OPERATION MANUAL

OSCILLOSCOPE

MODEL 5531

80.2.21

KIKUSUI ELECTRONIC 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.

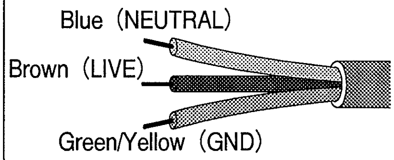
☐ AC power cable

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.

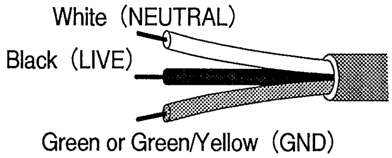
WARNING

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

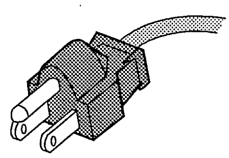
☐ Without a power plug



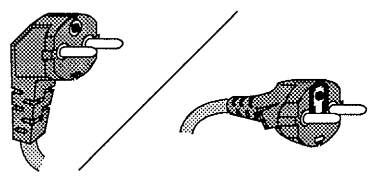
☐ Without a power plug



☐ 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 5531 Oscilloscope is a wide band oscilloscope with a 5.5-inch dome-mesh post-acceleration internal-graticule CRT. The 5531 is a dual channel type, with sensitivity 1 mV/DIV (with 5 × MAG) and bandwidth DC - 35 MHz for each channel.

For triggering, both channels (CH1 and CH2) can select trigger signal sources mutually independently. The 5531 has a TV sync signal separator circuit, which is convenient for observation of TV signals.

The 5531 covers a wide sweep range, with 0.5 sec/DIV to 0.2 μsec/DIV as basic ranges. The maximum sweep speed is 40 nsec/DIV (with 5 × MAG). Sweep delay is possible for the ranges of 0.5 msec/DIV to 0.2 μsec/DIV with jitters of less than 1/10,000, for observation of an enlarged part of waveform.

The circuits consists of ICs and components of premium quality. The panel layout is designed for the best operability. The 5531 is ideal for observation of signals of digital circuits as well as those of analog circuits.

1.2 Features

- o Delayed sweep circuit:

  With the delayed sweep feature, any required part of the waveform displayed with the main sweep (A) can be enlarged for observation of details.

- 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.

- Rectangular CRT with internal graticule:

  The CRT is a 5.5-inch rectangular dome-mesh post-acceleration tube with internal graticule. It displays bright and sharp images which can be observed parallax free.

- Maximum sensitivity 1 mV/DIV, 15 MHz:

  The 5531 provides a high sensitivity and wide frequency range of 1 mV/DIV and 15 MHz, the highest performances for oscilloscopes of this class. Noise and drift are small even when in the 5 × MAG operation, making the oscilloscope a powerful instrument for measurement of low level signals.

- "Semi-automatic" focus circuit:

  The focus voltage follows the INTEN knob setting, thereby eliminating the requirement of adjustment of the FOCUS knob so far as the main sweep A operation is concerned.

- Variable hold-off circuit:

  A variable hold-off circuit is incorporated. This circuit enables to synchronize the sweep signal to the objective periodical component of a complicated signal waveform.

- TV sync signal separation circuit:

  The trigger circuit has a TV sync signal separation circuit for convenient observation of TV-H and TV-V signals.

- "B TRIG'D" circuit:

  Using the trigger signal of the main sweep A circuit, the B TRIG'D circuit makes easier the delayed sweep observation of a signal which is complicated with flutters or other sophisticating components.

- Various trigger sources:

  Four trigger sources are possible, namely, INT (CH1, CH2), LINE, and EXTERNAL. When the CH1 or CH2 is used as the trigger source, the phase relationship of the two vertical channels can be checked in a one-touch operation without interchanging the input connectors. The LINE trigger source is convenient for observation of signals related to the AC line frequency.

- Automatic CHOP/ALT switch and CHOP ONLY switch:

  Sweep operation is automatically switched between CHOP mode and ALT mode in conformity with 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 that of 0.5 msec or faster.) When the slide switch on the rear panel is set in the CHOP ONLY state, sweep operation is fixed in the chopping mode irrespective of setting of the TIME/DIV switch.

o Bright trace at high sweep speed:

Even when operating at the highest sweep speed in the AUTO mode, the trace line is clearly displayed if the input signal is disconnected. This feature is convenient when observing a waveform the zero level of which matters or when slanting of the base line is required to be checked. The 5531 employs an improved AUTO trigger circuit which provides a bright, flickerless trace.

o One-touch pushbuttons:

The 5531 employs pushbutton switches of excellent touch. Simply by pressing a pushbutton, the 5531 can be switched to operate in an X-Y mode.

o Trace rotation coil:

The 5531 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 5531 Oscilloscope comprises the following:

Main unit (oscilloscope unit) 1

Accessories	Code number	
Model 960 BNC probe (10:1,1:1)..	(89-03-0220)	2
Model 942A Terminal Adaptor ...	(W4-986-011)	1
External graticule plate	(S3-050-171)	1
Fuse (slow blow, 1 A)	(99-02-0101)	1
Fuse (slow blow, 0.5 A)	(99-02-0100)	1
Operation manual	( )	1

2. SPECIFICATIONS

Vertical Axis

Item	Specification	Remarks
Sensitivity	5 mV/DIV - 5 V/DIV, (1 mV/DIV - 2 V/DIV when 5 × MAG)	1-2-5 sequence, 10 positions
Sensitivity accuracy	Better than ±3% when VARIABLE knob is in CAL'D position	±5% or better when 5 × MAG
Continuously-variable adjustment of sensitivity	To 1/2.5 or less of dial-indicated value	
Frequency response	DC: DC - 35 MHz (DC - 15 MHz when 5 × MAG) AC: 2 Hz - 35 MHz (2 Hz - 15 MHz when 5 × MAG)	Within -3 dB, with 50 kHz 8 DIV reference
Rise time	10 nsec (23.3 nsec when 5 × MAG)	Calculated value
Input impedance	1 MΩ ±2%, 25 pF ±2 pF	Parallel
Input terminals	BNC receptacles	
Maximum allowable input voltage	400 Vp-p (DC + AC peak)	AC frequency not higher than 1 kHz

Item	Specifications		Remarks
Input coupling	AC, DC, or GND		
Base line shift caused by DC offset	Within ±0.2 DIV, when switched to any range		When switched to AC, DC or GND; without input signal
	Within ±2 DIV, when in 5 × MAG		When 5 × MAG switch is operated
Common mode rejection ratio	50:1 or higher, at 50 kHz sine wave		With uniform sensitivities of CH1 and CH2
Intermodulation between channels	1000:1 at 50 kHz 30:1 at 35 MHz		At 5 mV/DIV range
Linearity	Vertical contraction or expansion is within 0.1 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		
Operation modes of vertical axis	CH1	Single-channel operation with CH1	
	CH2	Single-channel operation with CH2	

Item	Specifications		Remarks
	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 200 kHz.	CHOP mode for 0.5 S to 1 mS ranges
	CHOP ONLY		Selectable at rear panel; when in dual mode
	ADD: CH1 ± CH2		

CH1 Output Signal

Item	Specifications	Remarks
Output voltage	Approx. 20 mV/DIV, with 1 MΩ load Approx. 10 mV/DIV, with 50 Ω load	Output voltage per 1 DIV on CRT screen
Output impedance	Approx. 50 Ω	
Frequency response	DC to 35 MHz, within -3 dB	50Ω termination
DC level of output	Approx. 0 volts	

Trigger circuit
(A Sweep only)

Item	Specifications		Remarks
Tirgger signal sources	INT	CH1, CH2	
	TV	TVH, TVV	Linked to TIME/DIV switch.
	EXT	Triggered with an external signal	
	LINE	Triggered with AC line signal	
Coupling modes	DC, AC, HF REJ		
Polarity	"+" and "-"		
Trigger sensitivity	DC: DC - 10 MHz 0.5 DIV (0.1 V) 10 MHz - 35 MHz 1 DIV (0.2 V) AC: Lower limit frequency is 5 Hz. TV: 1 DIV (0.2 V) HF REJ: DC - 50 kHz 0.5 DIV (0.1 V)		The figures enclosed in the parentheses are external triggering sensitivities.
AUTO	Satisfies the trigger sensitivity specification for repetitive signals of 20 Hz or over		When trigger signal is removed, sweep is in AUTO (FREE RUN) mode.

Item	Specification	Remarks
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.
Hold-off function	Continuously variable	
External input impedance	Approx. 1 MΩ, 30 pF or less	
Maximum allowable input voltage	100 Vp-p (DC + AC peak)	AC frequency not higher than 1 kHz

Horizontal Axis

A sweep and B sweep

Item	Specification	Remarks
Sweep time	0.2 μsec/DIV - 0.5 sec/DIV (A sweep) 0.2 μsec/DIV - 0.5 msec/DIV (B sweep)	1-2-5 sequence, 20 ranges 1-2-5 sequence, 11 ranges
Sweep time accuracy	±3%	VARIABLE 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.	For A sweep only
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	
DISPLAY	A, A INTEN BY B, B, B TRIG'D	

Delayed Sweep

Item	Specifications	Remarks
Delay system	Continuous delay Triggered delay (with trigger signal of sweep A)	
Sweep delay time	5 msec - 1 μsec	
Delay jitter	1/10,000 or less $\frac{\text{B sweep time}}{\text{A sweep time}} \times \frac{\text{Jitter width}}{\text{10 DIV}}$	Jitter width 1 DIV or less at A: 1 msec/DIV and B: 1 μsec/DIV

External Sweep

Item	Specification	Remarks
Mode	X-Y mode CH1 ... X axis (HOR) CH2 ... Y axis (VERT)	
Sensitivity	5 mV/DIV - 5 V/DIV (X=Y)	10 steps
Sensitivity accuracy	±3% or better	
Frequency response	X axis DC: DC - 2 MHz AC: 2 Hz - 2 MHz Y axis The same as CH2	With reference to 50 kHz, -3 dB
X-Y phase difference	3° or less (DC - 50 kHz)	

Calibration Voltage

Item	Specification	Remarks
Waveform	Positive-going square wave	
Frequency	Approx. 1 kHz	
Duty ratio	Within 45:55	
Output voltage	1 Vp-p, within ±2%	
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 response	DC - 1 MHz	
Input resistance	Approx. 10 kΩ	
Maximum allowable input voltage	50 Vp-p (DC + AC peak)	AC: 1 kHz or lower
Input terminals	Binding posts	Provided at rear

CRT Circuit

Item	Specification	Remarks
Type	5.5-inch rectangular domed mesh, post acceleration CRT with internal gradicule	Printed graticule line
Fluorescent screen	P31	
Acceleration voltage	Approx. 4.2 kV/-1.4 kV	Approx. 5.6 kV (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	
Unblanking	With G1	
Illumination	Continuously variable	When external graticule is used

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. 47 VA	

Mechanical Specification

Item	Specification	Remarks
External dimentions	365 W × 165 H × 525 D mm (14.37 W × 6.50 H × 20.7 D in.)	With handle in the portable state
	365 W × 165 H × 470 D mm (14.37 W × 6.50 H × 18.51 D in.)	Maximum dimentions
	365 W × (190)H × 470 D mm (14.37 W × (7.48)H × 18.51 D in.)	With handle on case top
	310 W × 150 H × 400 D mm (12.21 W × 5.91 H × 15.75 D in.)	Case only
Weight	Approx. 10 kg (22.1 lbs)	

Ambient Temperature and Humidity

	Temperature	Humidity	Remarks
Range for satisfying performance specification	5°C to 35°C (41°F to 95°F)	Less than 85%	
Operable range	0°C to 40°C (32°F to 104°F)	Less than 90%	

3. PRECAUTIONS FOR USE

3.1 Precautions for Operation

- Line Voltage

The AC line voltage must be within ±10% of the voltage set at the instrument rear. Note that the instrument may not properly operate or may be damaged if the AC line voltage is not within this range.

- Emvironments

The oscilloscope must not be operated or stored in high temperature (higher than 30°C or 86°F), high humidity (higher than 80%) for a long time since such will cause troubles or shorten the instrument life.

If the oscilloscope is operated in a strong electric or magnetic field, the displayed waveform may be distorted.

- Intensity of CRT beam

Do not make the CRT image excessively bright and do not leave the spot stationary for a long period, lest the CRT screen should be "burnt" shortening its life.

- Maximum allowable voltages of input terminals

The maximum allowable voltages of the input terminals and probe are as shown in the following table. Pay attention so that no voltages higher than the maximum allowable voltages are applied, lest the circuits should be damaged.

CH1, 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	50 V (DC + AC peak)

(Frequency not higher than 1 kHz)

3.2 Line Voltage Conversion

This instrument can be operated on various nominal AC line voltages, by changing the power transformer taps at the instrument rear.

The AC plug normally is of the 125V-6A rating (except for the instruments shipped for use on 200V AC lines). To use the instrument on a 200V AC line, the plug must be changed with that for the 200V AC line system. The plug together with cord is available from Kikusui (Parts Code No.: 85-10-0140, parts name: VM0099-VM0081 AC Cord).

