INSTRUCTION MANUAL

FOR

MODEL 5513SF OSCILLOSCOPE

KIKUSUI ELECTRONICS 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.

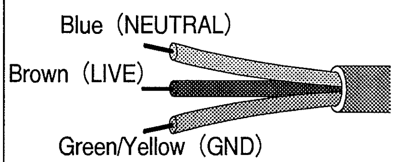
☐ AC power cable

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.

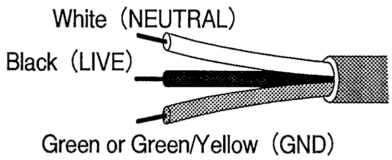
WARNING

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

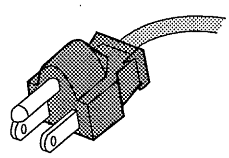
☐ Without a power plug



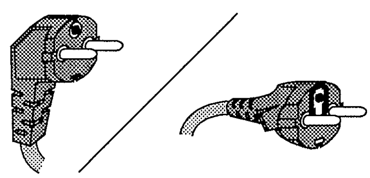
☐ Without a power plug



☐ 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

<u>TABLE OF CONTENTS</u>

1. GENERAL

1.1 Description

Kikusui Model 5513SF Oscilloscope is a trigger-synchronized dualtrace portable oscilloscope with a 133-mm round high-bright low-distortion cathode ray tube. Its sensitivity is 10 mV/DIV, bandwidth 10 MHz, and sweep speed 200 nsec/DIV (under 5 × MAG mode). Its outstanding feature is the SELF WAVE-FIXED function that a fixed number of waves are displayed on the CRT irrespective of input signal frequency change. It is sturdy and easy to operate, and it can be used for research and development of various electronic devices as well as for production and maintenance service. Features of the 5513SF can be summarized as follows:

1.2 Features

- SELF WAVE-FIXED circuit:

  When the SELF WAVE-FIXED switch is depressed, a fixed number of waves (adjustable for single wave to four waves) are displayed on CRT irrespective of input signal frequency change for a range of 10 Hz to 100 kHz. (This function is abbreviated as SF.)

- Front frame made of aluminium diecast:

  To provide a neat external view and a sufficient mechanical strength, the front frame is made of aluminium diecast.

- Excellent manipulatability:

  The 5513SF provides an excellent manipulatability with light-torque rotary switches and pushbutton switches.

- High-brightness CRT:

  The 5513SF employs a CRT of an excellent beam transmission factor, providing a sufficient trace brightness even at the highest sweep speed.

- Stable acceleration voltage:

  The acceleration voltage of the 5513SF is very stable against line voltage variation, as this high voltage is regulated with a unique control circuit.

- Rotation coil for trace leveling:

  The 5513SF employs a rotation coil which enables you to adjust (rotate) the base line for leveling when it has become slanted by terrestrial magnetism. Adjustment can be done at the front panel.

o Automatic CHOP/ALT switching:

The operating mode is automatically switched between CHOP mode and ALT mode in conformity with the sweep speed (linked to the TIME/DIV switch), thereby preventing troublesome manual switching between the two modes when in the dual-channel operation.

o Automatic TV·V/TV·H synchronization switching:

The TV synchronization separator circuit is automatically switched between TV·V and TV·H in conformity with the sweep time, being linked to the TIME/DIV switch.

o X-Y mode is switched by one-touch action:

Simply by switching the operation of the vertical axis, the oscilloscope can be converted into an X-Y scope with CH1 input for X-axis and CH2 input for Y-axis.

o Maximum sweep time 200 nsec/DIV (with 5 × MAG):

The sweep time can be magnified by 5 times. By magnifying the sweep time of 1 μsec/DIV by 5 times, a sweep time as fast as 200 nsec/DIV can be attained.

2. SPECIFICATIONS

Cathode-ray Tube

Item	Spec.	Remarks
Shape	Round, 133 mm	
Fluorescent screen	B31	Green
Acceleration voltage	Approx. 1600 V	Regulated
Area (graticule)	8 × 10 DIV	1 DIV = 9.5 mm
Unblanking	DC-coupling	at G1 of the CRT

Vertical Axis

Item	Spec.	Remarks
Sensitivity	10 mV/DIV ~ 5 V/DIV	1-2-5 sequence
Sensitivity accuracy	Better than ±5% of panel-indicated value when VARIABLE knob is set in CAL'D position	
Continuously-variable sensitivity adjustment	Continuously variable covering between two mutually adjoining ranges.	
Frequency response	DC: DC ~ 10 MHz AC: 2 Hz ~ 10 MHz	50 kHz, 8 DIV reference, within -3 dB
Rise time	Approx. 35 nsec	
Input impedance	1 MΩ ±2%, approx. 30 pF ±2 pF	Probe can be used
Input terminals	BNC receptacles	
Maximum allowable input voltage	600 Vp-p, for 1 minute. (400 Vp-p for 10, 20, and 50 mV/DIV ranges)	DC + AC peak, frequency not higher than 1 kHz.
Input coupling selection	AC, DC, GND	

Item	Spec.		Remarks
Base line shift caused by range selection	Less than ± 0.5 DIV		Including shift caused by disturbance of DC balance
Operation modes of vertical axis	CH1	Single-channel mode	
	CH2	Single-channel mode	
	DUAL	CHOP mode	When SF switch is OFF: 100 msec/DIV ~ 1 msec/DIV When SF switch is ON: Input frequency not higher than approx. 200 Hz
		ALT mode (linked to TIME/DIV switch when SF switch is OFF)	When SF switch is OFF: 100 μsec/DIV ~ 1 μsec/DIV When SF switch is ON: Input frequency higher than approx. 200 Hz
Chop frequency	Approx. 200 kHz		

Triggering

Item	Spec		Remarks
Trigger modes	NORM	When trigger signal is removed, base line is blanked out and sweep is in STANDBY state.	Satisfies the trigger sensitivity specification.
	AUTO	When trigger signal is removed, sweep is in AUTO(FREE RUN) mode.	Satisfies the trigger sensitivity specification for repetative signals of 10 Hz or over.
	TV	TV sync. separator circuit is connected to trigger circuit. When trigger signal is removed, sweep is in AUTO (FREE RUN) mode.	When SF switch is OFF: 100 msec ~ 100 μsec ..... TV·V 10 μsec ~ 1 μsec ..... TV·H When SF switch is ON: TV·V only
Trigger source	INT	As you set the VERT MODE switch in a single channel position (CH1 or CH2), the input signal of the selected channel is automatically used as the trigger signal.	

Item	Spec.		Remarks
		As you set the VERT MODE switch in the DUAL position, the signal CH1 alone is used as the trigger source.	
	EXT	The input signal of EXT TRIG terminal is used as the trigger signal.	
Internal trigger sensitivity WIDE HF·REJ TV	 3 Hz ~ 10 MHz: 0.5 DIV 3 Hz ~ 50 kHz: 0.5 DIV Video signal amplitude: 1.0 DIV		
External trigger sensitivity WIDE HF·REJ TV	 3 Hz ~ 10 MHz: 0.5 V 3 Hz ~ 50 kHz: 0.5 V Video signal: 1.0 V		
Polarity (SLOPE)	"+" and "-"		
Coupling	AC and HF REJ		
EXT trigger input impedance	Approx. 1 MΩ, 30 pF or less		

Item	Spec.	Remarks
Maximum allowable input Voltage	100 Vp-p (DC + AC peak)	Frequency not higher than 1 kHz
External input terminals	Binding post terminals	

Horizontal Axis

Item	Spec.	Remarks
Sweep time	1 μsec/DIV ~ 100 msec/DIV, 6 ranges	1, 10, step
Continuously variable range of sweep time	Continuously variable to 10 times or over of panel indicated value	
Sweep time accuracy	Better than ±3%	
Sweep time magnification	5 times	
Sweep magnification accuracy	Within ±5%	
Position shift caused by magnification	Less than 1 DIV at CRT screen center	

Item	Spec.	Remarks
X-Y mode	CH1 for X (horizontal) CH2 for Y (vertical)	
Sensitivity	The same spec's as CH1 of the vertical axis.	
Frequency response	DC: DC ~ 1 MHz AC: 2 Hz ~ 1 MHz	50 kHz, 10 DIV reference: within -3 dB
Input impedance	The same spec's as CH1 of the vertical axis.	
Maximum allowable input voltage	The same spec's as CH1 of the vertical axis.	
X-Y phase difference	Within 3° at 50 kHz	

SELF WAVE-FIXED Sweep

Item	Spec.	Remarks
Frequency response range	The number of displayed waves can be fixed within a range of one wave to four waves for an input signal frequency range of 10 Hz to 100 kHz.	One cycle of wave displayed in 10 DIV on horizontal axis is counted as one wave.
Variable range of wave number	Continuously variable for a range of one wave to four waves.	
Accuracy of swept wave number	±5% or better (5°C ~ 35°C)	

Z Axis

Item	Spec.	Remarks
Sensitivity	Intensity modulation discernible with an input of 3 Vp-p or over	
Frequency response	DC ~ 5 MHz	
Polarity	Positive-going: Darkened Negative-going: Brightened	
Input resistance	Approx. 10 kΩ	
Input terminals	Binding post terminals	

Calibration Voltage

Item	Spec.	Remarks
Waveform	Square wave, positive-going	
Output voltage	1 Vp-p, ±3%	
Frequency	1 kHz ±25%	
Duty ratio	45 : 55 ~ 55 : 45	
Output terminal	Chip terminal	

Power Requirements

Item	Spec.	Remarks
AC line voltage	100, 110, 120, 220, 230, or 240 V. (Within ±10% of each nominal voltage)	Selectable with transformer taps
Frequency	50 ~ 60 Hz	
Power consumption	Approx. 26 VA	

Mechanical Specification

Item	Spec.	Remarks
Overall dimensions	244 W × 184 H × 370 D mm (9.61W × 7.24H × 14.57D in.) 250 W × 210 H × 435 D mm (9.84W × 8.27H × 17.13D in.)	 Maximum dimensions
Weight	Approx. 7.5 kg (16.5 lb.)	

