circuit may be damaged if an input voltage higher than the specified value is applied.

CH1 and CH2 terminals	400 V (DC + AC peak)
Probe (960 BNC)	600 V (DC + AC peak)
EXT TRIG IN terminal	100 V (DC + AC peak)
Z-AXIS IN terminal	100 V (DC + AC peak)

Repetition frequency: Not higher than 1 kHz

3.4 AC LINE VOLTAGE MODIFICATION

The oscilloscope can be modified for other AC line voltages than 100 V, as shown in the following table, by changing transformer taps. The rating of the AC power cord which accompanies the oscilloscope is 125 V, 7A. When modifying the instrument for a voltage higher than 125 V, replace the cord with that of a higher voltage rating. The fuse rating should be as indicated in the table.

<table>
<tr><th>Set position</th><th>Nominal voltage</th><th>Operable voltage range</th><th>Fuse</th></tr>
<tr><td>A</td><td>100 V</td><td>90 - 110 V</td><td rowspan="2">1 A
slow blow</td></tr>
<tr><td>B</td><td>115 V</td><td>104 - 126 V</td></tr>
<tr><td>C</td><td>215 V</td><td>194 - 236 V</td><td rowspan="2">0.5 A
slow blow</td></tr>
<tr><td>D</td><td>230 V</td><td>207 - 253 V</td></tr>
</table>

4. OPERATION METHOD

Before turning on the oscilloscope power, set the switches and controls on the front panel as follows:

1	POWER				OFF
4	INTEN				Mid-position
5	FOCUS				Mid-position
	CH1 - CH2 - ADD			21	Press CH1 button
	TRIGGER	28	LEVEL		Mid-position
		34	FLAT - HF REJ		FLAT
		35	AC - DC		AC
		36	INT - EXT		INT
			SINGLE - NORM - AUTO	30	AUTO
		38	CH1 - CH2		CH1
26	TIME/DIV				0.2 mS
25	POSITION (horizontal)				Mid-position
21	CH1	17	POSITION (vertical)		Mid-position
		13	VOLTS/DIV		0.2 V (red knob in CAL'D position)
		9	AC - DC		DC
		11	GND		Press GND button

Connect the power cord to a power line outlet (100 V AC). Press the POWER switch. The oscilloscope power is turned on and the LED at upper left of the panel lights. Wait in this state about 10 seconds and, then turn the INTEN knob clockwise so that a trace of an appropriate brightness is displayed on the screen.

FOCUS adjustment:

Move the trace to the center of the screen by adjusting the CH1 POSITION knob and horizontal POSITION knob. Adjust the FOCUS knob so that the displayed trace is well focused.

4.1 CALIBRATION VOLTAGE SIGNAL DISPLAY

Display on the screen the CALIB signal of the oscilloscope by setting to CH1 input terminal the BNC terminal adaptor (supplied) and connecting the square wave calibration voltage signal using as short wires as possible. Set the switches and controls on the front panel as follows.

9	AC - DC (CH1) pushbutton switch:	DC
11	GND (CH1) pushbutton switch:	Not depressed
13	VOLTS/DIV (CH1) knob:	0.2 V
15	VARIABLE (CH1) knob:	CAL'D
26	TIME/DIV knob:	0.2 mS
27	VARIABLE knob:	CAL'D
29	+, -	+
	Other switches and controls:	As set when the power is turned on

When the switches and controls are set as above, a square wave with an amplitude of 5 DIV will be displayed on the screen.

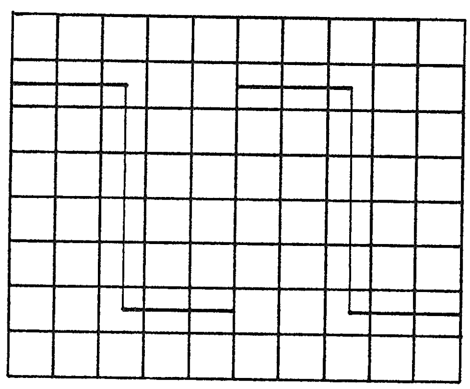


Figure 4-1

As you turn the VOLTS/DIV knob counterclockwise range by range, the vertical amplitude will be reduced in response. As you turn counterclockwise the VARIABLE knob, the amplitude will be reduced continuously. With these operations, you can know the effects of the VOLTS/DIV and VARIABLE knobs on the displayed waveform amplitude.

4.2 DUAL-CHANNEL OPERATION AND ADD OPERATION

Dual-channel operation

Set the MODE pushbutton switch in the DUAL mode. (Press the CH1 and CH2 pushbutton switches at the same time.) In the above operation, the signal was applied to CH1 only and no signal was applied to CH2. Apply the calibration signal also to CH2. In this case, leave the TRIGGER selector switch in the CH1 position so that the signal of CH2 also is triggered by the signal of CH1. If the signal applied to CH2 is in a synchronizing relationship with respect to that applied to CH1, the displayed waveforms of both CH1 and CH2 will be stationary.

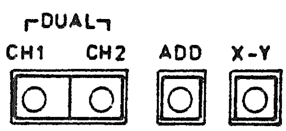


Figure 4-2

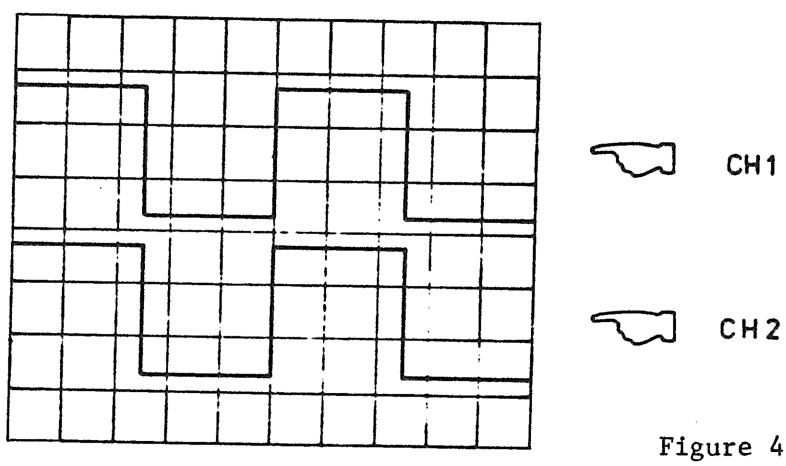


Figure 4-3

For dual-channel operation, this oscilloscope has no CHOP or ALT switch but has a DUAL pushbutton switch only. Switching between CHOP and ALT modes is done by the TIME/DIV knob -- CHOP mode for 0.5 S - 1 mS/DIV ranges and ALT mode for 0.5 mS - 0.2 μS/DIV ranges.

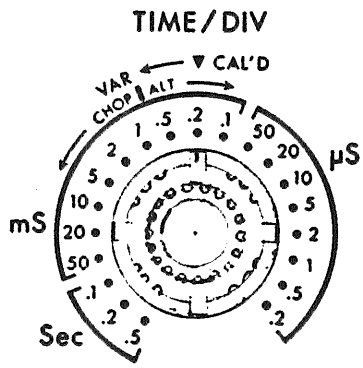


Figure 4-4

ADD operation:

Press the ADD button to set the oscilloscope in the ADD mode. The displayed waveform is the sum (or difference) of the two signals applied to CH1 and CH2.

CH1 ± CH2 = Add waveform

Next, set the CH2 polarity pushbutton switch in the INV mode. In this case the difference of CH1 - CH2 is displayed on the screen. (INV state: Polarity of CH2 signal is inverted by 180°.)

4.3 X-Y OPERATION

Press the X-Y button to set the oscilloscope in the X-Y mode. With this single action, the oscilloscope operates as an X-Y scope with CH1 as X-axis and CH2 as Y-axis.

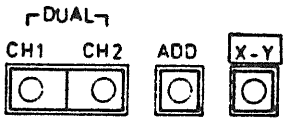


Figure 4-5

While the electrical performance of the Y-axis remains the same with that of CH2 operated in the single-channel CH2 mode, frequency bandwidth of the X-axis becomes DC - 1 MHz, -3 dB. (The CH1 POSITION knob remain idle.)

The X-axis position is adjustable with the horizontal POSITION knob. When in the X-Y mode, the operation is more pronounced than when in the sweep mode. The other electrical performances remain the same as when CH1 is operated in the single-channel CH1 mode.

Next, apply the CALIB signal to both X and Y axes and adjust the VOLTS/DIV switches so that two spots are displayed on a diagonal line on the screen. A Lissajous figure with frequency ratio 1:1 and phase angle $\cong$ 0 will be displayed.

When in the X-Y operation, the 5 × MAG switch (which is linked to the horizontal POSITION knob) remains idle.

4.4 Z-AXIS INPUT (INTENSITY MODULATION)

The Z-axis input terminals for intensity modulation are located at the rear of the oscilloscope. For intensity modulation, remove the short bar from the terminals and connect an external intensity modulation signal between red terminal and black (GND) terminal. When intensity modulation is not used, keep the short bar connected between the two terminals.

Z AXIS INPUT

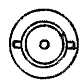


Figure 4-6

4.5 TRIGGER AND TIME BASE

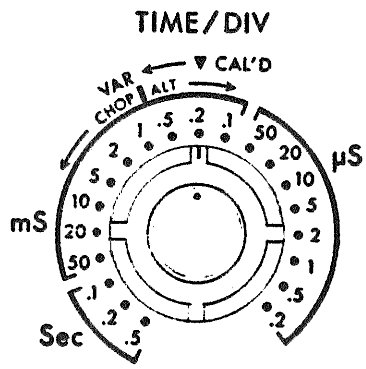


Figure 4-7

The CALIB voltage signal is a square wave of approximately 1 kHz. When the TIME/DIV knob is set in the 0.2 mS/DIV position, one cycle of the square wave is displayed with a horizontal magnitude of approximately 5 DIV.

As you turn the TIME/DIV knob clockwise, the sweep time becomes faster. The VARIABLE knob is for continuously-variable adjustment of sweep time.

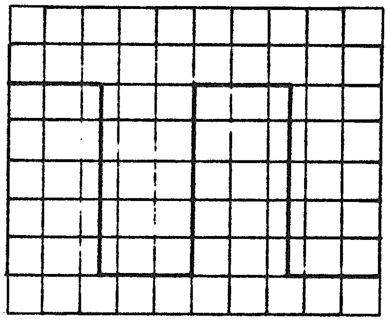


Figure 4-8

4.6 TYPES OF TRIGGER SIGNAL SOURCES

To display a stationary pattern on the screen, a signal which is synchronized to the input signal must be applied to the trigger circuit for triggering the sweep circuit. The three types of trigger signal sources are CH1 (signal of CH1), CH2 (signal of CH2), and EXT (external signal applied through the EXT TRIG IN terminal).

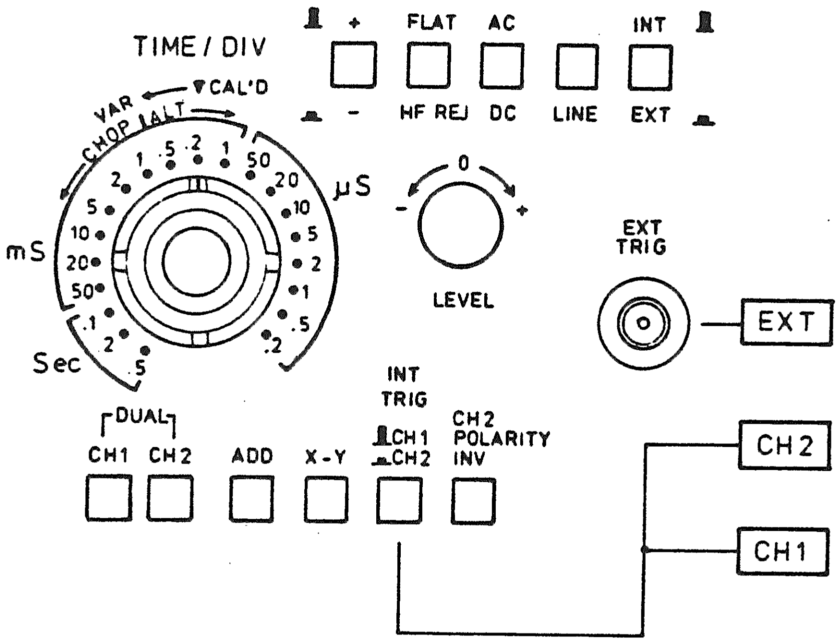


Figure 4-9

4.6.1 INTERNAL TRIGGER (CH1, CH2)

When in the internal trigger mode, the input signal is picked up at a point in the vertical amplifier and the signal is amplified to a sufficient level for triggering. The amplified signal is applied to the trigger circuit.

When in the CH1 mode, the input signal of CH1 alone is used as the trigger signal; when in the CH2 mode, the input signal of CH2 alone is used as the trigger signal.

4.7 AC- AND DC-COUPLING

This oscilloscope is capable of DC-coupling of the trigger signal. The DC-coupling is especially advantageous when the input trigger signal is 5 Hz - DC and when used in the single sweep mode. The AC-coupling is used for an trigger input signal of 5 Hz - 35 MHz or when the trigger signal has a DC component.

4.8 FLAT AND HF REJ

When in the HF REJ, low pass filter of 50 kHz is connected before the trigger input circuit in order to eliminate the noize and high frequency components which are superimposed on the trigger signal.

Triggering may be improved by setting in the HF REJ state when the oscilloscope is in the dual-channel mode and the TIME/DIV knob is in the CHOP range.

Waveform with 50 kHz or higher frequencies superimposed

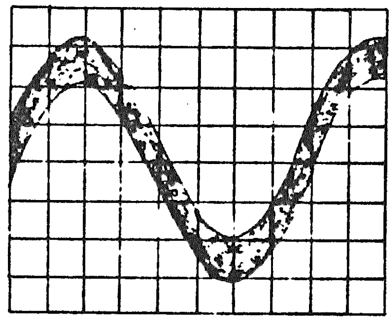


Figure 4-10

When in the FLAT mode, stable triggering can be done for a range of DC - 35 MHz.

4.9 LEVEL KNOB AND SLOPE SWITCH

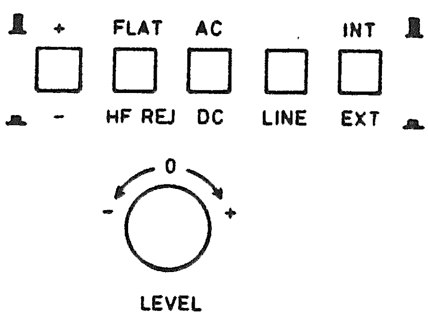


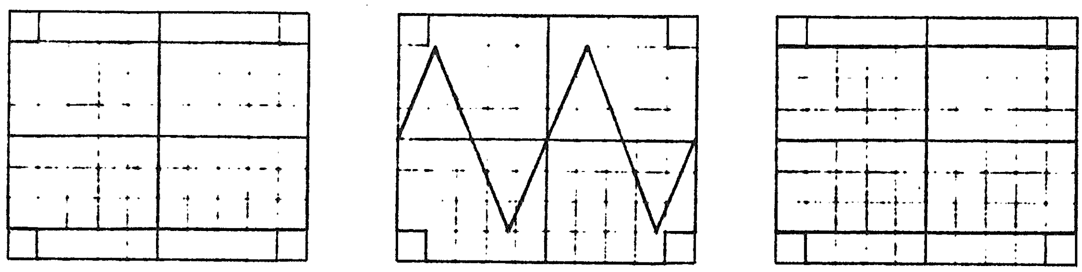
Figure 4-11

Apply a sinusoidal or triangular signal of approximately 1 kHz to the CH1 input terminal. (So adjust the input signal level or the input attenuator of the oscilloscope that the signal is displayed with an amplitude of 6 DIV or over.)

Set the switches and controls as follow:

FLAT - HF REJ:	FLAT
AC - DC:	AC
CH1, CH2	CH1
TIME/DIV	0.2 mS/DIV
AUTO, NORM, SINGLE:	AUTO
± SLOPE	+

Turning the LEVEL knob from the counterclockwise position to the clockwise position, observe that the displayed image changes from the free-run state to a synchronized state, the starting point of the waveform moves from upward to downward and again the displayed waveform free-runs.