Use fuses as follows:

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

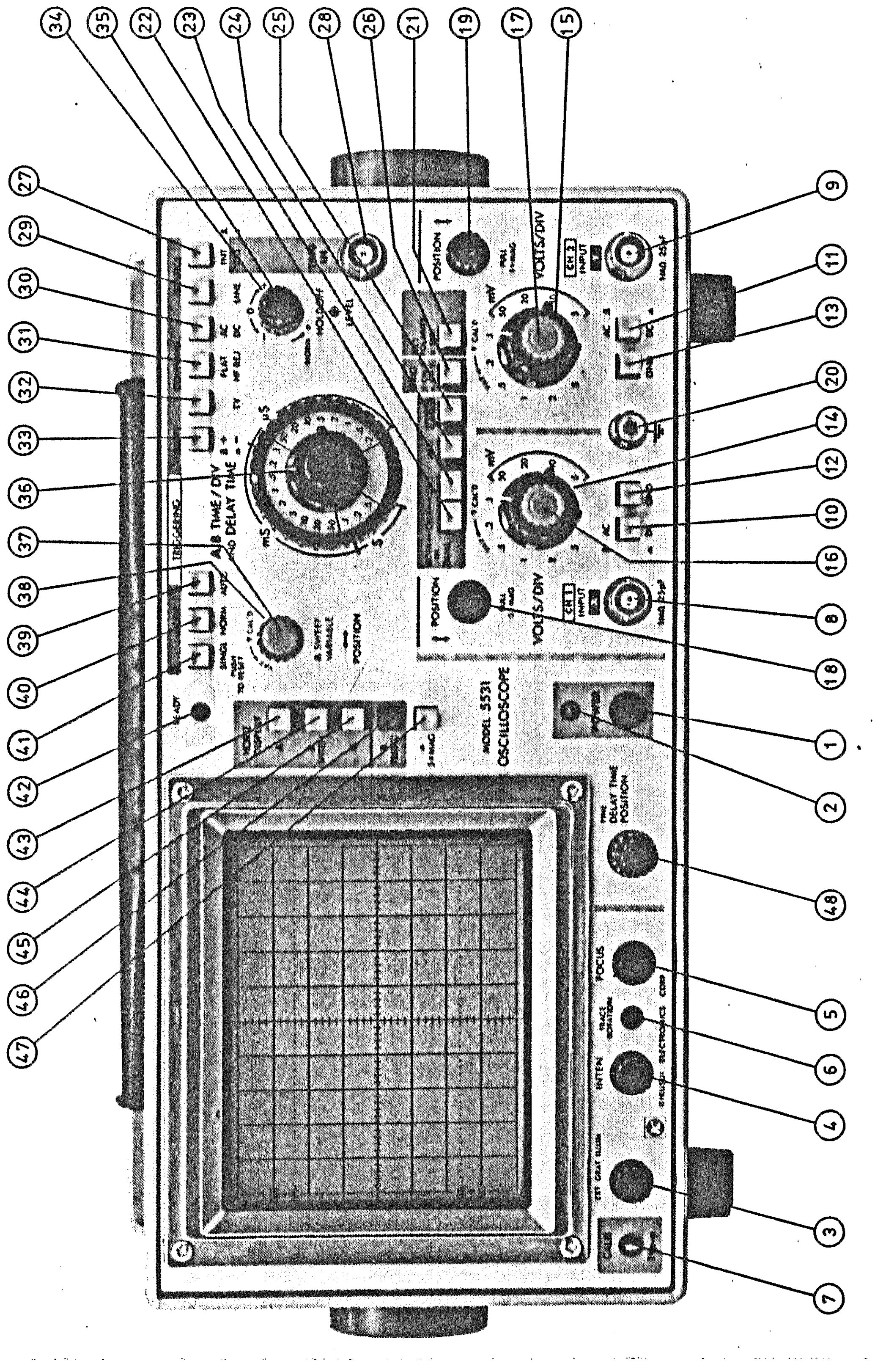
VOLTS/DIV
POSITION
A/B TIME/DIV
AND DELAY TIME
HOLDOFF
LEVEL
TRIGGERING
MODEL 5531
OSCILLOSCOPE
POWER
FOCUS
TRACE ROTATION
READY

Figure 1

4. OPERATING INSTRUCTIONS

4.1 Explanation of Front Panel (See Figure 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	EXT GRAT ILLUMI	To adjust illumination of external graticule. (The CRT has an internal graticule. The external graticule may be used for photographing.)
4	INTEN	Controls the brightness of the spot or trace.
5	FOCUS	For focussing the spot or trace to the sharpest image.
6	TRACE ROTATION	Semi-fixed potentiometer for aligning the horizontal trace in parallel with graticule lines.
7	CALIB (1 Vp-p)	Generates a pulse signal of 1 Vp-p, approx. 1 kHz. The signal is delivered through the chip terminal on the panel.

Vertical deflection	The functions of controls and terminals of CH1 and CH2 are identical. Explanations on items of CH1 are directly applicable to those of CH2.
8 CH1 (X) 9 CH2 (Y)	Input terminals for vertical axis, and also for X-Y operation. The terminals are BNC receptacles which are used also when the probe is used.
10 , 11 AC, DC	Pushbutton switch to select input coupling. The depressed state is for DC-coupling; the popped-up state is for AC-coupling. With AC-coupling, DC component of input signal is cut off and AC component alone is displayed. With DC-coupling, all components are displayed.
12 , 13 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 volt level on the CRT.
14 , 15 VOLTS/DIV	The black knob selects vertical sensitivity from 5 mV/DIV to 5V/DIV in 10 ranges. The range values are for 1 DIV vertical diflection with the VARIABLE (red) knob set in the CAL'D (extremly clockwise) position.
16 17 CAL'D ↙ VAR	Continuously-variable adjustment of vertical sensitivity. When turned to the extremely counterclockwise position, the sensitivity is reduced by approximately 1/2.5. The extremely clockwise position is the calibrated position.

(18) (19) POSITION ↕ PULL 5 × MAG	Vertical positioning of the spot or trace. When this knob is pulled up, the circuit becomes the 5 × MAG state and the vertical sensitivity is increased by 5 times.
(20) GND ⏚	This terminal is electrically connected to the instrument chassis and panel (both CH1 and CH2).
(21) 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 axis	4-gang pushbutton switches to select modes of CH1 and CH2 axis as follows:
(22) CH1	The instrument operates as a single-channel oscilloscope with CH1 alone.
(23) CH2	The instrument operates as a single-channel oscilloscope with CH2 alone.
(22) (23) BOTH-CH1-CH2 IN DUAL	When 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 1mS/DIV or in the ALT mode for 0.5 mS/DIV to 0.2 μS/DIV). It also is possible to operate in the CHOP mode for all ranges by selecting it with the CHOP ONLY switch at rear.

(24)	ADD	For measurement of algebraic addition of the CH1 and CH2 signals (or measurement of subtraction between the CH1 and CH2 signals when the CH2 POLARITY switch is depressed).
(25)	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 response of X axis becomes DC to 2 MHz, -3 dB.
(26)	TRIG CH1 CH2	Selects the CH1 or CH2 signal for the INT trigger source signal when in the DUAL or ADD mode. The popped up state is for CH1 and the depressed state is for CH2 as the trigger signal.

Trigger Circuit

(27)	INT EXT	Selects between INT trigger and EXT trigger. When in the INT trigger operation in the DUAL or ADD mode, the CH1 or CH2 signal as selected by TRIG pushbutton (26) is used as the trigger signal. When in the single-channel mode, the input signal of the channel is used as the trigger signal. When in the EXT trigger operation, the signal applied to TRIG IN terminal (28) is used as the trigger signal.
(28)	TRIG IN	When INT/EXT pushbutton (27) is in the depressed state, the external signal applied to this terminal is used as the trigger signal.

29	LINE	The AC line signal is used as the trigger signal.
30	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.
31	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 high-cut 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.
32	TV	The TV sync separation circuit is connected to the trigger circuit, and the sweep is triggered in synchronization with TV.V or TV.H signal as selected by A TIME/DIV switch 36. TV V: 0.5 sec/DIV - 0.1 msec/DIV TV H: 50 μsec/DIV - 0.1 μsec/DIV
33	SLOPE + -	Selects the triggering slope. "+": Triggering is effected when the trigger signal crosses the trigger level in positive-going polarity.

"-": Triggering is effected when the trigger signal crosses the trigger level in negative-going polarity.

(34) LEVEL	Controls the trigger level (the starting point of sweep) on the trigger signal. As this knob is turned clockwise, the trigger level moves upward; as the knob is turned counterclockwise, the level moves downward.
(35) HOLD OFF	This knob is used when the signal waveform is sophisticated and stable triggering cannot be attained with LEVEL knob alone. In other cases, this knob should be kept in the NORM state.

Time Base

(36) A, B TIME/DIV AND DELAY TIME	The larger knob is for the A TIME/DIV switch and DELAY TIME switch, and the smaller knob is for the B TIME/DIV switch. With the larger knob, when in the A SWEEP mode, the sweep time is selectable from 0.5 S/DIV to 0.2 μS/DIV in 20 ranges; when in the A INTEN mode, the sweep time of A SWEEP and the delay time from the start of A SWEEP to that of B SWEEP are indicated. When in the B sweep mode, the sweep time is selectable for 0.5 mS/DIV to 0.2 μS/DIV in 11 ranges. Note that the smaller knob is not effective for the 0.5 S/DIV to 1 mS/DIV ranges.

37	A SWEEP VARIABLE	Continuously variable control of the A sweep. The values indicated by A TIME/DIV switch 36 can be made slower by 2.5 times or over. When set in the CAL'D position, the sweep speed is calibrated to the value indicated by the A TIME/DIV switch.
38	←→ POSITION	For horizontal positioning of the spot or trace, which moves rightward as this knob is turned clockwise, or vice versa.
39	AUTO	When this pushbutton is pressed, the sweep runs in the AUTO (FREE RUN) mode. A bright trace is displayed on the screen even when no input signal is applied. Triggering is effected if the input signal frequency is 20 Hz or over and 0.5 DIV or over. (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.)
40	NORM	When no input signal is applied, the time axis 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.
41	SINGLE	Pushbutton switch for the single sweep (one-shot sweep) operation. When this button is pressed, the AUTO and NORM pushbuttons 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 has been done.
42	READY	This lamp (LED) lights to indicate that the single sweep circuit is in the READY state. When one sweep operation has been done, this lamp goes off automatically.

Horizontal Display

43	A	Main sweep (A sweep) mode for general waveform observation.
44	A INTEN	This sweep mode (delaying sweep) is used when selecting the section to be magnified of the A sweep. The B sweep section (delayed sweep) corresponding to the A sweep is displayed with high brightness.
45	B	Displays with the delayed sweep (B sweep) alone.
46	B TRIG'D	Selects between continuous delay (A sweep after delay) and B triggered delay. The undepressed state is for continuous delay. Sweep starts immediately after the sweep delay time determined by DELAY TIME switch 36 and DELAY TIME POSITION knob 48 has elasped, irrespective of trigger signal.

The depressed state is for B triggered delay. The B sweep starts when the signal has crossed the trigger level and a trigger pulse is generate after the sweep delay time determined by DELAY TIME switch (36) and DELAY TIME POSITION knob (48) has elapsed. If no trigger pulse is generated, the B sweep does not starts and the A sweep ends directly.

(47)	5 × MAG	The A or B sweep is magnified by 5 times horizontally, or the sweep speed becomes faster by 5 times.
(48)	DELAY TIME POSITION	The delay time shown by A sweep (36) can be continuously varied to select the position to be magnified on the A sweep.
	FINE	Fine adjustment for the DELAY TIME POSITION knob.

4.2 Explanation of Rear Panel

(49)	Z-AXIS INPUT	Input terminals for the external intensity modulation signal. The red terminal is for the hot line and the black terminal for the ground. When not in use, these terminals must be shorted with the shorting bar.
(50)	FUSE	Fuse holder for slow blow fuse. To replace the fuse, remove the cap by turning it counter-clockwise.

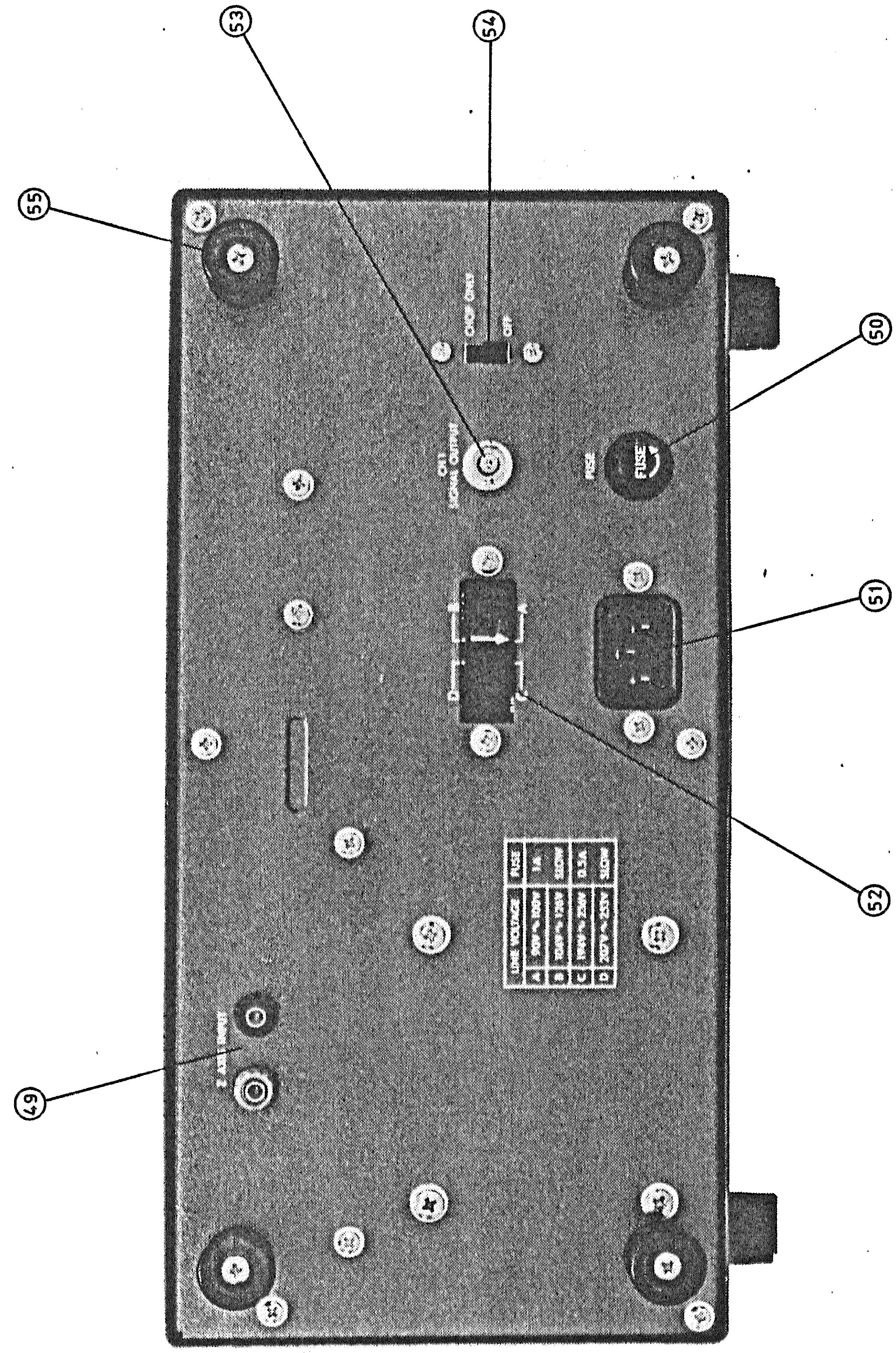

Figure 2

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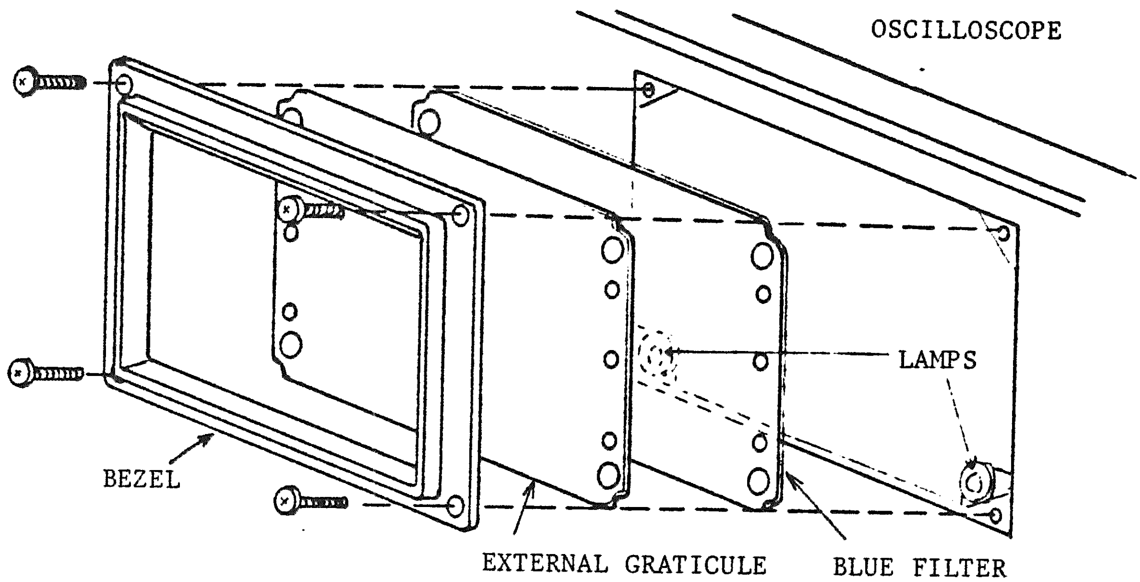
51	Power input	AC power input of the instrument. Connect the AC power cord to this connector.
52	Line voltage selector	Selects the AC line voltage. Insert the plug in conformity with the AC line voltage referring to the table in the left-hand side.
53	CH1 SIGNAL OUTPUT	Output terminal of CH1 signal. Used, for example, when measuring the signal with a frequency counter.
54	CHOP ONLY OFF	If this switch is set in the CHOP ONLY position, the dual traces are switched in the chop mode irrespective of setting of the TIME/DIV switch. Normally, this switch should be set in the OFF position.
55	Cord studs	These studs (four) are for taking up the instrument cord.