Accessories

Instruction manual 1

960 BNC Type Probe (10:1, 1:1) 2

942A Type Terminal Adaptor (BNC, binding post) 2

3. OPERATING INSTRUCTIONS

3.1 Explanation of Front Panel (See Fig. 1)

No.	Panel mark	Description
①	INTEN POWER OFF	Intensity control knob with POWER switch, Extremely counterclockwise position is POWER OFF. As turned clockwise, POWER is turned ON and intensity increases.
②		Indicates ON/OFF state of instrument power.
③	TRACE ROTATION	Semi-fixed resistor for level (horizontal inclination) adjustment of base line which may be inclined by terrestrial magnetism, etc. Adjust with a fine screwdriver.
④	FOCUS	So adjust this knob that the trace displayed on the screen becomes sharpest.
⑤	CAL 1 Vp-p	Output terminal which provides a calibration voltage used for oscilloscope sensitivity adjustment and probe calibration. The calibration voltage is 1 Vp-p, positive-going square wave of approx. 1 kHz.
⑥	⏚	Ground terminal

No.	Panel mark	Description
⑦	POSITION ↕	For vertical positioning of CH2 (or Y-axis). The trace moves upward as this knob is turned clockwise, and vice versa.
⑧ ⑨ ⑩ ⑪	MODE CH1 ⑪ DUAL ⑩ (CH1 TRIG) X-Y ⑨ CH2 ⑧	Pushbutton switch (4-gang) for operation mode switching of CH1 and CH2 amplifiers and for trigger signal source switching. CH1: Single-channel operation with CH1 vertical amplifier alone. The CH1 input signal is used as the trigger signal. CH2: Single-channel operation with CH2 vertical amplifier alone. The CH2 input signal is used as the trigger signal. DUAL: Dual-channel operation with CH1 and CH2 vertical amplifiers, in the CHOP or ALT mode. The CH1 input signal is used as the trigger signal. When SELF WAVE-FIXED switch ㉞ is OFF ▮, CHOP or ALT mode is automatically selected being linked to TIME/DIV switch.

No.	Panel mark	Description
		When SELF WAVE-FIXED switch (34) is ON, CHOP or ALT mode is automatically selected in conformity with the input signal frequency. X-Y: X-Y operation with CH1 as X-axis (horizontal) and CH2 as Y-axis (vertical).
(12)	POSITION ↕	For vertical positioning of CH2. The function is the same with that of No. (7).
(13) (15)	VOLTS/DIV	Vertical sensitivity selector switch for 10 mV/DIV ~ 5 V/DIV in 9 ranges, of CH1 (or X-axis) or CH2 (or Y-axis). Set in a position for attaining an appropriate deflection amplitude on CRT screen.
(14) (16)	VARIABLE	Continuously-variable adjustment of vertical sensitivity of CH1 (or X-axis) or CH2 (or Y-axis), covering between ranges selected by VOLTS/DIV switch ((13) or (15)). (At the CAL'D position, sensitivity is calibrated to the value indicated by VOLTS/DIV switch.)

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No.	Panel mark	Description
⑰ ⑱	CH1 (X) CH2 (Y)	Input terminals for CH (X-axis) and CH2 (Y-axis). When in X-Y operation, CH1 is used as X-axis (horizontal axis). The signal can be applied with BNC probe or BNC connector.
⑲ ㉑	▮ AC ▬ DC	Pushbutton switch for selection of input coupling of vertical amplifier. The popped up state (▮) is for AC coupling and the depressed state (▬) for DC coupling.
⑳ ㉒	▬ GND	Pushbutton switch for isolating the input signal from amplifier input point and grounding the amplifier input point. When this switch is depressed (grounded state), the input terminal becomes open. These switches are used for checking of 0 level, etc.
㉓	EXT TRIG IN	Input terminal for external trigger signal. When the TRIGGERING switch ㉙ is set in the EXT state, the sweep is triggered by the signal applied to this terminal.
㉔	TIME/DIV	Horizontal sweep time selector switch for 100 msec/DIV ~ 1 μsec/DIV in 6 ranges. This switch remains idle when SELF WAVE-FIXED switch ㉞ is ON.

No.	Panel mark	Description
㉕	VARIABLE	Continuously-variable adjustment of sweep time, covering between ranges selected by TIME/DIV switch ㉔ when SELF WAVE-FIXED switch ㉞ is OFF ▮ . (When this knob is set in the CAL'D position, the sweep time is calibrated at the value indicated by the TIME/DIV switch.)
	WAVE-FIXED VARIABLE	Continuously variable adjustment of the number of waves displayed on screen when SELF WAVE-FIXED switch ㉞ is ON ▬ , for a range of 1 ~ 4 waves or over.
㉙	LEVEL - ◄ 0 ► +	Trigger level adjustment for displaying stationary waveform. The trigger level rises as this knob is turned toward ► + and it falls as the knob is turned toward - ◄.
㉗ ㉘ ㉙	TRIGGERING ▮ INT WIDE + ▲ EXT HF REJ − ☐ ☐ ☐	Triggering switch circuit consisting of trigger source selector switch ㉙ , input coupling selector switch ㉘ , and slope selector switch ㉗ . Trigger source selector switch ㉙ ▮ INT: Trigger source is internal (the signal displayed on CRT screen is used as the trigger signal).

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No.	Panel mark	Description
		▁ EXT: Trigger source is external (the signal applied through TRIG IN terminal (23) is used as the trigger signal). Input coupling selector switch (28) ▌ WIDE: Trigger circuit is AC-coupled to the trigger source and triggering can be done for a range of 3 Hz ~ 10 MHz. ▁ HF·REJ: High frequency reject filter (50 kHz, -3 dB) is connected to the trigger source and triggering is done through AC coupling. Triggering slope selector switch (27) ▌ +: Triggering is effected when trigger signal crosses the trigger level from negative side to positive side. ▁ -: Triggering is effected when trigger signal crosses the trigger level from positive side to negative side.

No.	Panel mark	Description
(30)	←→ POSITION PULL 5× MAG	Horizontal positioning knob which is used in common for 5× sweep magnification. The displayed waveform moves rightward as this knob is turned clockwise, and vice versa. When this knob is pulled out, the sweep time is multiplied by a factor of 5, thereby magnifying the horizontal amplitude by 5 times. (When in X-Y operation, sensitivity is increased by 5 times, although the frequency range becomes narrower.) When SELF WAVE-FIXED switch (34) is ON ▬ , the magnifier circuit remains idle.
(31) (32) (33)	TRIG MODE NORM AUTO TV	Pushbutton switches for selection of trigger mode. NORM (31) : When trigger signal is removed, trace is blanked out and sweep is in STANDBY state. Used primarity for observation of signals lower than 10 Hz. AUTO (32) : When trigger signal is removed, trace is not blanked out but sweep runs in AUTO (FREE RUN) mode, thereby providing a convenient state for confirming existance/absence of input signal and checking of zero

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No.	Panel mark	Description
		level. This mode is convenient for observation of repetitive signals of 10 Hz or over. TV ㉝ : TV sync separator circuit is connected to the trigger circuit. Being linked to TIME/DIV switch ㉔ , trigger circuit is automatically switched to TV·V or TV·H sync. signal. When SELF WAVE-FIXED switch ㉞ is ON▂ , sweep can be triggered with TV·V only. When trigger signal is not applied, sweep runs in AUTO (FREE RUN) mode.
㉞	SELF WAVE-FIXED OFF █ ON ▂	A fixed number of waves are displayed. OFF █ : TIME/DIV switch ㉔ operates. ON ▂ : TIME/DIV switch ㉔ remains idle. A fixed number of waves (1 ~ 4 waves set by WAVE-FIXED VARIABLE knob ㉕) are displayed.

3.2 Explanation of Rear Panel (See Fig. 2)

No.	Panel mark	Description
(35)	———	AC power cord of the oscilloscope
(36)	———	Studs for using the oscilloscope in a vertical attitude. Also used as AC power cord take-up posts.
(37)	Z-AXIS INPUT	Input terminal (binding post) for external intensity modulation signal. Used when intensity is controlled with an external signal, when intensity markers are displayed, etc. When not in use, this terminal must be connected to the GND terminal (38) with the shorting bar.
(38)	———	GND terminal (binding post). Spacing is 19 mm to match Z-AXIS INPUT terminal (37).
(39)	(FUSE)	Fuse holder. Fuse rating is 0.5 A for 100 V system AC line or 0.3 A for 200 V system AC line. For replacing the fuse, remove the cap by turning it counterclockwise.

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3.3 Explanation of Bottom Panel (See Fig. 3)

No.	Panel mark	Description
40	ASTIG	Semi-fixed resistor for astigmatism control. So adjust this control is conjunction with the FOCUS control that the trace is made sharpest.
41	——	Studs which are used also for fixing the stand.
42	——	Stand for setting the oscilloscope in a slanted attitude for ease of observation. Do not use this stand when oscilloscope camera and adaptor are used.

