40MHz DUAL TRACE OSCILLOSCOPE

CS-5140

INSTRUCTION MANUAL

KENWOOD CORPORATION

91/12 11 10 9 8 7 6 5 4 3 2 1 90/12 11 10 9 8 7 6 5 4 3 2

SAFETY

Symbol in This Manual
⚠ This symbol indicates where applicable cautionary or other imformation is to be found.

Power Source
This equipment operates from a power source that does not apply more than 250 V rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product
This equipment is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the equipment input or output terminals.

Use the Proper Power Cord
Use only the power cord and connector specified for your product.

Use the Proper Fuse
To avoid fire hazard, use a fuse of the correct type.

Do not Operate in Explosive Atmospheres
To avoid explosion, do not operate this product in an explosive atmosphere.

Do not Remove Cover or Panel
To avoid personal injury, do not remove the cover or panel. Refer servicing to qualified personnel.

Voltage Conversion
If the power source is not applied to your product, contact your dealer. To avoid electrical shock, do not perform the voltage conversion.

CONTENTS

SAFETY 2
FEATURES 3
SPECIFICATIONS 4
PRECAUTIONS 7
CONTROLS AND INDICATORS 8
  FRONT PANEL 8
  REAR PANEL 12
DIRECTIONS FOR USE 13
OPERATION 14
 [A] OPERATION AS A GENERAL-USE OSCILLOSCOPE .. 14
 [1] NORMAL SWEEP DISPLAY OPERATION 14
 [2] SWEEP MAGNIFICATION OPERATION 16
 [3] X-Y OPERATION 16
 [4] VIDEO SIGNAL OBSERVATION 16
 [B] EQUIVALENT SAMPLING 16
 [C] READOUT OPERATION 17
APPLICATION 18
  PROBE COMPENSATION 18
  TRACE ROTATION COMPENSATION 18
  1. DC VOLTAGE MEASUREMENTS 18
  2. MEASUREMENTS OF THE VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM 19
  3. ELIMINATION OF UNDESIRED SIGNAL COMPONENTS 20
  4. VOLTAGE RATIO MEASUREMENT USING CURSORS 20
  5. TIME MEASUREMENTS 21
  6. TIME DIFFERENCE MEASUREMENT 21
  7. PULSE WIDTH MEASUREMENTS 22
  8. PULSE RISE TIME AND FALLTIME MEASUREMENTS 23
  9. PHASE DIFFERENCE MEASUREMENTS 24
  10. TIME RATIO MEASUREMENT USING CURSORS .. 25
  11. FREQUENCY MEASUREMENTS 26
  12. RELATIVE MEASUREMENTS 27
  13. APPLICATION OF X-Y OPERATION 28
  14. APPLICATION AS AN EQUIVALENT-SAMPLING OSCILLOSCOPE 29
MAINTENANCE 31
  RESETTING THE READOUT CALENDER AND CLOCK DISPLAY 32
ACCESSORIES 33

FEATURES

The CS-5140 is an oscilloscope incorporating 40 MHz real-time oscilloscope functions and a sampling function for the bandwidth of 100 MHz (with automatic sweep range switching). Information displayed on the CRT includes: calendar, vertical axis input sensitivity and sweep time due to readout function, time difference and voltage difference between two cursor lines due to cursor function. These features allow photographing for easier collection of data.

1. Vertical axis has high sensitivity and wide bandwidth and especially covers fully specified frequency response at 5 mV/div.
   REAL TIME: 40 MHz (−3 dB) [1 mV, 2 mV:5 MHz (−3 dB)]
   EQUIVALENT SAMPLING: 100 MHz (−3 dB) [1 mV, 2 mV:5 MHz (−3 dB)]
2. Holdoff control permits triggering of signals of intricate time relations.
3. Trigger coupling (HFREJ) assures triggering of signals containing high-frequency noise.
4. Vertical sensitivity range is selectable from 1 mV/div to 5 V/div with rotary switch continuously.
5. Time base permits high sweep speed.
   1 nsec/div (×10 MAG) (at sampling)
6. 150 mm rectangular, domed-mesh, type CRT with internal graticule and after acceleration (accelerating voltage 12 kV) ensures easy-to-see, parallax-free waveform observations.
7. For convenience in making rise time measurements, the 0%, 10%, 90% and 100% levels are marked on the graticule scale of the CRT.
8. Trace rotation is electrically adjustable from the front panel.
9. By SCALE ILLUM control, the waveform is easy observed in the dark and the photograph of the waveform is easy provided.
10. Selectable AUTO FREE RUN function provides sweep without trigger input signal.
11. The FRAME-LINE switch provides selection of sync pulse for sweep triggering from small amplitude to large amplitude without adjusting when viewing composite video waveforms.
12. X-Y operation is easily provided by one-touche button operation.
    CH1 Y axis,
    CH2 X axis
13. The real mode or sampling mode is automatically selected according to the sweep range, eliminating troublesome operation.
14 The readout function displays each scale factor on the CRT, eliminating troublesome confirmation of the range for waveform observation.
   When the provided probe PC31 is used, the vertical sensitivity display on the CRT will be magnified by 10 times.
15 The cursor measurement mode displays, in letters, voltage difference, voltage ratio, time difference, time ratio, frequency, and phase difference corresponding to the cursor movement. This display eliminates calculation having been made by an operator, resulting in accurate waveform observation.

SPECIFICATIONS

CRT		150 mm rectangular with internal graticule
Acceleration Voltage		12 kV
Display Area		8 × 10 div (1 div = 10 mm)
VERTICAL AXIS (CH1 and CH2)		
Sensitivity		1 mV/div to 5 V/div, ±3%
Attenuator		12 steps, 1 mV/div to 5 V/div in 1-2-5 sequence. Vernier control for fully adjustable sensitivity between steps.
Input Impedance		1 MΩ ±2% approx. 24 pF
Frequency Response	DC	REAL TIME: DC to 40 MHz, −3 dB (5 mV to 5 V/div) DC to 5 MHz, −3 dB (1 mV, 2 mV/div) EQUIVALENT SAMPLING: DC to 100 MHz, −3 dB (5 mV to 5 V/div) DC to 5 MHz, −3 dB (1 mV, 2 mV/div)
	AC	REAL TIME: 5 Hz to 40 MHz, −3 dB (5 mV to 5 V/div) 5 Hz to 5 MHz, −3 dB (1 mV, 2 mV/div) EQUIVALENT SAMPLING: 5 Hz to 100 MHz, −3 dB (5 mV to 5 V/div) 5 Hz to 5 MHz, −3 dB (1 mV, 2 mV/div)
Rise Time		REAL TIME: 8.8 nsec or less (40 MHz, −3 dB) 70 nsec or less (5 MHz, −3 dB) EQUAL SAMPLING: 3.5 nsec (100 MHz, −3 dB) 70 nsec (5 MHz, −3 dB)
Crosstalk		−40 dB minimum
Operating Modes	CH1	single trace
	CH2	single trace
	ALT	Two-waveforms display alternting
	CHOP	do
	ADD	CH1 + CH2 added display
Chop Frequency		Approx. 250 kHz
⚠ Maximum Input voltage		500 Vp-p or 250 V (DC + AC peak)
HORIZONTAL AXIS		Input thru CH2, ×10 MAG not included
Operating Modes		With TRIG MODE switch, X-Y operation is selectable (REAL TIME) CH1 ; Y axis CH2 ; X axis
Sensitivity		Same as vertical axis (CH2)
Input Impedance		Same as vertical axis (CH2)
Frequency Response	DC	DC to 500 kHz, −3 dB
	AC	5 Hz to 500 kHz, −3 dB
X-Y Phase Difference		3° or less at 50 kHz
⚠ Maximum Input Voltage		Same as vertical axis (CH2)
SWEEP		
Sweep System	NORM	Triggering sweep
	AUTO	Sweep free runs in absence of trigger
Sweep Time		0.2 s/div to 10 ns/div, ±3%, in 23 ranges, in 1-2-5 sequence. Vernier control provides fully adjustable sweep time between steps. REAL TIME: 0.2s~0.2 μs/div EQUIVALENT SAMPLING: 0.1 μ~10 ns/div

Sweep Magnification		×10 (ten times) ±5%
Linearity		±3% (×10 MAG, 0.2 μs～10 μs, ±5%)
HOLD OFF		Adjustable by the controller
TRIGGERING		
Internal Sync	CH1	Triggered by CH1 signal
	CH2	Triggered by CH2 signal
	LINE	Triggered by line frequency
External Sync	EXT	Triggered by signal applied to EXT TRIG INPUT jack
External Sync Input Impedance		Approx. 1 MΩ, approx. 32 pF
⚠ Max. External Trigger Voltage		50 V (DC+AC peak)
Coupling		AC, HFrej, TV FRAME, TV LINE
Sync sensitivity	At NORM position	
	AC	Sync frequency range : 10 Hz～50 MHz INT : 1 div, EXT : 0.1 Vp-p Sync frequency rage : 10 Hz～100 MHz INT : 1.5 div, EXT : 0.2 Vp-p
	HFrej	The sync frequency range is more than 10 kHz, and the minumum amplitude (Voltage) required for sync is increased.
	TV	FRAME, LINE INT : 1.5 div, EXT : 0.15 Vp-p
	(AUTO)	Rating shown above is provided at 50 Hz or over.
CALIBRATION VOLTAGE		1 V ±3%, square wave, positive polarity, approx. 1 kHz
INTENSITY MODULATION		
Sensitivity		+5 V, positive voltage decreases brightness.
Input Impedance		Approx. 10 kΩ
Usable Frequency Range		DC to 2 MHz
⚠ Maximum Input Voltage		50 V (DC+AC peak)
READOUT		
Calendar		Year/Month/Day/O'clock/Minute Clock accuracy : ±2 min./month Battery life : About 20,000 hours (at room temperature)
Set value		CH1/CH2 scale factor (with probe detection); V-UNCAL, ADD, INVERT Sweep scale fatör (magnification conversion); SWEEP VARIABLE-UNCAL, X-Y
Cursor mode:	ΔV1:	Voltage difference between ΔREF and Δ cursors on the basis of CH1 scale factor
	ΔV2:	Voltage difference between ΔREF and Δ cursors on the basis of CH2 scale factor
	ΔT:	Time difference between ΔREF and Δ cursors on the basis of sweep scale factor
	1/ΔT:	Frequency between ΔREF and Δ cursors on the basis of sweep scale factor
		Ratio: Voltage ratio and time ratio between ΔREF and Δ cursors, supposing 5 div. on the CRT as 100%
		Phase: Phase difference between ΔREF and Δ cursors, supposing 5 div. on the CRT as 360°
	NOTE: The X-Y mode allows ΔV1 measurement only.	
Cursor measurement	Resolution	10 bits
	Measurement accuracy	±4 %
	Measurable range	ΔV, Ratio: ±3.6 div or more from the CRT center ΔT, 1/ΔT, Ratio, Phase: ±4.6 div or more from the CRT center

TRACE ROTATION (Electrical, adjustable from front panel)	
POWER REQUIREMENT	
Line Voltage	100 V/120 V/220 V/240 V AC ±10%
Line Frequency	50/60 Hz
Power Consumption	Approx. 53 W
DIMENSIONS (W×H×D)	319 (341)×132 (145)×380 (442) mm ( ) dimensions include protrusion from basic outline dimensions
WEIGHT	Approx. 9.5 kg
ENVIRONMENTAL	
Within Specifications	10°C to 35°C, 85% max. relative humidity
Full Operation	0°C to 40°C, 85% max. relative humidity
ACCESSORIES SUPPLIED	
Probe	PC-31 (READOUT compatible probe)×2 Attenuation..............1/10 Input impedance........10 MΩ ±1%, 14 pF ±10%
Power supply cable	1
Replacement Fuse	1.2A×2, 0.8A×2
Instruction Manual	1

* Circuit and rating are subject to change without notice due to developments in technology.