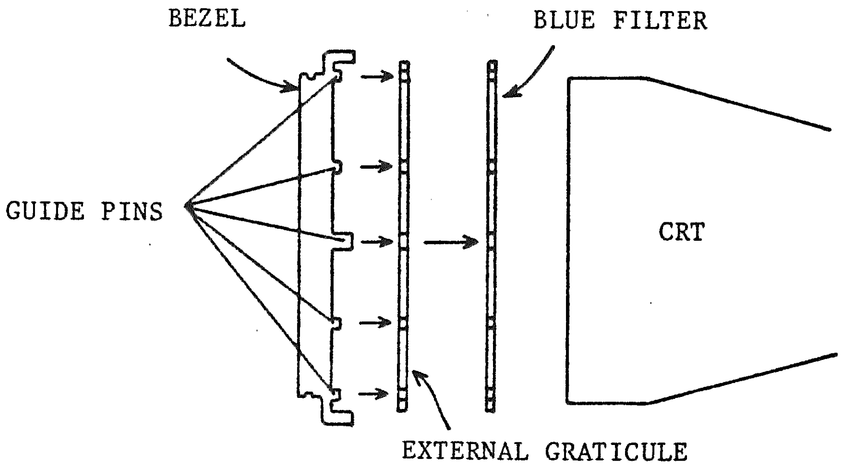
4.3 Use of Illuminatable External Graticule

The CRT of this oscilloscope has an internally-printed graticule (parallax free). However, this graticule cannot be illuminated for photographing.

If a graticule is required to be photographed together with the waveform displayed on the CRT screen, this can be done by installing the illuminatable external graticule (an accessory) before the blue filter on the CRT screen as illustrated below:



So place the external graticule that its printed side is positioned toward the CRT and align its guide holes with the guide pins of the bezel.



The external graticule and blue filter can be clamped with the bezel, aligning its guide pins with the guide holes of the graticule and filter.

5. OPERATION METHOD

5.1 Basic Operation

Before connecting the power cord to an AC line outlet, check that the AC line voltage selector plug on the rear panel of the instrument is correctly set for the AC line voltage. Next, set the switches and controls of the instrument as shown in the following table.

Item	No.	Setting
POWER	1	OFF position
INTEN	4	Mid-position
FOCUS	5	Mid-position
EXT GRAT ILLUM	3	Counterclockwise position
DUAL-CH1-CH2	22	CH1
↕ POSITION	18 19	Mid-position (both CH1 and CH2)
VOLTS/DIV	14 15	20 mV (both CH1 and CH2)
VARIABLE	16 17	CAL'D (clockwise position) (both CH1 and CH2)
AC-GND-DC	12 13	DC, GND (both CH1 and CH2)
PULL 5 × MAG	18 19	Push (both CH1 and CH2)
CH2 POLARITY	21	Undepressed
SOURCE	27	INT (LINE-OFF)
COUPLING	29 30 31 32	AC, FLAT (TV-OFF)

Item	No.	Setting
SLOPE	33	+
LEVEL	34	Mid-position
HOLD OFF	35	NORM (counterclockwise)
SWEEP MODE	39	AUTO
HORIZ DISPLAY	43	A
B TRIG'D	46	⊥ OFF
5 × MAG	47	OFF
TIME/DIV	45	0.5 mS
VARIABLE	37	CAL'D (clockwise)
←→ POSITION	38	Mid-position

After setting the switches and controls as above, connect the power cord to the AC line outlet and, then, proceed as follows:

1) Turn-ON the POWER switch and ensure that the power pilot lamp (LED) above is also turned on. In about 20 seconds, a trace will appear on the CRT screen.

2) Adjust the trace to an appropriate brightness and sharpest image with the INTEN control and FOCUS control.

3) Align the trace with the horizontal center line of graticule by adjusting the CH1 POSITION control and TRACE ROTATION control (semi-fixed potentiometer).

4) Connect the probe (supplied) to the CH1 INPUT terminal, and apply the 1 Vp-p signal from the CALIB terminal.

5) Set the GND switch of the input circuit in the AC state. A waveform as shown in Figure 3 will be displayed on the CRT screen.

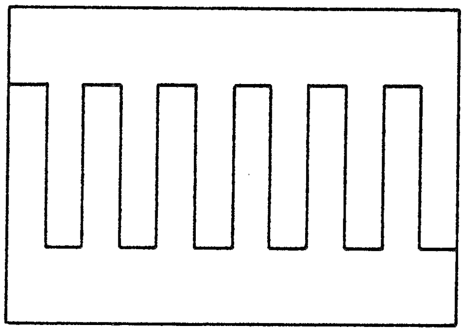


Figure 3

6) So adjust the FOCUS control that the trace image becomes sharpest.

7) For signal observation, set the VOLTS/DIV switch and TIME/DIV switch in appropriate positions so that the signal waveform is displayed with an appropriate amplitude and an appropriate number of cycles.

8) Adjust the ↕ POSITION control and ↔ POSITION control to appropriate positions so that the displayed waveform is aligned with the graticule and the voltage (Vp-p) and period (T) can be read conveniently.

The above is the basic operating procedure for the oscilloscope. Further operation methods are explained in the subsequent sections.

5.2 Dual-channel Operation and ADD Operation

Dual-channel Operation

Depress both CH1 22 and CH2 23 pushbutton switches (BOTH IN DUAL state). At the stage of setting of the preceding section, the calibration signal in applied to the CH1 only and no signal is applied to the CH2. Now, apply the calibration signal also to the CH2. In this case also, select the CH1 signal for the trigger source signal as is the case for the preceding section.

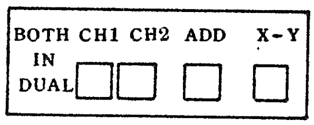


Figure 4

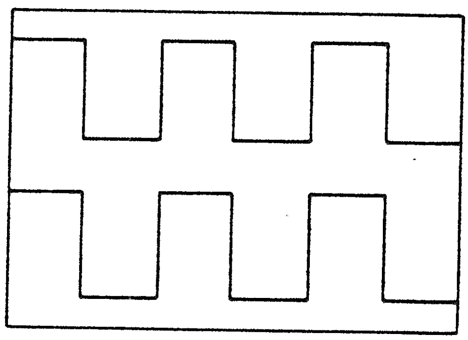


Figure 5

So far as the signal applied to the CH2 is in a periodical relationship with respect to that applied to the CH1, the displayed waveforms of both channels can be adjusted stationary.

This oscilloscope has eliminated from its front panel the CHOP/ALT selector switch. The DUAL switch alone is provided on the front panel for the dual-channel operation. Actually, the CHOP/ALT modes are switched being linked to the TIME/DIV switch 36. The 0.5 S/DIV to 1 mS/DIV ranges are with the CHOP mode and the 0.5 mS/DIV to 0.2 μS/DIV ranges are with the ALT mode. The CHOP ONLY switch 54 is provided at the rear of the instrument, for the CHOP operation irrespective of setting of the TIME/DIV switch.

Stable triggering may not be obtained when operating in a CHOP range and the level of the signal applied to the CH1 is low and the S/N ratio is poor. In such a case, stable triggering may be obtained by pressing the HF REJ button 31 so that components higher than 50 kHz are eliminated.

ADD Operation

An algebraid addition of the CH1 and CH2 signals can be displayed on the CRT screen by pressing the ADD button 24. The displayed signal is the subtraction between CH1 and CH2 signals if the CH2 POLARITY switch 21 is set in the INV state.

For accurate addition or subtraction, it is a prerequisite that the sensitivities of the two channels are adjusted accurately at the same value by means of the VAR knobs. Vertical positioning can be done with the ↕ POSITION knob of both channels. In view of the linearities of the vertical amplifiers, it is most recommendable to set them in their mid-positions.

5.3 X-Y Operation

Press the XY pushbutton switch 25. With this simple procedure, the instrument operates as an XY scope with CH1 for X-axis and CH2 for Y-axis.

For the Y-axis, the CH2 operates in the same electrical performances and procedure as when in the regular operation. Regarding the X-axis, the frequency response becomes DC - 2 MHz and the horizontal POSITION control 38 becomes effective for the X-axis. The CH1 POSITION control 18 becomes idle.

Apply the calibration signal to both X and Y axes, and adjust the VOLTS/DIV switches of respective axes so that a Lissajous figure of a diagonal line (for frequency ratio 1:1, phase difference = 0) is displayed.

When in the XY operation, the horizontal 5 × MAG pushbutton 47 is in the operable state. However, it is not recommended to use this magnification function because noise and drift will increase.

5.4 Triggering

Proper triggering is essential for efficient operation of an oscilloscope. The user of the oscilloscope must made himself thoroughly familiar with the triggering functions and procedures.

(1) Functions of INT TRIG (internal trigger) switch

The signals applied to the input terminals of CH1 and CH2 are picked off from respective preamplifiers in order to be used as internal trigger signals. When in the single-channel operation, the input signal is directly used as the internal trigger signal. When in the dual-channel operation or the ADD operation, the signal of the channel selected by the TRIG select pushbutton 26 is used as the internal trigger signal. A block diagram of the trigger system is shown in Figure 6.

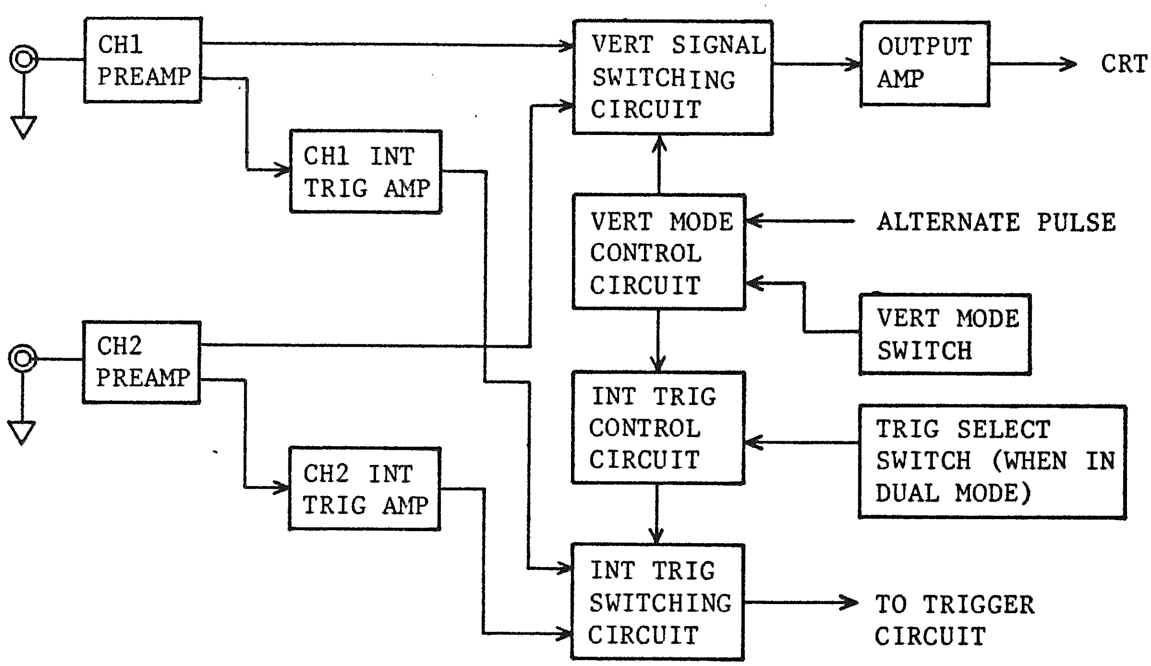


Figure 6

(2) Functions of TRIG SOURCE Switch

To display a stationary pattern on the CRT screen, the displayed signal itself or a trigger signal which has a certain time relationship with respect to the displayed signal is required to be applied to the trigger circuit. The SOURCE switch selects such signal for the trigger signal.

INT: This internal trigger method is used most commonly. The signal applied to the vertical input terminal is branched off from a point in the amplifier circuit and is fed to the trigger circuit through the INT TRIG switch. (See Figure 6.) Thus, a very stable waveform can be readily displayed on the CRT screen.

EXT: The sweep is triggered with an external signal applied to the EXT TRIG IN terminal. An external signal which has a certain time relationship with respect to the measured signal is used. Since the measured signal (vertical input signal) is not used as the trigger signal, waveform can be displayed independently for the measured signal.

LINE: The AC power line frequency signal is used as the trigger signal. This method is effective when the measured signal is in a certain relationship with respect to the AC line frequency, especially for measurements of low level AC noise of audio circuits, thyristor circuits, etc.

(3) Functions of COUPLING switch

This switch is used to select the coupling of the trigger signal to the trigger circuit in accordance with the characteristics of the measured signal.

AC: This coupling is for AC triggering which is used most commonly. As the trigger signal is applied to the trigger circuit through an AC-coupling circuit, stable triggering can be attained without being affected by the DC component of the input signal. The low-range cut off frequency is 5 Hz (-3 dB).

HF REJ: The trigger signal is applied to the trigger circuit through an AC-coupling circuit and a high cut filter of 50 kHz, -3 dB, in order that the high frequency signal or noise component of the trigger signal is eliminated and triggering is effected with the low frequency component alone.

TV: This coupling is for TV triggering for observation of TV video signals. The trigger signal is AC-coupled and fed via the trigger circuit (level circuit) to the TV sync signal separation circuit. The separation circuit picks off the sync signal and this signal is used as the trigger signal. Thus, the video signal can be displayed very stably.

Being linked to the TIME/DIV switch, the sweep speed is switched for TV.V and TV.H as follows:

TV.V: 0.5 sec - 0.1 msec

TV.H: 50 µsec - 0.1 µsec

The SLOPE switch should be set in conformity with the video signal as shown in Figure 7.