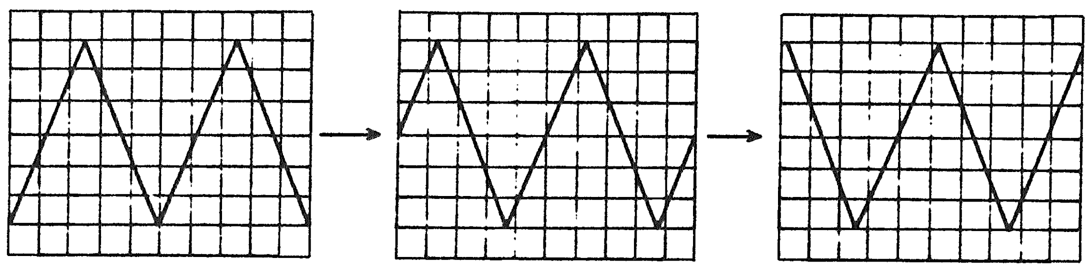
(a) Free-run

(b) Synchronized waveform

(c) Free-run

Figure 4-12

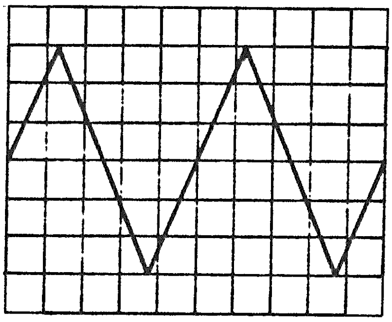
As you turn the LEVEL knob clockwise from the position where the displayed waveform has become stationary, the waveform will move from right to left on the screen and the starting point of the waveform also will move from a lower position to an upper position.



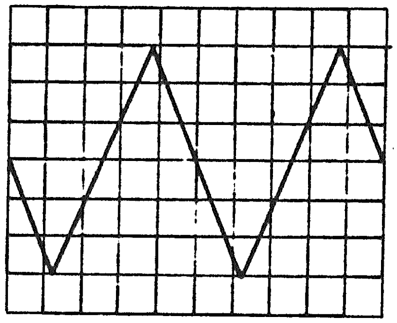
Trigger level shift

Figure 4-13

Next, press the ± SLOPE switch. The slope of the starting point of the waveform will be inverted, indicating that triggering is effected with the negative polarity.



± SLOPE switch
not pressed



± SLOPE switch
pressed

Figure 4-14

4.10 AUTO OPERATION

Adjust the displayed waveform amplitude to approximately 0.5 DIV with the input attenuator. Also, by adjusting the trigger LEVEL knob, make it sure that the displayed waveform remains stationary. (This can be observed more clearly by setting the TIME/DIV knob in the 1 mS/DIV position.) A synchronized stationary waveform is displayed even when the amplitude is increased to 8 DIV or over.

When set in the AUTO mode, the sweep circuit operates without requiring any trigger input signal and a bright trace is displayed even at a fast sweep range, enabling to check easily the zero level.

4.11 NORM OPERATION

When set in the NORM mode, the sweep circuit is in the standby state and no trace is displayed on the screen if no input signal is applied to the oscilloscope, if the external signal applied to the EXT TRIG IN terminal is less than 200 mVp-p, or if the setting of the LEVEL knob is exceeding the triggering point.

4.12 SINGLE-SWEEP OPERATION

For the single-sweep operation, proceed as follows:

(a) Apply a repetitive signal to CH1 or CH2, set the trigger circuit in the NORM mode, and adjust the trigger LEVEL knob so that the signal waveform is displayed on the screen.

(b) Change the trigger mode from NORM to SINGLE.

(c) Disconnect the input signal.

(d) Press the SINGLE switch again. (PUSH TO RESET operation)

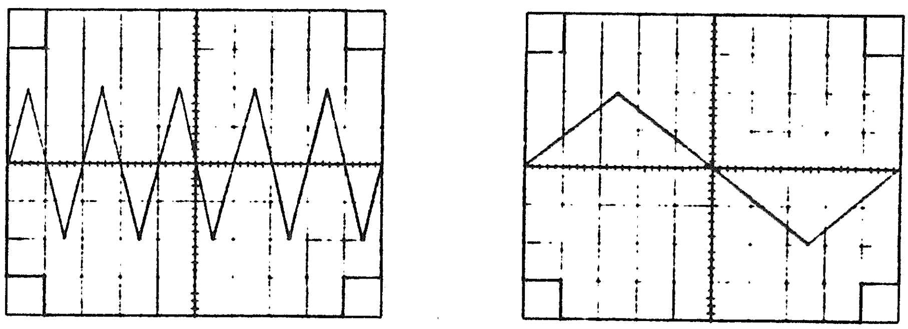
(e) As you release the switch, it is reset to the original state and the READY lamp at upper right on the front panel lights to indicate that the sweep circuit is in the standby state.

(f) Apply the signal to be observed. The sweep circuit will be triggered with this signal and the sweep circuit will operate only once and the READY lamp will go off. The sweep circuit does not operate again unless the SINGLE pushbutton switch is pressed again.

4.13 SWEEP MAGNIFICATION (PULL 5 × MAG)

When you want an enlarged waveform of a certain part of the input signal, you may use a fast sweep time. However, if you use a fast sweep when the part to be observed is away from the start point of the sweep, the required part may run off the screen. In such a case, this sweep magnification feature is used.

As you pull out the horizontal POSITION knob to the 5 × MAG state, the displayed waveform is magnified horizontally by 5 times with the center of screen as center of magnification.



(a) Before magnification (b) After magnification

Figure 4-14

The sweep time when in the magnification can be calculated as follows:

TIME/DIV (DIAL VALUE) ÷ 5 = SWEEP TIME/DIV

Thus the maximum sweep speed of this oscilloscope become 40 nS/DIV as 0.2 μS/DIV is magnified by five times with sweep magnification.

The trace intensity is reduced when operated in the sweep magnification mode. Therefore, this mode should not be used except when in the following cases:

(1) When a part which is away from the start point of the displayed waveform is required to be magnified.

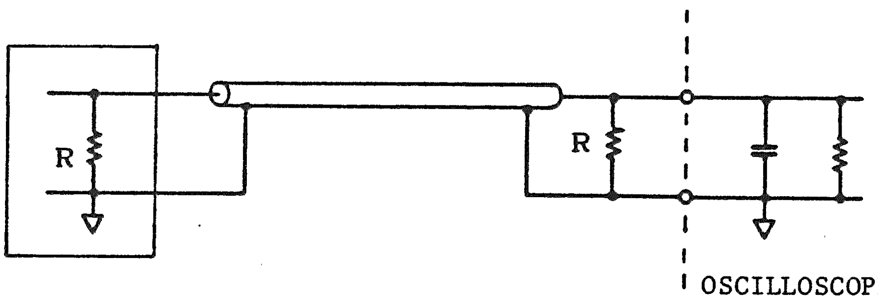
(2) When a Sweep speed faster than 0.2 μS/DIV is required.

4.14 APPLICATION METHOD OF VERTICAL INPUT SIGNAL

4.14.1 USING A COAXIAL CABLE

When the signal source impedance is 50 or 75 ohms a coaxial cable of matched impedance may be used so that a signal which has high frequency components can be transmitted with less attenuation. For impedance matching, terminate the cable at the oscilloscope side using a purely-resistive resistor of 50 or 75 ohms.

COAXIAL CABLE OF 50 Ω OR 75 Ω



OSCILLOSCOPE

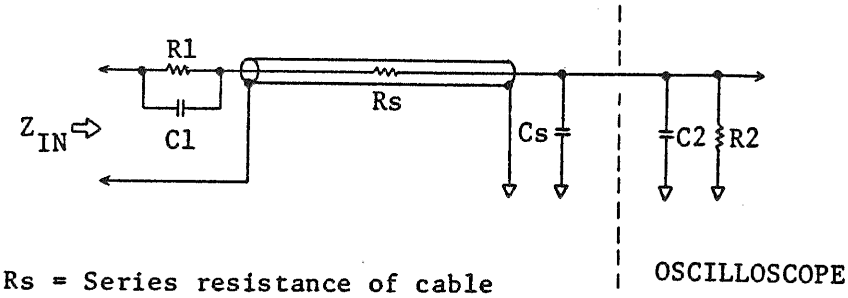
MEASURED SIGNAL SOURCE

R = 50 OR 75Ω

Figure 4-16

4.14.2 USING THE PROBE

The signal to be observed can be fed most effectively by using the 10:1 attenuation probe which is supplied as an accessory item. The cable from the probe to the oscilloscope and the probe itself are shielded to prevent external noise.



Rs = Series resistance of cable

Cs = Stray capacitance plus cable capacitance

$$Z_{IN} = \frac{R1 + R2}{\omega C\ (R1 + R2) + 1}$$

$$C = \frac{C1 \times (C2 + Cs)}{C1 + C2 + Cs}$$

Figure 4-17

Attenuation resistor R1 and its parallel capacitor C1 make up a wide band attenuator. The use of this probe is especially advantageous when the measured signal source impedance is high or when the signal has high frequency components. The use of the probe reduces the loading effect on the measured signal source. The attenuation ratio is 10:1 as calculated below:

$$\frac{R2}{R1 + R2} = \frac{1\ M\Omega}{9\ M\Omega + 1\ M\Omega} = \frac{1}{10}$$

The purpose of attenuation is not to lower the signal voltage level but is to reduce the loading effect on the measured signal source.

4.14.3 NOTES WHEN USING THE PROBE

(1) Make sure that the measured signal is not higher than the specified maximum allowable input voltage.

(2) When measuring a wide frequency signal at a high sensitivity, be sure to use the ground wire supplied. Also use the ground wires supplied when measuring in the dual-channel mode.

(3) Make sure that the phase of the probe is accurately adjusted. Be sure to use the probe supplied as an accessory of the oscilloscope.

(4) Be careful not to apply abnormally large mechanical shocks or vibration to the probe. Do not pull or sharply bend the probe cable.

(5) The probe body and its tip are not highly heat resistant. Do not apply a soldering iron to a point close to the probe.

4.15 VOLTAGE MEASUREMENTS

4.15.1 DC VOLTAGE MEASUREMENT

(1) Set the trigger switch in the AUTO mode and the TIME/DIV switch at 1 mS/DIV to display a trace line.

(2) Set the GND pushbutton switch of the vertical input circuit in the GND state. This trace position is used as the reference position (0 V position) for voltage measurement. Move the trace to a convenient position with the POSITION knob.

(3) Set the AC-DC pushbutton switch in the DC state, apply the voltage to be measured to the vertical input terminal, and determine the vertical deflection of the trace on the screen.

(4) If the trace is deflected off the screen upward, turn counterclockwise the VOLTS/DIV switch to select a lower sensitivity range so that the trace is deflected to an easily measurable position.

(5) If the trace is deflected upward, the porality of the measured signal is positive; if it is deflected downward, the polarity is negative.

(6) Voltage measurement with or without probe

- o When the signal is applied directly to the input terminal:

  Voltage V = VOLTS/DIV indication × Deflection (DIV)

- o When the signal applied using the 10:1 probe:

  Voltage V = VOLTS/DIV indication × Deflection (DIV) × 10

4.15.2 AC VOLTAGE MEASUREMENT

If the AC-DC switch is set in the DC state when measuring an AC voltage superimposed on a DC voltage and if the DC component is large as compared to the DC voltage, the AC voltage may be deflected off the screen. It may be possible to bring the AC voltage component onto the screen by adjusting the vertical POSITION control. It also is possible to bring the AC voltage component onto the screen by turning the VOLTS/DIV switch to a lower range position.

In general, however, the AC voltage is measured by setting the AC-DC pushbutton switch in the AC state to cut off the DC component and displaying the AC voltage component alone with an appropriate amplitude.

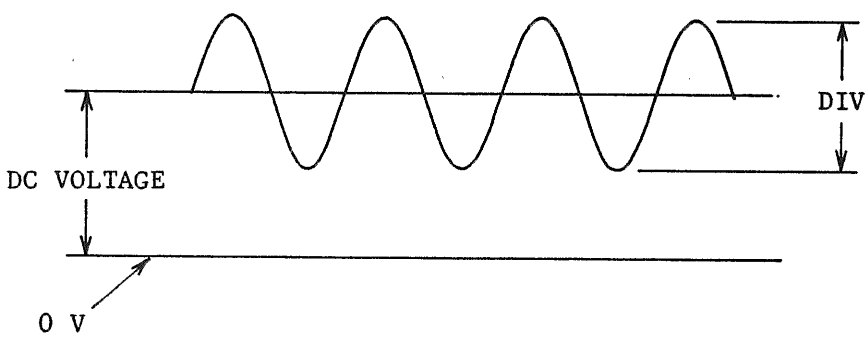


Figure 4-18

From the deflection amplitude (DIV determined on the screen), the voltage is calculated as follows:

Voltage Vp-p = VOLTS/DIV indication × Deflection (DIV)

When the 10:1 probe is used, the voltage is calculated as follows:

Voltage Vp-p = VOLTS/DIV indication × Deflection (DIV) × 10

4.15.3 OPERATION IN AC-COUPLING

To observe an AC signal superimposed on a DC component the AC-coupling is used in general. When the frequency is lower than 1 kHz, however, pay attention to that the phase may lead or lag and the amplitude may be decreased. When a square wave of 1 kHz is applied, for example, sag may be caused and the waveform may be distorted as illustrated.

Figure 4-19

The waveform of (1) shows typical sag which is caused when the low frequency component is in a leading phase and the amplitude is attenuated. The waveform of (2) shows typical sag which is caused when the low frequency component is in a lag phase and the amplitude is attenuated. The use of DC-coupling is ideal.

The input impedance of the oscilloscope is 1 MΩ, with the 0.1 μF AC-coupling capacitor connected in series. When a low frequency square wave or stepwise signal is applied, sag as shown in waveform (1) is caused.

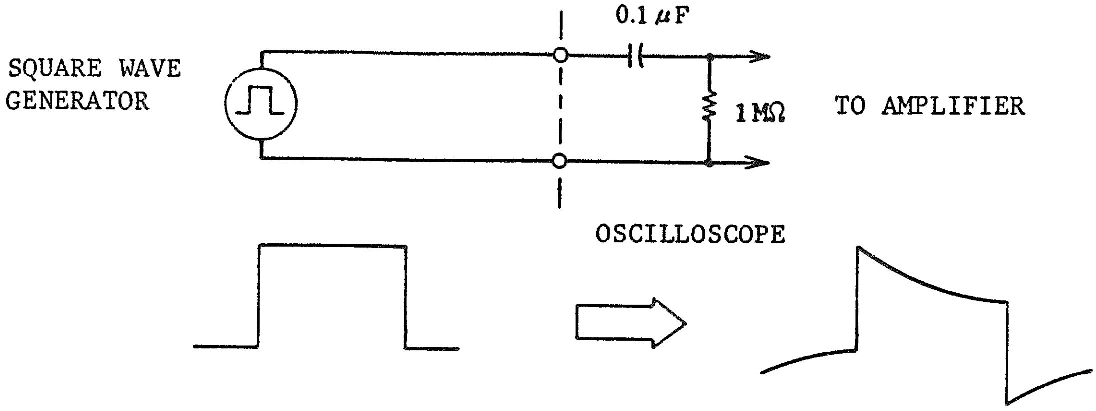


Figure 4-20

Percentage of sag can be calculated as follows:

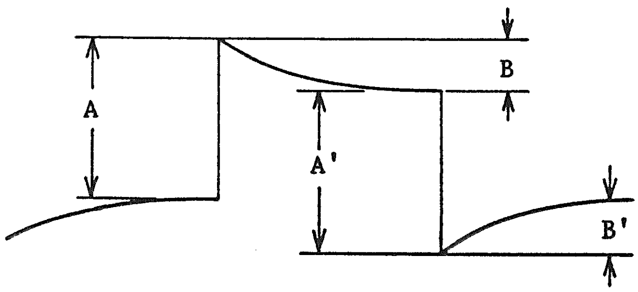


Figure 4-21

A: Basic amplitude

B: Sag

$$\text{Sag } (\%) = \frac{B}{A} \quad (\text{or } \frac{B'}{A'}) \times 100$$

Typical percentages of sag of this oscilloscope are shown in the following:

Repetition frequency	Sag (%)
10 Hz	26
50 Hz	4
100 Hz	2
500 Hz	0.6

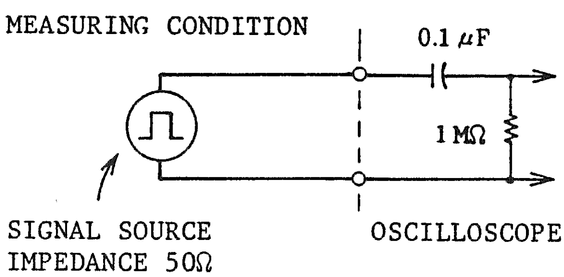


Figure 4-22

Typical percentages of sag when the 10:1 probe is used are shown in the following:

Repetition frequency	Sag (%)
10 Hz	2.6
50 Hz	0.4
100 Hz	0.2
500 Hz	0.06

MEASURING CONDITION

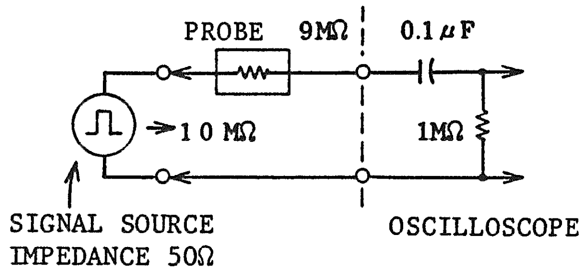


Figure 4-23

As can be seen in the above table, sag is reduced to about 1/10 when the 10:1 probe is used from that when the signal is directly fed to the oscilloscope. When the probe is used, however, the input signal voltage is reduced to 1/10. The use of the probe is advantageous when the signal cannot be DC-coupled and yet a waveform with less sag is required.