PRECAUTIONS

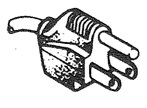
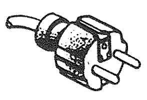
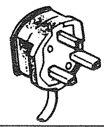
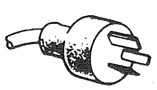
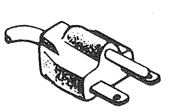
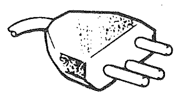
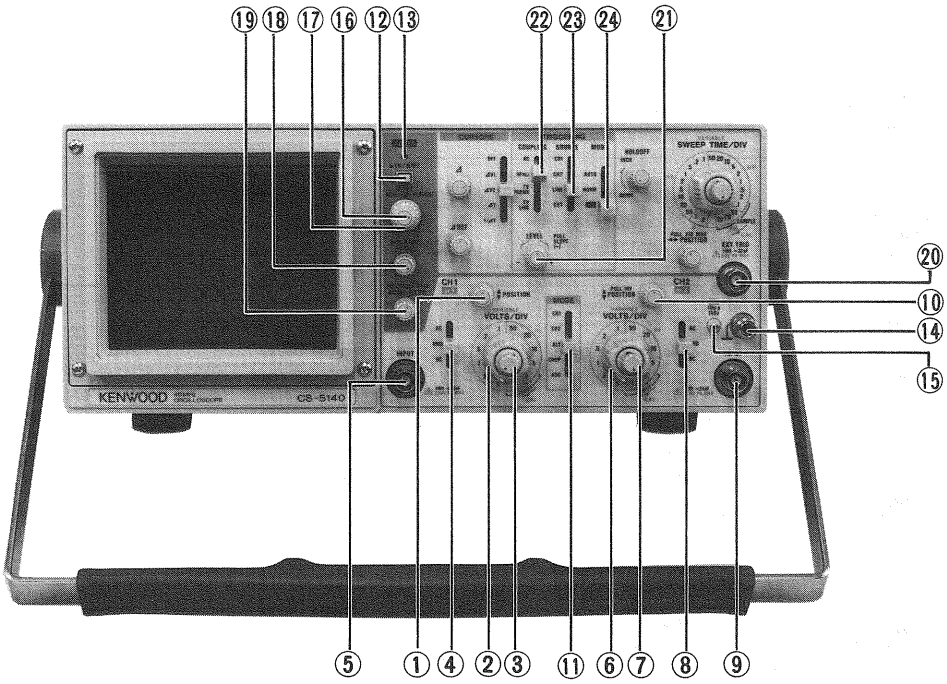
Plug configuration	Power cord and plug type	Factory installed instrument fuse	Line cord plug fuse
	North American 120 volt/60 Hz Rated 15 amp (12 amp max; NEC)	1.2 A, 250 V Fast blow 6×30 mm	None
	Universal Europe 220 volt/50 Hz Rated 16 amp	0.8 A, 250 V T. lag 5×20 mm	None
	U.K. 240 volt/50 Hz Rated 13 amp	0.8 A, 250 V Fast blow 6×30 mm	0.8 A Type C
	Australian 240 volt/50 Hz Rated 10 amp	0.8 A, 250 V Fast blow 6×30 mm	None
	North American 240 volt/60 Hz Rated 15 amp (12 amp max; NEC)	0.8 A, 250 V Fast blow 6×30 mm	None
	Switzerland 240 volt/50 Hz Rated 10 amp	0.8 A, 250 V Fast blow 6×30 mm	None

Fig. 1 Power Input Voltage Configuration

1. Check the power supply voltage before use. A voltage selector/fuse holder is provided on the left side of the AC inlet socket, on the rear panel of the set. The line voltage setting is indicated by a triangle mark above the fuse holder. If the voltage is different from the power supply in your area, set it correctly to prevent danger and malfunctions. Be sure to check the voltage before connecting the power plug to an AC outlet.
   - When converting the voltage, refer to the Maintenance section.
2. The CS-5140 should be installed at a place meeting the following conditions:
   1 Direct sunlight
   2 High temperature and humidity.
   3 Frequet mechanical vibration.
   4 Strong magnetic rays or impulse voltage possibly generated from equipment located nearby.
3. Never apply more than the maximum rated voltage to the oscilloscope input jacks.
   ⚠ CH1, CH2 input jacks:
   500 Vp-p or 250 V (DC+AC peak)
   EXT TRIG, Z AXIS input jacks:
   50 V (DC+AC peak)
   Never apply external voltage to the oscilloscope output terminals.
4. Do not increase the intensity more than required.
5. Never allow a small spot of high brilliance to remain on the screen for extended periods of time.
6. Never cover the ventilating holes in the top of the scope, as this will increase the temperature inside the case thereby causing malfunction.
7. When removing the case, observe the maintenance instruction contained in this manual to prevent a safety hazard because this instrument contains high voltage circuits.
8. To protect against safety hazards always ground the instrument using the GND terminals on the panel.
9. When turning on and off the POWER switch repeatedly, keep an interval of about 5 seconds. Faster on and off operation may cause malfunction to the instrument.
10. Do not use the provided PC-31 Probe with other measuring equipment because it incorporates a terminal for READOUT detection which might damage the other equipment.
11. For proper use of the calendar and clock display, be sure to adjust the date and time correctly. (Refer to the "Maintenance and Adjustment" section.)
12. The calendar and clock display are backed up by an incorporated battery. If the battery is nearly exhausted, the date and time will be delayed. If this happens, the incorporated battery must be replaced with a new one. Please contact your dealer or Kenwood service agent for assistance.

CONTROLS AND INDICATORS



FRONT PANEL

Fig. 2

① **CH1 ⇕ POSITION**
Rotation adjusts vertical position of CH1 waveform on the screen. In X-Y operation, this control adjusts Y axis position.

② **CH1 VOLTS/DIV**
Vertical attenuator for channel 1. Provides step adjustment of vertical sensitivity in 1-2-5 sequence. VARIABLE ③ control is turned to the CAL position, the calibrated vertical sensitivity is obtained. In X-Y operation, this control serves as the attenuator for Y axis.

③ **CH1 VARIABLE Control**
Rotation provides fine control of channel 1 vertical sensitivity. In the fully clockwise (CAL) position, the vertical attenuator is calibrated. In X-Y operation, this control serves as the Y axis attenuation fine adjustment.

④ **CH1 AC-GND-DC**
This switch is the CH1 vertical axis coupling mode selector, for X-Y operation, the Y-axis coupling mode control.

AC: AC input coupling with blocking of any DC signal component.

GND: Vertical amplifier is disconnected from the input signal and connected to ground. This mode is useful in determining the zero reference.

DC: DC coupling, with both the DC and AC components of the input signal displayed on the CRT.

⑤ **CH1 INPUT Jack**
Vertical input for channel 1 trace in normal sweep operation. Vertical input for X-Y operation.

⑥ **CH2 VOLTS/DIV**
Vertical attenuator for CH2. Provides the samė function as VOLTS/DIV Control ② for CH1. In X-Y operation, the control serves as the X-axis attenuator.

⑦ **CH2 VARIABLE Control**
Rotation provides fine control of channel 2 vertical sensitivity.
Provides the same function as VARIABLE Control ③ for CH1.
In X-Y operation, this control serves for X-axis attenuation fine adjustment.

⑧ **CH1 AC-GND-DC**
Selects the coupling of channel 2 vertical input signal. In X-Y operation, the switch provides input selection of X-axis and performs the same function as AC-GND-DC ④ for CH1.

⑨ **CH1 INPUT Jack**
Vertical input for channel 2 trace in normal sweep operation. External horizontal input in X-Y operation.

⑩ **CH2 ⇕ CH2 POSITION, PULL INV**

⇕ CH2 POSITION: Rotation adjusts vertical position of channel 2 trace.

INV: Push-pull switch selects channel 2 signal inverted (PULL INV) when pulled out.
(Hereafter PULL INV is described as CH2 INV.)

⑪ **MODE**

Selects the basic operating modes of the oscilloscope.

- CH1: Only the input signal to channel 1 is displayed as a single trace.
- CH2: Only the input signal to channel 2 is displayed as a single trace.
- ALT: Alternate sweep is selected regardless of sweep time.
- CHOP: Chop sweep is selected regardless of sweep time at approximately 250 kHz.
- ADD: The waveforms from channel 1 and channel 2 inputs are added and the sum is displayed as a single trace. When the CH2 INV ⑩ button is engaged, the waveform from channel 2 is subtracted from the channel 1 waveform and the difference is displayed as a single trace.

⑫ **POWER**

Power switch. A press of this switch turns the power ON.

⑬ **POWER LED**

Lights when oscilloscope is turned on.

⑭ **⏊ GND terminal/binding post.**

Earth and chassis ground.

⑮ **CAL**

Provides approximately 1 kHz, 1 V peak-to-peak square wave signal. This is useful for probe compensation adjustment.

⑯ **INTENSITY (REAL)**

Adjusts the intensity of trace.

⑰ **READOUT INTENSITY**

Adjusts the intensity of the characters in the READ OUT line and the cursor. Full counterclockwise rotation turns off the READOUT function.

⑱ **FOCUS/PULL ASTIG**

- FOCUS: Adjusts the trace for optimum focus.
- ASTIG: Used to bring the waveform into the best condition with the FOCUS adjustment by adjusting trace and spot aberration. Pull the knob to make a spot circular.

⑲ **SCALE ILLUM/PULL TRACE ROTA**

- SCALE ILLUM: Brightness adjustment of the scale of the CRT. For photographing, rotate the knob to adjust brightness to prevent halation caused by too bright illumination.
- TRACE ROTA: Use a screwdriver to adjust the trace to a horizontal position. Once adjusted, this control does not require frequent readjustment.

⑳ **EXT TRIG INPUT Jack**

Input terminal for external trigger signal.
When SOURCE switch is selected in EXT position, the input signal at the EXT TRIG INPUT jack becomes the trigger.

㉑ **LEVEL/PULL SLOPE (−)**

- LEVEL: Trigger level adjustment determines point on waveform where sweep starts.
  When COUPLING switch is selected in VIDEO-FRAME or LINE, the trigger level adjustment has no effect.
- PULL SLOPE (−) Switch: Two-position push-pull switch. Pulled out position selects negative going (−) slope and pushed in position selects positive-going (+) slope as triggering point.

㉒ **COUPLING**

Selects coupling for AC sync trigger signal.

- AC: Trigger is ac coupled. Blocks DC component of input signal; most commonly used position.
- HFrej: Sync signal is coupled through a low-pass filter to eliminate high frequency components for stable triggering of low frequency signals.
- TV : FRAME: Vertical sync pulses of a composite video signal are selected for triggering.
- TV : LINE: Horizontal sync pulses of a composite video signal are selected for triggering.

㉓ **SOURCE**

- CH1: Channel 1 signal is used as a trigger source.
- CH2: Channel 2 signal is used as a trigger source.
- LINE: Sweep is triggered by line voltage (50/60 Hz).

  NOTE:
  When the COUPLING switch is set to other than AC synchronization may not be obtained.
  In this case, set the COUPLING switch to the AC position.
- EXT: Sweep is triggered by signal applied to EXT TRIG INPUT jack ⑳ .

㉔ **TRIGGERING MODE (TRIG MODE)**

Selects triggering mode.

- AUTO: Triggered sweep operation when trigger signal is present, automatically generates sweep (free runs) in absence of trigger signal.
- NORM: Normal triggered sweep operation. No trace is presented when a proper trigger signal is not applied.
- X-Y: X-Y operation. Channel 1 input signal produces vertical deflection (Y axis). Channel 2 input signal produces horizontal deflection (X axis).
  This operates regardless vertical MODE selection.

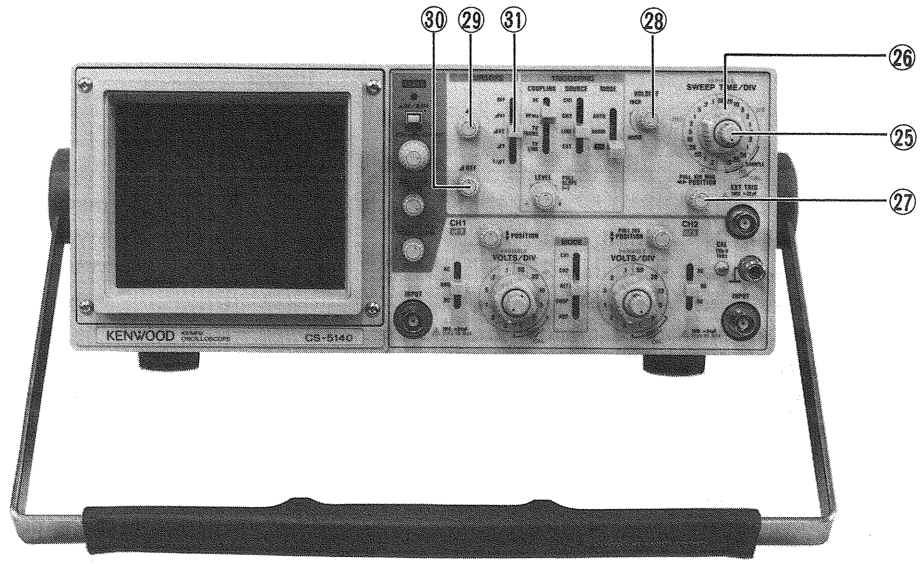


Fig. 3

㉕ **SWEEP VARIABLE Control**

This is the sweep rate fine-adjustment control, which allows continuous variation between SWEEP TIME/DIV ranges.

The sweep rate can be calibrated when the control is turned fully clockwise to the CAL position.

㉖ **SWEEP TIME/DIV**

Horizontal coarse sweep time selector.

Selects calibrated sweep times of 0.2 μs/div to 10 ns/div in 23 steps when sweep time VARIABLE control ㉕ is set to CAL position (fully clockwise).

Measurement in the range between 0.1 μs/div and 10 ns/div is automatically performed in the equivalent sampling mode, allowing observations of repetitive waveforms. At the same time, the bandwidth is extended to 100 MHz provided that the vertical axis attenuator is in the range between 5 mV/div and 5 V/div.

㉗ **◄► POSITION/PULL ×10 MAG**

Horizontal position controller, which provides horizontal shift of waveform. By pulling the knob, the sweep time is quickened ten times.

In the X-Y operation mode. It functions as an X position controller. Also functions as an X position controller of the storage waveform.

NOTE: In X-Y operation, keep this knob pressed (normal sweep mode).

㉘ **HOLDOFF**

Adjusts the sweep-to-sweep interval. Turning the HOLDOFF from the NORM (full c.c.w.) position varies the holdoff time to more than ×10 at the MAX (full c.w.) position.

㉙ **Δ**

Controller for shifting the measuring cursor (rough dotted line) out of two cursor lines displayed on the CRT in the cursor measurement. By rotating the controller clockwise, the cursor line moves upward or rightward: by rotating counterclockwise, it moves downward or leftward.

㉚ **Δ REF**

Controller for shifting the reference cursor (small-dotted line) out of two cursor lines displayed on the CRT in the cursor measurement. By rotating the controller clockwise, the cursor line moves upward or rightward: by rotating counterclockwise, it moves downward or leftward.

㉛ **CURSORS**

Cursor measurement mode select switch.

OFF: Cursor measurement is not performed. The cursor, and cursour measurement mode and cursor measurement value are not displayed on the CRT.

ΔV1: Two horizontal cursor lines are displayed on the CRT, and voltage difference and voltage ratio between them are displayed in the upper right on the CRT posterior to the cursor measurement mode display.

Setting the CH1 VARIABLE controller ③ to the CAL position causes voltage difference measurement, and a value calculated in accordance with setting of the CH1 VOLTS/DIV dial ② is displayed posterior to ΔV1.

Setting the CH1 VARIABLE controller ③ to the UNCAL position causes voltage ratio measurement, and a value calculated assuming that 5 div. is 100% is displayed posterior to the RATIO.