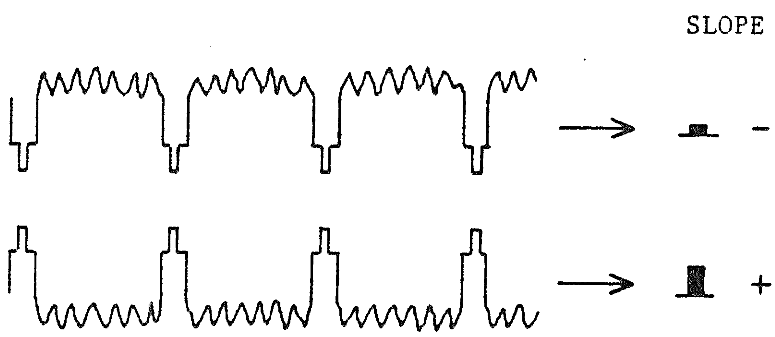


Figure 7

802240

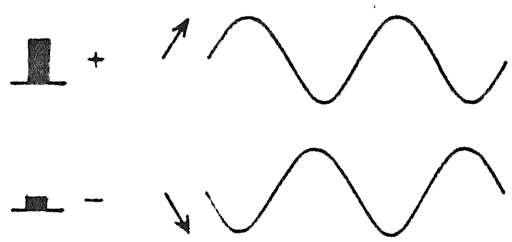
DC: This coupling is for DC triggering. The trigger signal is DC-coupled to the trigger circuit. This mode is used when triggering is required to be effected including the DC component of the trigger signal or when a very low frequency signal or a signal of a large duty cycle ratio is required to be displayed. Triggering is not effected if the trigger signal is superimposed on a DC signal and the trigger level is not within the range of the AC component of the trigger signal.

(4) Functions of SLOPE switch

This switch selects the slope (polarity) of the trigger signal.

"+": When set in the "+" state, triggering is effected as the trigger signal crosses the trigger level in the positive-going direction.

"-": When set in the "-" state, triggering is effected as the trigger signal crosses the trigger level in the negative-going direction.



Positive-going slope

Negative-going slope

Figure 8

(5) Functions of LEVEL control (34)

The function of this control is to adjust the trigger level in order to display a stationary image. At the instant the trigger signal has crossed the trigger level set by this control, the sweep is triggered and a waveform is displayed on the screen.

The trigger level changes in the positive direction (upward) as this control knob is turned clockwise and it changes in the negative direction (downward) as the knob is turned counterclockwise.

(6) Functions of A HOLD OFF control

When the measured signal is of a sophisticated waveform with two or more repetition frequencies (periods), triggering with the above-mentioned LEVEL control alone may not be sufficient for attaining synchronization for stable waveform display. In such a case, the sweep can be synchronized to the measured signal waveform rather forcefully by adjusting the HOLD OFF time (sweep pause time) of the sweep waveform. Thus, the HOLD OFF knob is used to synchronize the trigger signal to a sophisticated waveform by varying the HOLD OFF time. The function is illustrated in Figure 8.

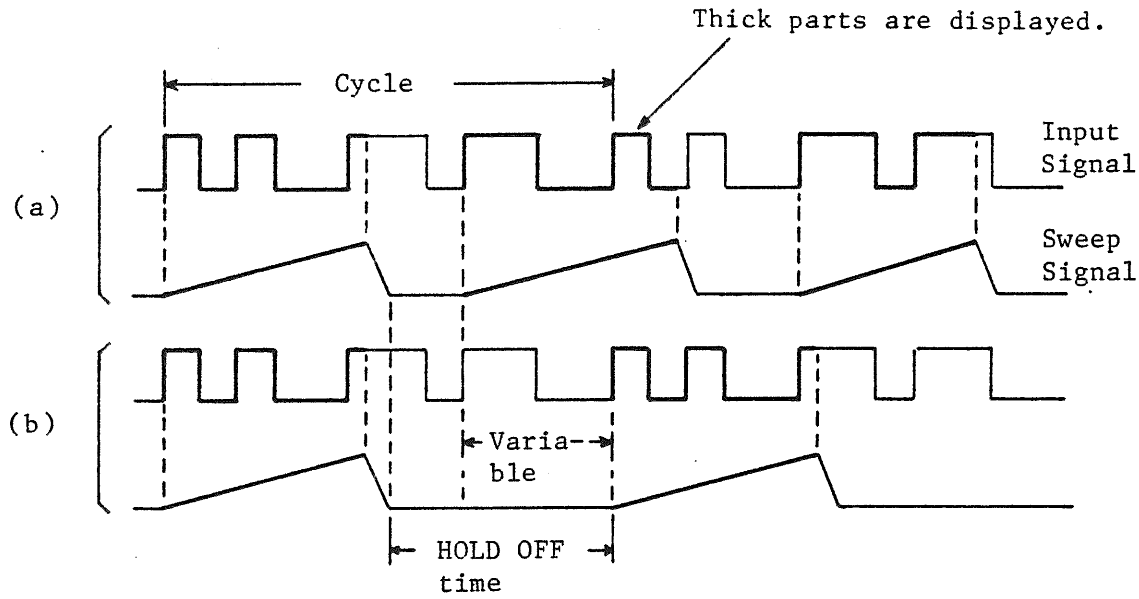


Figure 9

Figure 9 (a) shows a waveform displayed under the NORM mode (the HOLD OFF function not effected). The patterns of the 1st and 2nd cycles are different and various patterns are overlapped as displayed on the CRT screen.

Figure 9 (b) shows a waveform displayed under the HOLD OFF mode. By adjusting the time during which the sweep is held off (for the time corresponding to the complicated pattern), a waveform without overlapping can be displayed.

5.5 Single-sweep Operation

When the measured signal is of a non-repetitive nature (has no fixed cycle period) or when it is of a one-shot nature (transiential signal), the waveform cannot be displayed repetitively and stantionarily on the CRT screen. In such a case the sweep circuit should be operated in the single-sweep mode and the displayed one-shot image should be carefully observed or be photographed with a camera.

o Measurement of non-repetitive signal:

(1) Set the HORIZ DISPLAY in the "A" state (43) and the SWEEP MODE in the NORM state (40).

(2) Apply the measured signal to the vertical input terminal and adjust the trigger level (34).

(3) Press the SINGLE button (41). The NORM button is reset (the three buttons pop out.) This circuit now is for the single-sweep operation.

(4) Press the SINGLE button again. This action is for the PUSH TO RESET function, and the READY lamp lights.

(5) As the trigger signal crosses the trigger level, the sweep runs for only one cycle. Then, it returns to the state of (3) above and remains in this state.

o Measurement of one-shot signal:

(1) Set the HORIZ DISPLAY switch in the "A" state (43) and the SWEEP MODE in the NORM state (40).

(2) Apply the calibration signal (CALIB (7)) to the vertical input terminal, and adjust the trigger level at a value corresponding to the predicted amplitude of the measured signal.

(3) Set the SWEEP MODE in the SINGLE state (41). Apply the measured signal instead of the calibration signal to the vertical input terminal.

(4) Depress the PUSH TO RESET button (the same with SINGLE button 41). The sweep circuit will become the ready state and the READY lamp will turn on.

(5) As the one-shot signal is effected in the input circuit, the sweep runs for one cycle and the one-shot signal is displayed on the CRT screen.

The single-sweep operation can be done also with A INTEN and B sweep. However, it cannot be done in the ALT mode dual-channel operation. (TIME/DIV switch ranges of 0.5 mS/DIV to 0.2 μS/DIV). For dual-channel one-sweep operation, use the CHOP for all ranges by setting the CHOP ONLY switch 54 to the CHOP ONLY state at the instrument rear.

5.6 Sweep Magnification

When a certain part of the displayed waveform is required to be expanded timewise, a faster sweep speed may be used. However, if the required part is apart from the start point of the sweep, the required part may run out of the CRT screen. In such a case, depress the "5 × MAG" switch 47 so that the displayed waveform is expanded by 5 times to right and left with the center of screen as the center of expansion.

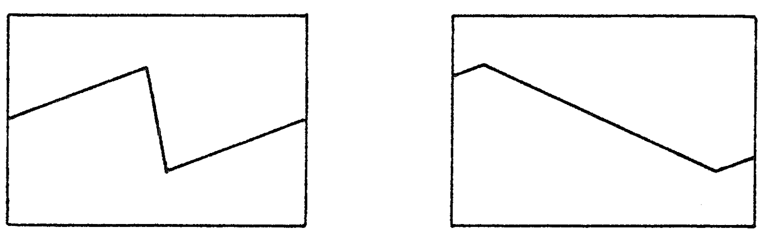


Figure 10

Before magnification After magnification

The sweep time when in the magnification operation is as follows:

(Value indicated by TIME/DIV switch) ÷ 5 = Sweep time/DIV

With this instrument, by magnifying the regular fastest sweep speed of 0.2 μsec/DIV, the magnified fastest speed of 40 nsec/DIV can be attained. However, as the sweep speed becomes faster, the trace intensity is reduced. Therefore, when a sweep speed faster than 0.2 μsec/DIV is required, it is more recommendable to use the B sweep mode for waveform expansion as explained in the subsequent section.

5.7 Waveform Magnification with Delayed Sweep

With sweep magnification of the preceding section, although the magnification method is simple, the magnification ratio is limited at 5. With the delayed sweep method of this section, on the other hand, the sweep can be expanded for a wide range of from several times to several thousands times depending on the ratio between A sweep time and B sweep time.

As the measured signal frequency becomes high and the A sweep range for the non-expanded signal becomes higher, the available expansion ratio becomes smaller. Further, as the magnification ratio becomes larger, the trace intensity becomes lower and the delay jitter increases. To cope with these situations, a continuously-variable delay circuit and a triggered delay (B TRIG'D) circuit are incorporated.

(1) Continuously-variably delay:

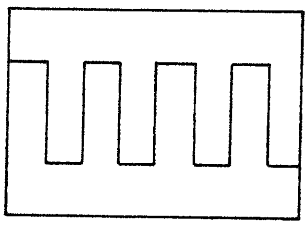
Set the HORIZ DISPLAY switch in the A state 43 and display the signal waveform with the A sweep in the regular operation method. (See Figure 11 (a)).

Next, set the B TIME/DIV switch 36 (smaller knob) in a position faster by several steps than the A TIME/DIV switch 36 (larger knob). After ensuring that the B TRIG'D switch 46 is in the OFF state, turn the HORIZ DISPLAY switch to the A INTEN position 44. A part of the displayed waveform will be accentuated as shown in Figure 11 (b). (This is the READY state for delayed sweep.) The part of the accentuated brightness denotes the section corresponding to the B sweep time (DELAYED SWEEP). This part is expand on the B sweep as the B button 45 of the HORIZ DISPLAY switch is pressed.

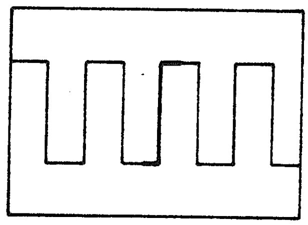
The period from the start of the A sweep to that of the B sweep (the period to that the trace is accentuated) is called "SWEEP DELAY TIME." This period is continuously variable by means of the DELAY TIME POSITION knob 48.

The B sweep time is set by the B TIME/DIV switch 36 (smaller knob) and the magnification ratio becomes as follows:

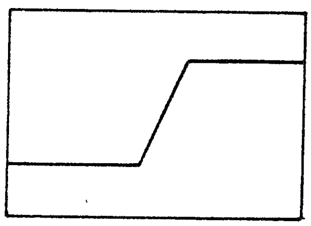
$$\text{Magnification ratio} = \frac{\text{A TIME/DIV indication}}{\text{B TIME/DIV indication}}$$



(a) Before magnification



(b) A INTEN



After magnification

Figure 11

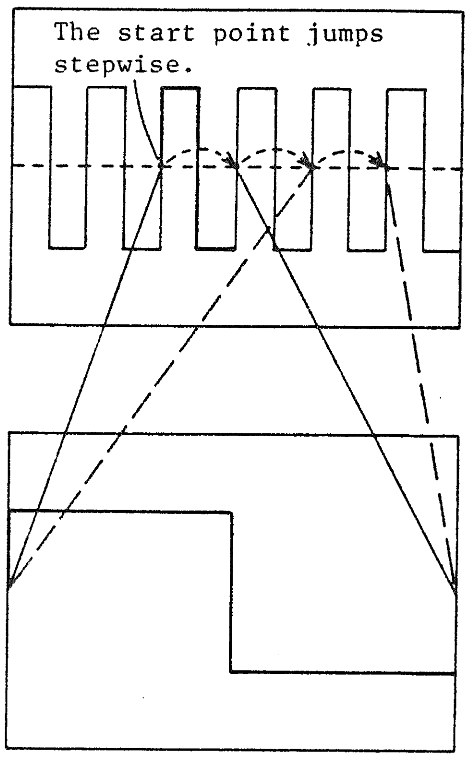
(2) Triggered delay:

When the displayed waveform is magnified by 100 times or over in the above-mentioned continuous delay method, delay jitter is produced. To suppress the jitter, this triggered delay method is used.

With the triggered delay, delay jitter is reduced by triggering again the B sweep after a certain delay time caused by the continuous delay method has elapsed.

For this operation, the B trigger circuit operates as the B TRIG'D switch 46 is pressed and the B sweep is triggered by the B trigger pulse. Therefore, even when the delay time is continuously varied by rotating the DELAY TIME POSITION knob 48 , the starting point does not vary continuously but varies stepwise between trigger points. This operation in the A INTEN mode can be observed as the accentuated section moves stepwise.

A INTEN



B trigger level

Figure 12

B TRIG'D

5.8 Z-axis Input Terminals

These terminals are for an external intensity-modulation signal application. To apply the signal, remove the short bar from the terminals and connect the hot line of the signal to the red terminal and the ground line to the black terminal. When not in use, short these terminals with the shorting bar.

6. MEASURING METHODS

6.1 Connection Method of Input Signal

The input impedance of the oscilloscope as viewed from the vertical input terminal is 1 MΩ with capacitance approximately 25 pF in parallel. When the probe is used, the impedance increases to resistance 10 MΩ with capacitance approximately 12 pF in parallel.

There are various methods of connection between measured signal source and oscilloscope. The most popular methods are with regular covered wires, with shielded wires, with a probe, or with a coaxial cable. Suitable one is used taking the following factors into consideration.