5. MEASUREMENTS

5.1 MEASUREMENT OF TIME

Measurement of time interval:

The time interval (T) between two points on the waveform can be measured by setting the TIME/DIV VARIABLE knob in the CAL'D position and determining the horizontal distance between the two points on the screen.

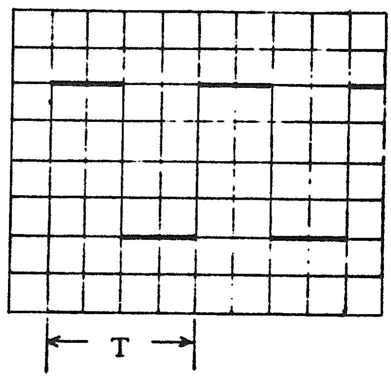


Figure 5-1

Time T (sec) = TIME/DIV (sec) × Distance (DIV) × Magnification factor .... (A)

The magnification factor is 1 when the sweep is not magnified or it is 1/5 = 0.2 when the sweep is magnified.

5.2 PULSE WIDTH MEASUREMENT

Display the pulse signal in the center of the screen with a horizontal magnitude of 2 - 4 DIV for easy observation.

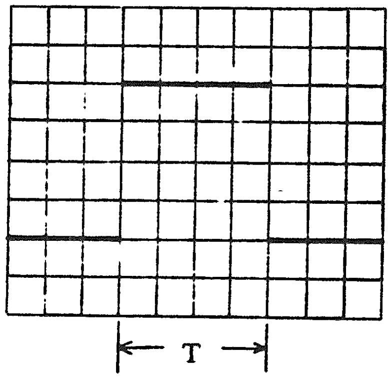


Figure 5-2

Set the TIME/DIV VARIABLE knob in the CAL'D position. When the pulse width is narrow, pull out the 5 × MAG switch as required. Determine the distance T and calculate the width using equation (A).

5.3 MEASUREMENT OF PULSE RISE TIME AND FALL TIME

Determine distance T in the same manner as is done for pulse width measurement and calculate the time using equation (A). When the rise time of the oscilloscope itself (10 nsec) is negligible as compared with the measured pulse rise or fall time, the value can be immediately known. When it is not negligible, correct the value using the following equation:

$$T_n = \sqrt{T^2 - T_O^2 - T_G^2}$$

Tn: True value

T: Measured value

T_O: Rise time of oscilloscope, 10 nsec (theoretical value)

T_G: Rise time of signal of pulse generator

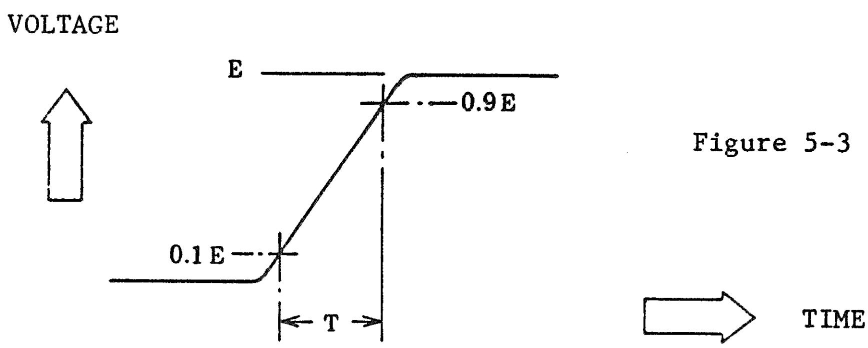


Figure 5-3

5.4 LISSAJOUS MEASUREMENT OF FREQUENCY

When the signal frequency is not higher than 10 kHz and is of a simple waveform such as sine wave, the signal frequency can be measured by operating the oscilloscope as an X-Y scope and displaying a Lissajous figure on the screen. For the X-Y operation, see Section 4.3.

MEASURING SETUP

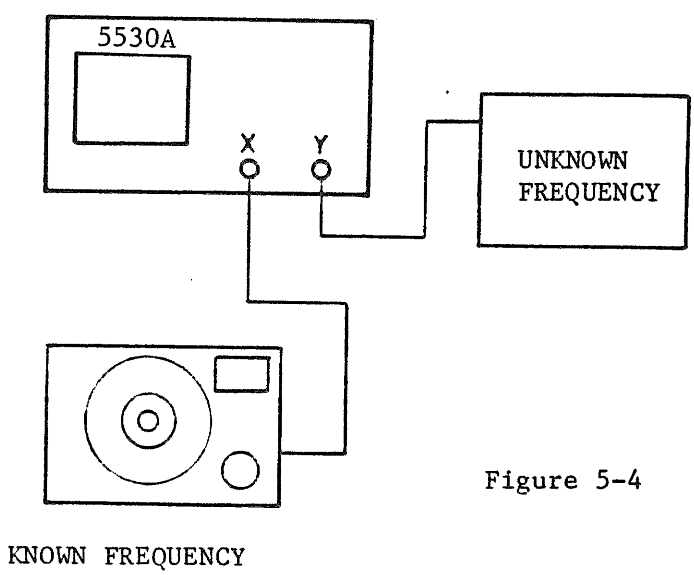


Figure 5-4

Make roughly equal the horizontal and vertical amplitudes of the displayed figure by adjusting the VOLT/DIV switches or VARIABLE controls of both channels. Gradually change the known frequency until a 1:1 Lissajous figure as shown in Figure 5-5 is displayed.

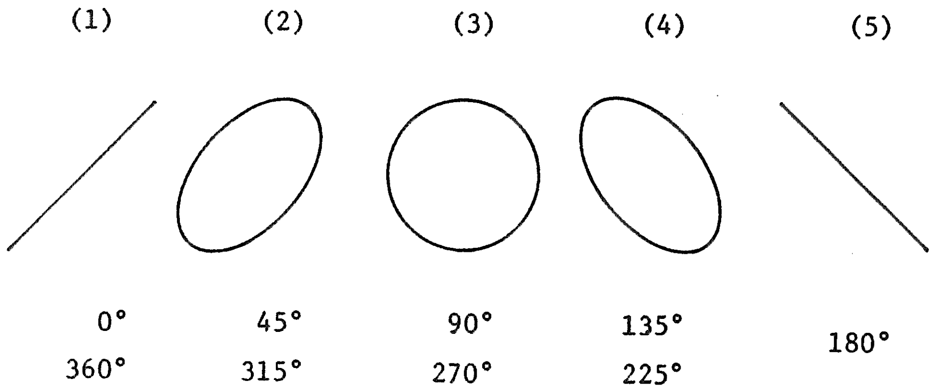


Figure 5-5

When the frequency ratio is 1:1, the displayed Lissajous figure is either a circule, an ellipse, or a line. When the frequency ratio has become close to 1:1, the displayed figure will vary in the sequence of (1) → (5) → (1), repeatedly. As the known frequency becomes closer to the unknown frequency, the change becomes slower. When the two frequencies have become the same, the displayed figure remains stationary in one of the patterns of (1) - (5). Now the unknown frequency is the same as the known frequency.

5.5 PHASE MEASUREMENT

(1) Phase measurement with Lissajous figure:

In the same method as that for frequency measurement, operate the oscilloscope in the X-Y mode and display a Lissajous figure.

Operate the X-axis and Y-axis amplifiers at as high sensitivity as possible. Determine distances A and B on the screen and calculate the phase difference using the following the equation:

Phase difference $\theta = \sin^{-1} \frac{A}{B}$

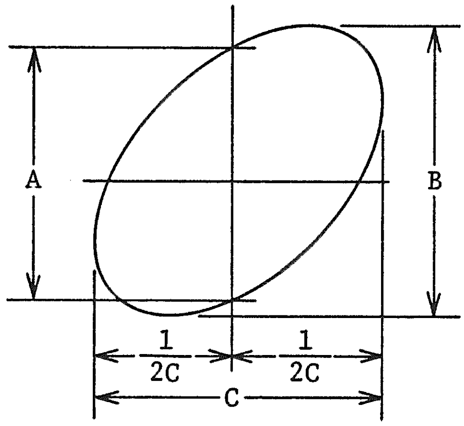


Figure 5-6

Phase measurement in the Lissajous figure method has disadvantages as follows:

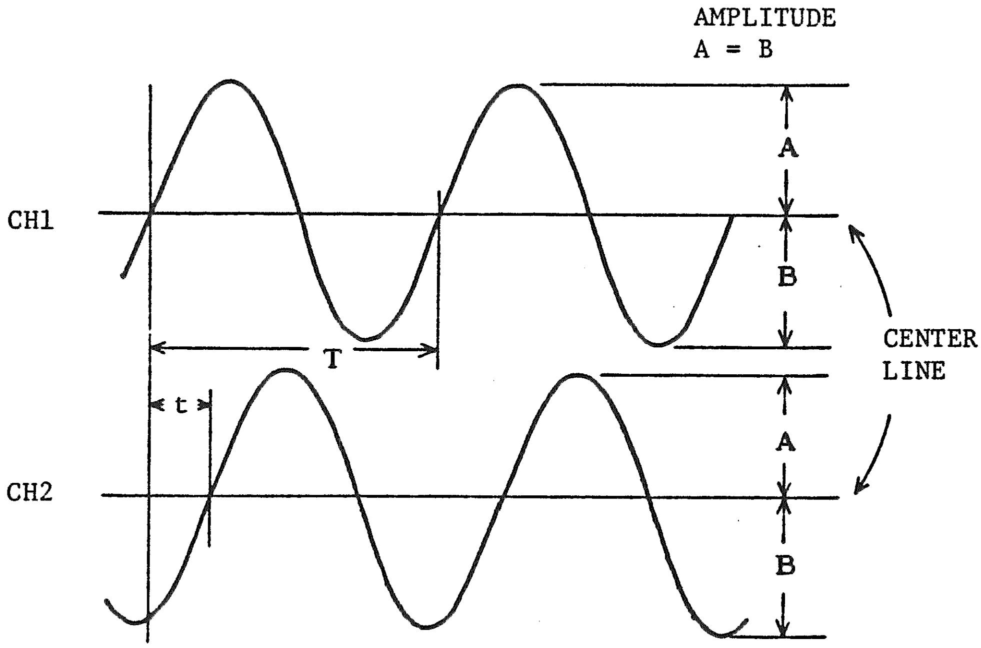
(1) With the conventional oscilloscope, the frequency response of the X-axis is narrow and a large phase difference is caused by the oscilloscope itself.

(2) Phase difference measuring accuracy is comparatively poor.

Due to the above reasons, the dual-channel method explained next is recommended when more accurate phase difference measurement is required.

(2) Phase difference measurement in the dual-channel method:

Set the vertical-axis MODE switches in the DUAL state and press the TRIGGER CH1 button. Apply the reference signal to CH1 and the measured signal to CH2 so that waveforms as shown in Figure 5-7 are displayed.



PHASE DIFFERENCE $\theta = \frac{1}{T} \times 360°$

Figure 5-7

Display waveforms as large as possible by increasing the signals applied to CH1 and CH2 or increasing the sensitivities of both channels. Center both signals on the graticule for A = B. If probes are to be used, use probes for both channels and adjust accurately the phase characteristics of both channels using the CALIB signal.

The phase difference measurement in the dual-channel method has the advantages that even a small phase difference can be measured and the leading or lagging state can be known at a glance.

6. OPERATION DESCRIPTION

6.1 GENERAL

The OSCILLOSCOPE is a visual instrument (SCOPE) for observation of electrical signal change (OSCILLATION).
Its circuits operate so that its input signal is displayed in an easily observable form with an electron beam on a cathode-ray tube screen. A block diagram of the oscilloscope is shown in Figure 6-1.

The signal applied to the vertical input axis is amplified by the vertical amplifier and the amplified signal is applied to the Y-axis deflection plates of the CRT. The electron beam emitted from the CRT cathode is vertically deflected by this signal.

Additionally, the vertical signal is branched off and amplified by the trigger amplifier and a trigger pulse signal which is synchronized with the vertical signal is produced.
The trigger pulse signal is applied to the sweep generator circuit which produces a sawtooth signal. The sawtooth signal is amplified by the horizontal amplifier and applied to the X-axis deflection plates of the CRT in order to deflect the electron beam in the X-axis direction. Thus, a stationary waveform being synchronized with the input signal is displayed on the CRT screen.

The Z-axis amplifier amplifies the unrequired portion of the signal and its output is applied to the CRT so that the unrequired portion of the signal is blanked out. The power supply circuit and high voltage supply circuit provide the required voltages to the functional circuits and CRT. The calibration voltage generator circuit provides a quality square wave signal for calibration of the probe.

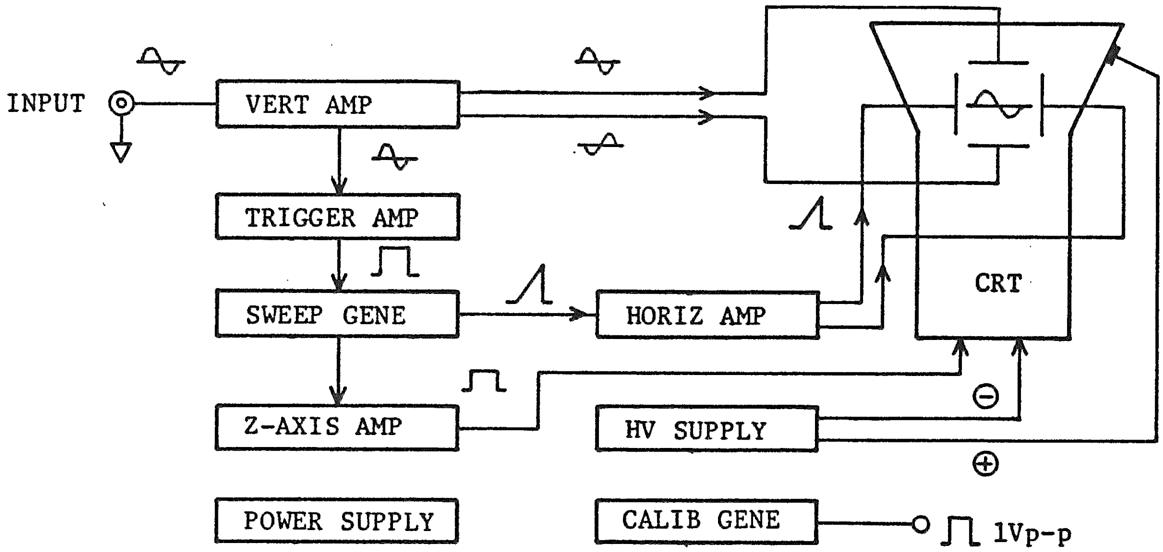


Figure 6-1. A block diagram of the oscilloscope

6.2 VERTICAL AMPLIFIER

The vertical amplifier deflects the beam spot in the Y-axis direction on the CRT screen. This oscilloscope has two channels of vertical amplifiers. Each of which has an input circuit, an attenuator, a preamplifier, a CH1/CH2 selector circuit (in common for both channels), a delay circuit, and an output stage amplifier the output of which is applied to the Y-axis deflection plates of the CRT. All circuits from the preamplifier to the Y-axis deflection plates are of a differential circuit type.