When the Δ cursor is below the Δ REF cursor, a negative value is displayed.

NOTE: Setting of the MODE select switch ⑪ to the CH2 position causes Δ V2 mode cursor measurement.

ΔV2: Two horizontal cursor lines are displayed on the CRT, and voltage difference and voltage ratio between them are displayed in the upper right on the CRT posterior to the cursor measurement mode display.

Setting the CH2 VARIABLE controller ⑦ to the CAL position causes voltage difference measurement, and a value calculated in accordance with setting of the CH1 VOLTS/DIV dial ⑥ is displayed posterior to ΔV2.

Setting the CH2 VARIABLE controller ⑦ to the UNCAL position causes voltage ratio measurement, and a value calculated on the basis of 5 div. as 100% is displayed posterior to the RATIO.

When the Δ cursor is below the ΔREF cursor, a minus value is displayed.

NOTE: Setting of the MODE select switch ⑪ to the CH1 position causes ΔV1 mode cursor measurement.
Setting of the MODE select switch ㉔ to the X-Y position disables ΔV2 mode measurement.

ΔT: Two vertical cursor lines are displayed on the CRT, and time difference and time ratio between them are displayed in the upper right on the CRT posterior to the cursor measurement mode display.

Setting the SWEEP VARIABLE controller ㉕ to the CAL position causes time difference measurement, and a value calculated in accordance with setting of the SWEEP TIME/DIV dial ㉖ is displayed posterior to ΔT.

Setting the SWEEP VARIABLE controller ㉕ to the UNCAL position causes time ratio measurement, and a value calculated assuming that 5 div. is 100% is displayed posterior to the RATIO.

When the Δ cursor is on the left of the Δ REF cursor, a minus value is displayed.

NOTE: Setting of the MODE select switch ㉔ to the X-Y position disables ΔT mode measurement.

1/ΔT: Two vertical cursor lines are displayed on the CRT, and frequency and phase difference between them are displayed in the upper right on the CRT posterior to the cursor measurement mode display.

Setting the SWEEP VARIABLE controller ㉕ to the CAL position causes frequency measurement, and a value calculated in accordance with setting of the SWEEP TIME/DIV dial ㉖ is displayed posterior to 1/ΔT.

Setting the SWEEP VARIABLE controller ㉕ to the UNCAL position causes phase difference measurement, and a value calculated assuming that 5 div. is 360° is displayed posterior to the PHASE.

When the Δ cursor is on the left of the Δ REF cursor, a minus value is displayed. However, frequency is displayed in an absolute value.

NOTE: Setting of the MODE select switch to the X-Y position disables 1/ΔT mode measurement.

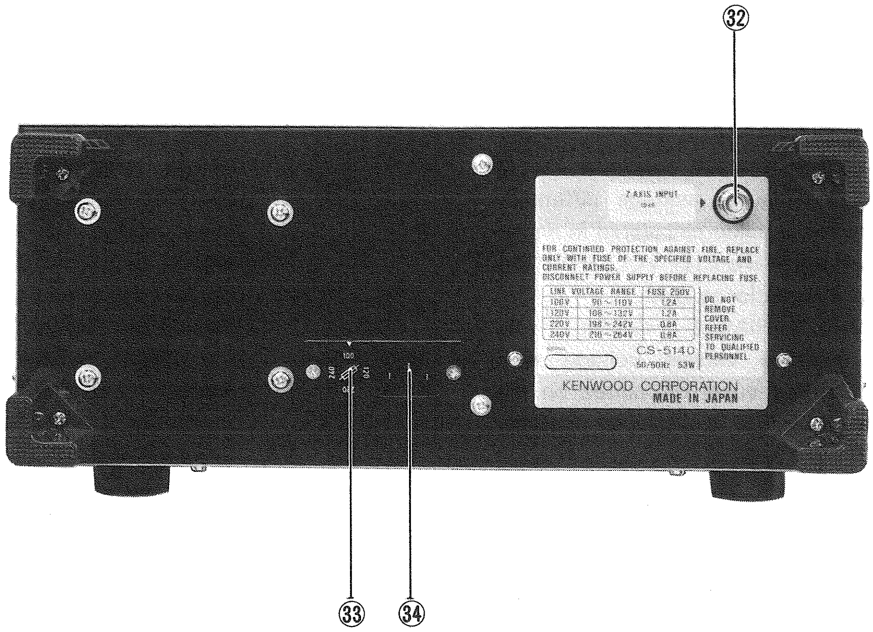


Fig. 4

REAR PANEL

㉜ **Z AXIS INPUT**
External intensity modulation input; TTL compatible. Positive voltage increases brightness, negative voltage decreases brightness.

㉝ **Fuse Holder, Line Voltage Selector**
Contains the line fuse. Verify that the proper fuse is installed when replacing the line fuse.
100 V, 120 V .... 1.2 A
220 V, 240 V .... 0.8 A
After pulling the power cord plug from the power outlet, adjust this selector to your line voltage.

㉞ **Power Input Connector**
Input terminals of power supply. Connect the AC cord provided.

DIRECTIONS FOR USE

READOUT DISPLAY

(1) POSITIONS OF THE DISPLAY

Displays the calendar, scale factors, cursor measurement data, etc. at the following positions on the CRT.

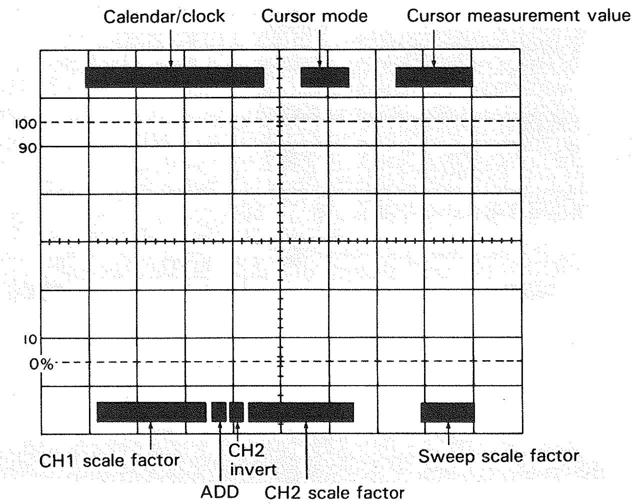


Fig. 5

(2) DISPLAY CONTENTS

1 Calendar/Clock

Displays a calendar and clock in the following order:
Month-Day-Year-O'clock-Minute

Month: JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC
Day: 01 to 31
Year: 00 to 99
O'clock: 00 to 23
Minute: 00 to 59

These setting can be changed with the switch located on the bottom. (For resetting, refer to the Maintenance section.)

2 Cursor Mode

The current setting cursor mode, which depends on the combination of the operation controls, is displayed.
ΔV1, ΔV2, ΔT, 1/ΔT, RATIO, PHASE

3 Cursor Measuring Data

The result measured by the two cursors is displayed. In the 1/ΔT mode, when the two cursors approach each other and the measurement nears its limit, a "?" will be displayed in front of the measured data. This shows that the measured data is not available.

4 CH1 Scale Factor

Displays the CH1 vertical axis sensitivity to one division. When not in CAL mode. a ">" is displayed after CH1.

NOTE: This is not displayed when the MODE control ⑪ is set to CH2.

5 CH2 Scale Factor

Displays the CH2 vertical axis sensitivity to one division. When not in CAL mode. a ">" is displayed after CH2.

NOTE: This is not displayed when the MODE control ⑪is set to CH1.

6 ADD

"+" is displayed when the MODE control ⑪ is set to ADD.

7 CH2 INVERT

The inverted polarity of CH2 "↓" is displayed by controlling the ⇕ POSITION/PULL INV ⑩ .

8 Sweep Scale Factor

Displays the sweep range set by the SWEEP TIME/DIV. When the SWEEP VARIABLE is not in CAL mode, a ">" is displayed. When TRIGGERING MODE is set to X-Y, this display is changed to "X-Y".

OPERATION

INITIAL STARTING PROCED

Prior to turning the power ON, set the switches as in the drawing below in advance. For details of switch setting, refer to the item "Front Panel". In the case of using a probe, refer to the Operation Manual attached to the probe as well as the application example "Probe Compensation".

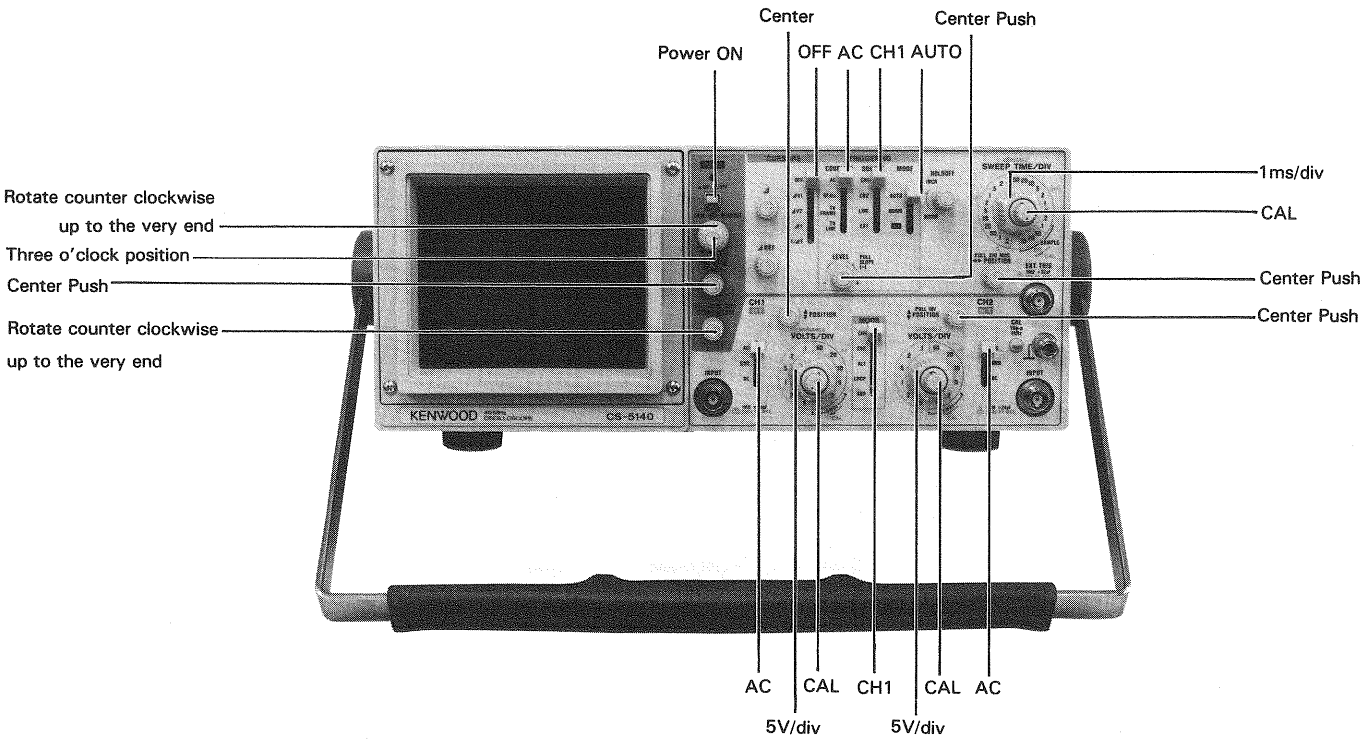


Fig. 6

[A] OPERATION AS A GENERAL-USE OSCILLOSCOPE

[1] Normal sweep display operation

1. Press the POWER switch ⑫ to supply power, and the POWER LED ⑬ lights.
2. A bright line appears in the CRT center. If it is not in the center, adjust its position to the center with the ⇕ POSITION controller ① . Then, adjust the brightness with the INTENSITY controller ⑯ , and the focus, with the FOCUS controller ⑱ as required for easy observation.
3. Supply input signal into the CH1 INPUT jack ⑤. Rotate the VOLTS/DIV dial ② to adjust waveform to appropriate dimensions.
   Set the MODE select switch ⑪ to CH2, and the TRIGGERING SOURCE select switch ㉓ to CH2. Then, supply input signal into the CH2 INPUT connector ⑨. Its waveform is displayed on the CRT in the same procedures with channel 1.
   When the MODE select switch is set to ADD, the composite waveforms of CH1 and CH2 (the algebraic sum of CH1 + CH2) is displayed on the CRT. In this status, if CH2 INV is engaged by pulling out the CH2 ⇕ POSITION, the algebraic difference between CH1 and CH2 (CH1 -CH2) will be displayed.
   The sensitivity of the ADDed waveform becomes the same as the value indicated by VOLTS/DIV provided that tne same VOLTS/DIV value has been set for the waveforms of the two channels.
   When the MODE select switch ⑪ is set to ALT, the channel-1 and channel-2 waveforms are displayed alternately in every sweep. In this case, the SOURCE select switch ㉓ should be set to the channel to be synchronized.
4. The display on the screen will probably be unsynchronized. Refer to TRIGGERING procedure below for adjusting synchronization and sweep speed to obtain a stable display showing the desired number of waveform.

TRIGGERING

The input signal must be properly triggered for stable waveform observation. TRIGGERING is possible the input signal INTernally to create a trigger or with an EXTernally provided signal of timing relationship to the observed signal, appliying such a signal to the EXT. TRIG INPUT jack ⑳ .

(1) The selection of a signal that serves as the trigger signal is made using the SOURCE switch ㉓ .

★Internal Sync

When the SOURCE selection is in INT (CH1, CH2, LINE), the input signal is connected to the internal trigger circuit. In this position, a part of the input signal fed to the INPUT ⑤ or ⑨ jack is applied from the vertical amplifier to the trigger circuit to cause the trigger signal triggered with the input signal to drive the sweep.

With the SOURCE selector set to CH1 or CH2, a trigger is developped by the CH1 or CH2 signal regardless of the MODE setting.