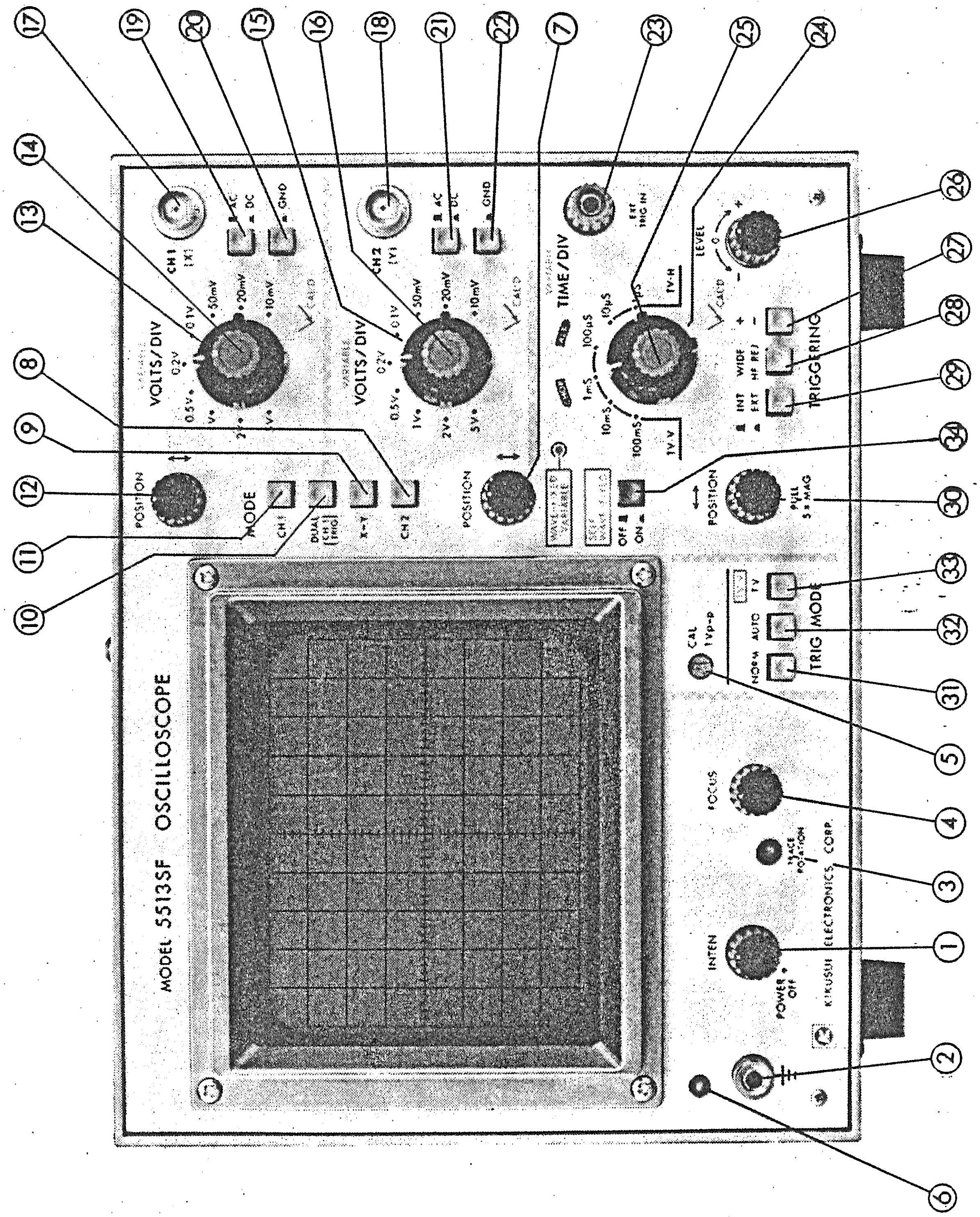
MODEL 5513SF OSCILLOSCOPE
KIKUSUI ELECTRONICS CORP.
VOLTS/DIV
TIME/DIV
TRIGGERING
TRIG MODE
MODE
POSITION
FOCUS
INTEN
CAL 1Vp-p
CH1 (X)
CH2 (Y)
EXT TRIG IN
LEVEL
NORM
AUTO
TV
X-Y
AC
DC
GND
POWER OFF
TRACE ROTATION
PULL 5×MAG
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Fig. 1

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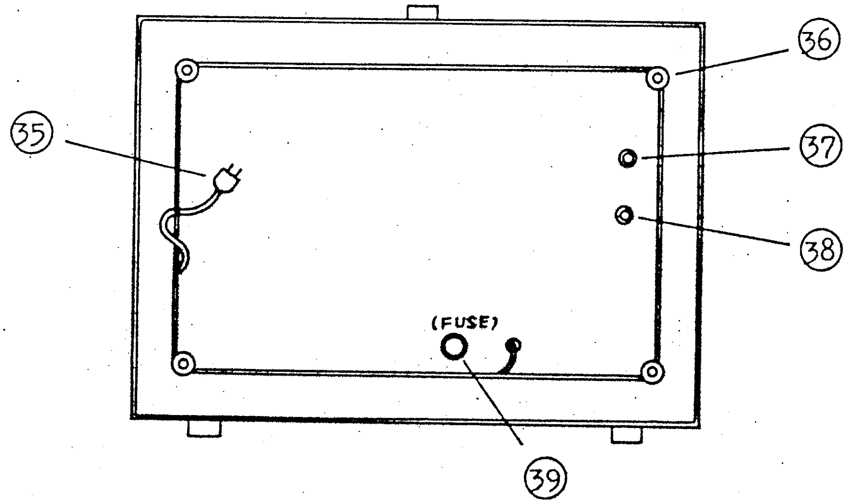


Fig. 2

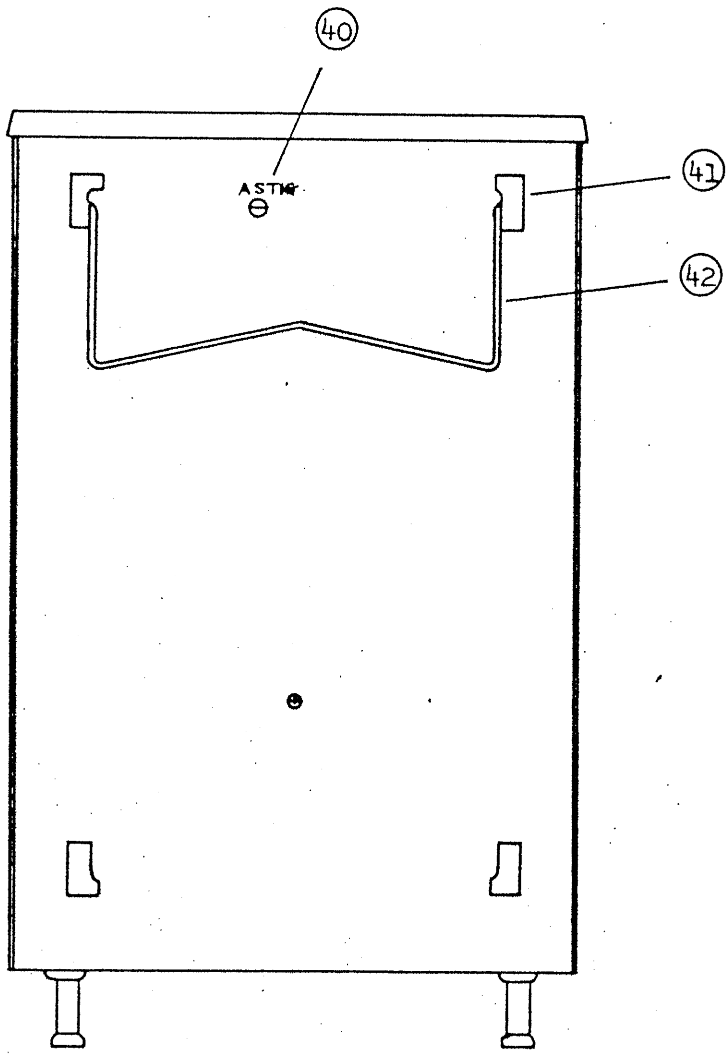


Fig. 3

3.4 Precautions in Operation

- Line voltage:

  The oscilloscope is set for operation on a 100 V $\pm 10\%$ AC line voltage. To operate the oscilloscope on other AC line voltage, it must be modified as explained in Para. 3.5 "AC Line Voltage Conversion." Note that the oscilloscope will not operate properly or may be damaged if it is operated on a wrong AC line voltage.

- Ambient temperature:

  The ambient temperature range for normal operation of the oscilloscope is $0^{\circ}C \sim 40^{\circ}C$.

- Environments:

  The oscilloscope must not be operated or stored in high temperature, high humidity atmosphere for a long period 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.

- Allowable voltages of input terminals:

The maximum allowable voltages of input terminals and probe 960 BNC are as shown in the below table. Note that the circuit may be damaged if a voltage larger than the allowable maximum is applied.