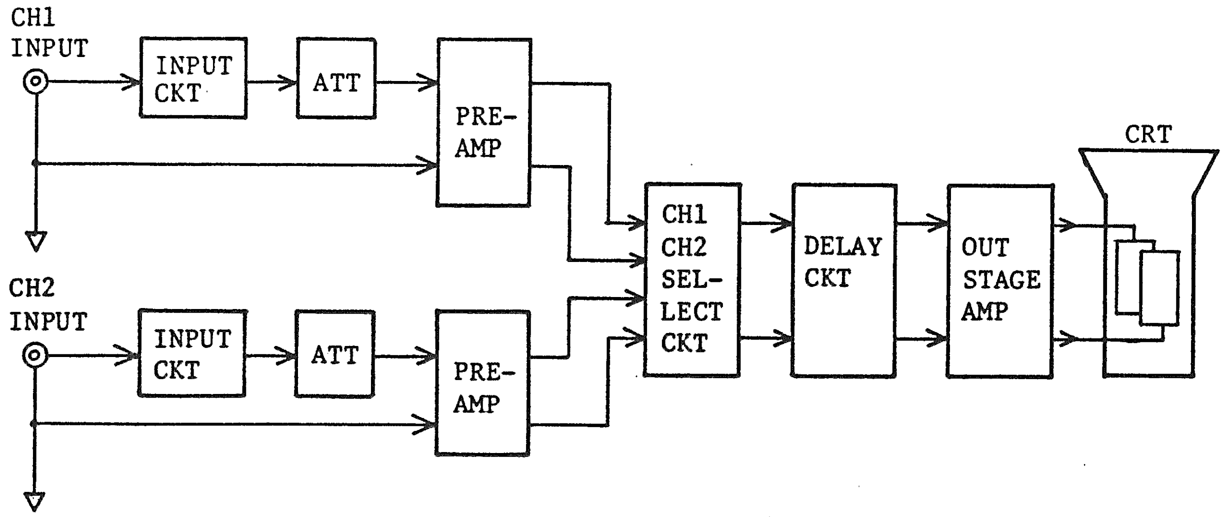


Figure 6-2. A block diagram of the vertical amplifier

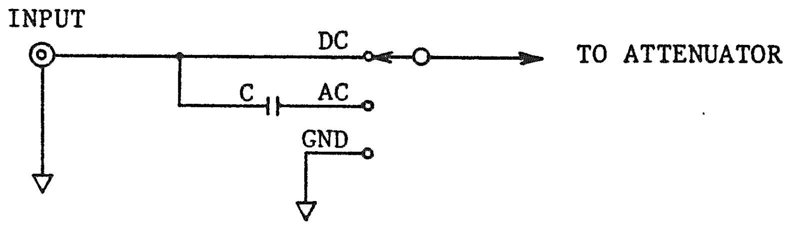


Figure 6-3. The input circuit

The input circuit selects the input mode for DC, AC, or GND. The DC coupling mode is for measurement of a DC signal, the AC coupling for observation of an AC signal superimposed on a DC component, and the GND position is for confirming the zero level position on the CRT screen. A basic diagram of the input circuit is shown in Figure 6-3.

The function of the attenuator circuit is to reduce the input signal with a certain ratio. With combinations of the 1/2, 1/4, 1/10 and 1/100 attenuation circuits, a total attenuation range of 1/2 - 1/1000 can be covered. The attenuator circuit is so designed that the impedance as viewed from the input side remains constant even when conbinations are changed.

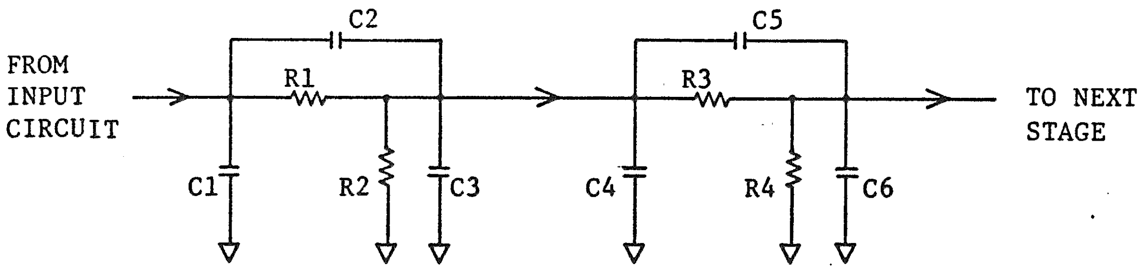


Figure 6-4. An example of combination of attenuator circuits

The preamplifier consists of an input protection circuit, an impedance converter circuit, a differential converter circuit, a gain switching circuit (5×MAG), a trigger signal amplifier circuit, a positioning circuit, and a CH1 signal output circuit (for CH1 only) or a polarity switching circuit (for CH2 only).

The input protection circuit has a diode to clamp the input signal when its voltage is abnormally large, in order to protect the subsequent circuits.

The impedance converter circuit provides a large input impedance and a small output impedance in order to prevent loading on the attenuator circuit to ensure reliable attenuation ratios. This circuit employs a dual FETs which operate as a source follower with a constant current circuit. The FETs employed are such that two premium-quality chips of equal characteristics are sealed in one package attaining excellent thermal balance.

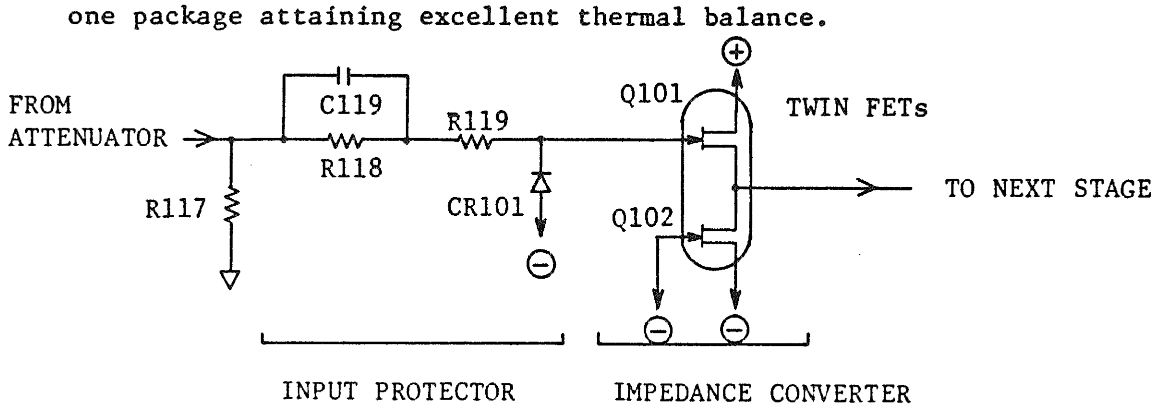


Figure 6-5. The input protector and impedance converter

For the differential converter circuit and gain switching circuit, a differential cascade amplifier is used. To attain good thermal balance, premium-quality transistors are used and thermal coupling is provided. For differential coupling, a constant-current circuit is used to improve the common mode characteristics.

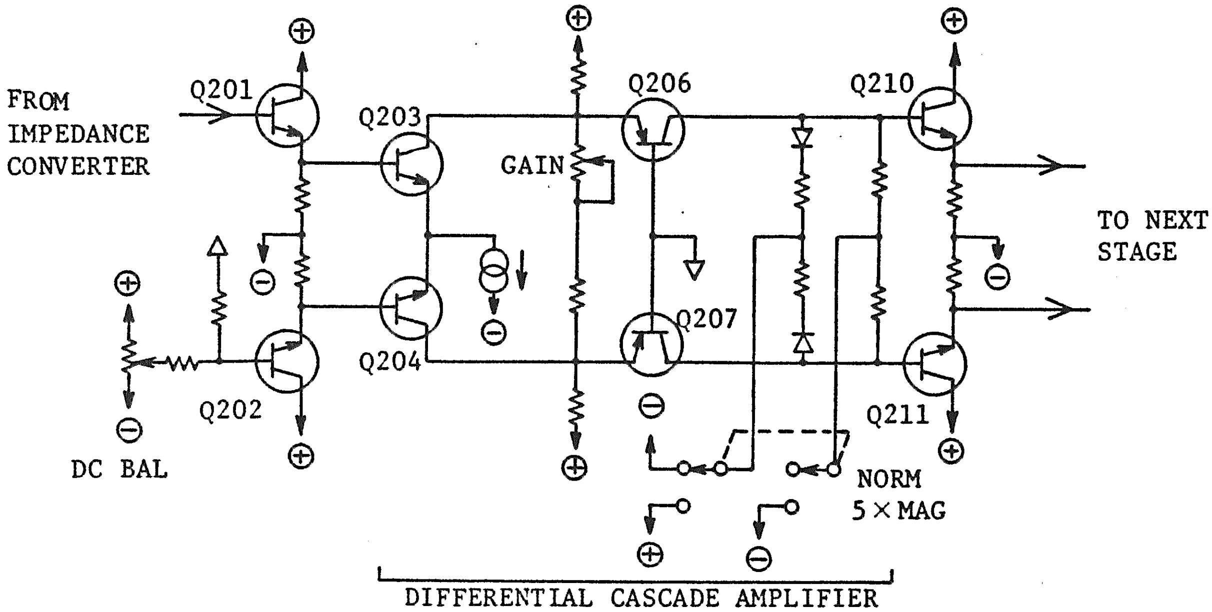


Figure 6-6. The preamplifier (front stages)

The positioning circuit also employs a differential cascade amplifier of the same type as that shown in Figure 6-6 and the differential balance is varied on purpose to move the trace position. The polarity switching circuit provides an inverted output by changing the connections between cascade circuits to the opposite polarity. The CH1 signal output circuit amplifies the signal, maintaining the DC balance using the differential signal. This circuit provides a 50-ohm output impedance so that the signal can be fed into a 50-ohm cable.

As explained above, the input signal applied to the oscilloscope is attenuated to an appropriate level by the attenuator, converted into a differential signal, fed through the required functional circuits, and amplified by the output circuit. Then the signal is fed to the CH1/CH2 selector circuit.

The CH1/CH2 selector circuit selects channel 1 or channel 2 depending on the front panel switch setting. The signal is slightly amplified and them it is applied to the delay circuit. A schematic diagram of the CH1/CH2 selector circuit is shown in Figure 6-7.

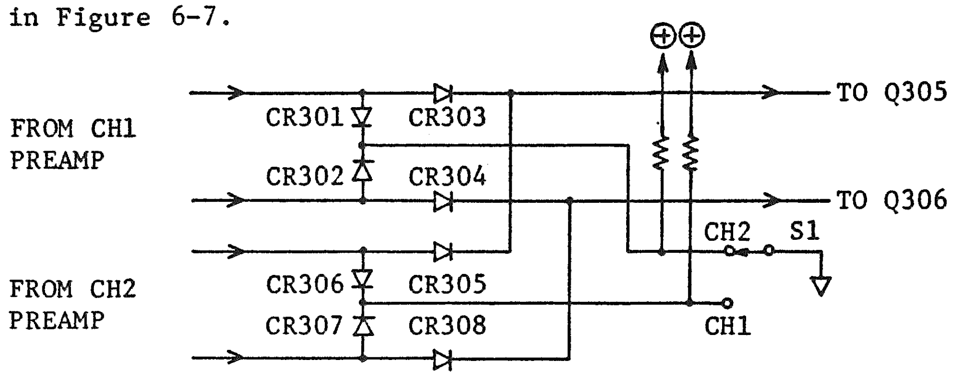


Figure 6-7. The CH1/CH2 selector circuit

Assume that S1 has been connected to the CH2 side. In this case, diodes CR301 and CR302 are ON and CR303 and CR304 are OFF. Therefore, the signal fed from the the CH1 preamplifier is fed via CR301 and CR302 to ground and it does not flow in Q305 and Q306. To Q304 and Q305, the signal of the CH2 preamplifier is fed as CR305 and CR308 are ON and CR306 and CR307 are OFF.

When switch S1 is connected to the CH1 side, the operations are in the reverse of the above and the signal of the CH1 preamplifier is fed to Q305 and Q306.

The delay circuit has a delay cable of approximately 120 nsec. The delay cable has its characteristic impedance, and impedance matching is done to prevent reflections. This causes the output voltage to be reduced to about a half. Therefore, the signal must have been amplified to a sufficient level to drive the output amplifier and the output impedance of the preceding stage must be sufficiently low.

The power amplifier is a differential cascade amplifier and employs high-f_T drive transistors and high-voltage high-frequency transistors in combination. In order that the pair of the deflection plates of the CRT are driven with a signal of an accurate symmetricity of amplitudes in both polarities, the differential coupling circuit is constant-current driven.

As above, most of the vertical amplifier is designed with differential circuits and, thus, the amplifier provides sufficient power for deflecting the electron beam, ensuring excellent frequency response and phase characteristics for amplifying the input signal.

6.3 TRIGGER CIRCUIT AND SWEEP GENERATOR CIRCUIT

The trigger circuit selects the internal trigger signal of CH1 or CH2, the external trigger signal, or the line trigger signal, and produces a trigger pulse signal which is synchronized with the input signal so that a stationary waveform can be displayed on the CTR screen.

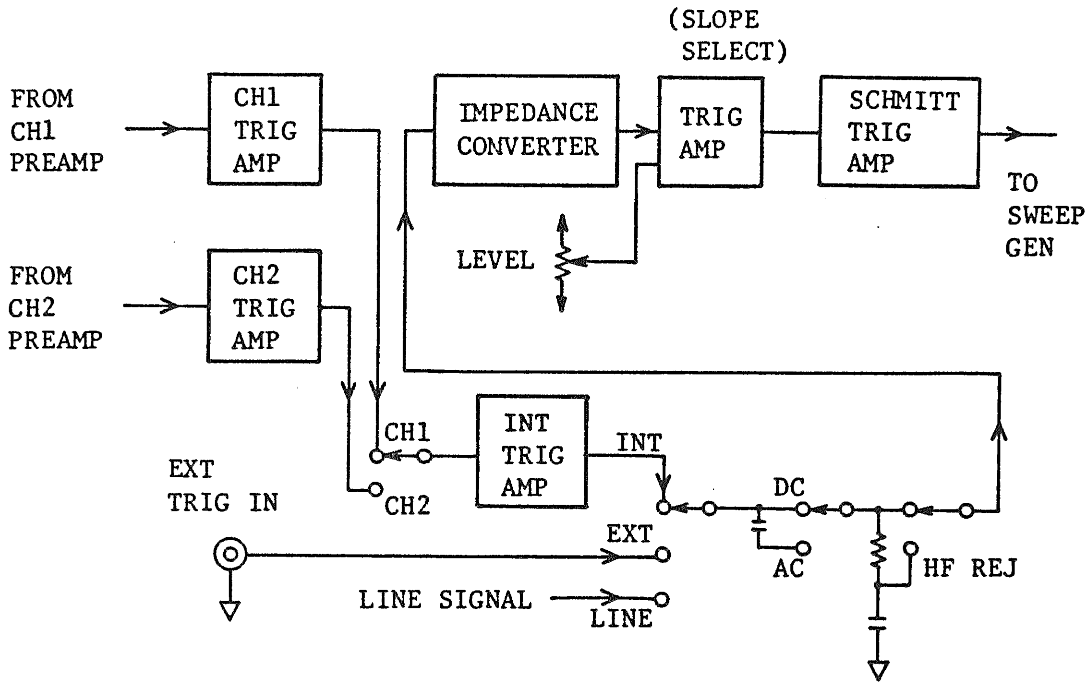


Figure 6-8. A block diagram of the trigger circuit

The signals fed from CH1 and CH2 preamplifiers are amplified and converted into current signals by CH1 and CH2 trigger amplifiers, respectively. By front panel switch setting, either CH1 or CH2 trigger signal is selected with a switching circuit the basic function of which is the same with that of the CH1/CH2 vertical axis selector circuit shown in Figure 6-7. The selected current signal is converted into a voltage signal by the internal trigger amplifier. For the trigger signal, either the output signal of the internal trigger amplifier, an external trigger signal applied to the EXT TRIG IN terminal, or the line trigger signal which is synchronized with the AC line frequency can be selected by front panel switch setting. The selected signal is fed via the AC/DC coupling selector circuit and the HF reject circuit (can be bypassed) to the impedance converter circuit.