- Output impedance of input signal source
- Level and frequency of input signal
- External induction noise
- Distance between input signal source and oscilloscope

Types of input signals and connection methods are tabulated in the following:

Type of input signal \ Connection method			Covered wire	Shielded wire	Probe	Coaxial cable	Others
Low frequency	Low impedance	Near	○	○	○	○	
		Far		○		○	
	High impedance	Near		◍	○	◍	
		Far		◍		◍	
High frequency	Low impedance	Near			○	○	
		Far				○	
	High impedance	Near			○	◍	
		Far					

(○: Good, ◍: Fair)

o Connection with regular covered wires:

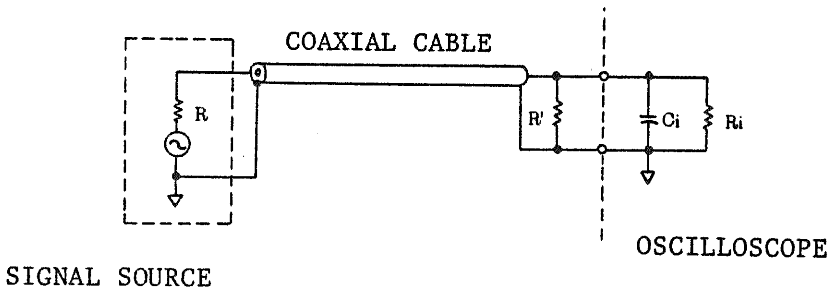
Set a BNC Type Adaptor (Type 942A, accessory) to the vertical input terminal and connect regular covered wires to the adaptor. This method is simple and the input signal is not attenuated. However it is susceptible to induction noise when long wires are used or when the signal source impedance is high. Another disadvantage is a large stray capacity with respect to the ground. As compared with the case the 10 : 1 probe is used, larger effects are caused by the stray capacity.

o Connection with shielded wire:

The use of a shielded wire prevents external induction noise. However, the shielded wire has as large stray capacitance as 50 pF/m ~ 100 pF/m and this method is not suitable when the signal source impedance is high or the measured signal frequency is high.

o Connection with coaxial cable:

When the output impedance of the signal source is 50 Ω or 75 Ω, the input signal can be fed without attenuation up to high frequencies by using a coaxial cable which enables impedance matching. For impedance matching, terminate the coaxial cable with a 50 Ω or 75 Ω pure-resistive resistor corresponding to the characteristic impedance of the coaxial cable, as shown in Figure 11.



R = R'

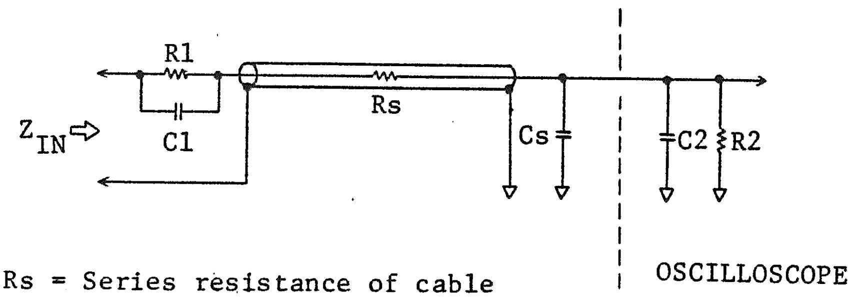
When R = 50 Ω, use a 50 Ω coaxial cable.

When R = 75 Ω, use a 75 Ω coaxial cable.

Figure 13

o Connection with probe:

The 10:1 probe supplied as an accessory of the oscilloscope has a probe circuit and a probe cable shielded to prevent induction noise. The probe circuit makes up a wide-range attenuator in conjunction with the input circuit of the oscilloscope, thereby enabling a distortionless connection from DC to high frequencies. When the probe is used, although the signal level is attenuated to 1/10, the input impedance becomes very high (resistance 10 MΩ, capacitance approx. 12 pF) and the loading effect on the measured signal source is greatly reduced. Details of the probe are as follows:



Rs = Series resistance of cable

Cs = Stray capacitance plus cable capacitance

Figure 14

The probe makes up a wide-range attenuator with its resistor R1 which make up an attenuator circuit with respect to input resistor R2 of the oscilloscope and with its capacitor C1 which compensates for input capacitor C2 of the oscilloscope and stray capacitance (Cs) of the cable. The input impedance Z_{IN} is expressed as follows:

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

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

Attenuation factor A is expressed as follows:

$$A = \frac{R2}{R1 + R2} \quad \left(= \frac{1\ M\Omega}{9M\Omega + 1M\Omega} = \frac{1}{10} \right)$$

The values enclosed in the parentheses are for the probe supplied as an accessory of the oscilloscope.

Precautions:

- o Observe the maximum allowable input voltages mentioned in Section 3.1 "Precautions for Operation."

- o Be sure to use the ground lead wire which accompanies the probe. When used in the dual-channel mode also, be sure to use the ground lead wires for individual channels.

- o Before commencing measurement, be sure to accurately adjust the phase of the probe without fail.

- o Do not apply unreasonably large machanical shocks or vibration to the probe. Do not sharply bend or strongly pull the probe cable.

- o The probe unit and tip are not highly heat resistant. Do not apply a soldering iron to a circuit close to the point where the probe is left hooked up.

6.2 Voltage Measurement

To measure an AC signal which has no DC component or to measure the AC component alone of a signal which has a DC component superimposed on the AC component, set the vertical input AC/DC selector switch (10 , 11) in the AC position. To measure a signal which has a DC component, set the switch in the DC position.

Before commencing voltage measurement, set the VARIABLE attenuator knob (16 , 17) to the CAL'D position and calibrate the sensitivity to the value indicated by the VOLTS/DIV selector (14 , 15).

Apply the signal to be measured, display the signal with an appropriate amplitude on the screen, and determine the amplitude on the graticule. (For DC voltage measurement, determine the shifted distance of the trace.) The voltage can be known as follows:

(1) When measured signal is directly applied to input terminal:

Voltage (V) = Deflection amplitude (DIV) × Indication of VOLTS/DIV switch

(2) When the 10 : 1 probe is used:

Voltage (V) = Deflection amplitude (DIV) × Indication of VOLTS/DIV switch × 10

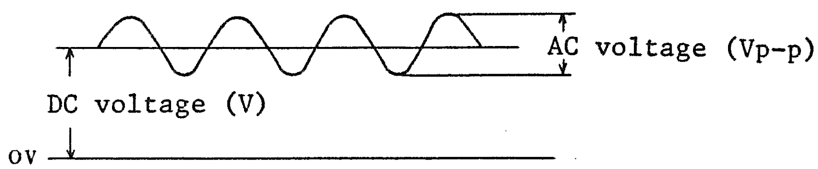


Figure 15

6.3 Current Measurement (Voltage Drop Method)

Connect a small-resistance resistor (R) in series in the circuit in which the current (I) to be measured flows and measure the voltage drop across the resistor with the oscilloscope. The current can be known from Ohm's law as follows:

$$I = \frac{E}{R} \quad (A)$$

The resistance should be as small as that it does not cause any change to the measured signal source.

In the above method, currents from DC to high frequencies can be measured quite accurately.

6.4 Measurement of Time Interval

The time interval between any two points on the displayed waveform can be measured by setting the TIME/DIV VARIABLE knob 37 in the CAL'D position and referring to the indication of the TIME/DIV switch 36 .

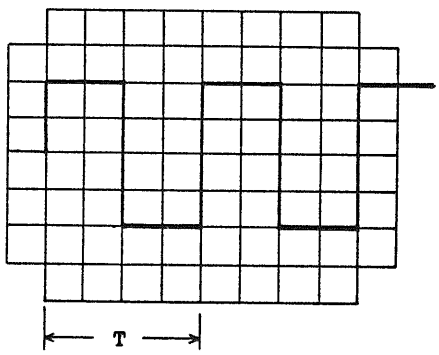


Figure 16

Time T (sec) = Indication of TIME/DIV × Horizontal span (DIV)

When the sweep is magnified (5 × MAG 47), the time is 1/5 of the value determined as above.

6.5 Frequency Measurement

- Frequency measurement by determining time (T) per one cycle of the displayed waveform:

  Time T (period) is measured as explained in Section 6.4 and the frequency is calculated by using the following formula.

$$\text{Frequency of (Hz)} = \frac{1}{\text{Period T (sec)}}$$

- Frequency measurement with Lissajous figure (See Figures 17 and 18):

  Set the MODE switch in the X-Y state so that the instrument operates as an X-Y scope. (See Section 5.3 "X-Y Operation.")

  Apply to the X-axis a known frequency from a signal generator (SG) and to the Y-axis the frequency to be measured. So adjust the required controls that a pattern is displayed on the overall surface of the CRT screen. Then so adjust the frequency of the signal generator that the displayed pattern becomes stationary as shown in Figure 17. From the displayed waveform, the unknown frequency can be calculated as follows:

$$\begin{array}{l}\text{Unknown}\\ \text{frequency}\\ \text{(Hz)}\end{array} \doteqdot \frac{\begin{array}{l}\text{The number of crossing points}\\ \text{over horizontal scale line}\end{array}}{\begin{array}{l}\text{The number of crossing points}\\ \text{over vertical scale line}\end{array}} \times \begin{array}{l}\text{Frequency}\\ \text{of signal}\\ \text{generator}\\ \text{(Hz)}\end{array}$$

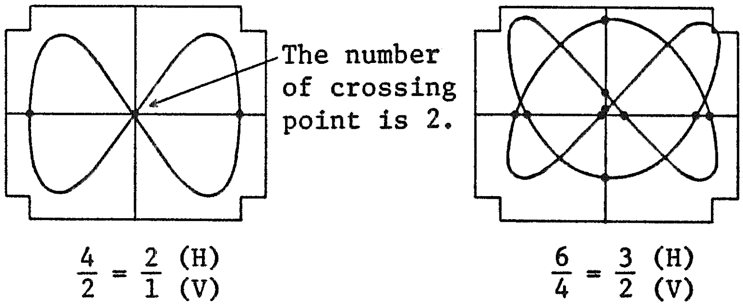


Figure 17

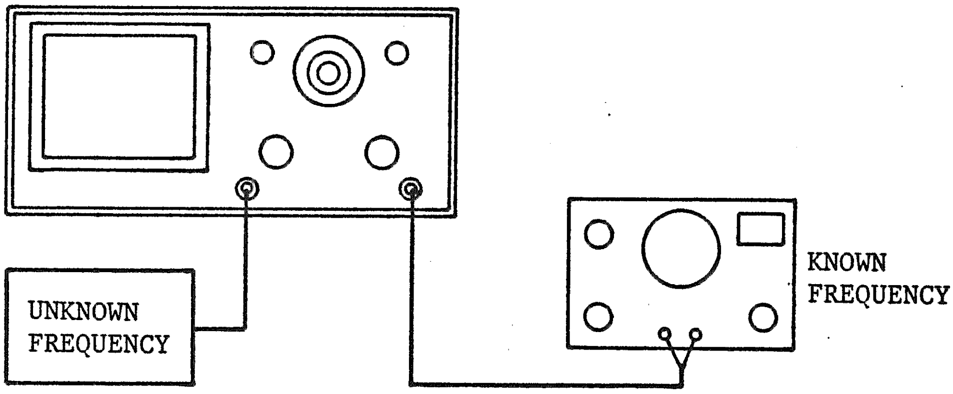


Figure 18

6.6 Measurement of Phase Difference

- Measurement of phase difference with Lissajous figure (See Figures 18, 19 and 20):

  Operate the oscilloscope in the X-Y mode as explained in the paragraph for frequency measurement, and apply two signals of the same frequency (such as stereophonic signals) to the X and Y axes so that a Lissajous figure is displayed on the CRT screen. The phase difference between the two signals can be known by measuring displayed waveform and employing the following equation:

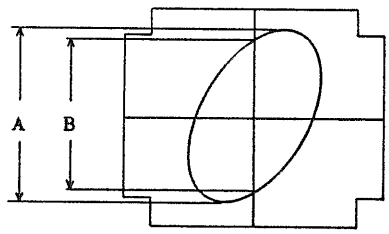


Figure 19

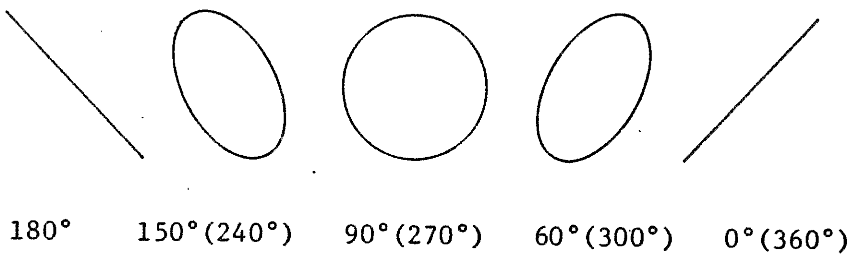


Figure 20

6.7 Measurement of Pulse Waveform Characteristics

A theoretically ideal pulse waveform is such that the signal changes instantaneously from a certain level to another level, held in this level for a certain period, and returns instantaneously to the original level. However, actual pulse waves are distorted. Nomenclature of distortions is given in Figure 20.

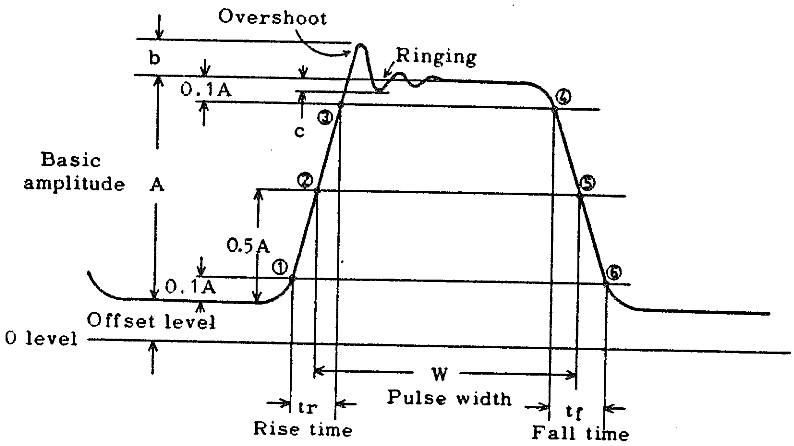


Figure 21

Pulse amplitude: Basic amplitude (A) of pulse

Pulse width: Time between points ② and ⑤ where signal amplitude is 50% of basic amplitude

Rise time: Time between 10% basic amplitude point ① and 90% basic amplitude point ③

Fall time: Time between 90% basic amplitude point ④ and 10% basic amplitude point ⑥

Overshoot: Amplitude of the first maximum excursion beyond basic amplitude. Expressed in terms of $b/A \times 100$ (%)

Ringing: Oscillation which follows the first maximum excursion. Expressed in terms of $c/A \times 100$ (%)

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o Measurement of rise time:

The rise time of a pulse can be known by determining the value of t_r on the CRT screen in the method of "Time Measurement." It must be noted that tr determined on the CRT screen includes the rise time of the oscilloscope itself. The closer the rise time of the oscilloscope (t_o) to the rise time of the measured pulse (t_n), the larger is the error introduced. To eliminate this error, calculation should be done as follows:

$$\text{True rise time } t_n = \sqrt{(t_r)^2 - (t_o)^2}$$

where, tr: Rise time measured on CRT screen

t_o: Rise time of oscilloscope itself (approx. 10 nsec when at 35 MHz band with this oscilloscope)

For example, when a pulse wave with rise time 30 nsec is measured on the CRT screen, the error is approximately 6%.

o Measurement of Sag

Pulse waveforms may have slanted-sections as shown in Figure 22, other than those distortions mentioned in Figure 21. (For example, slants are caused when the signal is amplified with an amplifier which has poor low-frequency characteristics, resulting from attenuation of the low frequency component.) The slanted section (d or d') is called "sag," which is calculated as follows:

$$\text{Sag} = \frac{d}{A} \left(\text{or } \frac{d'}{A'}\right) \times 100\ (\%)$$

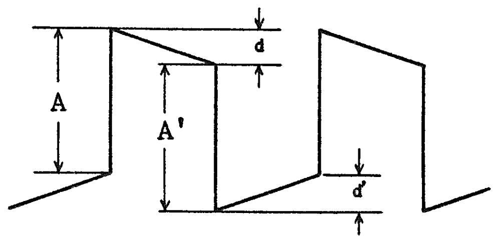

Figure 22

Note: If the AC-coupling mode is used for measurement of a low frequency pulse, sags are caused. For measurement of low frequency pulses, use always the DC-coupling mode.