Setting the SOURCE select switch ㉓ to LINE causes synchronization with commercial power frequency.

★ **External Sync**

When the SOURCE selection is in EXT, the input signal at the EXT. TRIG INPUT ⑳ jack becomes the trigger. This signal must have a time or frequency relationship to the signal being observed to synchronize the display. External sync is prefered for waveform observation in many applications. For example, Fig. 7 shows that the sweep circuit is driven by the gate signal when the gate signal in the burst signal is applied to the EXT. TRIG INPUT jack.

Shows the input/output signals, where the burst signal generated from the signal is applied to the instrument under test. Thus, accurate triggering can be achieved without regard to the input signal fed to the INPUT ⑤ or ⑨ jack so that no further triggering is required even when the input signal is varied.

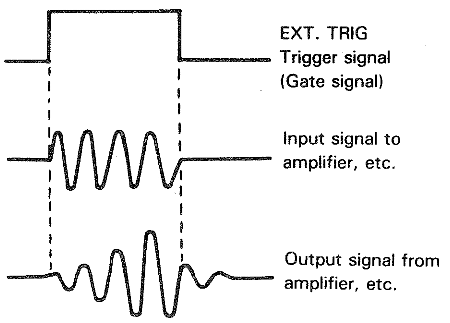


Fig. 7

(2) After the SOURCE has been set, the trigger point can be set by rotating LEVEL/SLOPE control ㉑ .

(3) Select the coupling switch ㉒ .

AC:

The trigger signal is capacitively coupled, so its DC component is cut, giving a stable trigger which is not affected by the DC component. With this advantage, this position of the coupling switch is conveniently selected for ordinary applications. However, if the trigger signal is lower than 10 Hz, the trigger signal level becomes attenuated, resulting in difficulty in triggering.

HF REJ:

The trigger signal is supplied through a low-pass filter to eliminate the high-frequency component (higher than 10 kHz), giving a stable triggering with low-frequency component. When high-frequency noise is superimposed over the trigger signal as shown in Fig. 8, the high-frequency noise is cut to provide a stable trigger.

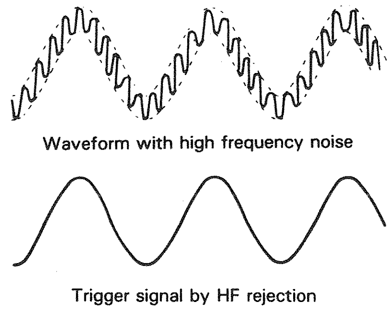


Fig. 8

★ **Triggering Level**

Trigger point on waveform is adjusted by the LEVEL/PULL SLOPE ㉑ control. Shows the relationship between the SLOPE and LEVEL of the trigger point. Triggering level can be adjusted as necessary.

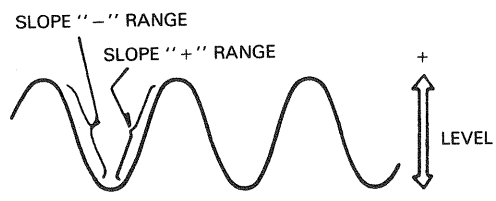


Fig. 9

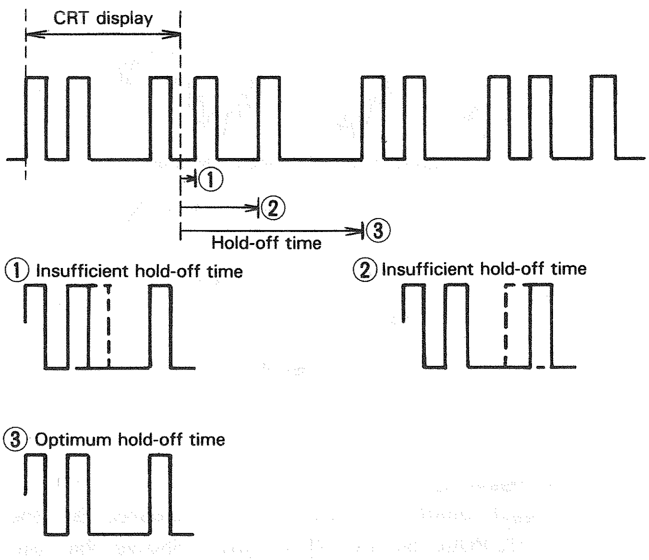
★ **Auto Trigger**

When the TRIG MODE ㉔ selection is in AUTO, the sweep circuit becomes free-running as long as there is no trigger signal, permitting a check of GND level. When a trigger signal is present, the trigger point can be determined by the LEVEL control for observation as in the normal trigger signal. When the trigger level exceeds the limit, the trigger circuit becomes free-running where the waveform starts running.

NOTE: If, with the TRIG MODE switch set to NORM, no trigger signal is input or the trigger signal exceeds the triggering range, sweeping is stopped and trace will not be displayed.

★ **HOLD OFF**

In case of triggering difficulties that may occur with signals containing different pulse durations although the pulse repetition itself is constant as shown below, or with complicated signals such as a TV signal, turn the HOLD OFF control ㉘ to obtain a stable triggering.



5. Adjust the SWEEP TIME/DIV control ㉖ to obtain an appropriate display. Now a normal sweep display is obtained.

[2] SWEEP magnification operation

Merely shortening the sweep time to magnify a portion of observed waveform can result in the desired portion disappearing off the screen. the desired portion can be displayed without such trouble if the sweep magnification feature is used (also refer to "Sweep Magnification" on page 5).
Using the ◄► POSITION control, adjust the desired portion of waveform to the CRT. Pull out the PULL×10 MAG control to magnify the display 10 times. For this type of display the sweep time is the SWEEP TIME/DIV setting divided by 10.

[3] X-Y operation

X-Y operation permits the oscilloscope to perform many measurements not possible with conventional sweep operation.
Set the TRIGGER MODE switch ㉔ to the X-Y position. In this mode, channel 1 becomes the Y axis input and channel 2 becomes the X axis input.
The X and Y positions are now adjusted using the ◄► POSITION ㉗ and CH1 ♦ POSITION controls respectively.
X and Y sensitivity are set by using the channel 2 and channel 1 VARIABLE VOLTS/DIV controls respectively.

[4] VIDEO signal observation

Setting the COUPLING ㉒ switch, to the TV FRAME or TV LINE position permits selection of vertical or horizontal sync pulses for sweep triggering when viewing composite video waveforms.
This makes stable triggering in video signal observations possible regardless of the TRIG LEVEL control ㉑ .
At most points of measurement, a composite video signal is of the polarity, that is, the sync pulses are negative and the video is positive. In this case, use "−" SLOPE.
If the waveform is taken at a circuit point where the video waveform is inverted, the sync pulses are positive and the video is negative. In this case, use "+" SLOPE.

[B] EQUIVALENT SAMPLING

The equivalent sampling mode is activated automatically when the SWEEP TIME/DIV control ㉖ is set to the range between 0.1 μs/div and 10 μs/div. When the mode is swtiched from the real-time mode to equivalent sampling mode, the bandwidth is also switched from 40 MHz (−3 dB) to 100 MHz (−3 dB) so that the display amplitude may vary with higher input signal frequencies.
When it is required to observe amplitude variations, fix the mode either to the real-time or equivalent sampling mode.
With a sampling oscilloscope, different parts of the input signal are sampled with certain time differences, and the signals obtrained are amplified and applied to the vertical amplifier. At the same time, the time signals corresponding to the sampling time difference are applied to the horizontal amplifier, so that the same image as the input signal is reconstructed on the display using the two types of signals.
This system therefore necessitates that the input signal is a repetitive waveform, and the repetitions shall continue for a certain period and shall be stable.

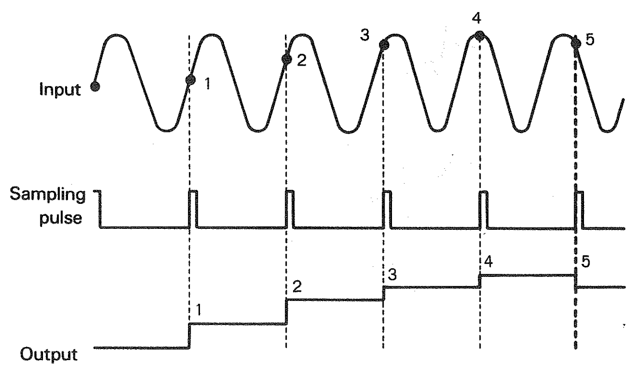


Fig. 10

Fig. 10 shows a case in which a sampling pulse that is delayed by a specified period from the input signal is generated, and the signal held by the sampling pulse becomes the output signal.
In the example shown in this figure, the output signal SYNC is 1/12 of the input signal.

NOTE: When the input signal frequency is low, the dots of the waveform observed by equivalent sampling become coarse.
If triggering is applied incorrectly, the equivalent sampling operation will be abnormal, so that the displayed waveform will be totally different from the real input signal.

[C] READOUT OPERATION

1 CRT surface readout

By rotating the INTEN (READOUT) controller ⑰ clockwise up to the very end, characters are displayed on the CRT. Adjust the brightness as necessity requires. The CH1 and CH2 scale factors are displayed in the lower part of the CRT in accordance with setting of the MODE select switch ⑪ . The sweep scale factor is displayed in the lower right part. By pulling the ◄► POSITION/PULL×10 MAG switch ㉗ , a tenth scale factor of the SWEEP TIME/DIV dial ㉖ is displayed. The calendar is displayed in the upper left.

NOTE: If the DATA-ON/OFF switch on the bottom is set to OFF position, the calendar is not displayed. For the calendar setting, refer to the item "Maintenance and Adjustment".

When the readout values are displayed, brilliance modulation may influence the real-time waveform in some cases. In such a case, rotate the INTEN (READOUT) controller ⑰ counter-clockwise up to the very end. The readout function turns OFF, and the brilliance modulation on the real-time waveform disappears.

2 Cursor measurement

ΔV1: Set the MODE select switch ⑪ to ALT and the CURSORS select switch ㉛ to ΔV1, and two horizontal cursor lines are displayed on the CRT and voltage difference between cursor lines calculated in accordance with setting of the CH1 VOLTS/DIV dial ② is displayed in the upper right on the CRT. By setting the CH1 VARIABLE controller ③ to the UNCAL position, voltage ratio is displayed.
Move the cursors to the positions to be measured with the ΔREF controller ㉚ and Δ controller ㉙ .

ΔV2: Set the CURSORS select switch ㉛ to V2, and voltage difference in accordance with the CH2 range setting is displayed in the upper right on the CRT similarly with the above.

ΔT: Set the CURSORS select switch ㉛ to ΔT, and two vertical cursor lines are displayed on the CRT and time difference between the cursor lines calculated based on the sweep scale factor displayed in the lower right is displayed in the upper right. By setting the SWEEP VARIABLE controller ㉕ to the UNCAL position, time ratio is displayed.

1/ΔT: Set the CURSORS select switch ㉛ to 1/ΔT, and two vertical cursor lines are displayed on the CRT and frequency between the cursor lines calculated based on the sweep scale factor displayed in the lower right is displayed in the upper right. By setting the SWEEP VARIABLE controller ㉕ to the UNCAL position, phase difference is displayed.

In the case shown in Fig. 10, the sampling pulse is generated with a certain delay with respect to the input signal, and the signal held by this sampling pulse becomes the output signal.
In this figure, the period of the output signal is 1/12 of the input signal.

NOTE: When the equivalent sampling is applied to an input signal with a low frequency, the dots of the waveform obtained will be coarse.
When triggering is inaccurate, the equivalent sampling operation will be abnormal and the waveform displayed on the screen will be totally different from the input signal.

APPLICATIONS

PROBE COMPENSATION

For accurate measurement, perform appropriate probe correction prior to measurement.

1. Connect a probe to the INPUT terminal, and set each switch so that normal sweep is displayed.
2. Connect the probe to the CAL terminal on the front panel, and adjust the SWEEP TIME/DIV switch so that several cycles of this signal are displayed.
3. Adjust compensation trimmer on probe for optimum square wave waveshape (minimum overshoot, rounding off, and tilt).

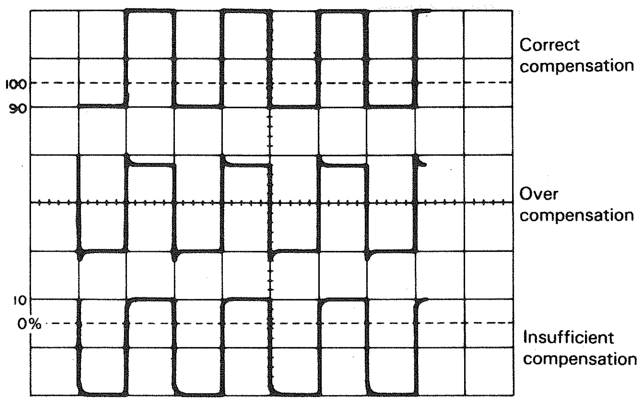


Fig. 11

TRACE ROTATION COMPENSATION

Rotation from a horizontal trace position can be the cause of measurement errors.

Adjust the controls for a single display. Set the AC-GND-DC switch to GND and A TRIG MODE to AUTO. Adjust the ⇕ POSITION control such that the trace is over the center horizontal graticule line. If the trace appears to be rotated from horizontal, align it with the center graticule line using the TRACE ROTATION control located on the front panel.

1. DC VOLTAGE MEASUREMENT

Two types of measurement methods are provided; ordinary measurement and cursor measurement.