The impedance converter circuit employs a source follower comprising a dual-FET constant-current circuit as is the case for the impedance converter circuit shown in Figure 6-5. The trigger signal, the level of which is insufficient so far, is amplified further by the trigger amplifier to a sufficient level. At the same time, an offset signal is applied to the amplifier to control the trigger level. Also, an inverted signal is generated so that the trigger slopes can be switched from the front panel. The output signal of the trigger amplifier is fed to the Schmitt trigger circuit which produces a trigger pulse signal of a sharp rising or falling edge when the input signal has crossed the threshold level.

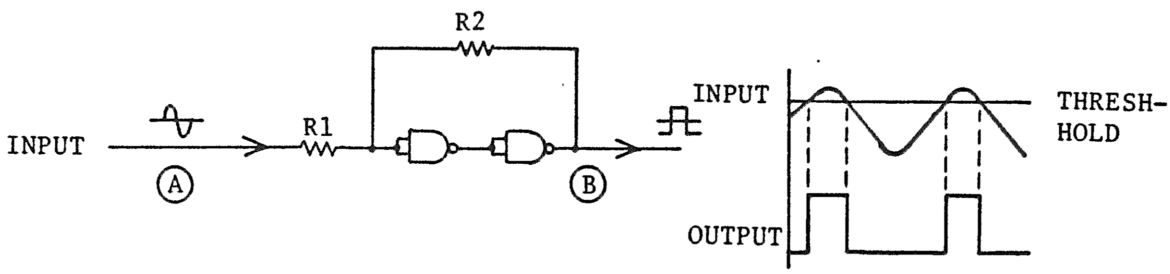


Figure 6-9. Schmitt trigger circuit

The trigger pulse signal generated as above is applied to the sweep signal generator circuit of the next stage, which with its Miller integration circuit generates a sawtooth signal.

Most oscilloscopes employ a Miller integration circuit for their sweep circuit and incorporate a gate circuit to control generating timing of the sawtooth wave. A block diagram of the sweep signal generator circuit of this oscilloscope is shown in Figure 6-10.

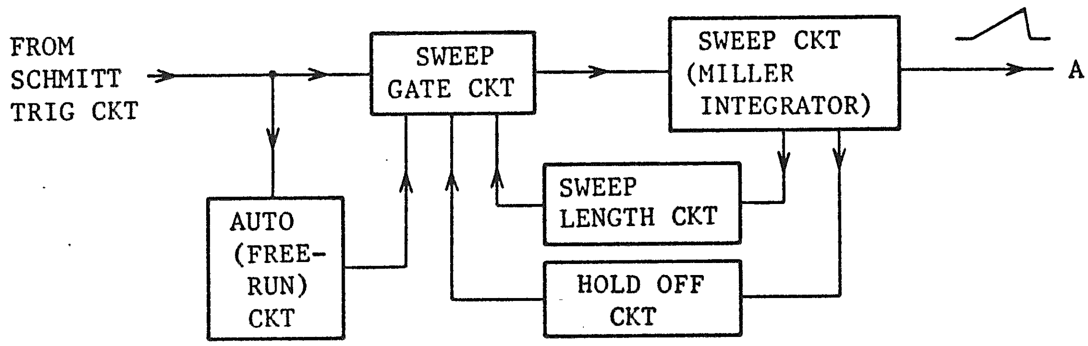


Figure 6-10. A block diagram of the sweep generator circuit

The trigger pulse signal which is applied to the sweep gate circuit is applied also to the AUTO circuit in order that, when the SWEEP MODE switch on the front panel is set in the AUTO mode, the sweep circuit is driven by a trigger signal applied and operates in the automatic trigger mode if no trigger signal is applied.

When the SWEEP MODE switch is set in the NORM or SINGLE mode, the AUTO circuit is disconnected. The sweep circuit is driven by a trigger signal applied or it does not operates if no trigger pulse is applied.

When the output signal of the Schmitt trigger circuit is applied to the sweep gate circuit, it produces a sweep start command signal. In compliance to this command signal, the sweep circuit starts its integration operation and its output voltage increases at a certain rate. When the output voltage has reached a certain value, the sweep length circuit operates and produces a pulse. As this pulse is applied, the sweep gate circuit generates a sweep stop command signal so that the charge of the Miller integrater capacitor is instantaneously discharged and the output voltage of the sweep circuit rapidly returns to zero. The sweep circuit remains in this state for a certain period as dictated by the holdoff circuit (the period differs by the range of the sweep time selector switch). When the next trigger pulse is applied, the sweep circuit repeats the above operation. (See Figure 6-11.)

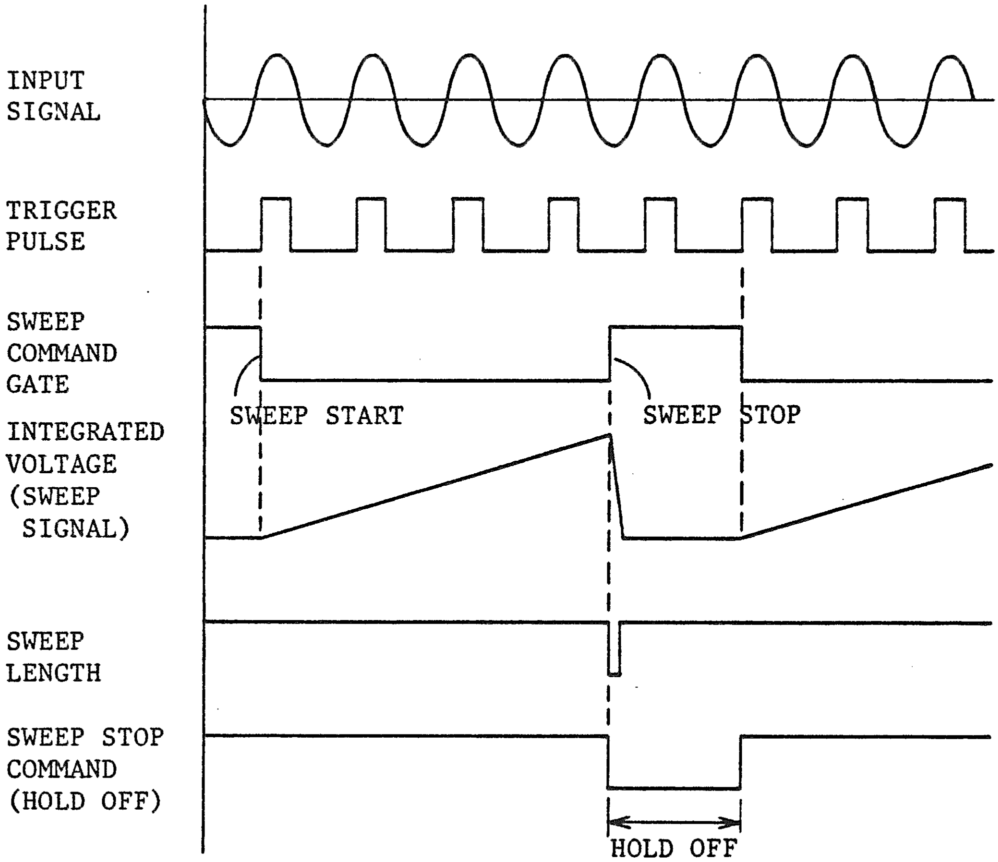


Figure 6-11. A timing chart of the sweep circuit

The sweep signal produced as abobe is applied, together with the X signal when in the XY operation, to the horizontal signal selector circuit which selects either one of these signals as controlled by switch setting on the front panel. The selected signal is fed to the horizontal amplifier.

6.4 HORIZONTAL AMPLIFIER

The horizontal amplifier amplifies the signal for deflecting the beam spot in the X-axis direction on the CRT screen. It is comprised of a 5 × MAG circuit, a preamplifier, and an output stage amplifier.

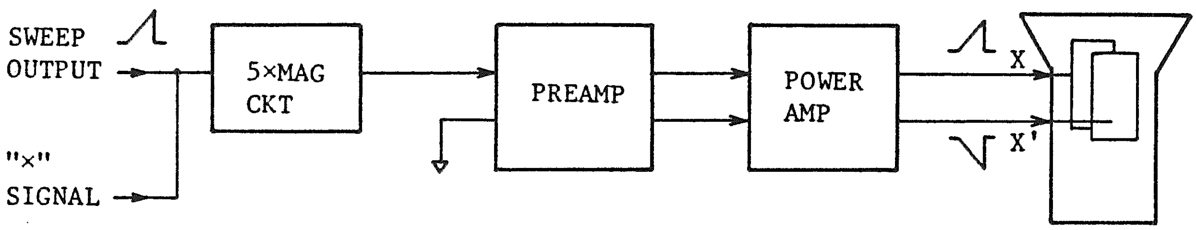


Figure 6-12. A block diagram of the horizontal amplifier

The 5 × MAG circuit is connected in cascade with the sweep circuit and X-signal circuit described in the preceding section. Figure 6-12 shows a block diagram of the horizontal amplifier. Figure 6-13 shows the concepts of the input circuit from the sweep circuit, the selecting circuit of the X-signal circuit, and the 5 × MAG circuit.

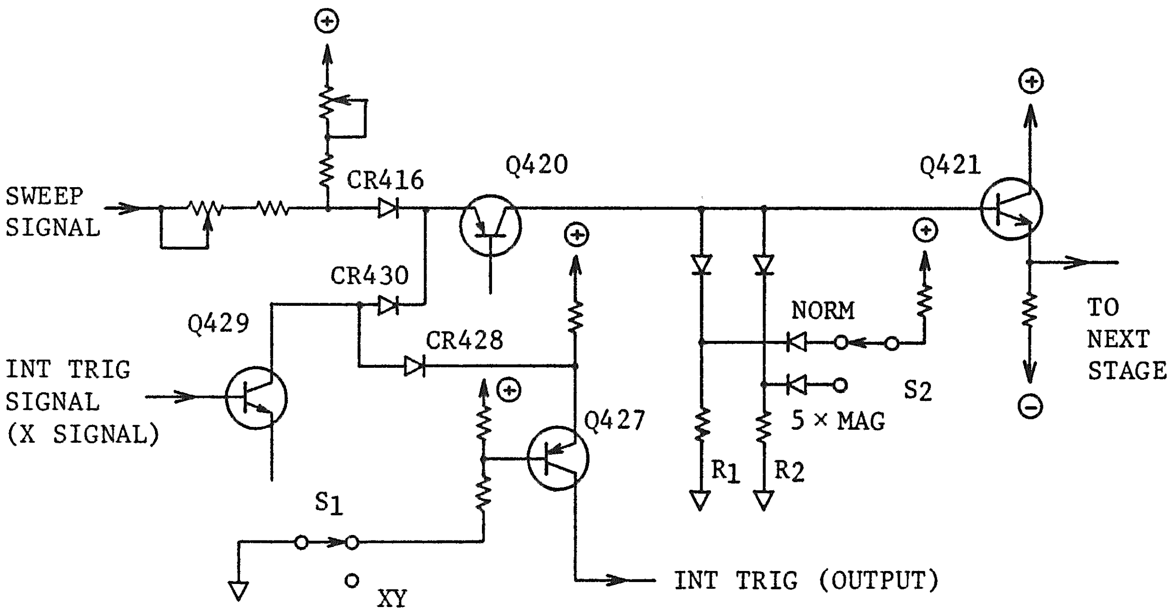


Figure 6-13

When the XY mode is selected on the front panel, switch S1 shown in Figure 6-13 is thrown to the XY position and Q427 becomes OFF. Q429 handles the output signal of the internal trigger amplifier. When in the above stage, no output signal of the internal trigger amplifier is delivered. When in this state, CR430 is ON, CR416 is OFF and the internal trigger signal of Q429 is delivered via CR430 to Q420. The sweep signal is not delivered to Q420 because CR416 is OFF.

When the sweep mode is selected on the front panel, switch S1 is thrown to the SWEEP position, Q427 and CR428 become ON, and CR430 becomes OFF. Consequently, the internal trigger signal is fed to Q427 and the internal trigger output signal is produced. The sweep signal is fed to Q420 as CR430 is OFF and CR416 is ON.

The 5 × MAG function of the horizontal axis is accomplished by changing the load resistor by 5 times when converting into a voltage signal the current signal delivered to Q420. Switching of the load resistors is done with diodes. Then, the horizontal signal is impedance-converted by Q421, fed to the preamplifier of the next stage in order to be converted into a differential signal and to be slightly amplified. This signal is fed to the output stage amplifier.

The output stage amplifier amplifies the X-axis signal to a sufficient level for driving the beam spot on the CRT screen. This amplifier is a negative feedback amplifier with cascade-connection active-load, so that the output (the voltage applied to the deflection plates of the CRT) is less affected by line voltage variation and power supply ripples.

6.5 Z-AXIS AMPLIFIER

The functions of the Z-axis amplifier is to vary the brightness of the beam spot as controlled with the INTEN knob on the front panel, for intensity modulation of the displayed trace with an external signal applied to the Z AXIS IN terminal, for blanking the return sweep traces, and for erasing the switching noise of the vertical axis signal when in the chopping mode.

The sweep gate signal or the CHOP blanking signal when in the dual-channel CHOP mode as selected with switches on the front panel is applied to the input of the Z-axis amplifier. The circuit construction is similar to that of the horizontal power amplifier: it is of cascade connection, active load type and a negative feedback circuit is incorporated in order to suppress the effect of line voltage variation.

The output signal of the Z-axis amplifier is shifted into a high voltage by the high voltage circuit explained in the next sub-section and, then, it is applied to the grid (G1) of the CRT.

6.6 HIGH VOLTAGE CIRCUIT

The high voltage circuit provides a high negative for the CRT cathode and a high positive voltage for CRT post-acceleration. The high voltages are produced with a blocking oscillator and a high-insulation high-voltage transformer. A high-frequency voltage produced in the secondary circuit of the high-voltage transformer is double-voltage rectified for the negative voltage supply and 6-times-voltage rectified for the positive voltage supply. The negative voltage is applied through a feedback circuit to the blocking oscillator in order to obtain a stable cathode voltage.

6.7 POWER SUPPLY

The power supply circuit provides the various voltages required by the various circuits of the oscilloscope. Supply voltages are regulated as required. To attain good insulation between the line power and the internal circuits, this oscilloscope employs a specially designed transformer. This transformer provides step-up or step-down voltages which are converted into DC supply voltages. Most of them are regulated. A block diagram of the power supply is shown in Figure 6-14.