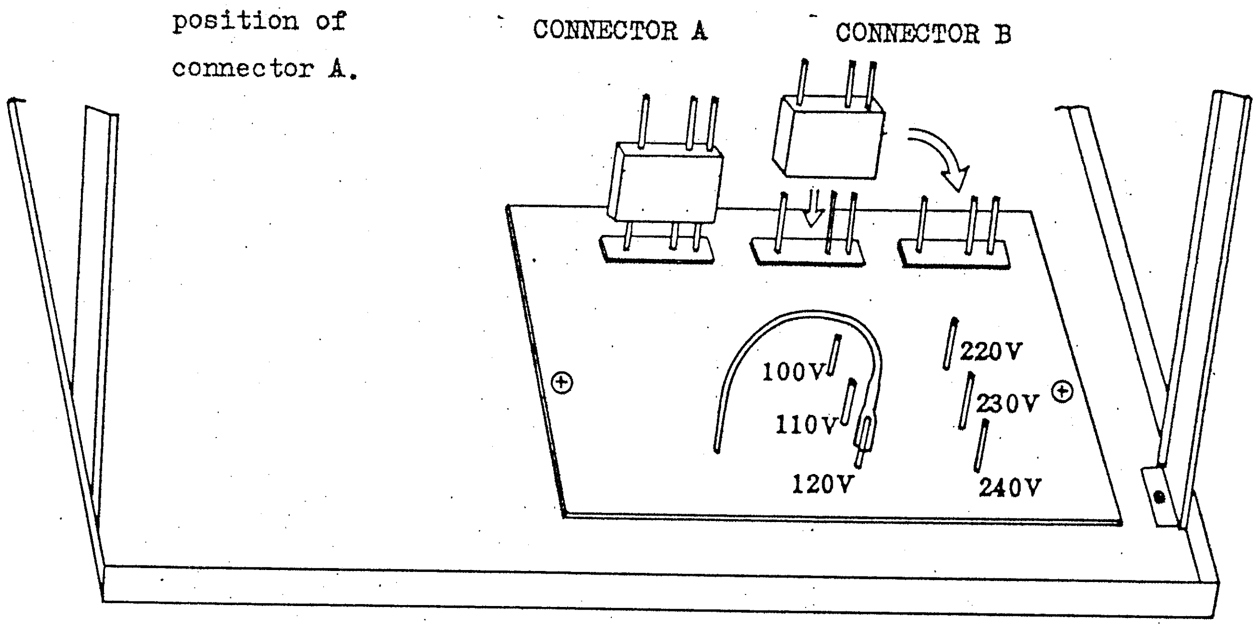
Terminal	Allowable maximum input voltage
Vertical input terminal	
10 mV, 20 mV, 50 mV/DIV ranges	400 Vp-p (DC + ACp, within 1 minute)
Other ranges	600 Vp-p (DC + ACp, within 1 minute)
Probe (960 BNC)	600 Vp-p (DC + ACp, within 1 minute)
EXT TRIG IN terminal	100 Vp-p (DC + ACp)
Z AXIS IN terminal	50 Vp-p (DC + ACp)
Repetition frequency of AC: Not higher than 1 kHz	

3.5 Line Voltage Conversion

As a general rule the 5513SF Oscilloscope is shipped being set for use on a 100 V AC line power. To operate the instrument on other AC line voltage, its AC power input circuit (power connector B, tap, and fuse) must be converted referring to the following table.

Nominal tap voltage	Applicable voltage range	Fuse	Connector
100 V 110 V 120 V	90 ~ 110 V 99 ~ 121 V 108 ~ 132 V	0.5 A	Connect the power connector B to the "100 V SYSTEM" pins.
220 V 230 V 240 V	198 ~ 242 V 207 ~ 253 V 216 ~ 264 V	0.3 A	Connect the power connector B to the "200 V SYSTEM" pins.

Do not disturb the connected position of connector A.



Connect the selector cord to the corresponding pin.

Fig. 4

Notes:

- Before performing AC line conversion, ensure that the AC power cord is disconnected from the AC power line outlet.

- Use a cord and a plug which meet the requirements of the line power to be used.

- The linefilter capacitor is not required to be changed.

4. OPERATING PROCEDURE

4.1 Preliminary Procedure (See Fig. 1)

Before turning-on the oscilloscope power, set the knobs on the front panel as shown in the following table:

Item	No.	Setting
INTEN (POWER OFF)	①	Extremely counterclockwise position (OFF position)
FOCUS	④	Mid-position
MODE	⑪	Press CH1 button ⑪
↕ POSITION	⑦ ⑫	Mid-position
VOLTS/DIV	⑬ ⑮	0.5 V/DIV position
VARIABLE	⑭ ⑯	CAL'D position
AC - DC	⑲ ㉑	AC position
GND	⑳ ㉒	GND position
TIME/DIV	㉔	1 mS/DIV position
VARIABLE	㉕	CAL'D position
TRIGGERING	㉗ ㉘ ㉙	"+" position WIDE position INT position
←→ POSITION	㉚	Mid-position, depressed state
TRIG MODE	㉜	AUTO position
SELF WAVE-FIXED	㉞	OFF position

Connect the power cord to an AC line outlet of the correct voltage and, then proceed as follows:

1) Turn the INTEN knob (1) from the POWER OFF position to the extremely clockwise position. A click sound (power-on sound) is generated and the LED light turns-on at an upper left of the knob.

2) In about 10 seconds after the above, a bold horizontal trace line will be displayed on the CRT screen. Adjust the trace to an appropriate brightness with the INTEN knob (1).

If no trace is displayed within about 20 seconds, repeat setting of each knob as indicated in the above table.

3) Connect the signal of the CAL (1 Vp-p) terminal to the vertical INPUT terminal (17) using the lead with BNC connector or other appropriate cord.

4) Set the ▁ GND (20) switch in the popped up state (▌), and so adjust the LEVEL knob (26) that the displayed waveform becomes stationary. A waveform as shown in Fig. 5 should be displayed on the CRT screen.

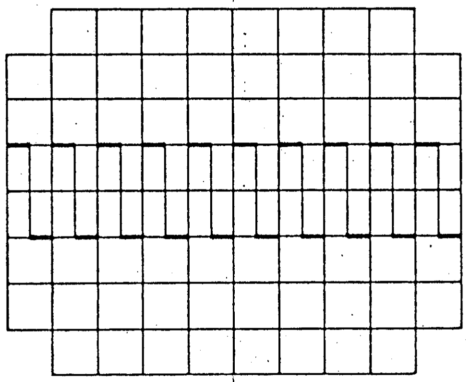


Fig. 5

5) So adjust the FOCUS knob (4) that the displayed waveform becomes sharpest.

6) So adjust the VOLTS/DIV switch (13) and TIME/DIV switch (24) that an appropriate number of peaks are displayed with an appropriate amplitude.

7) Align the displayed waveform with the graticule by adjusting the vertical POSITION knob (12) and horizontal POSITION knob (30), and determine the voltage (V) and period (T).

The above explanation is for the single-channel operation with CH1. The same explanation is applicable for the single-channel operation with CH2, simply by replacing "CH1" with "CH2". The dual-channel operation and general operation methods of the oscilloscope are explained in the subsequent sub-sections.

4.2 Dual-channel Operation

Change the MODE switch to the DUAL state ⑩ so that another trace is displayed in addition. This trace is of CH2. (The trace explained in the preceding sub-section is of CH1.) At this stage of procedure, the CH1 trace is the square wave of the calibration signal and the CH2 trace is a straight line as no signal is being applied to this line yet.

Now, apply the calibration signal also to vertical INPUT terminal ⑱ of CH2 as is the case for CH1 and set the GND switch ㉒ in the popped up state (▮). So adjust the vertical POSITION switches ⑦ and ⑫ that two channels of signals are displayed as shown in Fig. 6.

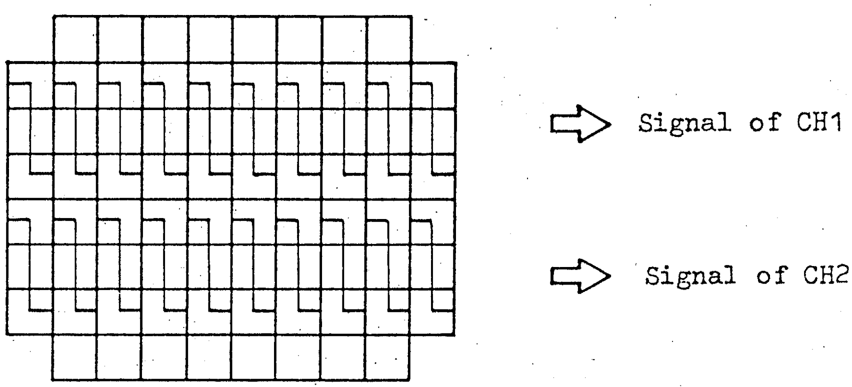


Fig. 6

When in the dual mode of operation, the trigger signal source is automatically switched the CH1 TRIG state and the sweeps are triggered by the CH1 signal alone. Therefore, if the CH2 signal is synchronized with the CH1 signal, the displayed waveforms of both channels are stationary.

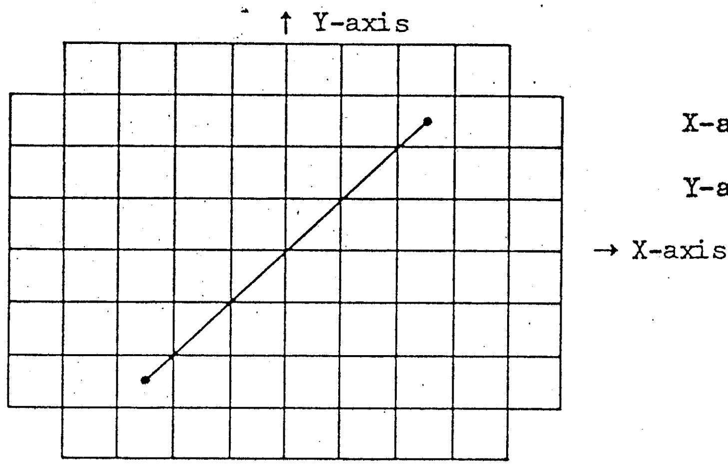
This oscilloscope has eliminated the selector switch between CHOP and ALT modes for dual-channel operation. The DUAL switch (10) alone is required to be manipulated for the dual-channel operation. Actually, the sweep modes are switched being linked to the TIME/DIV switch (24). At ranges the sweep speed is 1 msec/DIV or slower, the switching is in the CHOP mode; at ranges the sweep speed is 100 μsec/DIV or faster, the switching is in the ALT mode.

4.3 X-Y Operation

Set the MODE switch in the X-Y state (9). With this simple procedure, the instrument operates as an X-Y 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. Regarding the X-axis, the frequency response becomes DC ~ 1 MHz (-3 dB) and the horizontal POSITION control (30) becomes effective for the X-axis while the CH1 POSITION control (12) remains idle. Other electrical performance and procedure remains the same.