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 alon 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. For accurate calibration service, it is most recommendable to contact Kikusui's representative in your area.

7.2 Removing the Case

To remove the case, remove the four screws (Figure 23) and pull out the chassis forward.

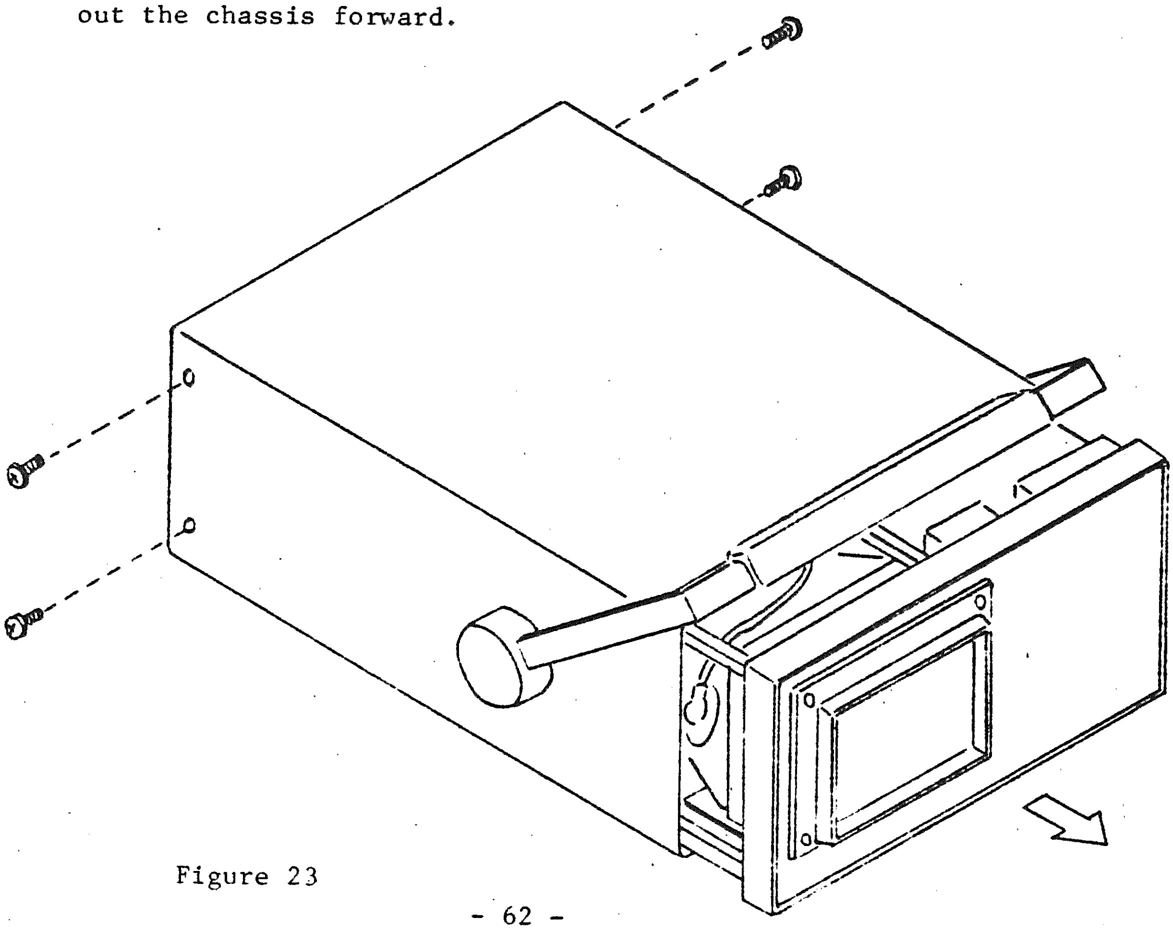

Figure 23

7.3 Check and Adjustment of DC Supply Voltages

When calibrating the oscilloscope, the DC supply voltages should be checked first of all. Check and adjust the +12V supply voltage at first and the other supply voltages next. The supply voltages and the check and adjustment points are shown in the following table.

Nominal voltage	Voltage range	Adjustment and check point
+5 V	+4.75 V to +5.25 V	TP-1, check
+12 V	+11.95 V to +12.05 V	TP-2, VR901 adjust
-12 V	-11.80 V to -12.20 V	TP-3, check
+30 V	+27 V to +33 V	TP-4, check
+95 V	+100 V to +90 V	TP-5, check
+200 V	+190 V to +210 V	TP-6, check
-1320 V	-1300 V to -1340 V	TP-7, VR803 adjust

For voltage check, measure the voltage between check point and ground using a reliable digital voltmeter. The +12V supply must be especially carefully adjusted because it provides a reference for other supplies. To measure the -1320V supply of which internal impedance is high, use a voltmeter of a high input impedance.

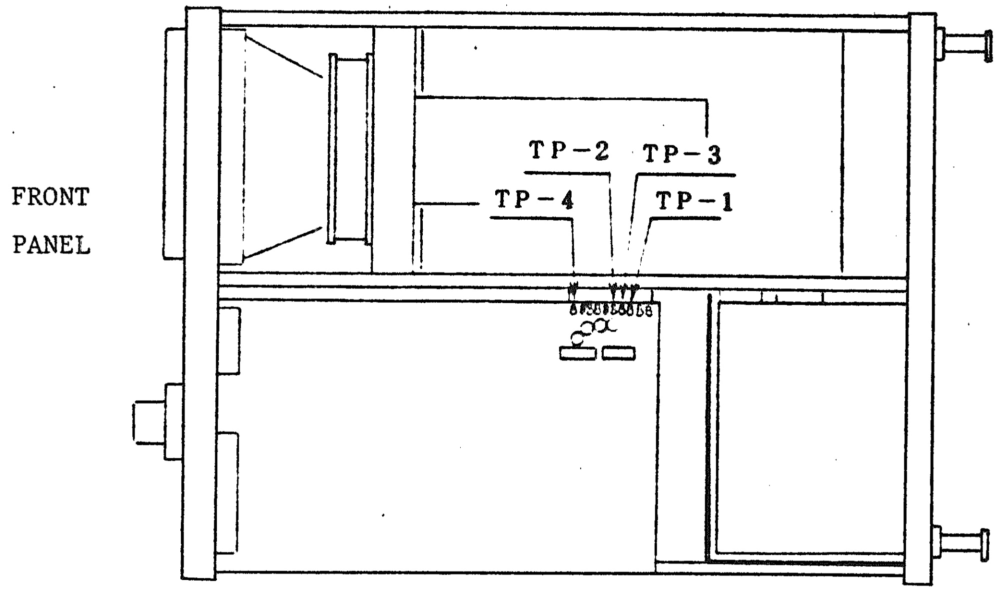

Figure 24 (Top view)

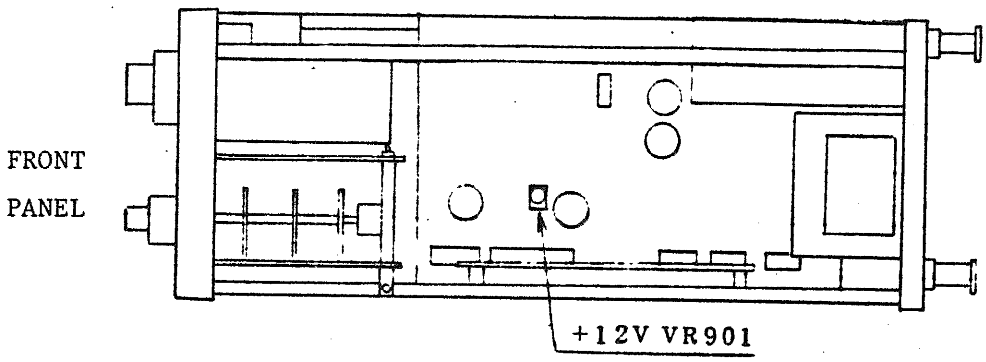

Figure 25 (Right hand side)

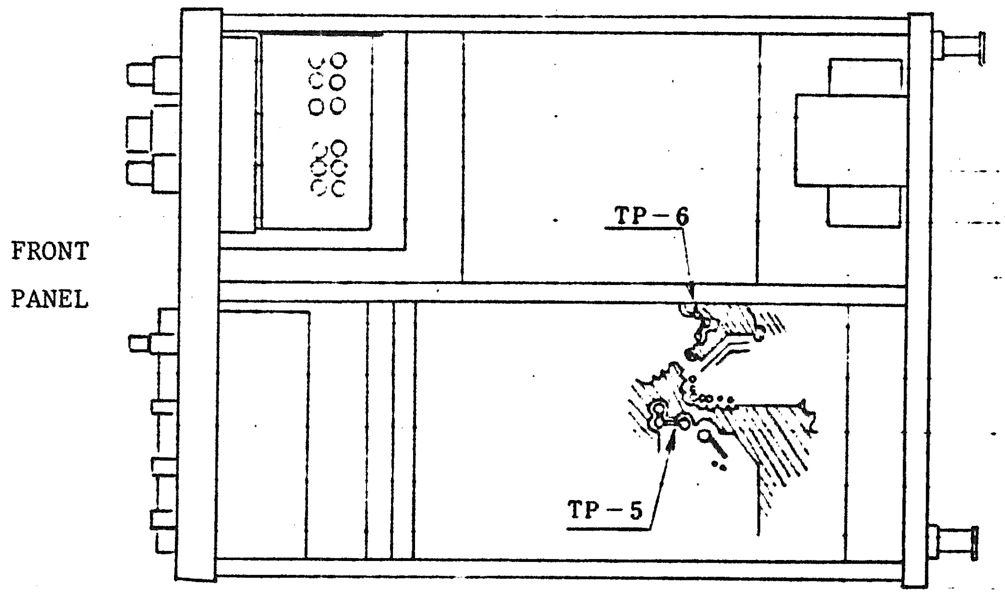

Figure 26 (Bottom view)

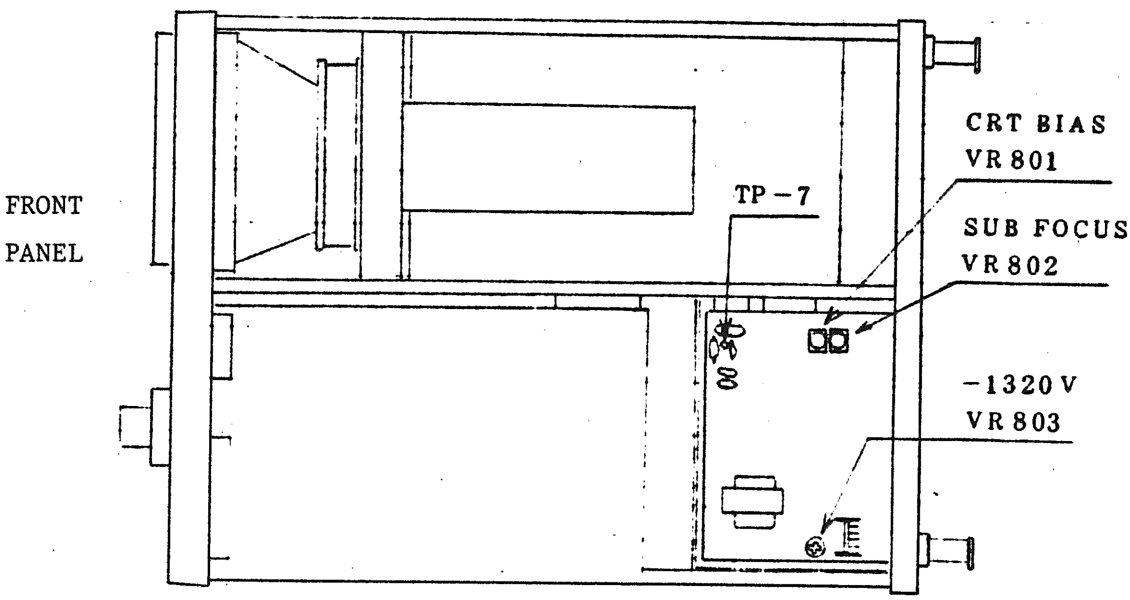

Figure 27 (Top view)

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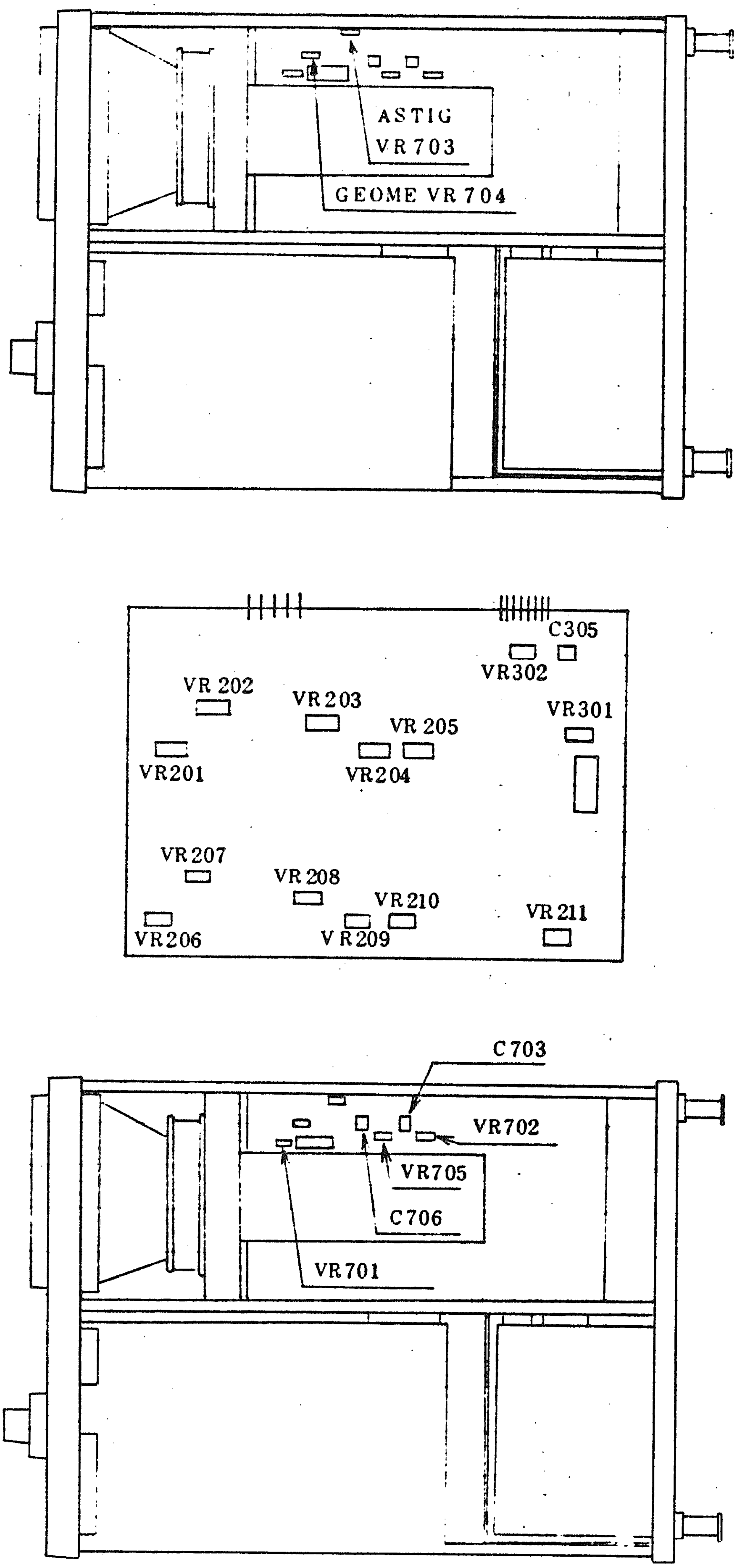

Figure 30 (Top view)

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7.4 Adjustment of CRT Circuits

o Adjustment of CRT BIAS:

This control is for adjusting the operating position of the INTEN knob 4.