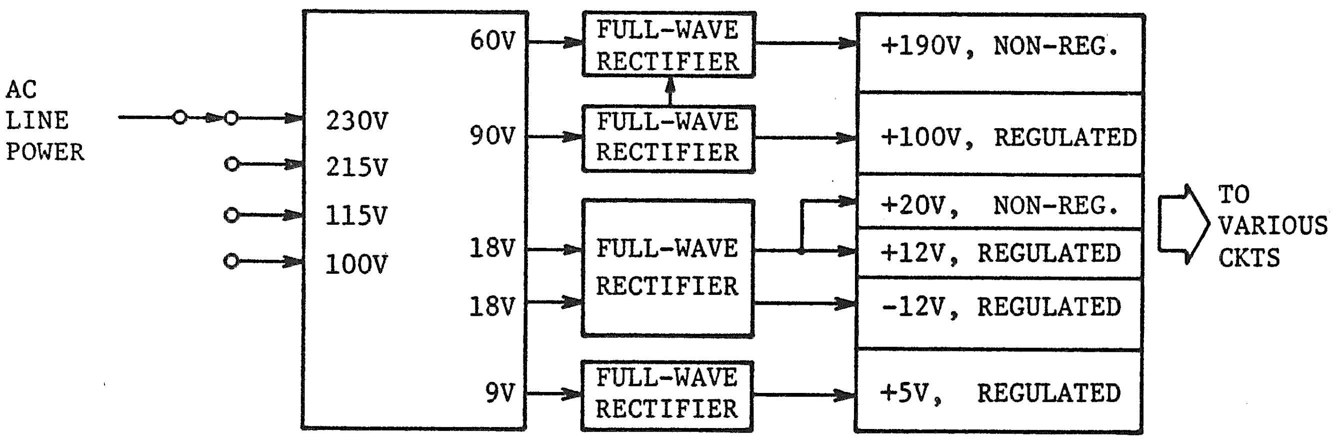


Figure 6-14. The power supply circuit

6.8 CALIBRATION VOLTAGE GENERATOR

The calibration voltage generator produces a quality square wave signal, with less sag and overshoot, to calibrate the phase characteristics of the probe, etc. The generator employs a CMOS multivibrator for signal generation and CMOS Schmitt trigger circuit to provide a quality square wave. The output voltage is divided into a 1 Vp-p signal with resistors and fed to the terminal which has a hole for easy connection to the probe.

7. MAINTENANCE

7.1 GENERAL

The oscilloscope should be calibrated at certain time intervals. Although calibration of overall performances is most recommendable, such partial calibration may serve the purpose that the time axis alone is calibrated when the time measuring accuracy is especially important or that the vertical axis alone is calibrated when the vertical sensitivity accuracy is of a prime importance. After the oscilloscope has been repaired, overall calibration is required although it depends on the type of repair. Simple calibration procedures are explained in this section.

7.2 REMOVING THE CASE

To remove the case, remove the four clamping-screws and pull out the chassis forward.

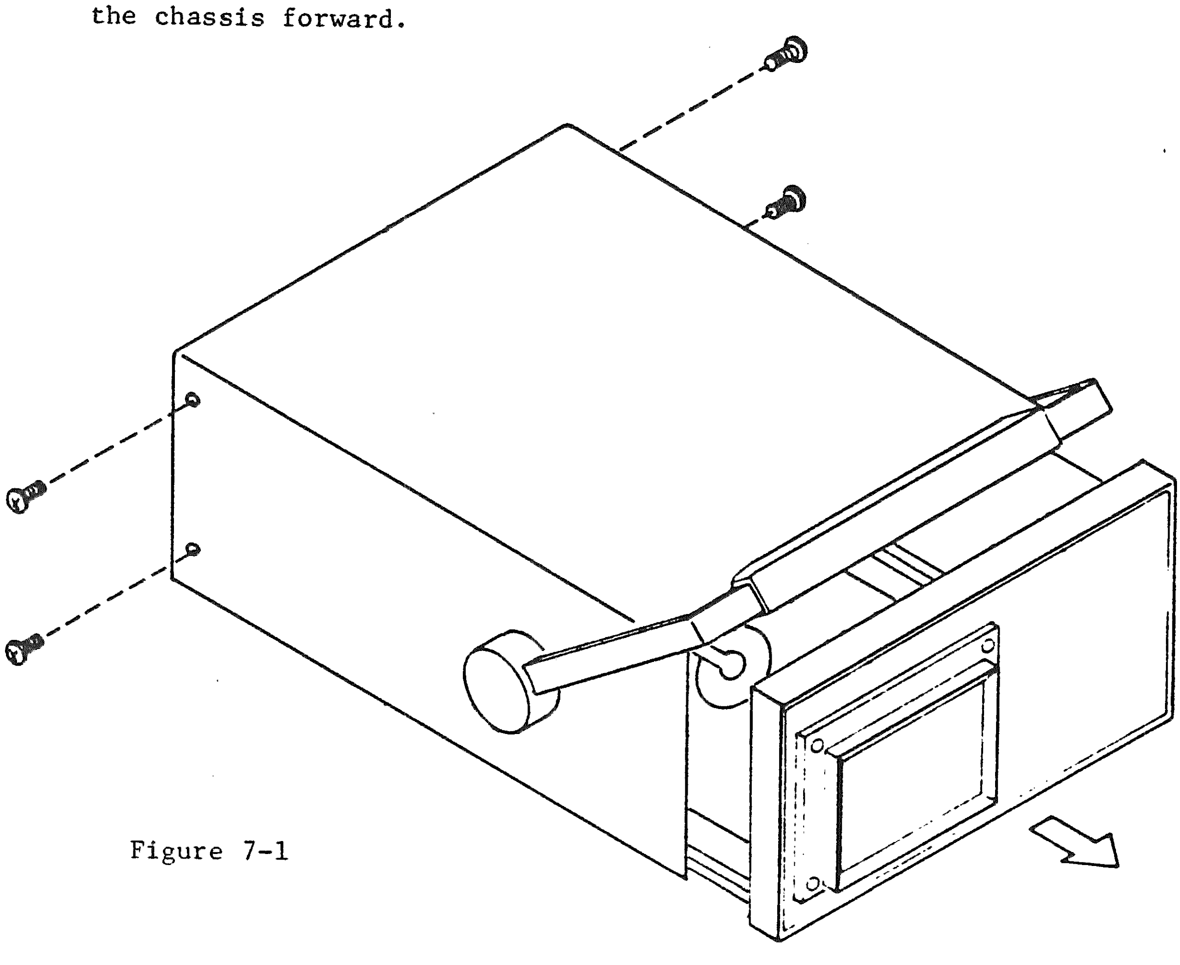


Figure 7-1

7.3 CHECK AND ADJUSTMENT OF DC SUPPLY VOLTAGES

When calibrating the oscilloscope, the DC supply voltages should be checked first of all. The supply voltages and the check and adjustment points are shown in the following table and drawings.

Nominal voltage	Type	Voltage tolerance	Adjustment	Remarks
+5 V	Regulated	+5 V 0.1 V		R722
+12 V	Regulated	+12 V 0.06 V	VR701	
-12 V	Regulated	-12 V 0.12 V		
+100 V	Regulated	+100 V 5 V	-	
+190 V	Non-reg.	+190 V 10V	-	
-1700 V	Regulated	-1700 V 20 V	VR601	

For voltage check, measure the voltage between check point and ground using a reliable digital voltmeter. Before checking the DC supply voltages make it sure that the AC line voltage is correct. The -1700 V supply is for the CRT acceleration voltage. Note that the trace intensity, and vertical and horizontal deflection sensitivities are largely affected if this voltage is varied.

Notes: Check and adjust the DC power supply voltages in the following sequence:

1. +12 V supply adjustment
2. -12 V supply check
3. +5 V check
4. +100 V check
5. +190 V check
6. -1700 V adjustment

To measure the -1320V supply of which internal impedance is high, use a voltmeter of a high input impedance (1000 MΩ or over) such as Kikusui Model 149-05A or 149-10A Precision Digital Voltmeter, or an equivalent instrument.

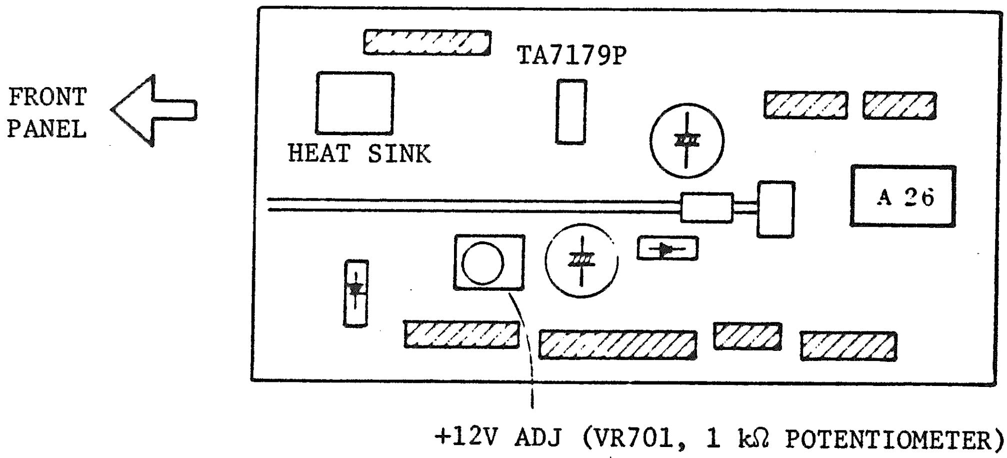


Figure 7-2

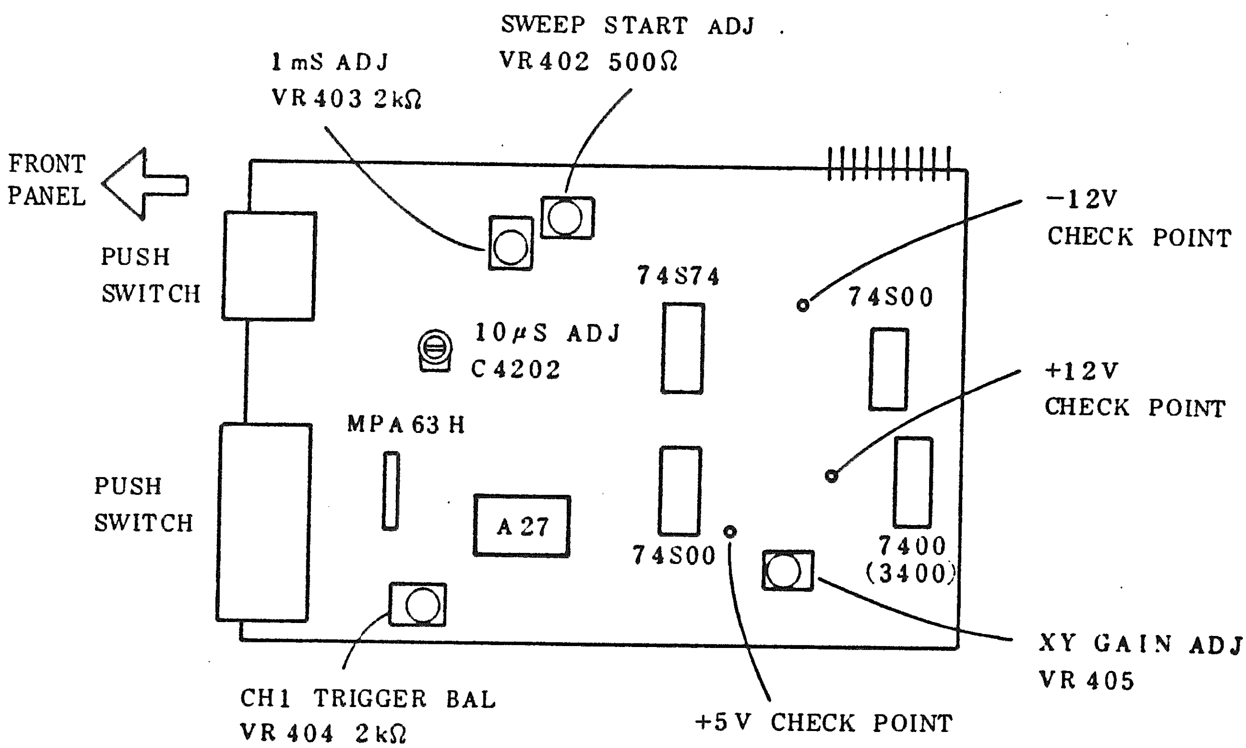


Figure 7-3

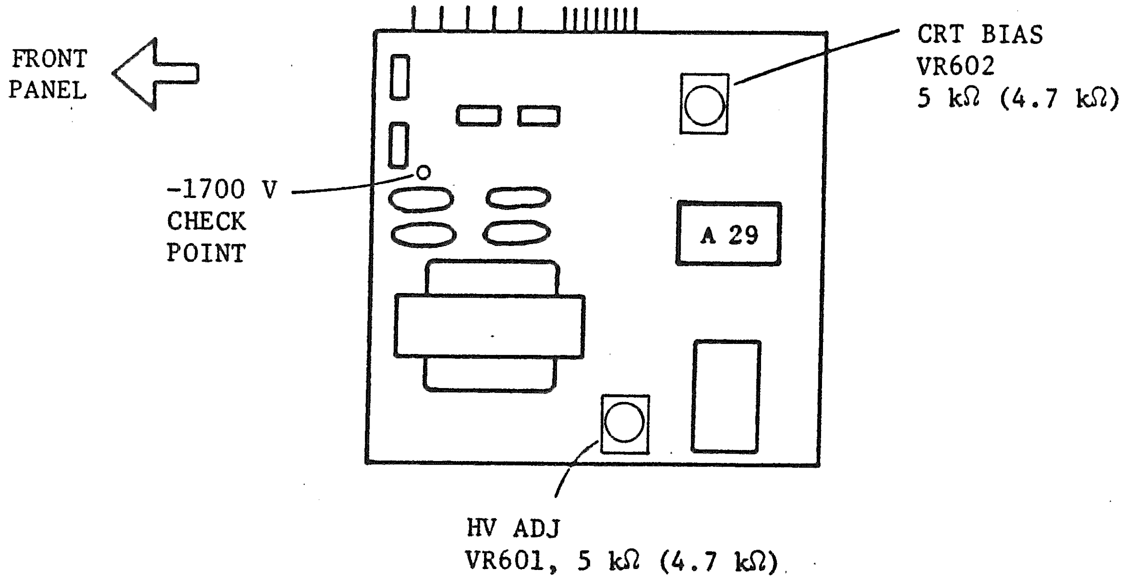


Figure 7-4

For locations of printed circuit board, see Figure 7-14 and 7-15.

7.4 ADJUSTMENT OF VERTICAL AXIS DC BALANCE

o Adjustment of DC balance

This adjustment is for minimizing the vertical shift of the trace when the VARIABLE knob is turned.

(1) Depress the GND switch so that the vertical circuit becomes the GND state and the base trace line is displayed on the CRT screen.

(2) Turning the VARIABLE knob, so adjust the DC BAL control (VR201 for CH1 or VR206 for CH2) that the shift of the trace becomes minimum.

o 5 × MAG DC BAL adjustment (1 mV DC BAL adjustment of CH1 and CH2):

This adjustment is for minimizing the vertical shift of the trace when in the 5 × MAG operation of CH1 and CH2.

(1) Depress the GND switch of CH1 or CH2 so that the vertical circuit becomes the GND state and the base trace line is displayed.

(2) So adjust the DC BAL control (VR203 for CH1 or VR208 for CH2) that, when the POSITION knob is pulled out and pushed in, the vertical shift of the trace becomes minimum.

o Adjustment of INV BAL:

This adjustment is for minimizing the vertical shift of the trace when the CH2 POLARITY INV switch is depressed.

(1) Press the GND switch so that the vertical circuit becomes the GND state and the base trace line is displayed.

(2) So adjust the INV BAL control (VR209) that the vertical shift of the trace becomes minimum when the CH2 POLARITY INV switch is depressed.

o Adjustment of ADD BAL:

This adjustment is for minimizing the vertical shift of the trace when the circuit is switched to the ADD state (with traces of CH1 and CH2 overlapped at the center of the screen).

(1) Press the GND switches of both channels so that they becomes the GND state. Position both traces overlapped at the center of the screen.

(2) So adjust the ADD BAL control (VR301) that the traces remain at the center of the screen when the operation is changed to the ADD mode.

The above controls (potentiometers) are mounted on PCB A23. For location of PCB A23, see Figure 7-15.

7.5 VERTICAL DEFLECTION SENSITIVITY

Apply to the vertical input terminals of CH1 and CH2 a signal of 20 mVp-p and 1 kHz, using a square wave generator of an output voltage accuracy of 0.5% or better. So adjust the CH1 GAIN ADJ VR202 and CH2 GAIN ADJ VR207 on PCB A23 that, with the VOLTS/DIV switch set in the 5 mV position, the signal displayed on the screen becomes accurately 4 DIV. For each position of the VOLTS/DIV switch, apply a signal with an amplitude of 4 times of the VOLTS/DIV indicated value, and check the displayed signal amplitude. The normal indication for all ranges is that the displayed value is within ±3% of the indicated value.