(1) Ordinary Measurement

To measure waveform DC level, carry out the following operations:

1. Connect the signal to be measured to the INPUT jack. For the channel which is selected by the vertical MODE switch, set the AC-GND-DC switch to DC and adjust the controls for normal sweep. Then adjust the VOLTS/DIV and SWEEP TIME/DIV controls to the optimum settings for measurement of the waveform.
   The VARIABLE switch should be set to CAL.
2. Set the TRIG MODE switch to AUTO and AC-GND-DC switch to GND. The trace displayed at this time is the GND level (reference line).
   Using the ⇕ POSITION control, adjust the trace position to the desired reference level position, making sure not to disturb this setting once made.
3. Set the AC-GND-DC switch to the DC position to observe the input waveform, including its DC component. If an appropriate reference level or VOLTS/DIV setting was not made, the waveform may not be visible on the CRT screen at this point. If so, reset VOLTS/DIV and/or the ⇕ POSITION control.
4. Use the ◄► POSITION control to bring the portion of the waveform to be measured to the center vertical graduation line of the CRT screen.
5. Measure the vertical distance from the reference level to the point to be measured, (the reference level can be rechecked by setting the AC-GND-DC switch again to GND).
   To obtain the real voltage, multiply the vertical distance value by the VOLTS/DIV indication value. When a 10:1 probe is used, further multiply the value by 10. Voltages above and below the reference level are positive and negative values respectively.

① When a 10:1 probe is used:
DC level = Vertical distance (div) × VOLTS/DIV setting × 10

② With direct measurement
DC level = Vertical distance in divisions × (VOLTS/DIV setting) × (probe attenuation ratio).

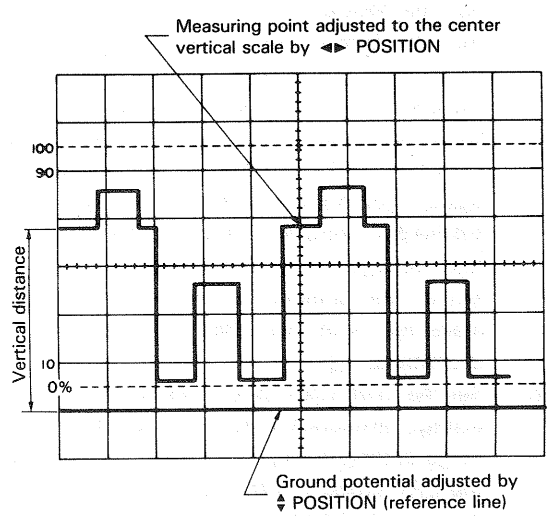


Fig. 12

[EXAMPLE]

For the example, the point being measured is 3.8 divisions from the reference level (ground potential).

If the VOLTS/DIV was set to 0.2 (V/div) and a 10:1 probe was used. (See Fig. 12)

Substituting the given values:

DC level = 3.8 (div) × 0.2(V) × 10 = 7.6 V

(2) Cursor measurement

1) Make the GND luminescent line be displayed by means of ordinary procedures 1) and 2).
2) Set the cursor mode to Δ VI or Δ V2 in accordance with the channel to be used.
3) Adjust the Δ REF cursor (reference line) to the GND luminescent line.
4) Set the AC-GND-DC switch to DC.
5) Adjust the Δ cursor to a point to be measured.
6) Measured value is displayed in the upper right part on the screen posterior to Δ V1 or Δ V2.
   If the attached probe PC-31 is used, measured value including the attenuation ratio is displayed. If a probe incompatible with the readout function is used, measured value is multiplied by the attenuation ratio.
   Lowering of the Δ cursor below the Δ REF cursor indicates negative voltage, displaying "−".

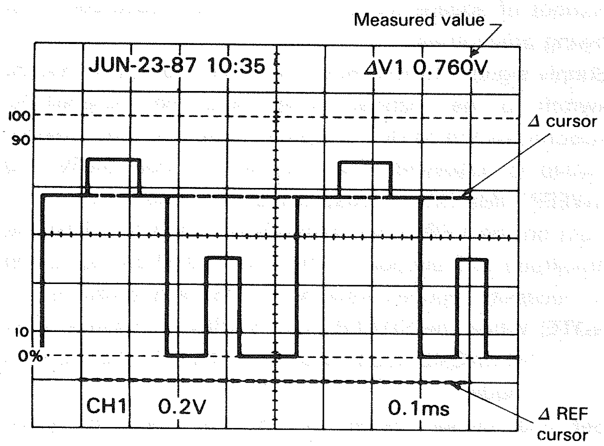


Fig. 13

2. MEASUREMENT OF THE VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM

(1) Ordinary measurement

This technique can be used to measure peak-to-peak voltages.

1. Apply the signal to be measured to the INPUT jack. Set the vertical MODE to the channel to be used. Set the vertical MODE to the channel to be used. Set the AC-GND-DC to AC, adjusting VOLTS/DIV and SWEEP TIME/DIV for a normal display. Set the VARIABLE control to CAL position.
2. Using the ⬍ POSITION control, adjust the waveform position such that one of the two points falls on a CRT graduation line and that the other is visible on the display screen.
3. Using the ◂▸ POSITION control, adjust the second point to coincide with the center vertical graduation line.
4. Measure the vertical distance between the two points and multiply this by the setting of the VOLTS/DIV control.
   When a 10:1 probe is used, further multiply the value by 10.

① When a 10:1 probe is used.
Volts peak-to-peak
= Vertical distance (div) × (VOLTS/DIV setting) × 10

② With direct measurement
Voltage between 2 points = Vertical distance (div) × 2 points.

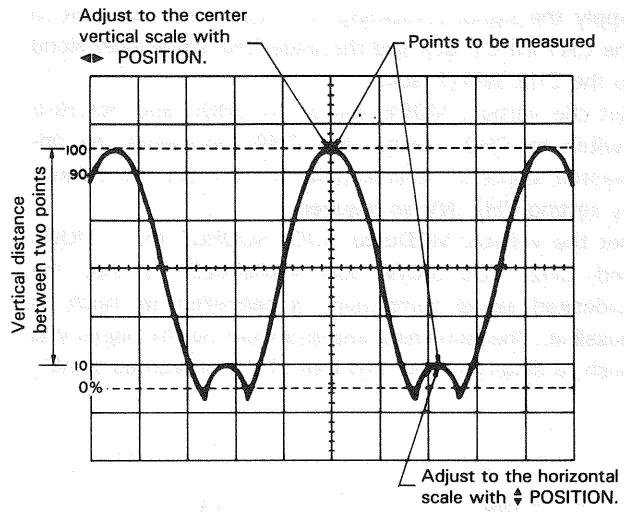


Fig. 14

[EXAMPLE]

For the example, the two points are separated by 4.5 divisions vertically. Set the VOLTS/DIV setting be 0.2 V/div and the probe attenuation be 10:1. (See Fig. 14)

Substituting the given value:
Voltage between two points
= 4.5 (div) × 0.2(V/div) × 10 = 9.0V

(2) Cursor measurement

1) Make waveform to be observed be displayed on the screen in ordinary procedure 1).
2) Set the cursor mode to Δ V1 or Δ V2 in accordance with the channel to be used.
3) Adjust the Δ REF cursor to a lower point to be measured. and the Δ cursor to another point.
4) Measured value is displayed in the upper right part on the screen posterior to Δ V1 or Δ V2.

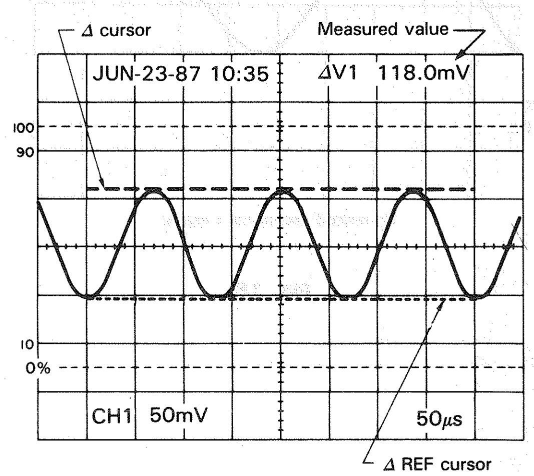


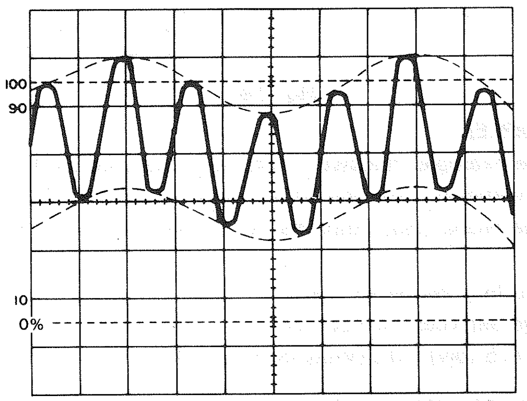
Fig. 15

3. ELIMINATION OF UNDESIRED SIGNAL COMPONENTS

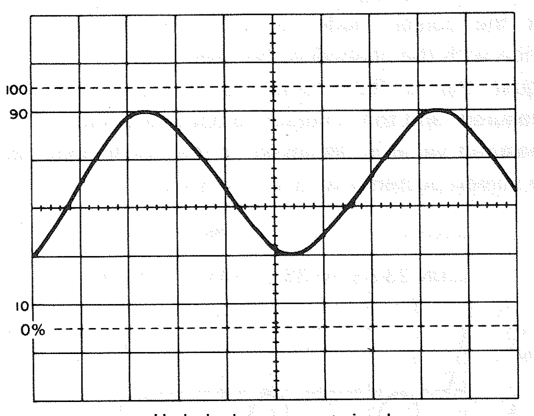
The ADD feature can be conveniently used to cancel out the effect of an undesired signal component which superimposed on the signal you wish to observe.

Procedure:

1. Apply the signal containing an undesired component to the CH1 INPUT jack and the undesired signal itself alone to the CH2 INPUT jack.
2. Set the vertical MODE switch to CHOP and SOURCE switch to CH2. Verity that CH2 represents the unwanted signal in reverse polarity. Reverse the polarity by setting CH2 INV as required.
3. Set the vertical MODE to ADD, SOURCE to V. MODE and CH2 VOLTS/DIV and VARIABLE so that the undesired signal component is cancelled as much as possible. The remaining signal should be the signal you wish to observe alone and free of the unwanted signal.

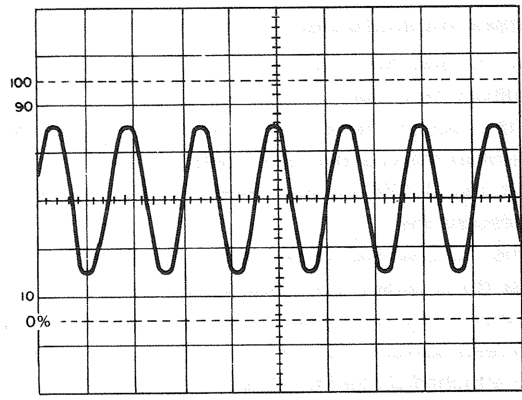


Signal containing undesired component
(Broken lines: undesired component envelope)



Undesired component signal

Fig. 16



Signal without undesired component

Fig. 17

4. VOLTAGE RATIO MEASUREMENT USING CURSORS

Overshoot of square waves. etc. can be measured in the following procedures:

1) Supply signal into the INPUT terminal. Set the V. MODE switch to the channel to be used. the AC-GND-DC selector switch to DC. and each switch so that ordinary sweep is displayed. Then adjust the VOLTS/DIV and SWEEP TIME/DIV for easy waveform observation.
2) Turn on the VERTICAL VARIABLE switch to adjust the amplitude to 5 div points (0% and 100%) on the screen as necessity requires with the ▲▼ POSITION switches.
   NOTE: When the SWEEP TIME VARIABLE switch is set to UNCAL, the unit is set to RATIO measurement mode.
3) Set the cursor mode to ΔV1 or ΔV2 in accordance with the channel to be used.
4) Adjust the Δ REF cursor to 100%.
5) Adjust the Δ cursor to a point overshoot at which is to be measured.
6) Overshoot voltage ratio with respect to the 5 div (100%) point is displayed in the upper right part on the screen posterior to RATIO.

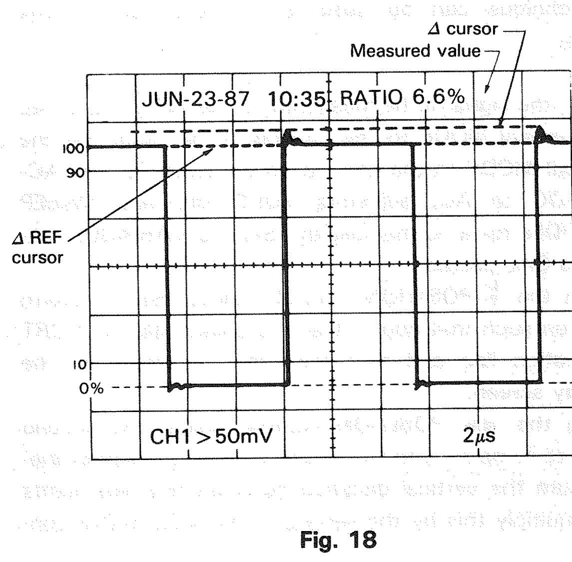


Fig. 18

5. TIME MEASUREMENTS

(1) Ordinary measurement

Time between two points on a wave can be measured from the SWEET TIME/DIV value and horizontal distance between two points.

Procedure:

1. Apply the signal to be measured to the INPUT jack. Set the vertical MODE to the channel to be used. Set the AC-GND-DC to DC, adjusting VOLTS/DIV and SWEEP TIME/DIV for a normal display. Set the VARIABLE control to CAL position.
2. ◄► POSITION control to set this point at the intersection of any vertical graduation line. Using the ▲▼ POSITION control, set one of the points to be used as a reference to coincide with the horizontal centerline.
3. Measure the horizontal distance between the two points.
   Multiply this by the setting of the SWEEP TIME/DIV control to obtain the time between the two points. If horizontal "×10 MAG" is used, multiply this further by 1/10.