Apply the calibration voltage signal to both X and Y axis and adjust the VOLTS/DIV knobs of individual axis so that a Lissajous figure as shown in Fig. 7 is displayed on the CRT screen.



X-axis: 200 mV/DIV

Y-axis: 200 mV/DIV

Fig. 7

Note: For measurement of high frequencies in the X-Y operation, pay attention to the frequency responses and phase difference between X-axis and Y-axis of the oscilloscope itself.

4.4 Intensity Modulation Operation

This mode of operation is employed when controlling the trace intensity with an external signal, when displaying intensity-modulated marker signal, etc.

Disconnect the shorting bar of the external intensity modulation signal input terminal (Z-AXIS INPUT (37) , see Fig. 2), and apply an intensity modulation signal between Z-AXIS INPUT terminal (37) and GND terminal (38) . When the intensity modulation is not used, keep the shorting bar connected.

The intensity can be controlled sufficiently with a TTL level signal. For the maximum allowable input voltage, refer to Item 3.4 "Precautions in Operation."

The intensity can be controlled also DC-wise. This feature can be utilized for remote control of intensity with an external DC signal.

4.5 Sweep Magnification (PULL 5 × MAG)

When a part of the input signal waveform is required to be enlarged for observation of details, a faster sweep speed may be used. However, if the part to be enlarged is apart from the start of the sweep, the part may run out of the screen. In such a case, by pulling out the HORIZONTAL POSITION knob (30) , the displayed waveform can be magnified by 5 times to right and left from the center of the screen as shown in Fig. 8.

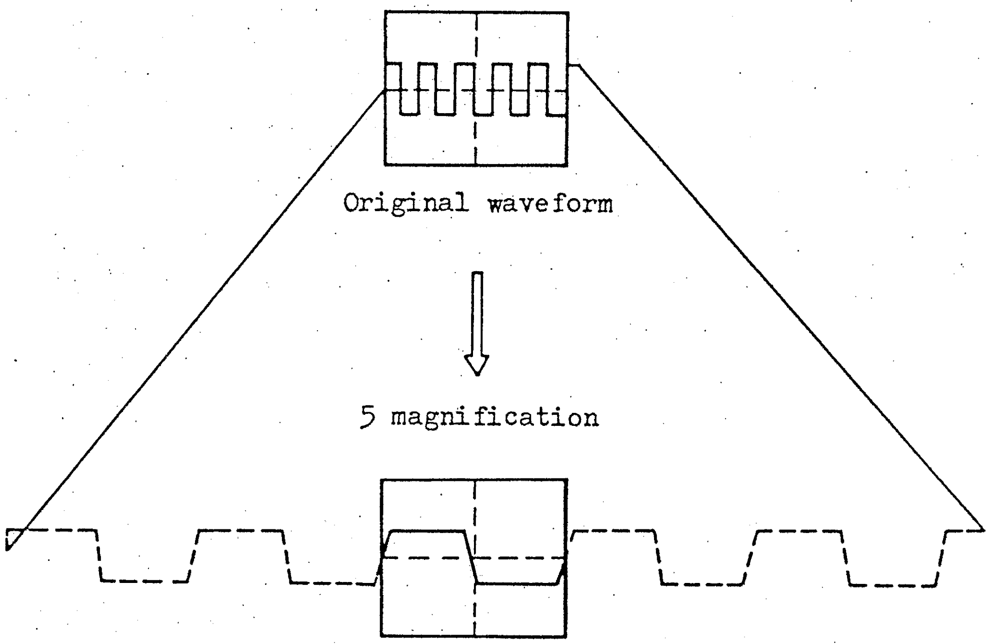


Fig. 8

When magnified, the sweep speed is as follows:

Indication of TIME/DIV switch $\times$ 1/5

The maximum sweep speed of the oscilloscope when this magnification function is effected becomes as follows:

$$1\ \mu\text{sec/DIV} \times 1/5 = 0.2\ \mu\text{sec/DIV}$$

When the trace is magnified, its intensity becomes lower. Therefore, the use of the magnification feature should be limited to the following cases:

(1) When a part apart from the start of the sweep is required to be enlarged.

(2) When a sweep speed faster than 1 μsec/DIV is required.

4.6 Selection of TRIG MODE

(1) NORM mode:

When the trigger level is within the trigger input signal amplitude, a trigger pulse signal is produced and this signal drives the sweep circuit so that a stationary waveform is displayed on the CRT screen. This state is called "being triggered" or "triggering is effected."

When no trigger input signal is applied or the trigger level is not within the trigger input signal amplitude, the sweep circuit is in the standby state and no trace is displayed on the CRT screen. This state is called "not being triggered" or "triggering is not effected."

When trigger is not effected, the fact may be mistaken for an incorrect setting (for example, mistaken for incorrect setting of the INTEN knob ① or vertical POSITION knob ⑦ or ⑫. Therefore, the AUTO mode should be used except the following cases:

(i) The repetition frequency of the trigger input signal is lower than 10 Hz.

(ii) The waveform is required to be displayed on the screen only when the input signal (trigger signal) is applied.

(2) AUTO mode:

A stable sweep operation can be obtained when the trigger input signal is higher than 10 Hz. When triggering is OFF, the sweep runs in the AUTO (FREE RUN) mode. Even at a fast sweep speed, a bright trace is displayed and the ZERO level can be easily checked. Thus, the AUTO mode is most convenient for general waveform display.

(3) TV mode:

This triggering mode is used for observation of TV video signals. The TV video signal applied to the trigger input circuit is fed to a sync. separation circuit for picking off the synchronization signal and this signal is used as the triggering source signal. Thus, the TV video signal is displayed very stably.

Also, being linked to the TIME/DIV knob, triggering is synchronized to the vertical sync. signal (TV·V) for the ranges of 100 msec/DIV ~ μsec/DIV and to the horizontal sync. signal (TV·H) for the ranges of 10 μsec/DIV ~ 1 μsec/DIV.

Set the SLOPE switch is conformity with the polarity of the sync. pulses of the video signal as shown in Fig. 9.

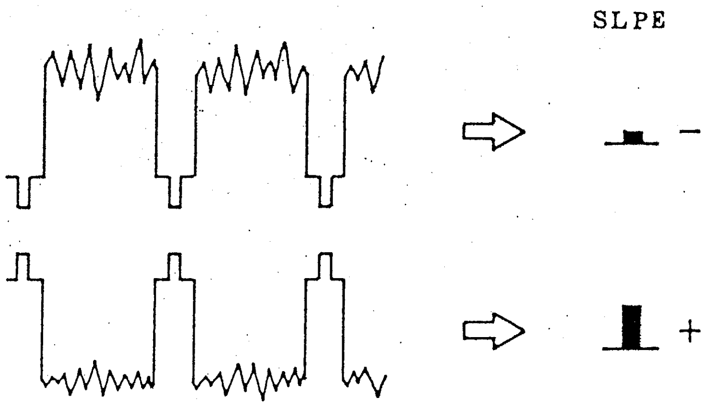


Fig. 9

4.7 Operation of SELF WAVE-FIXED Switch

Set the MODE switch in the CH1 position so that the oscilloscope operates in the single channel mode, apply a sinusoidal wave of 1 kHz to the CH1 INPUT terminal, and set the TIME/DIV switch in the 1 mS position. A waveform as shown in Figure 10 will be displayed on the CRT screen.

Set the WAVE-FIXED VARIABLE knob in the CAL'D position and turn-ON the SELF WAVE-FIXED switch. A single wave as shown in Figure 11 will be displayed on the screen. The displayed waveform will remain constant even when the input signal frequency is varied for a range of 10 Hz to 100 kHz.

The number of displayed waves is adjustable for a range of 1 wave to 4 waves with the WAVE-FIXED VARIABLE knob.

If the input signal frequency becomes lower than 10 Hz while the SELF WAVE-FIXED switch is ON, the displayed waveform is distorted. If the input signal frequency becomes higher than 100 kHz, the SELF WAVE-FIXED function is overriden and the operation becomes the same with that the switch is OFF and the number of displayed waves increases or decreases in proportion to the input signal frequency.

The SELF WAVE-FIXED function is successfully performed irrespective of the input signal waveform (sinusoidal wave, triangular wave, square wave, etc.) so far as the signal is with the fundamental frequency component alone. If the signal includes harmonics or noise, the SELF WAVE-FIXED function becomes unsuccessful. When the input signal frequency is lower than 50 kHz, the effect of noise can be reduced by setting the trigger switch in the HJ REJ _■_ state.

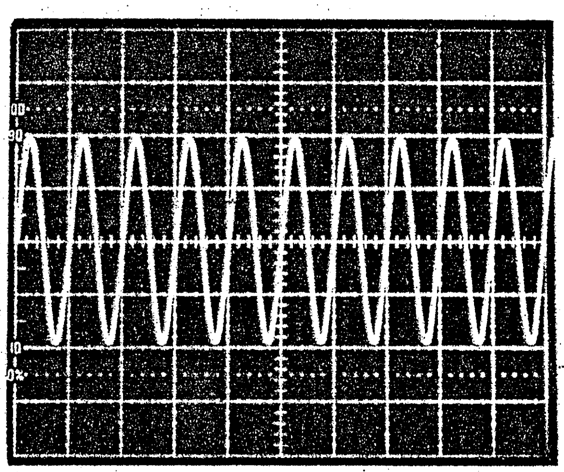


Fig. 10

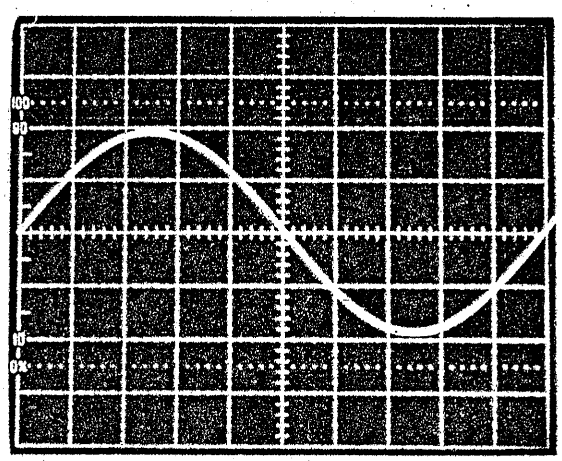


Fig. 11

5. METHODS OF MEASUREMENTS

5.1 Connection Method of Input Signal

The input impedance of the oscilloscope as viewed from the vertical input terminal is 1 MΩ with capacitance approximately 30 pF in parallel. When the probe 960 BNC is used, the impedance increases to resistance 10 MΩ with capacitance approximately 20 pF in parallel.