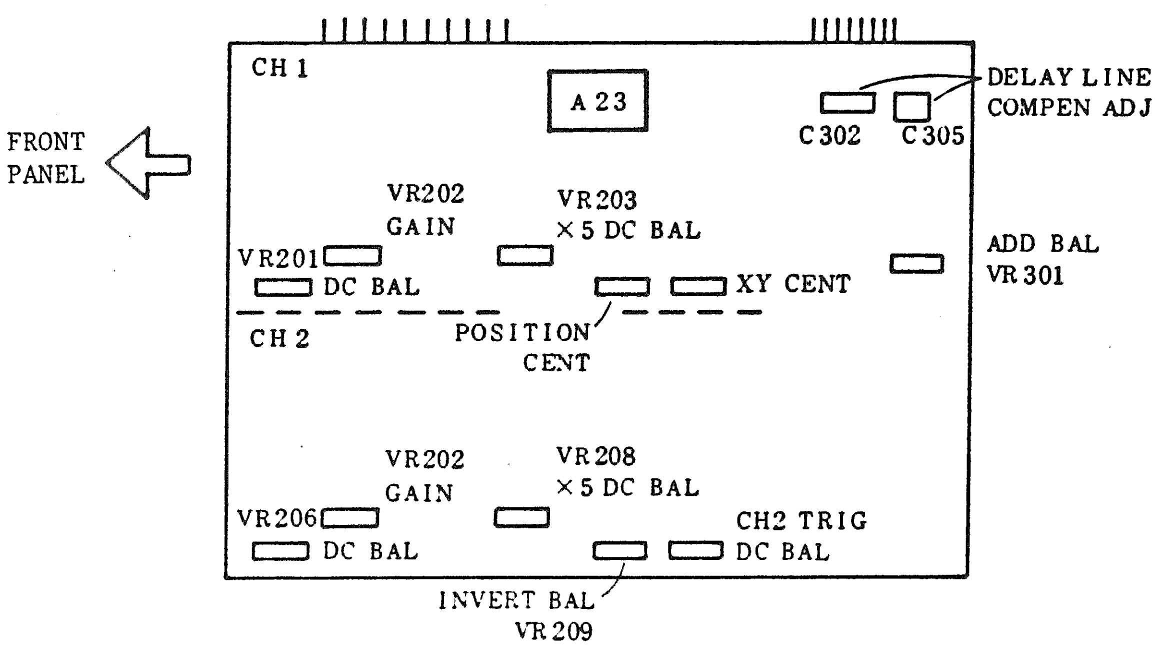


Figure 7-5

7.6 INPUT CAPACITANCES AND PHASE COMPENSATIONS OF VOLTS/DIV RANGES

Unless the phase characteristics at each position of the VOLTS/DIV switch are correctly adjusted, the frequency response may be degraded and the displayed waveforms may be distorted. The phase characteristics can be adjusted by varying the input capacitors and high-frequency compensation capacitors. For this adjustment, a capacitance meter for measurement of the input capacitance (24 - 26 pF) and a square wave generator which can provide a quality signal of approximately 1 kHz are required. For input capacitance measurement, bridge-type meters are inadequate. Use a low-capacitance C meter. For the 1 kHz square wave signal, the CALIB signal (for probe calibration) of this instrument can be used. For the square wave generator, use an instrument which provides waveforms with less sags or overshoots and with a rise time of faster than 1 sec. The trimmer capacitors for this adjustment are shown in the following table.

VOLTS/DIV switch position	CH1		CH2	
	Trimmer capacitors		Trimmer capacitors	
	Input capacitor	High frequency compensation capacitor	Input capacitor	High frequency compensation capacitor
5 mV	C121	-	C143	-
10 mV	C111	C110	C135	C133
20 mV	C114	C113	C137	C136
50 mV	C116	C116	C140	C139
0.1 V	C103	C104	C126	C127
0.2 V	C103	C104	C126	C127
0.5 V	C103	C104	C126	C127
1 V	C107	C106	C129	C130
2 V	C107	C106	C129	C130
5 V	C107	C106	C129	C130

The "-" mark signifies "no adjustment."

Adjust the input capacitances of the 20 mV/DIV range alone at 25.5 pF ±0.5 pF and those of all other ranges to 24.5 pF ±0.5 pF.

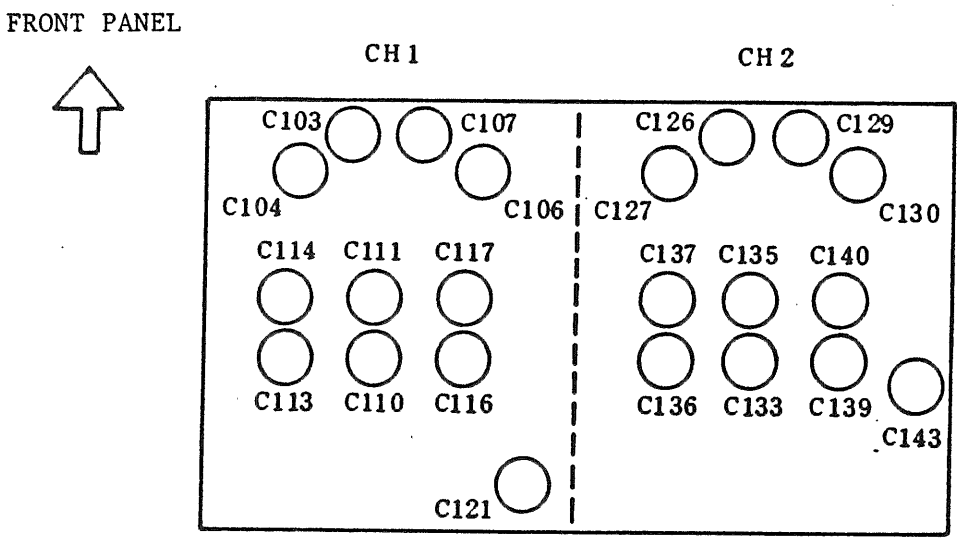


Figure 7-6

7.7 ADJUSTMENT OF HIGH FREQUENCY RANGE RESPONSE OF VERTICAL AMPLIFIERS

For this adjustment, use a quality square wave signal of rise time less than approximately 5 nsec and repetition frequency approximately 1 MHz.

1) Apply the above signal to the CH1 input terminal, set the VOLTS/DIV switch at the 5 mV range and the TIME/DIV switch at the 0.2 μsec range, and so adjust the signal voltage that it is displayed with an amplitude of 4 DIV.

2) Adjust flat the top section of the signal waveform with the DELAY LINE COMPENSATION ADJ potentiometer VR302 and trimmer capacitor C305 on PCB A23 shown in Figure 7-7.

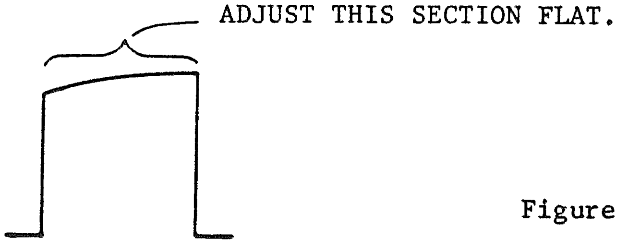


Figure 7-7

3) If the waveform is incorrect as shown in Figure 7-8, the cause is mismatching of the delay line. Correctly adjust the waveform with the DELAY LINE MATCHING ADJ potentiometer VR505 on PCB A28.

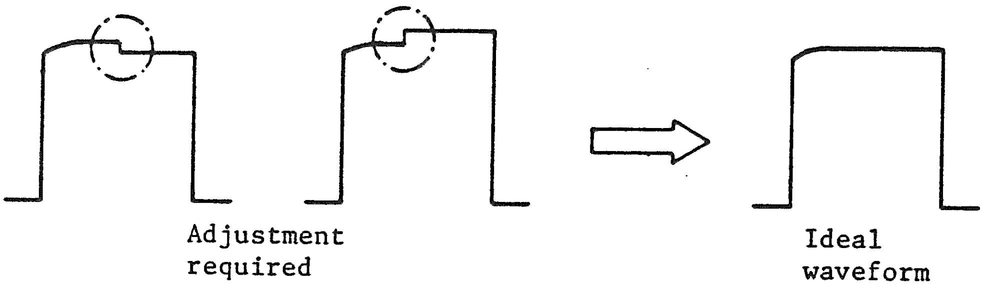


Figure 7-8

Note that the vertical sensitivity will be affected when VR505 is turned.

4) Adjust the square wave characteristics of the 1-MHz signal with VR501 and C501 on PCB A28.

5) Change the signal frequency to 100 kHz and check the waveform. If reverse sags are observed, adjust the waveform with VR502 and C503 on PCB A28.

6) Varying the signal frequency to 10 kHz, 1 kHz, 100 Hz and 10 Hz, check the waveform for distortions.

7) Next, apply the signal to CH2. Varying the signal frequency to 1 MHz, 100 kHz, 10 kHz, 1 kHz, 100 Hz and 10 Hz, check the waveform for distortions.

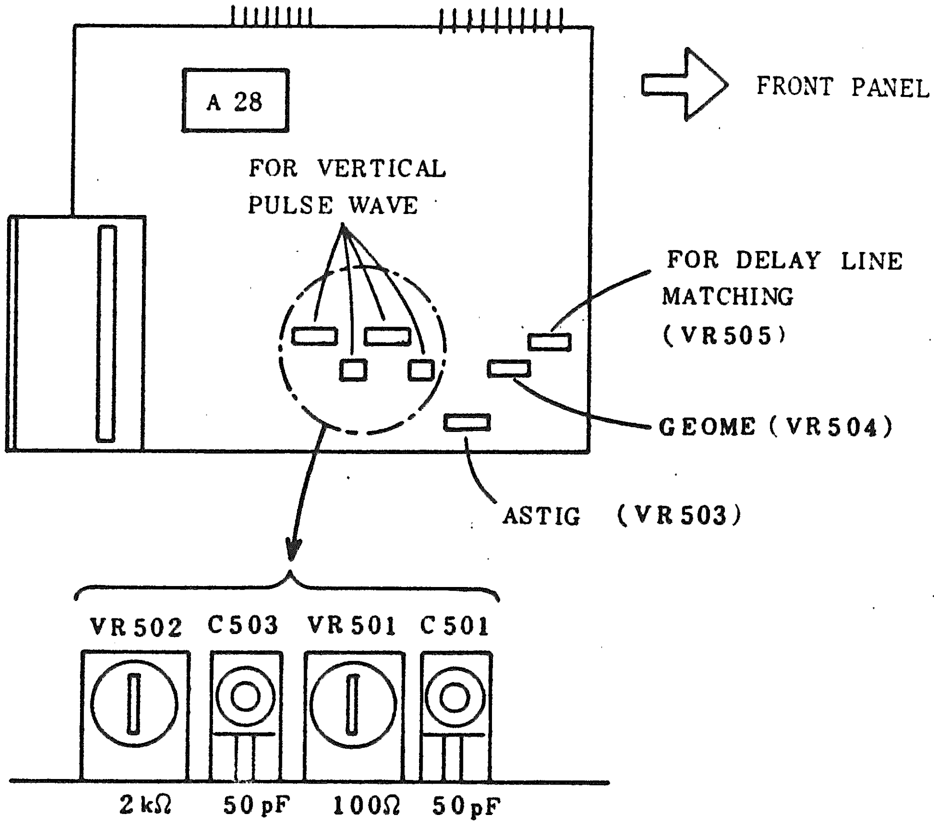


Figure 7-9

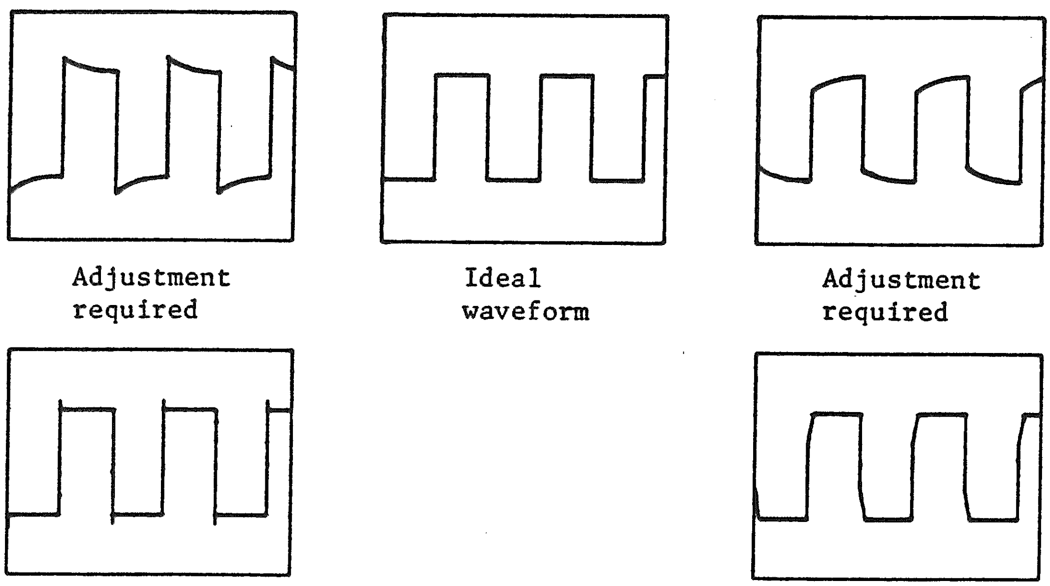


Figure 7-10

7.8 CHECK OF FREQUENCY BANDWIDTH

Prepare a sine wave signal generator of output voltage stability ±1.5% or better and frequency range 50 kHz to 35 MHz. Apply the 50 kHz signal to the CH1 channel, set the VOLTS/DIV switch at the 5 mV/DIV range, and display the waveform with an amplitude of 8 DIV. Vary the signal frequency to 35 MHz and check that the amplitude does not fall to less than 5.7 DIV (-3 dB). Check this also on the CH2 channel.

Note: Be sure to perform this frequency bandwidth check whenever the high frequency range response adjustment of Section 7.7 has been done.

7.9 SWEEP TIME

Set the TRIGGER MODE switch and TIME/DIV switch as follows and apply to the vertical input terminal an accurate time marker signal of 1 msec or a 1-kHz reference signal (preferably a square wave signal).

TRIGGER MODE:	AUTO
TIME/DIV:	1mS

The sweep time accuracy specification is satisfied if the measured value is within ±3% of the panel indication. The 1 msec/DIV range is used as the reference for other ranges and, therefore this range should be calibrated especially accurately. So adjust the SWEEP CAL (VR403) variable resistor that the accuracy becomes better than ±0.5%. Also, pull up the POSITION knob to the PULL 5 × MAG state and check that the accuracy is better than ±1.5%.

Next, change the TIME/DIV switch to the 10 μS range and apply to the vertical input terminal an accurate time marker signal of 10 μsec or a 100-kHz reference signal.

TRIGGER MODE: AUTO

TIME/DIV: 1 mS

So adjust C4202 that the accuracy becomes ±0.5% or better.

Set in the 5 × MAG state and check that the accuracy is ±1.5% or better. Note, however, that accuracies differ by ranges as follows:

0.5 S/DIV to 1 μS/DIV ranges: ±1.5%

0.5 μS/DIV to 0.2 μS/DIV ranges: ±3%

7.10 CALIBRATION OF PROBE

To calibrate the probe, use the calibration signal (1 Vp-p, 1 kHz) of the calibration voltage terminal.