(1) Set the larger knob of TIME/DIV switch 36 at 1 mS and display the single-line horizontal trace on the screen with A sweep.

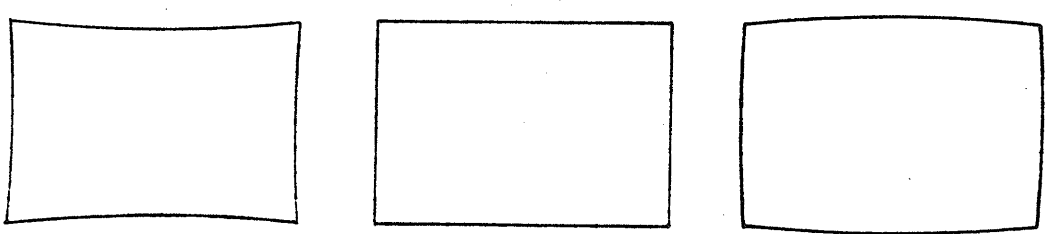
(2) Set the white mark of the INTEN knob in the upright position (noon position) and so adjust the CRT BIAS control (Figure 27, VR801) that the trace is displayed on the screen with a barely discernible intensity.

o Adjustment of GEOMETRY:

This control is for reducing geometrical distortions (pincushion distortions or barrel distortions) of the pattern displayed on the screen.

(1) Apply a sinusoidal signal of approximately 50 kHz to the vertical axis in the single-channel mode and display the signal with an amplitude of 8 DIV and with approximately 50 peaks.

(2) So adjust the GEOMETRY control (Figure 28, VR704) that the displayed pattern becomes as (b) in Figure 31.



(a) Pincushion distortion

(b) Normal

(c) Barrel distortion

Figure 31

o Adjustment of ASTIG:

The ASTIG control, in conjunction with the FOCUS control, must be so adjusted that the trace on the CRT screen becomes sharpest.

(1) Display a square wave of 1 kHz - 10 kHz, 4 DIV, in a mid-position of the CRT screen.

(2) So adjust the ASTIG control (Figure 28, VR703) and the FOCUS control on the front panel that the displayed image becomes sharpest.

o Adjustment of FOCUS:

This control must be so adjusted that focussing is not varied even when the intensity is varied with the INTEN knob. (semi-automatic focussing)

(1) Display a square wave of 1 kHz - 10 kHz, 4 DIV, in a mid-position of the CRT screen.

(2) Turn the INTEN knob of the front panel to a position slightly counterclockwise from the extremely clockwise position, so that a bright trace is displayed.

(3) So adjust the SUB-FOCUS control (Figure 27, VR802) that the image becomes sharpest.

(4) Check that the position of the FOCUS control is not required to be changed even when the trace intensity is lowered.

7.5 Adjustment of Vertical Axis

- Adjustment of DC balance

This adjustment is for minimizing the shift of the trace when the VARIABLE knob 16 or 17 is turned.

(1) Depress the GND switch 12 or 13 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 in Figure 29) that the shift of the trace becomes minimum.

- 5 × MAG DC BAL adjustment (1 mV DC BAL):

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

(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 1 mVDC BAL control (VR203 for CH1 or VR208 for CH2 in Figure 29) that, when the POSITION knob is pulled out and pushed in, the shift of the trace becomes minimum.

- Adjustment of INV BAL:

This adjustment is for minimizing the shift of the trace when the CH2 POLARITY INV switch 21 is depressed.

(1) Press the GND switch 13 so that the vertical circuit becomes the GND state and the base trace line is displayed.

(2) So adjust the INV BAL control (Figure 29, VR209) that the trace shift becomes minimum even when the CH2 POLARITY INV switch is depressed.

o Adjustment of CH1 POS CENT:

This control must be so adjusted that the trace is positioned in the center of the CRT screen when the white dot of CH1 POSITION knob 18 is set in the upward position (mid-position).

(1) Press the GND switch 12 of CH1 so that the base trace line is displayed.

(2) So adjust the CH1 POS CENT control (Figure 29, VR204) that the trace is in the mid-position of the screen when the white dot of the CH1 POSITION knob is in the upward position (mid-position).

o Adjustment of ADD BAL:

This adjustment is for minimizing the 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 (Figure 29, VR301) that the trace remains at the center of the screen when the operation is changed to the ADD mode by pressing the ADD button 24 of vertical mode selector switch.

o Adjustment of CH1 SIGNAL OUT DC BALANCE:

This adjustment is for DC balancing of the CH1 signal output.

(1) Depress the GND switch (12) of CH1 so that the base trace line is displayed.

(2) Measuring the DC potential of the CH1 SIGNAL OUT terminal (53) with a DC voltmeter or an oscilloscope, so adjust the CH1 SIGNAL OUT DC BAL control (Figure 29, VR211) that the DC potential becomes 0 ±10 mV.

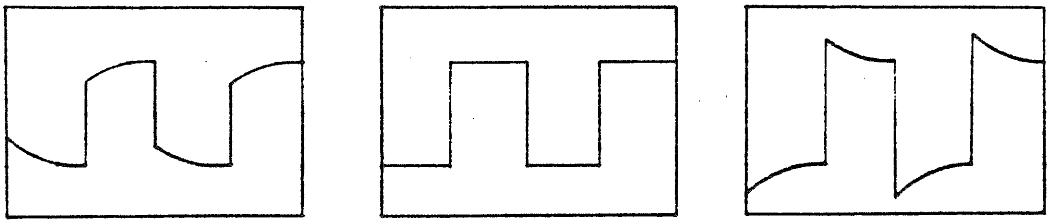
o Adjustment of square wave characteristics of vertical amplifiers:

This adjustment is to adjust the square wave characteristics of the vertical amplifiers so that their frequency response becomes flat. The adjustment for both channels should be done at the 5 mV/DIV range, using a quality square wave with rise time 3.5 nsec or faster and with less ringing, overshoots or sag.

(1) Adjustment of middle frequency range:

Set the VOLT/DIV switches (14) and (15) at 5 mV/DIV and the TIME/DIV switch (36) at 2 µS/DIV. Apply to the vertical input terminal a square wave of 100 kHz and so adjust the signal generator output that the waveform with an amplitude of 4 DIV is displayed.

Next, so adjust the DC COMP (Figure 29, VR302, C305) that the displayed waveform becomes as (b) in Figure 29.



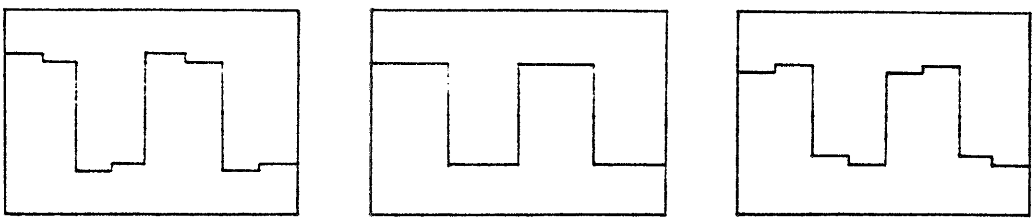
Adjustment required (a) | Ideal (b) | Adjustment required (c)

Figure 32

(2) Adjustment of high frequency range:

Change the input square wave signal frequency to 1 MHz and set the TIME/DIV switch 36 at 0.2 μS/DIV. Next, so adjust the FINAL COMP control (Figure 30, VR705 and C706, and VR702 and C703) that the displayed waveform becomes as flat as possible. In this case, use VR702 and C703 for the middle-higher range and VR705 and C706 for the high range, paying attention to peaking.

Also adjust matching of the delay line with VR701. If the delay line is mis-matched, the displayed waveform will be as (a) or (c) in Figure 33. (The pattern of (b) is normal.) Note that the vertical sensitivity is affected when this adjustment is done.



(a) | (b) | (c)

Figure 33

- Calibration of vertical sensitivity:

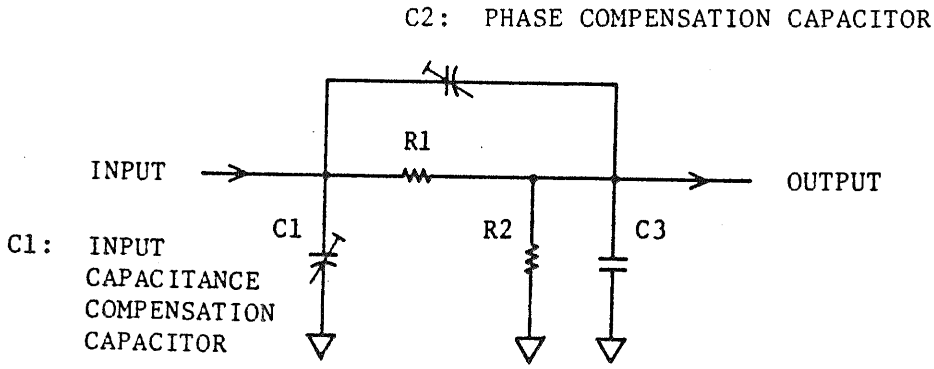
This procedure is to calibrate the gains of the vertical amplifiers to the values indicated by the VOLTS/DIV switches (14) and (15). For this calibration, use a signal generator which provides a square-wave output signal with a voltage setting accuracy of 0.5% or better at a frequency of 1 kHz.

(1) Set the signal generator output at 8 times of the voltage (Vp-p) indicated by the VOLTS/DIV switch and apply this signal to the vertical input terminal.

(2) Set the VARIABLE knob in the CAL'D position (extremely clockwise position). So adjust the GAIN ADJ control (Figure 29, CH1-VR202, CH2-VR207) that the signal is deflected to the full scale of the graticule.

- Adjustment of input attenuator:

The VOLTS/DIV switch selects the oscilloscope sensitivity by switching the attenuator circuit consisting of pre-stage attenuator (1/10, 1/100) and post-stage attenuator (1/2, 1/4, 1/10). With combinations of these attenuators, a wide range of 1/2 to 1/1000 can be covered. Each attenuator has two DC-voltage dividing resistors and three or four high frequency voltage dividing capacitors. A basic circuit diagram of the attenuator is shown in Figure 34.



R1, R2: DC-voltage dividing resistors

C2, C3: High frequency voltage dividing capacitors

C1: Input capacitance compensation capacitor

Figure 34

The phase compensation adjustment must be done first and the input capacitance adjustment next.

(1) Adjust at first the input capacitance when at 1/1, 5 mV range. Connect a low-capacitance C-meter to the input terminal and so adjust C1 that the input capacitance becomes 25 pF ±2 pF. No phase compensation adjustment is required for the 1/1 attenuator.

(2) Adjustment of post-stage attenuator (1/2, 1/4, 1/10):

Use a square wave signal generator which provides a quality square wave of rise time 1 μsec or faster, without sag or overshoot. Apply the signal for each of the ranges (10 mV, 20 mV, 50 mV) and display a waveform with an amplitude of 4 DIV. So adjust the phase compensation capacitor shown in the following table that an ideal waveform is displayed. Next, connect a low-capacitance C-meter to the input terminal and so adjust the input-capacitance compensation capacitor that the input capacitance at each range becomes 25 pF ±2 pF.

		CH1		CH2	
		Phase compen-sation	Input capaci-tance	Phase compen-sation	Input capaci-tance
	1/1 (5mV)	--	C121	--	C143
Post-stage	1/2 (10mV)	C110	C111	C133	C135
	1/4 (20mV)	C113	C114	C136	C137
	1/10 (50mV)	C116	C117	C139	C140
Pre-stage	1/10 (0.1V)	C104	C103	C127	C126
	1/100 (1 V)	C106	C107	C130	C129

(3) Adjustment of pre-stage attenuator:

In a similar manner as (2) above, adjust the phase compensation capacitor and input-capacitance compensation capacitors shown in the above table for each of the ranges (0.1 V and 1 V). Locations of the trimmer capacitors are shown in Figure 35.

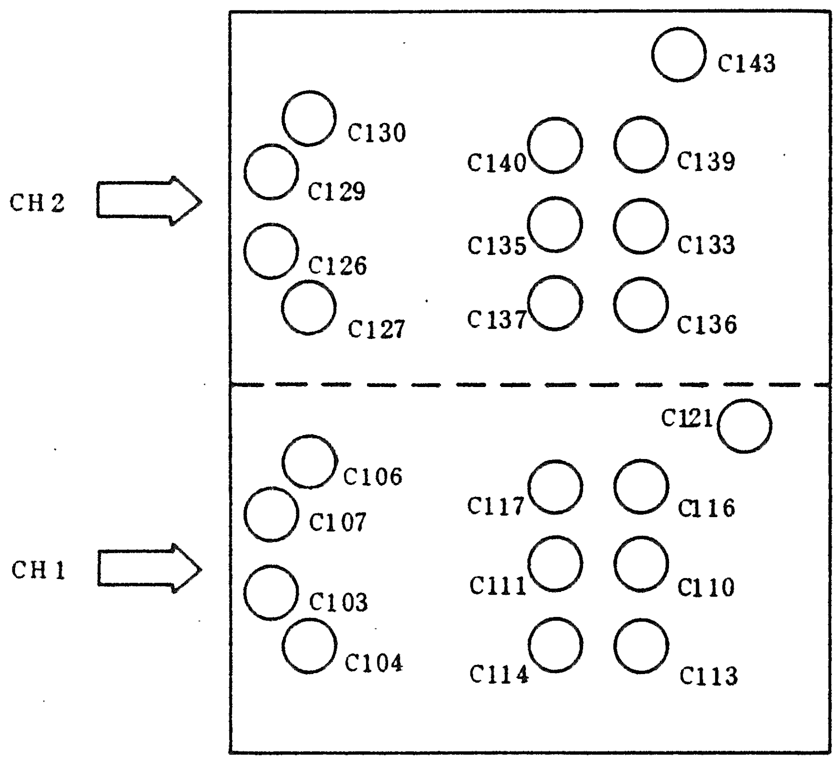


Figure 35

o Adjustment for XY operation:

This procedure is for sensitivity and position adjustment for XY operation.