Using the formula:
Time = Horizontal distance (div) × (SWEEP TIME/DIV setting) × "×10 MAG" value^{-1} (1/10)

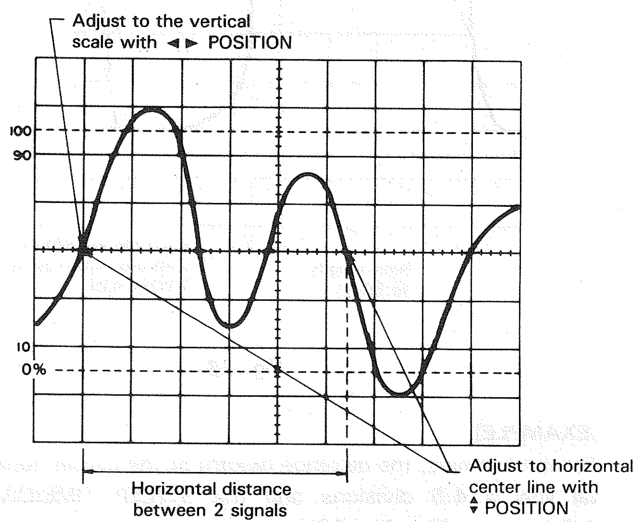


Fig. 19

[EXAMPLE]
For the example, the horizontal distance between the two points is 5.4 divisions.
If the SWEEP TIME/DIV is 0.2 ms/div we calculate. (See Fig. 19)

Substituting the given value:
Time = 5.4 (div) × 0.2 (ms/div) = 1.08 ms

(2) Cursor measurement

1. In the same way as the ordinary measurement. adjust the waveform to be measured to an easy-to-observe point.
2. Set the cursor mode to Δ T.
3. Adjust the Δ REF cursor to the left of the two point to be measured. and the Δ cursor to the right.
4. Measured value is displayed in the upper right part on the screen posterior to Δ T.

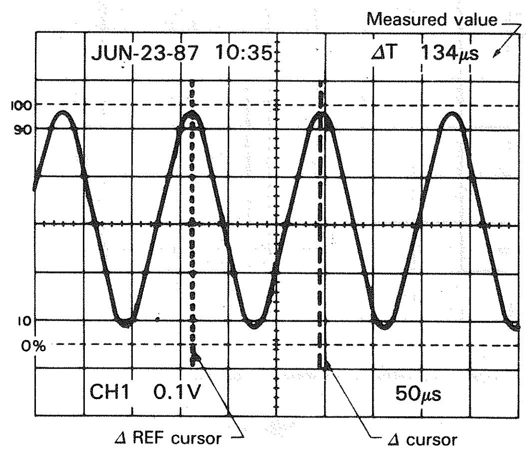


Fig. 20

6. TIME DIFFERENCE MEASUREMENTS

(1) Ordinary measurement

Time difference between two synchronized signals can be measured as follows:

Procedure:

1. Apply the two signals to CH1 and CH2 INPUT jacks. Setting the vertical MODE to either ALT or CHOP mode. Generally for low frequency signals CHOP is chosen with ALT used for high frequency signals.
2. Select the faster of the two signals as the SOURCE and use the VOLTS/DIV and SWEEP TIME/DIV to obtain an easily observed display.
   Set the VARIABLE control to CAL position.
3. Using the ▲▼ POSITION control set the waveforms to the center of the CRT display and use the ◄► POSITION control to set the reference signal to be coincident with a vertical graduation line.
4. Measure the horizontal distance between the two signals and multiply this distance in divisions by the SWEEP TIME/DIV setting.
   If "×10 MAG" is being used multiply this again by 1/10.

Using the formula:
Time = Horizontal distance (div) × (SWEEP TIME/DIV setting) × "×10 MAG" value^{-1} (1/10)

[EXAMPLE]

For the example, when the horizontal distance between two signals is 4.4 divisions. The SWEEP TIME/DIV is 0.2 (ms/div). (See Fig. 21)

Substituting the given value:
Time = 4.4 (div) × 0.2 (ms/div) = 0.88 ms

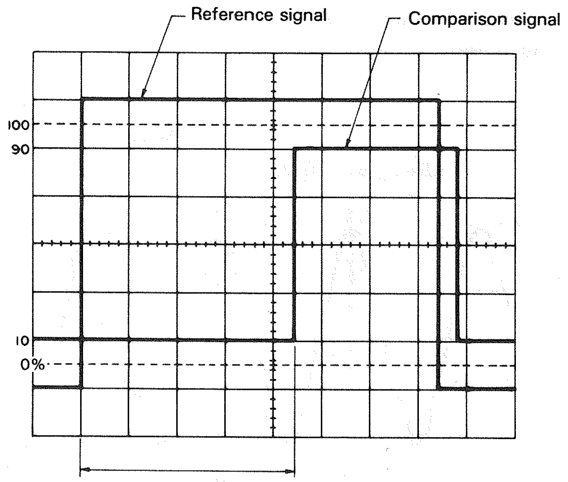


Fig. 21

(2) Cursor measurement

1. In the same way as the ordinary measurement, adjust waveforms to be measured to an easy-to-observe position.
2. Set the cursor mode to Δ T.
3. Adjust the Δ REF cursor to the left point time difference between which is to be measured. and the Δ cursor to the right.
4. Measured value is displayed in the upper right part on the screen posterior to Δ T.

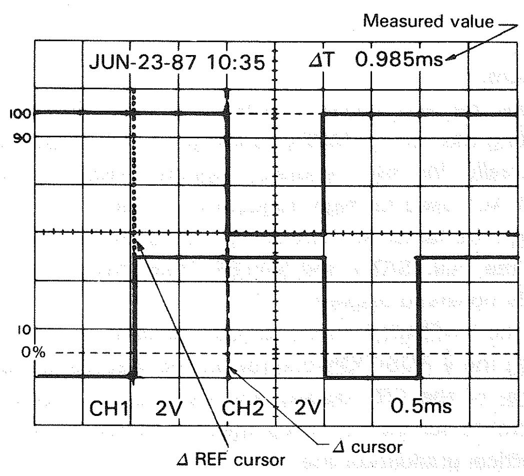


Fig. 22

7. PULSE WIDTH MEASUREMENTS

(1) Ordinary measurement

Pulse width can be measured as follows:

Procedure:

1. Apply the pulse signal to the INPUT jack. Set the vertical MODE to the channel to be used.
2. Use the VOLTS/DIV, VARIABLE and ⬍ POSITION to adjust the waveform such that the pulse is easily observed and such that the center pulse width coincides with the center horizontal line on the CRT screen.
3. Set the SWEEP VARIABLE switch to CAL. Measure the horizontal distance between the intersections of the pulse waveform and CRT center horizontal line in divisions, and multiply the measured distance by the value indicated by SWEEP TIME/DIV. If the "×10 MAG" mode is activated, also multiply the value by 1/10.

Using the formula:

Pulse width = Horizontal distance (div) × (SWEEP TIME/DIV setting) × "×MAG 10"value^{-1} (1/10)

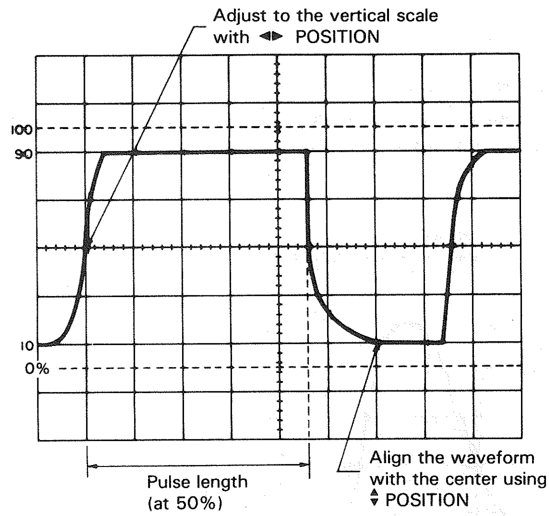


Fig. 23

[EXAMPLE]

For the example, the distance (width) at the center horizontal line is 4.6 divisions and the SWEEP TIME/DIV is 0.2 (ms/div.) (See Fig. 23)

Substituting the given value:
Pulse width = 4.6 (div) × 0.2 (ms/div) = 0.92 ms

(2) Cursor measurement

1. In the same way as the ordinary measurement. adjust waveforms to be measured to an easy-to-observe position.
2. Set the cursor mode to Δ T.
3. Adjust the Δ REF cursor to the left edge of the pulse signal to be measured, and the Δ cursor to the right edge.
4. Measured value is displayed in the upper right part on the screen posterior to Δ T.

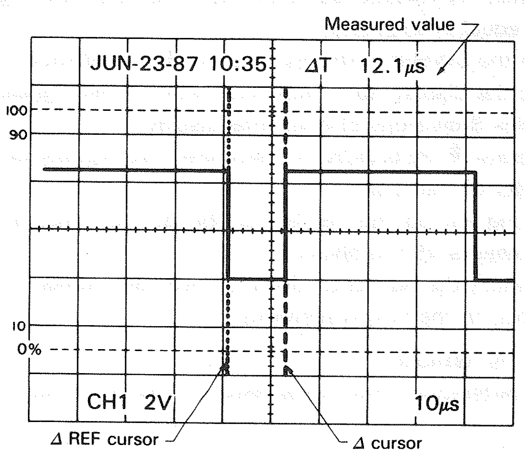


Fig. 24

8. PULSE RISETIME AND FALLTIME MEASUREMENTS

(1) Ordinary measurement

For risetime and falltime measurements, the 10% and 90% amplitude points are used as starting and ending reference points.

Procedure:

1. Apply a signal to the INPUT jack. Set the vertical MODE to the channel to be used.
   Use the VOLTS/DIV and VARIABLE to adjust the waveform peak-to-peak height to five divisions.
2. Using the ▲▼ POSITION control and the other controls, adjust the display such that the waveform is centered vertically in the display. Set the SWEEP TIME/DIV to as fast a setting as possible consistent with observation of both the 10% and 90% points. Set the SWEEP VARIABLE control to CAL position.
3. Use the ◄► POSITION control to adjust the 10% point to coincide with a vertical graduation line and measure the distance in divisions between the 10% and 90% points on the waveform. Multiply this by the SWEEP TIME/DIV and also by 1/10, if "×10 MAG" mode was used.

NOTE: The graticule on the CRT includes the 0, 10, 90, and 100% lines assuming that 5 divisions correspond to 100%. Use them as a reference for accurate measurements.

Using the formula:
Risetime = Horizontal distance (div) × (SWEEP TIME/DIV setting) × "×10 MAG" value^{-1} (1/10)

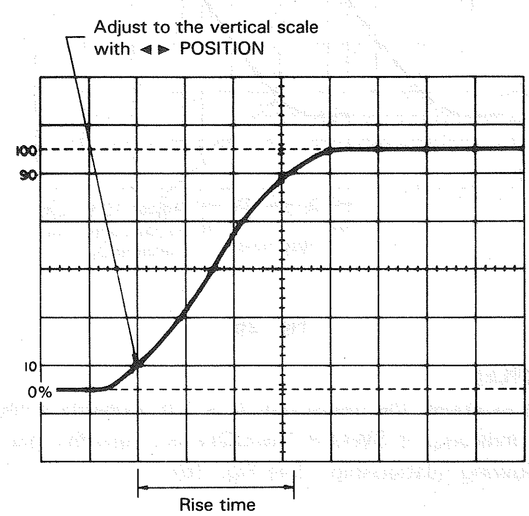


Fig. 25

[EXAMPLE]
For the example, the horizontal distance is 3.3 divisions. The SWEEP TIME/DIV is 2 (μs/div). (See Fig. 25)

Substituting the given value:
Risetime = 3.3 (div) × 2 (μs/div) = 6.6μs

Risetime and falltime can be measured by making use of the alternate step 3 as described below as well.

4. Use the ◄► POSITION control to set the 10% point to coincide with the center vertical graduation line and measure the horizontal distance to the point of the intersection of the waveform with the center horizontal line. Let this distance be D_1. Next adjust the waveform position such that the 90% point coincides with the vertical centerline and measure the distance from that line to the intersection of the waveform with the horizontal centerline. This distance is D_2 and the total horizontal distance is then D_1 plus D_2 for use in the above relationship in calculating the risetime or falltime.

Using the formula:
Risetime = $(D_1 + D_2)$ (div) × (SWEEP TIME/DIV setting) × "×10 MAG" value^{-1} (1/10)

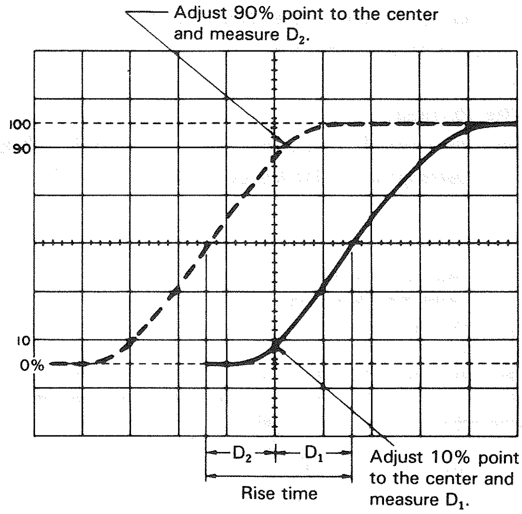


Fig. 26

[EXAMPLE]

For the example, the measured D_1 is 1.6 divisions while D_2 is 1.4 divisions. If SWEEP TIME/DIV is 2 (μs/div) we use the following relationship. (See Fig. 26)

Substituting the given value:
Risetime = (1.6 + 1.4) (div) × 2 (μs/div) = 6 μs

(2) Cursor measurement

1. In the same way as the ordinary measurement, adjust the waveform height displayed on the screen to 5 divisions, and align the bottom and top of the waveform with 0% and 100% respectively using the ⧫ POSITION switches.
2. Set the cursor mode to ΔT.
3. Adjust the Δ REF cursor to the crossing of the waveform and the 10% division of the scale, and the Δ cursor to the crossing of the waveform and the 90% division.
4. Measured value is displayed in the upper right part on the screen posterior to ΔT.