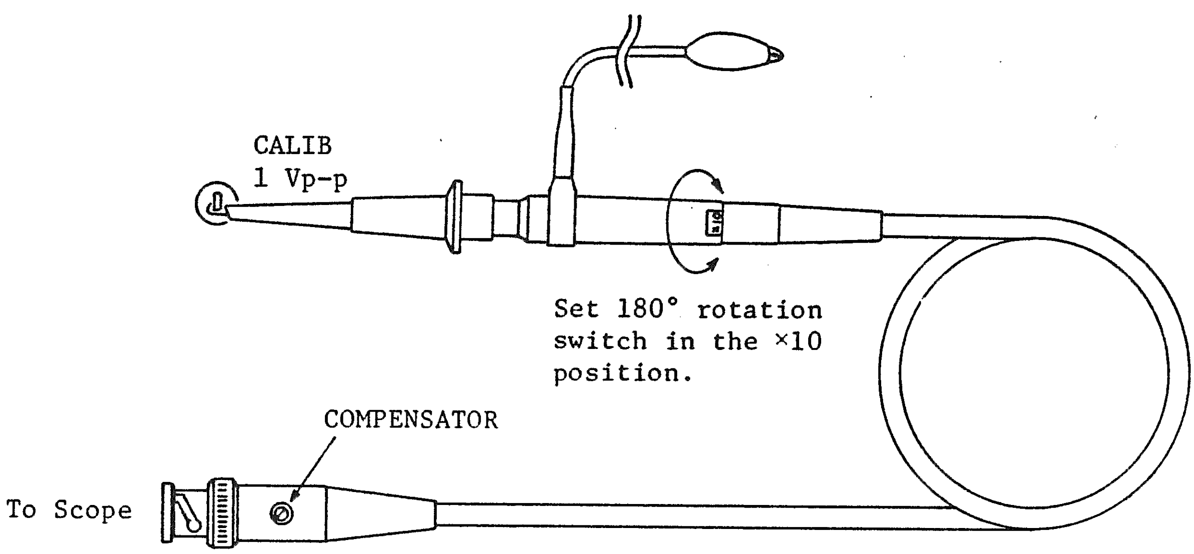
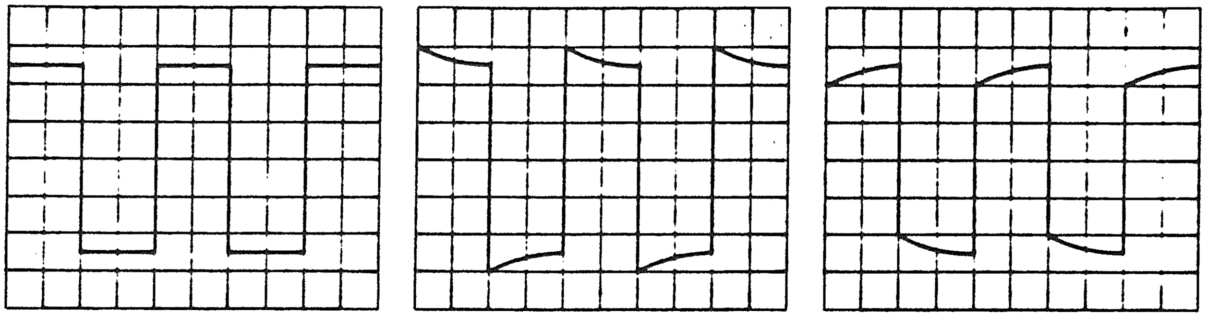


Figure 7-11

Connect the probe to the CH1 or CH2 input terminal and set the range at 20 mV. Touch the 1 Vp-p calibration voltage terminal with the probe tip, and a square wave signal with an amplitude of 5 DIV will be displayed on the screen. So adjust the compensator of the probe with a small screwdriver that a correct waveform is obtained.



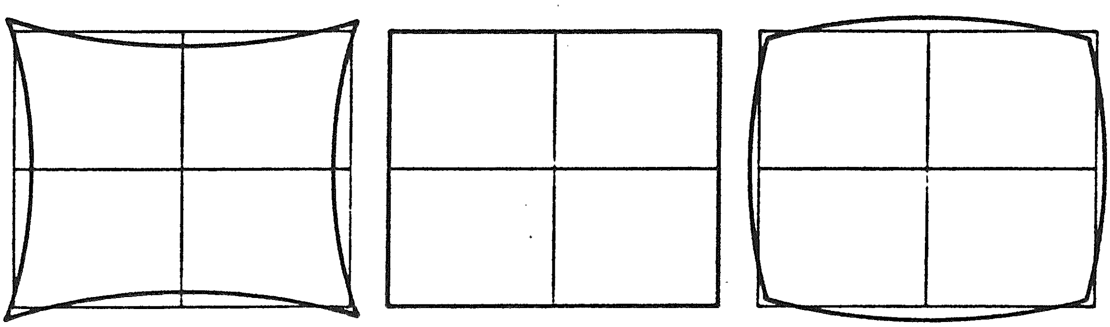
Ideal waveform | Adjustment required | Adjustment required

Figure 7-12

7.11 ADJUSTMENT OF ASTIGMATISM AND GEOMETRY

ASTIG (VR503): So adjust this control, together with the FOCUS control, that the displayed trace or spot becomes sharpest.

GEOMETRY (VR504): This control is for correction of barrel or pincushion distortion.



Pincushion distortion | Normal waveform | Barrel distortion

Figure 7-13

LAYOUT OF COMPONENTS (TOP VIEW)

A27, A28, A29: PCB

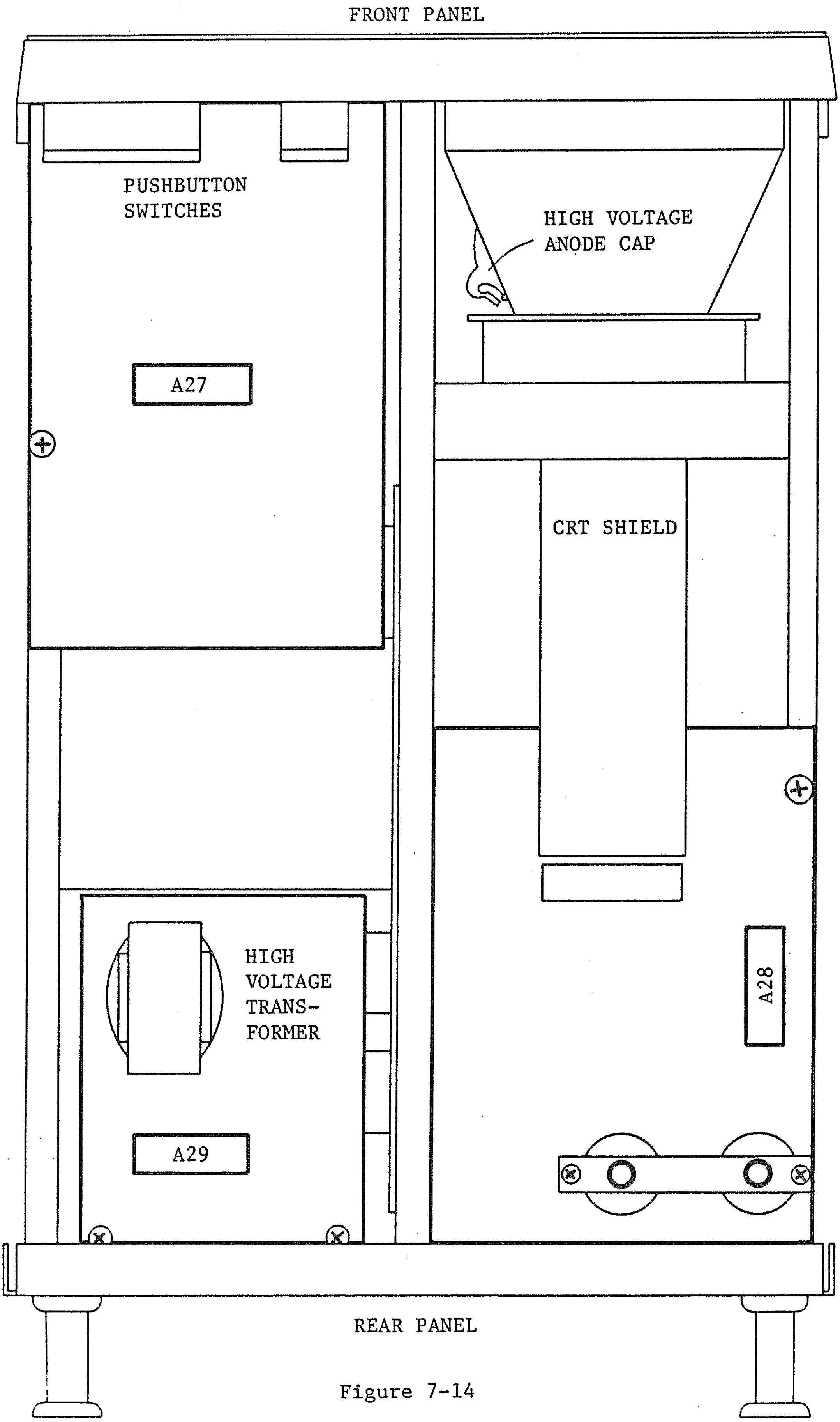


Figure 7-14

LAYOUT OF COMPONENTS (SIDE VIEW)

A23, A26: PCB

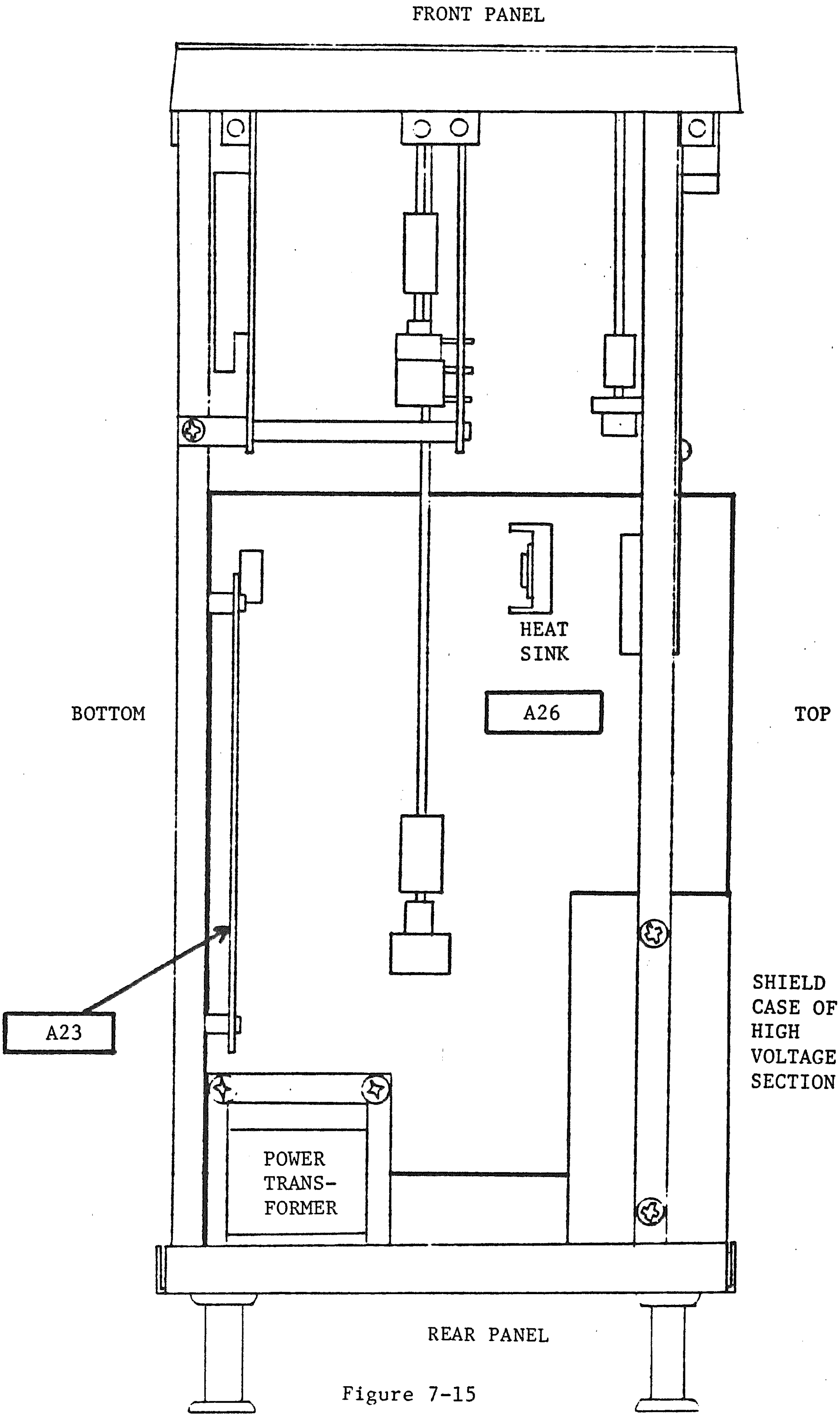


Figure 7-15

LAYOUT OF COMPONENTS (BOTTOM VIEW)

(LOCATION OF VERTICAL AXIS VOLTS/DIV ADJUSTMENTS)

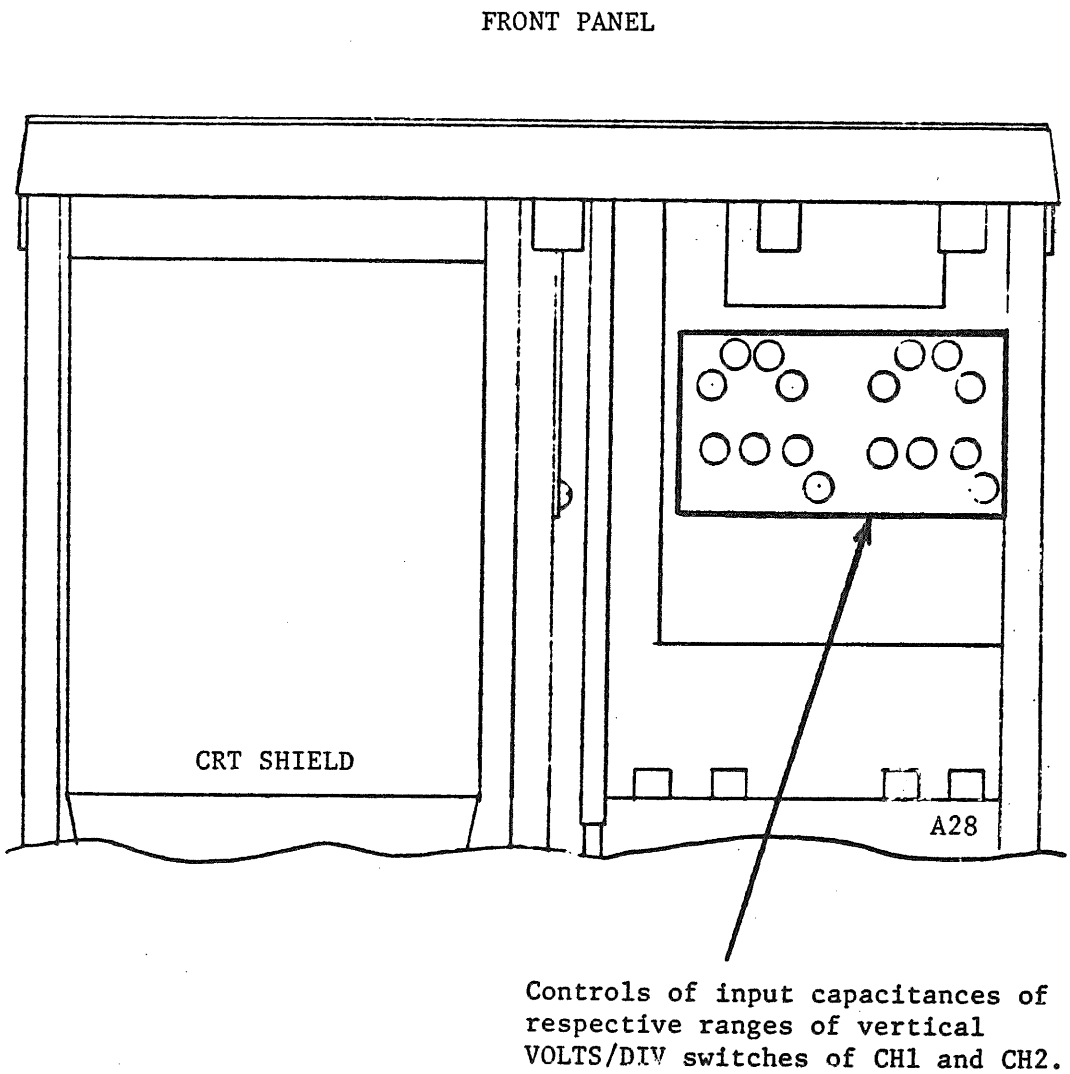


Figure 7-16