(1) Calibration of XY sensitivity:

Operate the instrument as an XY-scope and apply a square wave signal of 50 mVp-p to the X-axis input using the same signal generator used for vertical axis calibration. Set the X-axis sensitivity at 5 mV/DIV and so adjust the XY GAIN ADJ control (Figure 36, VR402) that the signal is deflected with an amplitude of 10 DIV on the screen.

(2) XY position adjustment:

Operate the instrument as an XY-scope and ground the input circuits of both axes. So set the POSITION knob 38 that its white dot is positioned upward and, under this state, so adjust the XY CENT control (Figure 29, VR205) that the spot is positioned at the center of the CRT screen.

7.6 Adjustment of Trigger Circuits

This procedure is for DC BAL adjustment of internal trigger circuits.

Ground the input circuits of both CH1 and CH2 channels. Operate the instrument as a single-channel oscilloscope with CH1 channel alone. Measure the DC voltage between TP-8 and ground (Figure 34), using a multimeter, a digital voltmeter or an oscilloscope. So adjust the CH1 TRIG DC BAL (Figure 36, VR403) so that the DC voltage becomes 0 V ±0.2 V.

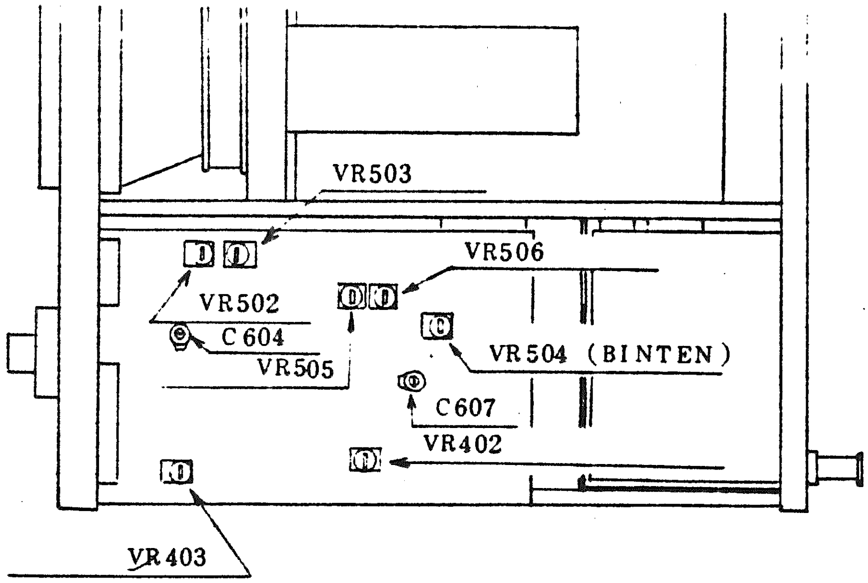


Figure 36 (Top view)

Next, operate the instrument as a single-channel oscilloscope with CH2 channel alone. So adjust the CH2 TRIG DC BAL (Figure 29, VR210) that the DC voltage becomes 0 V ±0.2 V.

7.7 Adjustment of Sweep Circuit

This adjustment is for calibrating the A and B sweep time and the sweep start point for each type of sweep.

- Calibration of A sweep time:

For this calibration, use an accurate time marker signals of 1 msec and 10 µsec or signals of accurate frequencies of 1 kHz and 100 kHz.

(1) Apply to the vertical input terminal a time marker signal of 1 msec or a signal of 1 kHz, and display the signal with an appropriate amplitude on the screen.

(2) Set the A SWEEP VARIABLE knob 37 in the CAL'D position. Set the TIME/DIV switch 36 (larger knob) at 1 mS.

(3) So adjust the A SWEEP CAL (Figure 36, R502) that the displayed waveform conforms with scale divisions of the graticule.

(4) Change the input signal to a time marker signal of 10 μS or sinusoidal wave signal of 100 kHz and change the TIME/DIV switch to 10 μS.

(5) So adjust the A 10 μS CAL (Figure 36, C604) that the displayed signal waveform conforms with scale divisions of the graticule.

When the above calibration is complete, the sweep speeds of the remaining ranges also are calibrated at an accuracy of ±3%.

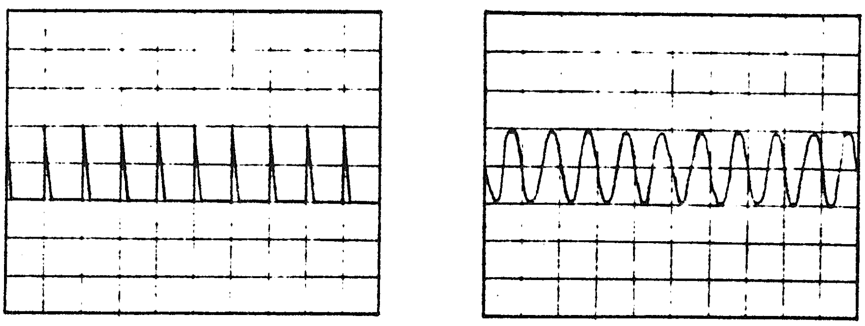


Figure 37

- Calibration of B sweep time:

Using the same signal generator used for calibration of A sweep time, adjust the sweep time for HORIZ DISPLAY B 45 .

(1) Apply a signal of 1 mS (or 1 kHz) to the vertical axis and display the signal with an appropriate amplitude on the CRT screen.

(2) Set the smaller knob of TIME/DIV switch (36) at 0.5 mS and the larger knob at 1 mS. So adjust the DELAY TIME control that more than five peaks are displayed on the CRT screen.

(3) So adjust the B SWEEP CAL control (Figure 36, VR506) that the peaks of the displayed waveform are aligned with every other graticule lines as shown in Figure 38.

(4) Change the input signal to 10 μS (or 100 kHz) and change the smaller knob of the TIME/DIV switch to 10 μS and the larger knob to 20 μS.

(5) So adjust the B 10 μS CAL control (Figure 36, C607) that the peaks are aligned with the graticule scale division lines.

When the above calibration is complete, the sweep speeds of the remaining ranges also are calibrated at an accuracy of ±3%.

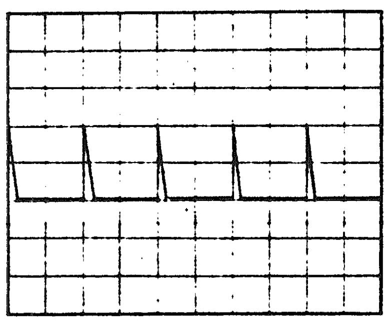


Figure 38

o Adjustment of sweep start position:

This adjustment is for attaining such state that, when the white dot of the horizontal POSITION knob 38 is set at the upward position, the sweep starts from the left hand end of the graticule.

(1) Set the larger knob of TIME/DIV switch 36 at 1 mS and the smaller knob at 0.5 mS. Press the A button 43 of the HORIZ DISPLAY switch.

(2) Set the white dot of the horizontal POSITION knob in the upward position. So adjust the A SWEEP POSITION control (Figure 36, VR503) that the sweep starts from the left hand end of the graticule.

(3) Press the B button 45 of the HORIZ DISPLAY switch.

(4) So adjust the B SWEEP POSITION control (Figure 36, VR505) that the sweep starts from the left hand end of the graticule.

o Adjustment for DELAY TIME POSITION control:

This procedure is for adjusting the variable range of the DELAY TIME position knob 48 .

(1) Press the A INTEN button 44 of the HORIZ DISPLAY switch. Set the larger knob of TIME/DIV switch 36 at 1 mS and the smaller knob at 0.1 mS.

(2) Adjust to appropriate brightness the accentuated portion of the B sweep with the B SWEEP INTEN ADJ control (Figure 36, VR504).

(3) Turn to the extremely counterclockwise position both inner and outer DELAY TIME POSITION knobs. So adjust the LOWER LEVEL ADJ control (Figure 39, VR907) that the left-hand end point of the B sweep portion is set at 0.5 DIV from the left-hand end of the graticule.

(4) Turn to the extremely clockwise position both inner and outer DELAY TIME POSITION knobs. So adjust the UPPER LEVEL ADJ control (Figure 39, VR906) that the left-hand end point of the B sweep portion is set at 0.5 DIV outside of the right-hand end of the graticule.

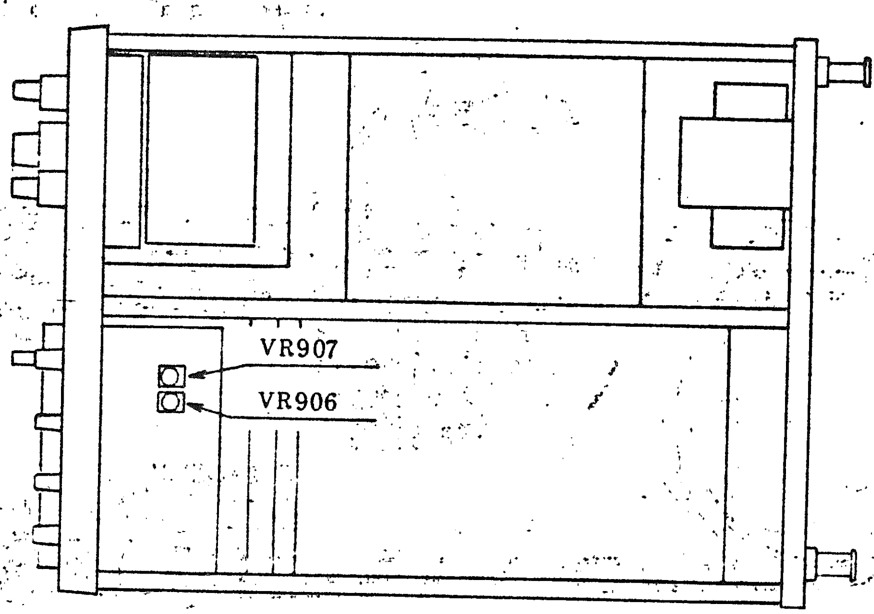


Figure 39 (Bottom view)

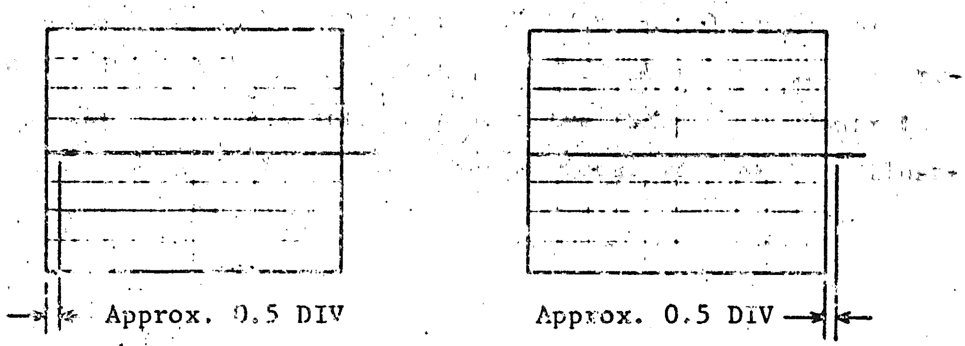


Figure 38

7.8 Calibration of Probe

For probe calibration, use the calibration signal of the CALIB terminal of the front panel.

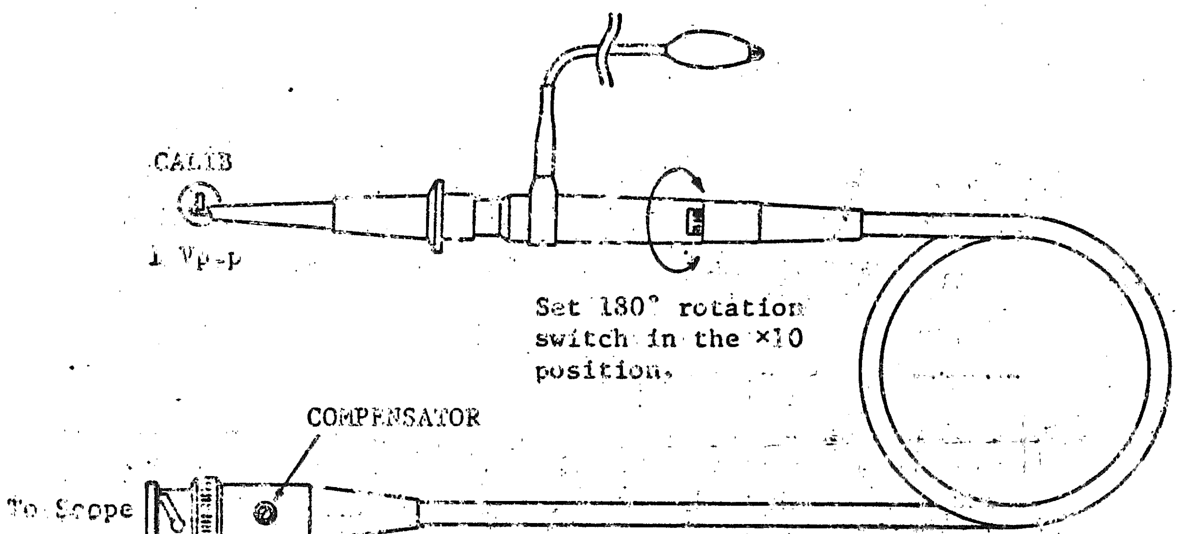
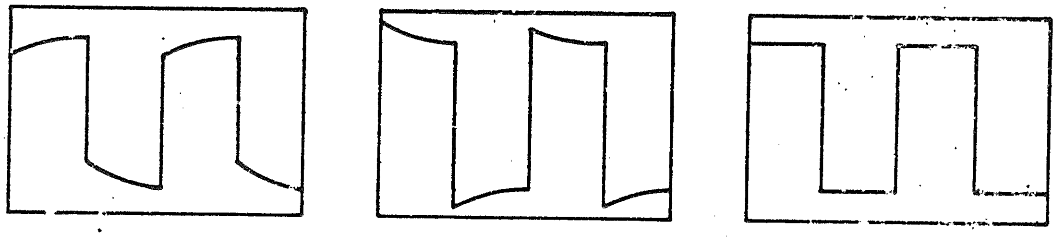


Figure 39

Connect the probe connector to the INPUT terminal of CH1 or CH2 and set the VOLTS/DIV swicch in the 20 mV position. Observing the displayed waveform, so adjust the COMPENSATOR control with an insulated screw-driver that an ideal waveform as illustrated below is obtained.



Adjustment required | Adjustment required | Ideal

Figure 40

The accessory probe (960 BNC) is capable of switching between 10:1 and 1:1. When used with this instrument, its specifications are as follows:

Specification	10:1	1:1
Frequency response	DC - 50 MHz (within -3 dB)	DC - 6 MHz (within -3 dB)
Input resistance	10 MΩ (±3%)	1 MΩ (oscilloscope)
Input capacitance	20 pF (±10%)	Approx. 190 pF
Attenuation ratio	1/10	1/1
Maximum input voltage	600 V (DC+AC peak)	400 V (DC+AC peak)