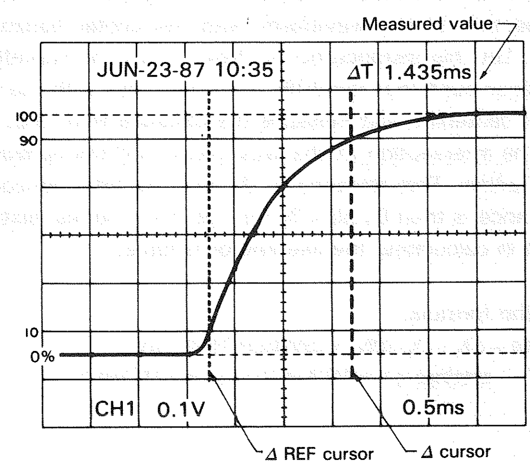


Fig. 27

9. PHASE DIFFERENCE MEASUREMENTS

(1) Ordinary measurement

Phase difference between two sine waves of the same frequency, etc. can be measured as follows:

Procedure:

1. Apply the two signals to the CH1 and CH2 INPUT jacks, setting the vertical MODE to either CHOP or ALT mode.
2. Set the controls to obtain normal sweep. Set the SOURCE switch to select the signal which is leading in phase (reference signal), and adjust the VOLTS/DIV and vertical VARIABLE controls such that the two signals are equal in amplitude.
3. Use the SWEEP TIME/DIV and SWEEP VARIABLE to adjust the display such that one cycle of the signals occupies 8 divisions of horizontal display.
   Operate ⧫ POSITION to shift the two signals on the center of the scale.
   Having set up the display as above, one division now represents 45° in phase.
4. Measure the horizontal distance between corresponding points on the two waveforms.

Using the formula:
Phase difference = Horizontal distance (div) × 45°/div

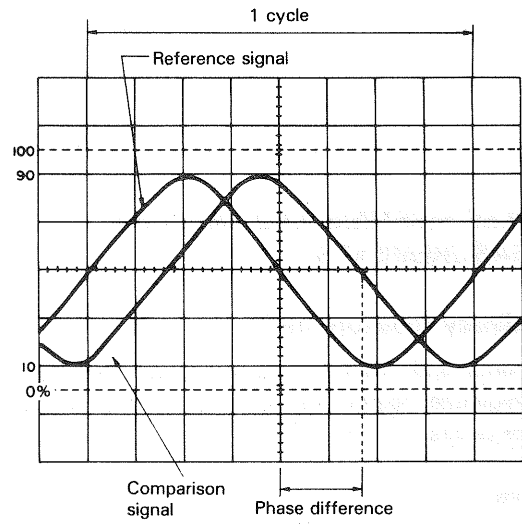


Fig. 28

[EXAMPLE]

For the example, the horizontal distance is 1.7 divisions. (See Fig. 28)

Substituting the given value:
The phase difference = 1.7 (div) × 45°/div = 76.5°

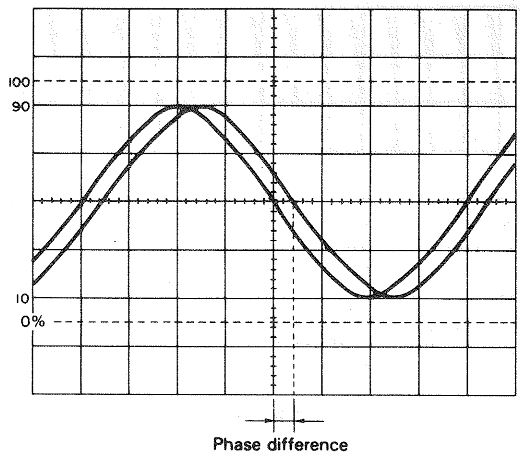
The above setup allows 45° per division but if more accuracy is required the SWEEP TIME/DIV may be changed and magnified without touching the VARIABLE control and if necessary the trigger level can be readjusted.

In this case, the phase difference can be obtained from the SWEEP TIME/DIV setting for 8 divisions/cycle and the new SWEEP TIME/DIV setting changed for higher accuracy, by useing the following formula.

Phase difference = Horizontal distance of new sweep range (div) × 45°/div

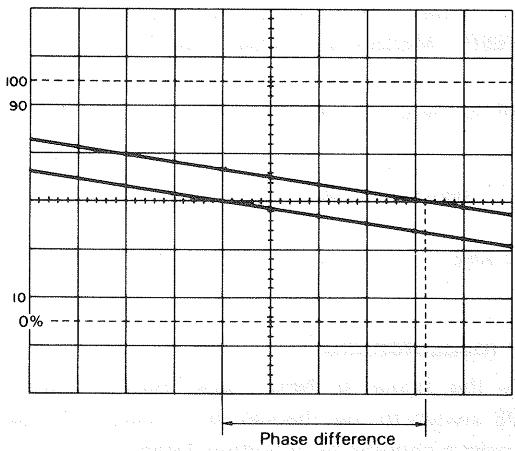
$$\times \frac{\text{New SWEEP TIME/DIV setting}}{\text{Original SWEEP TIME/DIV setting}}$$

Another simple method of obtaining more accuracy quickly is to simply use ×10 MAG for a scale of 4.5°/div.



One cycle adjusted to occupy 8 div.

Fig. 29



Expanded sweep waveform display.

Fig. 30

(2) Cursor measurement

1. In ordinary procedures 1 and 2, adjust waveforms to be measured to an easy-to-observe position.
2. Adjust 1 cycle's waveform to 5 divisions with the SWEEP TIME/DIV. VARIABLE controller. Then move two waveforms to the center of the scale with the ▲▼ POSITION switches.
3. Set the cursor mode to 1/ΔT.
   NOTE: When the SWEEP TIME VARIABLE switch is set to UNCAL, the unit is set to PHASE measurement mode.
4. Bring the Δ REF cursor to the intersection of the phaseleading signal and center line of the horizontal scale, and bring the Δ cursor to the intersection of the phase-lagging signal and center line of the horizontal scale.
5. Measured value is displayed in the upper right part on the screen posterior to PHASE.

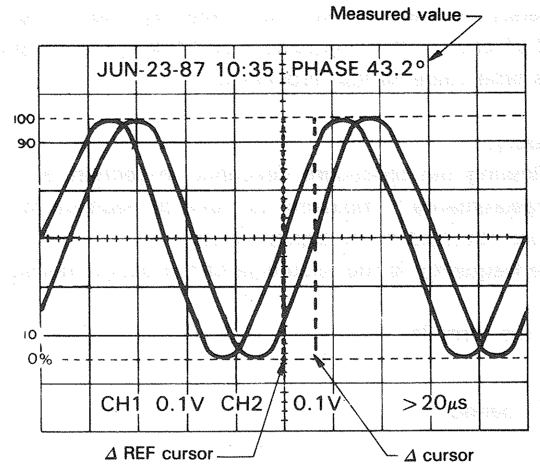


Fig. 31

10. TIME RATIO MEASUREMENT USING CURSORS

Duty ratio of square waves can be measured as follows:

1. Supply signal into the INPUT terminal. Set the V. MODE switch to the channel to be used, the AC-GND-DC selector switch to DC, and each switch so that ordinary sweep is displayed. Then adjust the VOLTS/DIV and SWEEP TIME/DIV for easy waveform observation.
2. Turn the SWEEP TIME VARIABLE switch on to adjust 1 cycle's waveform to 5 divisions on the screen with the ◄► POSITION switches as necessity requires.
   NOTE: When the SWEEP TIME VARIABLE switch is set to UNCAL, the unit is set to RATIO measurement mode.
3. Set the cursor mode to ΔT.
4. Adjust the Δ REF cursor to the left of the two points to be measured, and the Δ cursor to the right.
5. Duty ratio with respect to the 5 div (100%) point is displayed percentagewise in the upper right part on the screen posterior to RATIO.

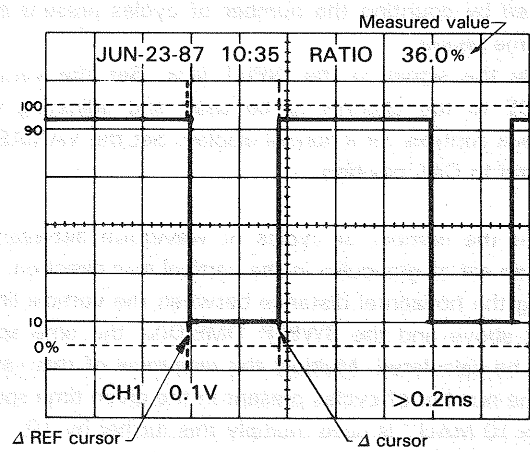


Fig. 32

11. FREQUENCY MEASUREMENTS

Frequency measurements are made by measuring the period of one cycle of waveform and taking the reciprocal of this time value as the frequency.

Procedure:

1. Following the proceudre described in section 5 "Time Measurements", measure the time of each cycle. The figure obtained in the signal period.
2. The frequency is the reciprocal of the period measured.

Using the formula:

$$\text{Freq} = \frac{1}{\text{period}}$$

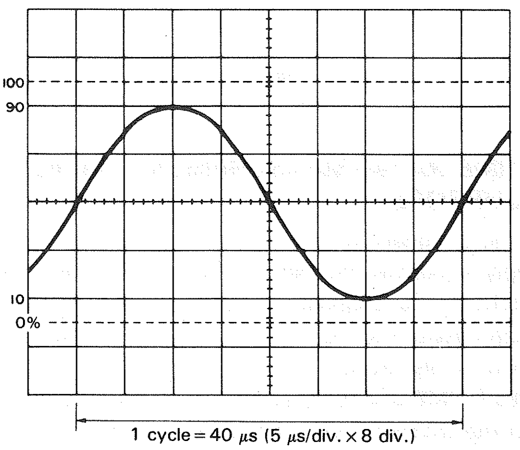


Fig. 33

[EXAMPLE]

A period of 40 μs is observed and measured. (See Fig. 33)

Assuming that SWEEP TIME/DIV indicates 5 μs/div, substituting the given Value:

$\text{Freq} = 1/[40 \times 10^{-6}] = 2.5 \times 10^{4} = 25$ kHz

While the above method relies on the measurement directly of the period of one cycle, the frequency may also be measured by counting the number of cycles present in a given time period.

1. Apply the signal to the INPUT jack. Set the vertical MODE to the channel to be used and adjusting the various controls for a normal display. Set the VARIABLE control to CAL position.

2. Count the number of cycles of waveform between a chosen set of graticules in the vertical axis direction. Using the horizontal distance between the vertical lines used above and the SWEEP TIME/DIV, the time span may be calculated. Multiply the reciprocal of this value by the number of cycles present in the given time span. If "×10 MAG" is used multiply this further by 10. Note that errors will occur for displays having only a few cycles.

Using the formula:

$$\text{Freq} = \frac{\text{\# of cycles} \times \text{"}\times 10\text{ MAG" value}}{\text{Horizontal distance (div)} \times \text{SWEEP TIME/DIV setting}}$$

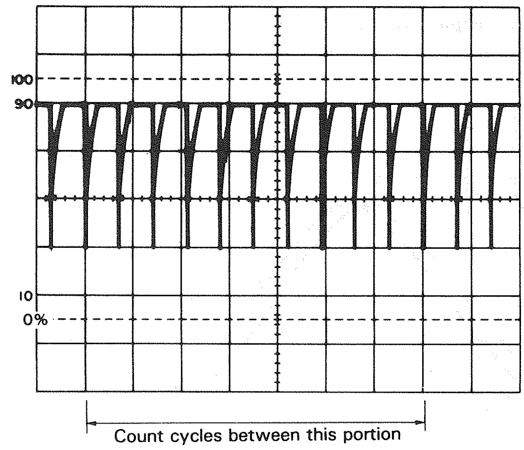


Fig. 34

[EXAMPLE]

For the example, within 7 divisions there are 10 cycles. The SWEEP TIME/DIV is 5 μs/div. (See Fig. 34)

Substituting the given value:

$$\text{Freq} = \frac{10}{7\text{ (div)} \times 5\ (\mu\text{s/div})}$$

$\fallingdotseq 285.7$ kHz

Cursor measurement

1. Apply the signal to INPUT jack, setting the vertical MODE switch to the channel to be used and adjusting the various controls for a normal display. VOLTS/DIV and SWEEP TIME/DIV to obtain an easily observed display. Set the VARIABLE to CAL.
2. Set the cursor mode to 1/ΔT.
3. Adjust the Δ REF cursor to the left of the points to be measured, and the Δ cursor to the right.
4. Measured value is displayed in the upper part on the screen posterior to 1/ΔT.

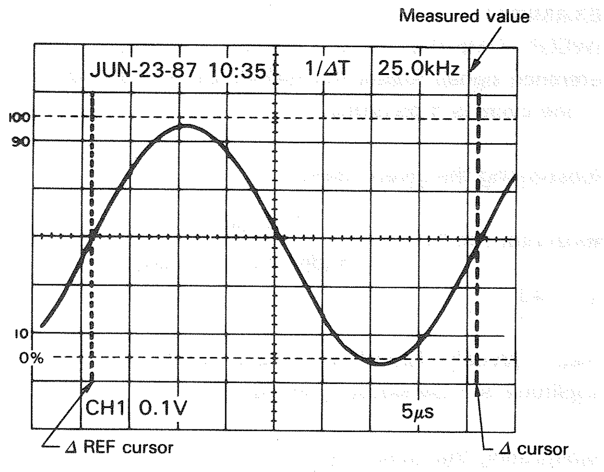


Fig. 35

12. RELATIVE MEASUREMENTS

If the frequency and amplitude of some reference signal are known, an unknown signal may be measured for level and frequency without use of the VOLTS/DIV or SWEEP TIME/DIV for calibration.
The measurement is made in units relative to the reference signal.

★ Vertical Sensitivity
Setting the relative vertical sensitivity using a reference signal.