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

Output impedance of input signal source
Level and frequency of input signal
External induction
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			General 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 wires:

Set a BNC Type Adaptor (Type 942A, accessory) to the vertical input terminal and connect regular wires to the adaptor. This method is simple and the input signal is not attenuated. However it 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 960 BNC is used, larger effects are caused by the stray capacity.

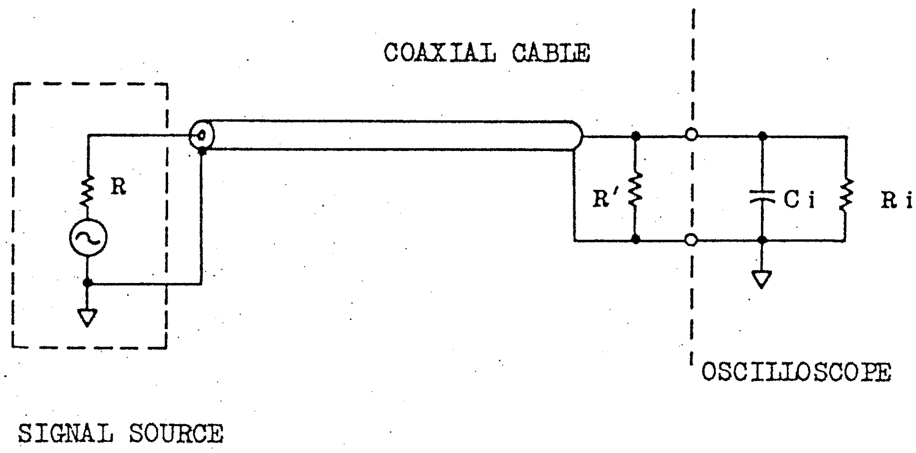
o Connection with shielded wire:

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 Fig. 12.



R = R'

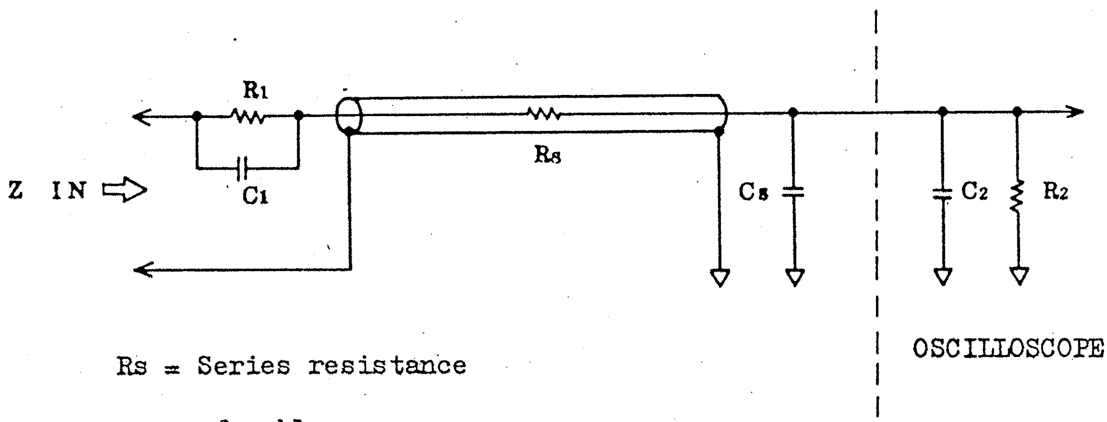
When R = 50 Ω, use a 50 Ω coaxial cable.

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

Fig. 12

o Connection with probe:

A probe with an attenuation ratio of 10 : 1 is available as an accessory. The probe circuit and probe cable are 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. 20 pF) and the loading effect on the measured signal source is greatly reduced as explained in the following:



Rs = Series resistance of cable

Cs = Stray capacitance plus cable capacitance

Fig. 13

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:

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

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

Attenuation factor A is expressed as follows:

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

Precautions:

- Observe the maximum allowable input voltages mentioned in Item 3.4 "Precautions in Operation."
- 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.
- Before commencing measurement, accurately adjust the phase of the probe without fail.

- o Do not apply unreasonably large mechanical shocks or vibration to the prove. 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.

5.2 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 (⑲ , ㉑) 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 (⑭ , ⑯) to the CAL'D position and calibrate the sensitivity to the value indicated by the VOLTS/DIV selector (⑬ , 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

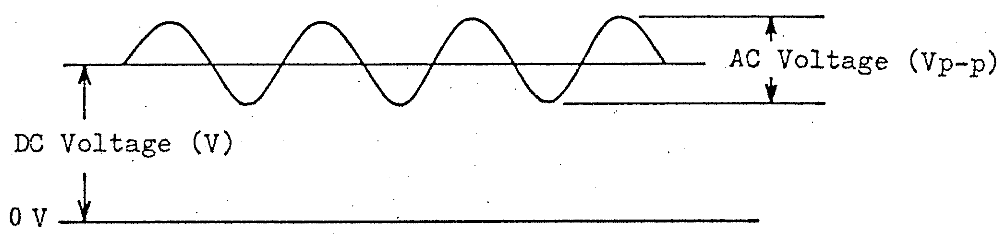


Fig. 14

5.3 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 is 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.

5.4 Time Measurement

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 (25) in the CAL'D position and referring to the indication of the TIME/DIV switch (24).

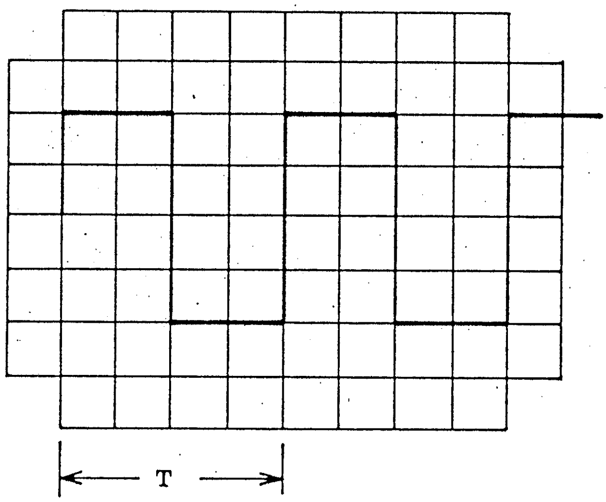


Fig. 15

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

When the sweep is magnified (5 × MAG (30)), the time is 1/5 of the value determined as above.

5.5 Frequency Measurement

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

  Time T (period) is measured as explained in Item 5.4 and the frequency is calculated by using the following formula.

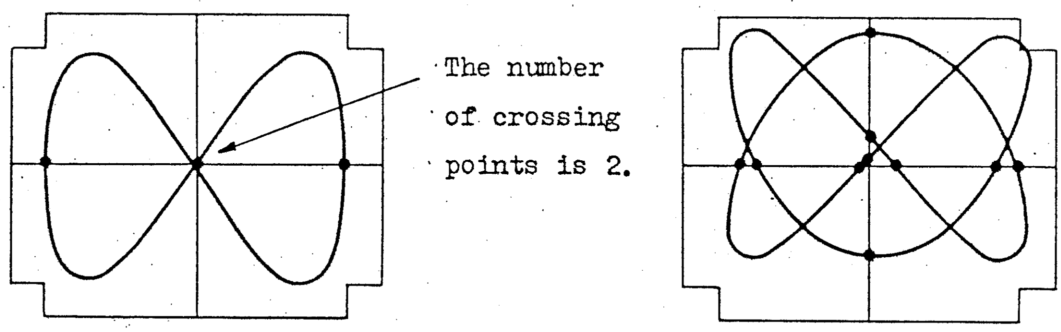
$$\text{Frequency } f \text{ (Hz)} = \frac{1}{\text{Period } T \text{ (sec)}}$$

- o Frequency measurement with Lissajous figure (See Figs. 16 and 17.):

  Set the MODE switch in the X-Y state so that the instrument operates as an X-Y scope. (See Item 4.3 "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 Fig. 16. From the displayed waveform, the unknown frequency can be calculated as follows:

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



$$\frac{4}{2} = \frac{2}{1} \quad \begin{matrix} (H) \\ (V) \end{matrix}$$

$$\frac{6}{4} = \frac{3}{2} \quad \begin{matrix} (H) \\ (V) \end{matrix}$$

Fig. 16

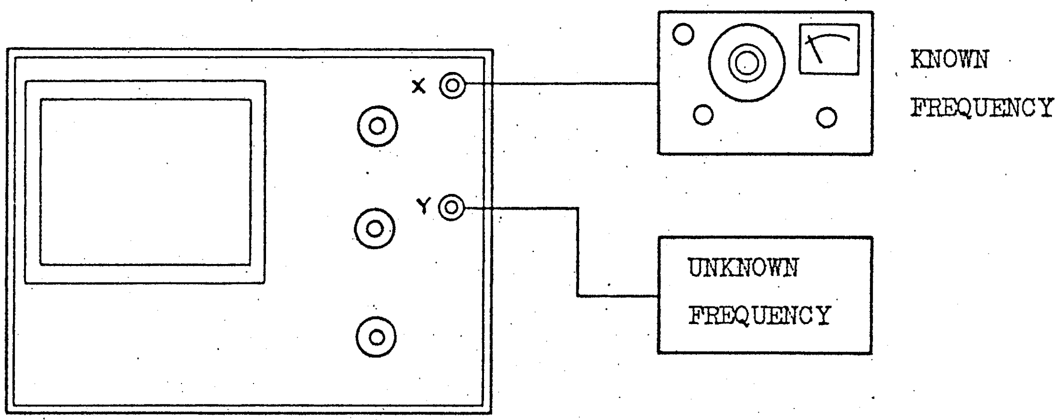


Fig. 17

5.6 Measurement of Phase Difference

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o Measurement of phase difference with Lissajous figure (See Figs. 17, 18 and 19):

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:

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

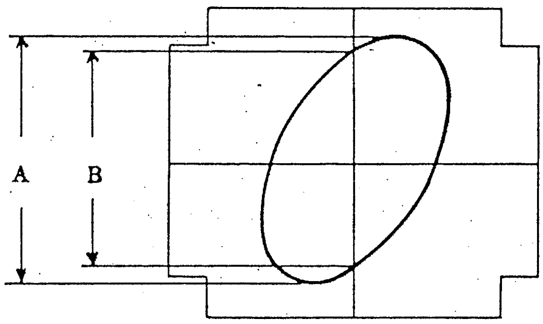
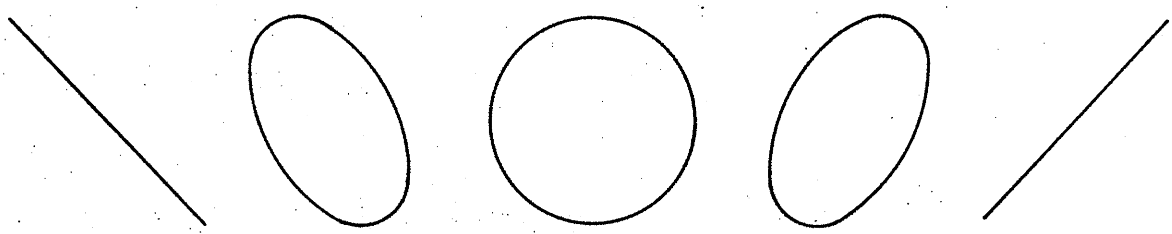


Fig. 18



180° 150°(240°) 90° (270°) 60° (300°) 0° (360°)

Fig. 19

o Measurement of phase difference with dual-channel mode:

Set the MODE switch in the DUAL state ⑩ , and connect to CH1 the signal to be used for reference and to CH2 the signal to be measured. So adjust the oscilloscope that it displays signals as shown in Fig. 20.

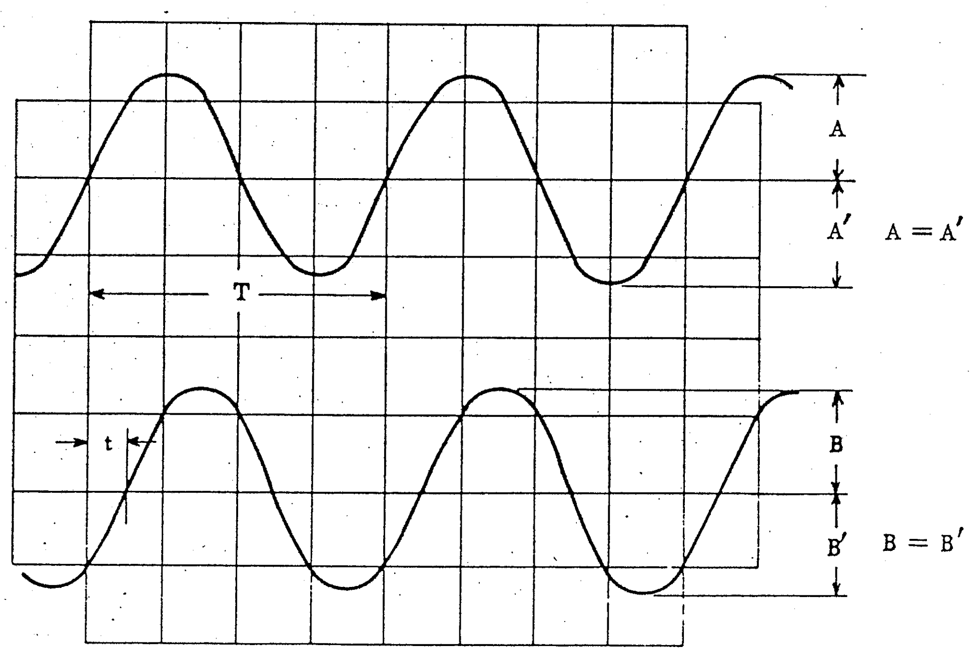


Fig. 20

The phase difference (θ) can be calculated as follows:

$$\theta = \frac{t}{T} \times 360^{\circ}$$

In this dual-channel method, very small values of t can be measured. Another advantage is that the phase can be known at a glance whether it is leading or lagging.

5.7 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 Fig. 21.

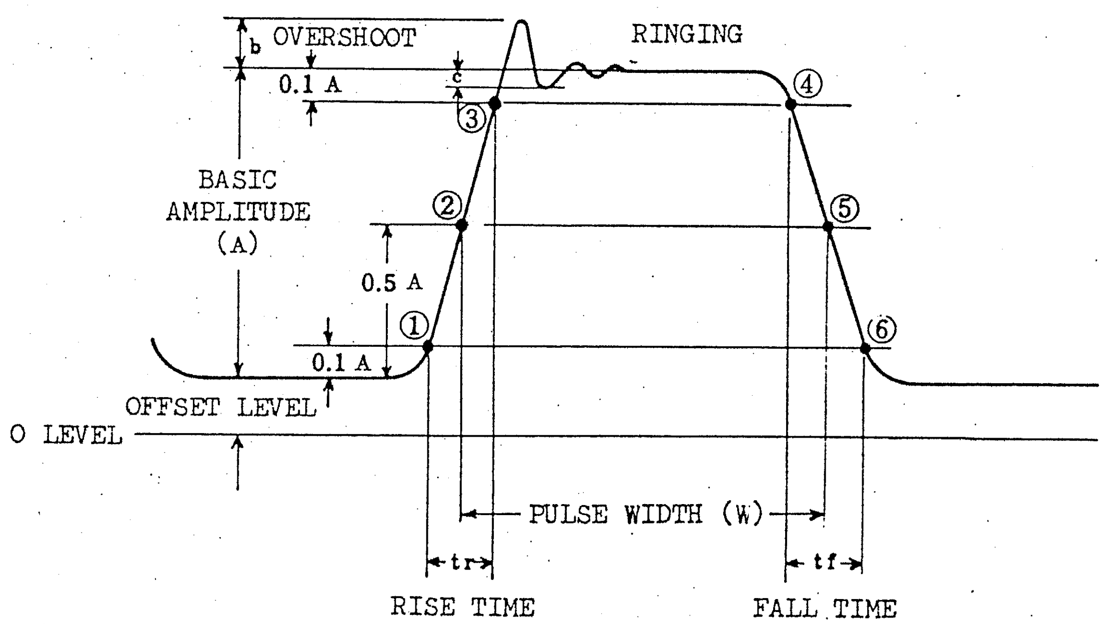


Fig. 21

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 × 100 (%)

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

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 t_r 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, t_r: Rise time measured on CRT screen

t_o: Rise time of oscilloscope itself (approx. 35 nsec)

For example, when a pulse wave with rise time 100 nsec (about 3 times of that of the oscilloscope) is measured on the CRT screen, the error is approximately 6%.

o Measurement of Sag

Pulse waveforms may have slanted sections as shown in Fig. 22, other than those distoryions mentioned in Fig. 21. (For example, slants are caused when the signal is amplified with an amplifier which has poot 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:

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

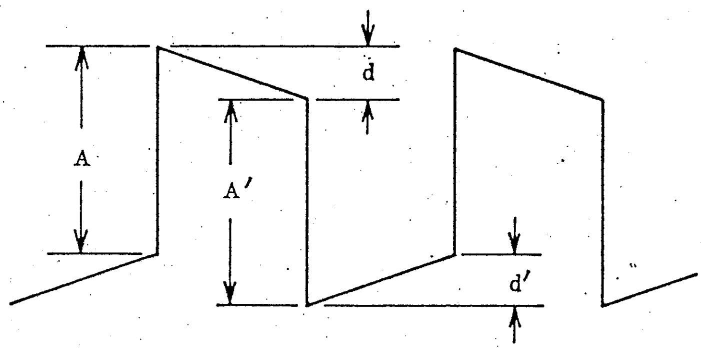


Fig. 22

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.

6. Application Examples

6.1 Waveform Observation for Frequency Response Measurement

A test setup as shown in Figure 23 may be used to measure the frequency response of a tape recorder, a disc record player or an amplifier. In this setup, the measured device is connected to a millivoltmeter which has an output terminal which is connected to the 5513SF. With this test setup, even when the frequency of the signal source (signal generator, test tape, test disc record, or other device) varies, a pattern with a constant number of peaks is displayed on the screen and, therefore, the waveform can be monitored very conveniently.

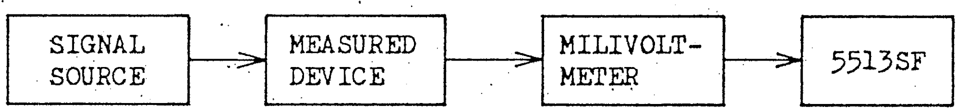


Fig. 23

o Waveform observation for frequency response measurement of magnetic tape playback head:

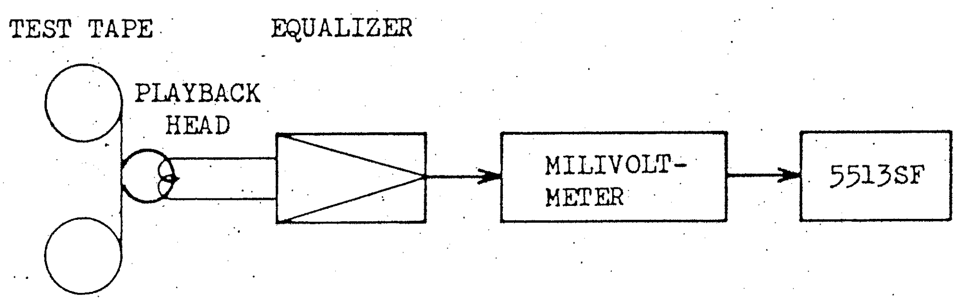


Fig. 24

o Waveform observation for frequency response measurement of disc record pickup:

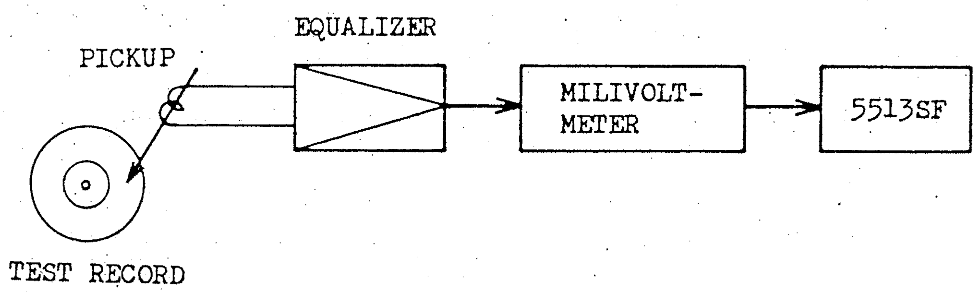


Fig. 25

6.2 Waveform Observation of Electronic Circuits

The various waveforms of electronic circuits can be rapidly measured with this instrument. Even when the measured signal frequency has change, the waveform displayed on the screen remains a constant number of peaks unlike the case of the conventional oscilloscope in which case the time axis adjustment is required to cope with change in measured signal frequency. Therefore, measurement can be done very conveniently and rapidly.

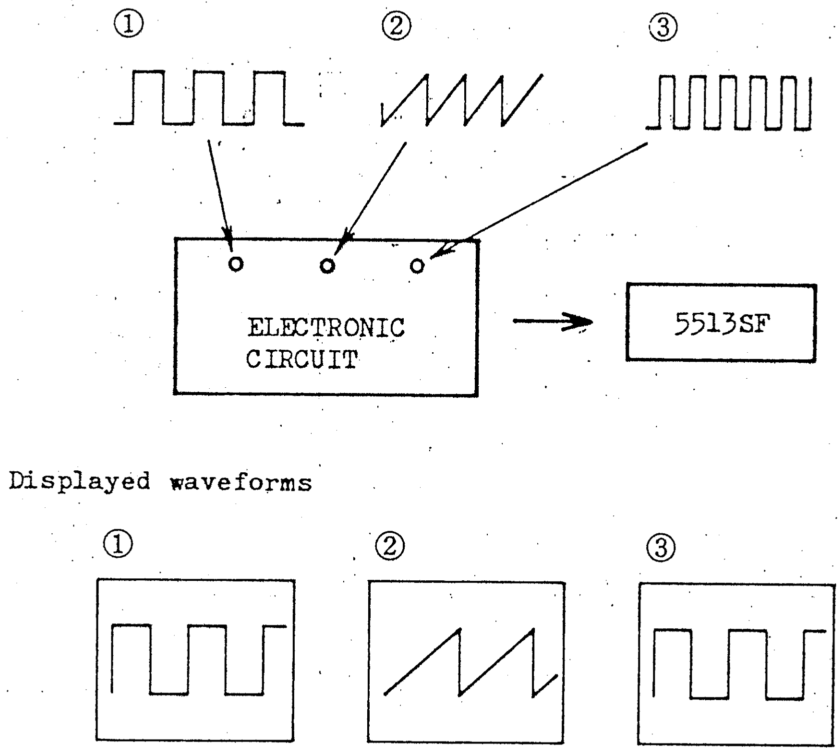


Fig. 26

If the noise superimposed on the measured signal is more than 0.2 DIV in term of deflection amplitude on the screen in the measurement of Section 6.1 or 6.2, the SF circuit of the instrument may trip erroneously. In order to prevent erroneous trip, so adjust the VOLTS/DIV switches 13 and 15 that the noise component becomes less than 0.2 DIV.

If the measured signal frequency is lower than 50kHz, set the triggering switch 28 in the HF REJ state (▁▄▁) whenever possible.

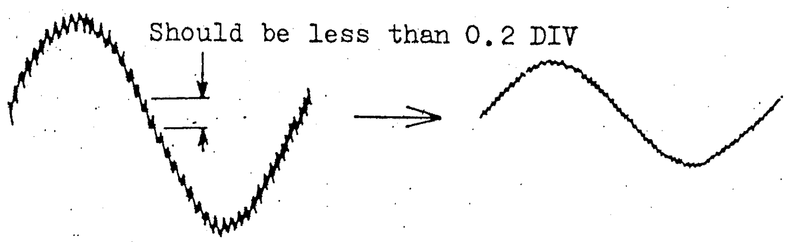


Fig. 27

7. BLOCK DIAGRAM

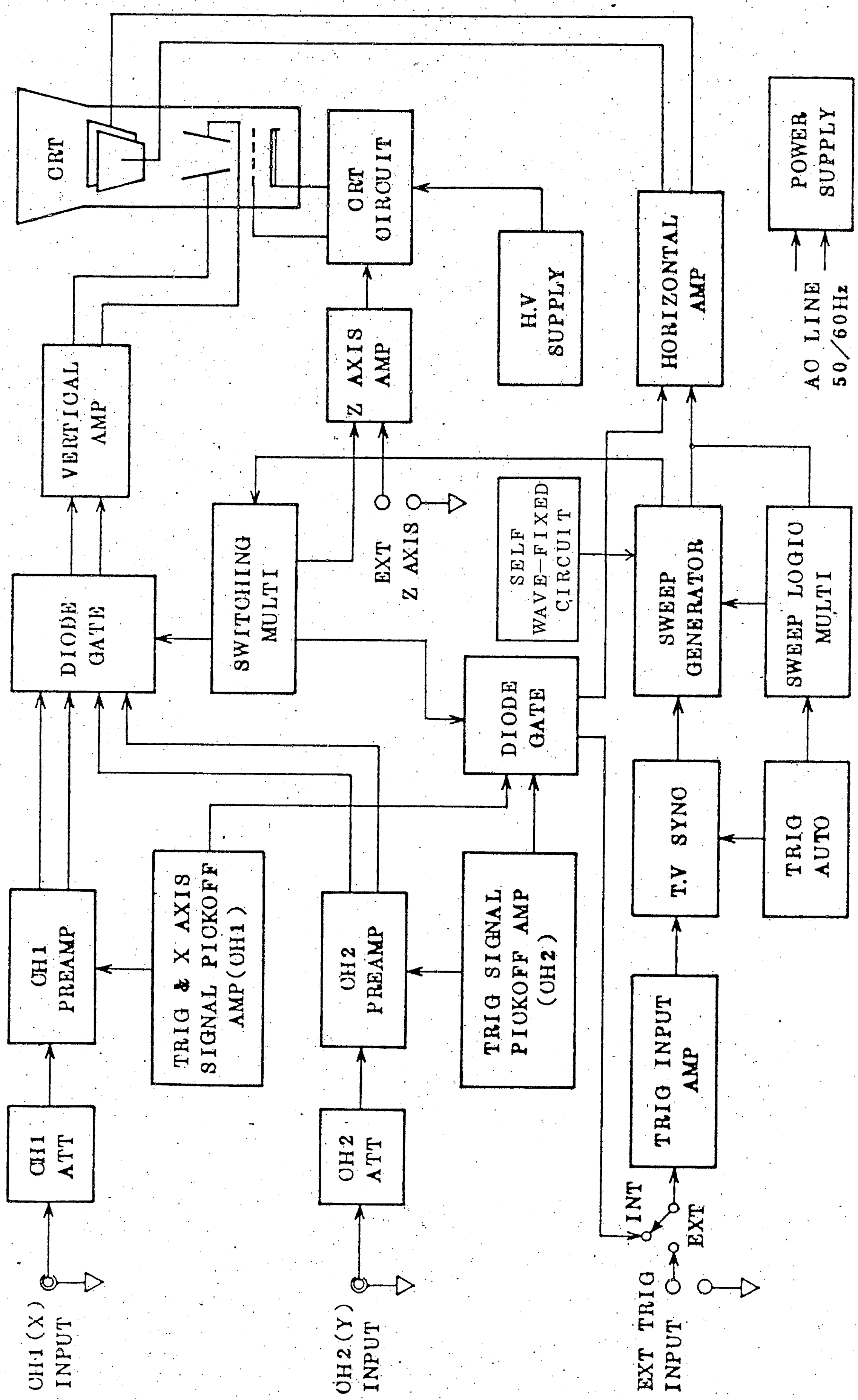


Fig. 28

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