Procedure:

1. Apply the reference signal to the INPUT jack and adjust the display for a normal waveform display.
   Adjust the VOLTS/DIV and VARIABLE so that the signal coincides with the CRT face's graduation lines. After adjusting, be sure not to disturb the setting of the VARIABLE control.

2. The vertical calibration coefficient is now the reference signal's amplitude (in volts) divided by the product of the vertical amplitude set in step 1 and the VOLTS/DIV setting.

   Using the formula:
   Vertical coefficient

   $$= \frac{\text{Voltage of the reference signal (V)}}{\text{Vertical amplitude (div)} \times \text{VOLTS/DIV setting}}$$

3. Remove the reference signal and apply the unknown signal to the INPUT jack, using the VOLTS/DIV control to adjust the display for easy observation. Measure the amplitude of the displayed waveform and use the following relationship to calculate the actual amplitude of the unknown waveform.

   Using the formula:
   Amplitude of the unknown signal (V)
   = Vertical distance (div) × Vertical coefficient
   × VOLTS/DIV setting

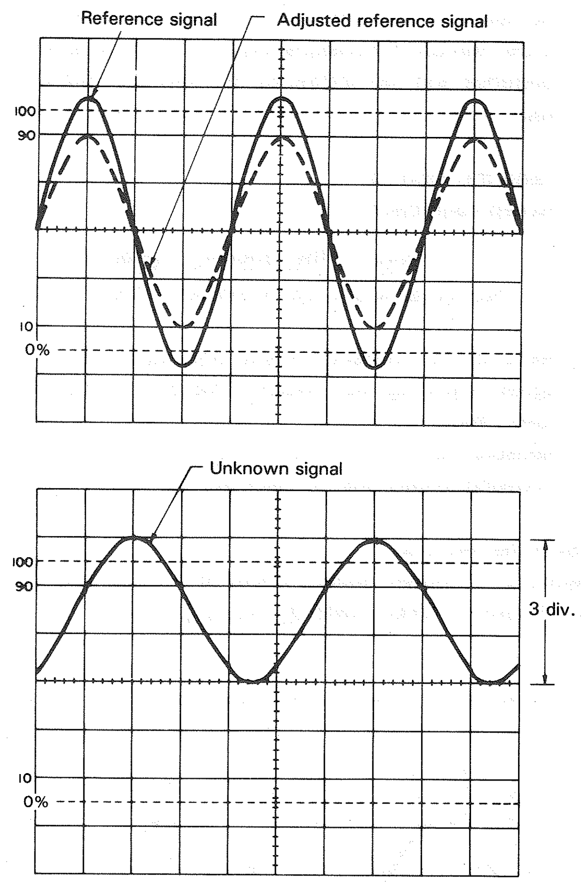


Fig. 36

[EXAMPLE]
For the example, the VOLTS/DIV is 1 V/div.
The reference signal is 2 Vrms. Using the VARIABLE, adjust so that the amplitude of the reference signal is 4 divisions. (See Fig. 36)

Substituting the given value:

$$\text{Vertical coefficient} = \frac{2\ \text{(Vrms)}}{4\ \text{(div)} \times 1\ \text{(V/div)}}$$

$= 0.5$

Then measure the unknown signal and VOLTS/DIV is 5 (V/div) and vertical amplitude is 3 divisions.

Substituting the given value:
Effective value of unknown signal = 3 (div) × 0.5 × 5(V/div)
= 7.5 V rms

★ Period
Setting the relative sweep coefficient with respect to a reference frequency signal.

Procedure:

1. Apply the reference signal to the INPUT jack, using the VOLTS/DIV and VARIABLE to obtain an easily observed waveform display.
   Using the SWEEP TIME/DIV and VARIABLE adjust one cycle of the reference signal to occupy a fixed number of scale divisions accurately. After this is done be sure not to disturb the setting of the VARIABLE control.

2. The Sweep (horizontal) calibration coefficient is then the period of the reference signal divided by the product of the number of divisions used in step 1 for setup of the reference and the setting of the SWEEP TIME/DIV control.

Using the formula:
Sweep coefficient

$$= \frac{\text{Period of the reference signal (sec)}}{\text{horizontal width (div)} \times \text{SWEEP TIME/DIV setting}}$$

3. Remove the reference signal and input the unknown signal, adjusting the SWEEP TIME/DIV control for easy observation.
   Measure the width of one cycle in divisions and use the following relationship to calculate the actual period.

Using the formula:
Period of unknown signal = Width of 1 cycle (div) × sweep coefficient × SWEEP TIME/DIV setting

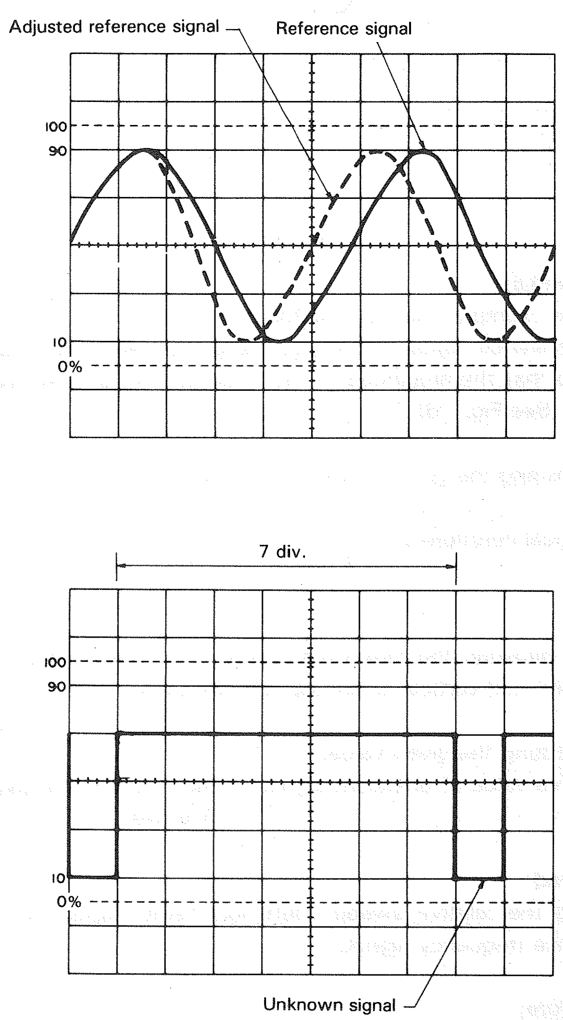


Fig. 37

[EXAMPLE]
SWEEP TIME/DIV is 0.1 ms/div and apply 1.75 kHz reference signal. Adjust the VARIABLE so that the distance of one cycle is 5 divisions.

Substituting the given value:

$$\text{Horizontal coefficient} = \frac{1.75\ (\text{kHz})^{-1}}{5\ (\text{div}) \times 0.1\ (\text{ms/div})}$$

$\fallingdotseq 1.143$

Then, SWEEP TIME/DIV is 0.2 ms/div and horizontal amplitude is 7 divisions. (See Fig. 37)

Substituting the given value:
Pulse width = 7 (div) × 1.143 × 0.2 (ms/div) ≒ 1.6 ms

13. APPLICATION OF X-Y OPERATION

★ **Phase Shift Measurement**

A method of phase measurement requires calculations based on the Lissajous patterns obtained using X-Y operations. Distortion due to non-linear amplification also can be displayed.
A sine wave input is applied to the audio circuit being tested. The same sine wave input is applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting waveform.
To make phase measurements, use the following procedure.

1. Using an audio signal generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.
2. Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may be observed on the oscilloscope. If the test circuit is overdriven, the sine wave display on the oscilloscope is clipped and the signal level must be reduced.
3. Connect the channel 2 probe to the output of the test circuit.
4. Select X-Y operation by placing the TRIG MODE switch in the X-Y position.
5. Connect the channel 1 probe to the input of the test circuit.
   (The input and output test connections to the vertical and horizontal oscilloscope inputs may be reserved.)
6. Adjust the channel 1 and 2 gain controls for a suitable viewing size.
7. Some typical results are shown in Fig. 39.
   If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal gain are properly adjusted, this line is at a 45° angle. A 90° phase shift produces a circular oscilloscope pattern. Phase shift of less (or more) than 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in Fig. 38.

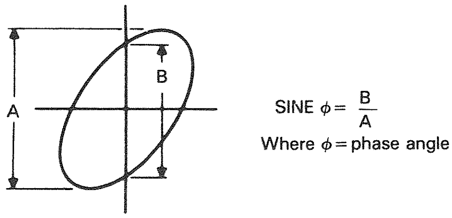


Fig. 38 Phase shift calculation

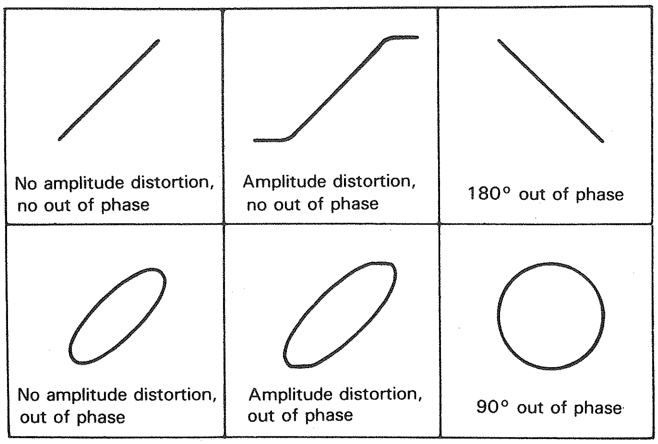


Fig. 39 Typical phase measurement oscilloscope display

★ **Frequency Measurement**

1. Connect the sine wave of known frequency to the channel 2 INPUT jack of the oscilloscope and select X−Y operation. This provides external horizontal input.
2. Connect the vertical input probe (CH1 INPUT) to the unknown frequency.
3. Adjust the channel 1 and 2 size controls for convenient, easy-to-read size of display.
4. The resulting pattern, called a Lissajous pattern, shows the ratio between the two frequencies.

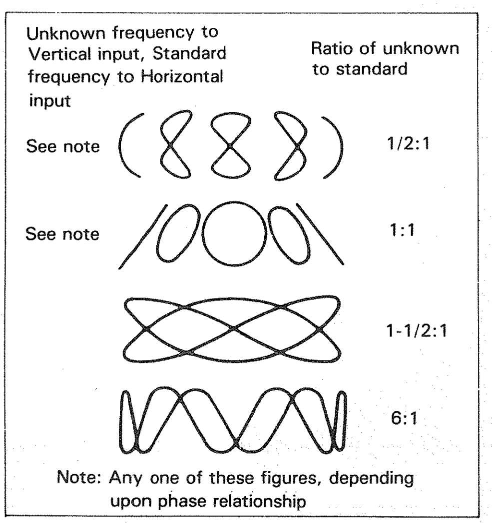


Fig. 40 Lissajous waveforms used for frequency measurement

14. APPLICATION AS AN EQUIVALENT SAMPLING OSCILLOSCOPE

The equivalent sampling allows the observation of high-frequency signals that cannot be observed with low-bandwidth scopes, square waves with fast rise, etc. However, the waveform subject to equivalent sampling must be a repetitive waveform.

(1) Measurement of Percentage Modulation

Measure percentage modulation as follows.

1) Apply the signal to be measured to an INPUT connector, and set the vertical MODE switch to the channel used.
2) Adjust the VOLTS/DIV, VARIABLE and SWEEP TIME/DIV controls as required for optimum observation.
3) Set the sursor mode to ΔV1 or ΔV2 according to the channel used.
4) Align the ΔREF cursor with the lower peak of the waveform, and align the Δcursor with its higher peak. Assume that the resulting measurement is A.
5) Next, align the ΔREF cursor with the lower trough of the waveform, and align the Δcursor with its lower peak. Assume that the resulting measurement is B.
6) The percentage modulation is calculated by the following equation:

$$\text{Percentage Modulation} = \frac{A-B}{A+B}$$

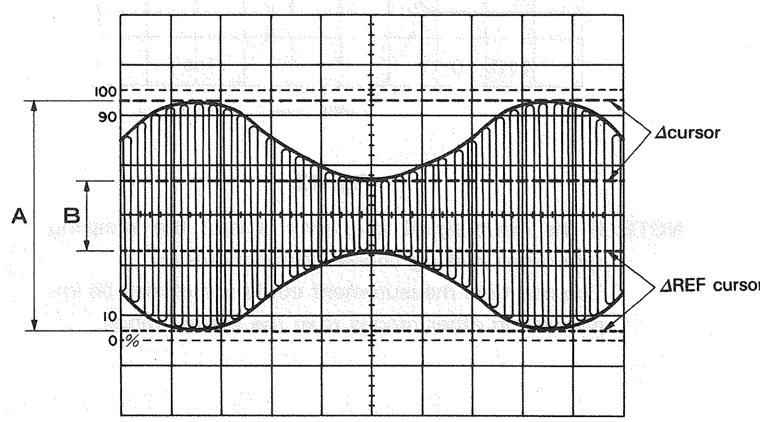


Fig. 41

(2) Pulse rise (fall) time measurement

Measuring procedure

The rise (fall) time can be obtained by measuring the time between the 10% and 90% of the peak value.

1) Connect the signal to be measured to the INPUT terminal, set the vertical MODE switch to the channel used, and adjust the VOLTS/DIV. VARIABLE control so that the displayed waveform occupies 5 divisions.
2) Set the SWEEP TIME/DIV. control to the fastest range, and set the SWEEP VARIABLE to CAL.
3) Adjust ⇕ POSITION so that the waveform is positioned between 0% and 100% of the scale.
4) Set the cursor mode to ΔT.
5) Align the ΔREF sursor with the point where the measured waveform crosses the 10% scale, and the Δ cursor to the point where the measured waveform crosses the 90% scale.
6) The measurement result is displayed on the right of ΔT on the screen.

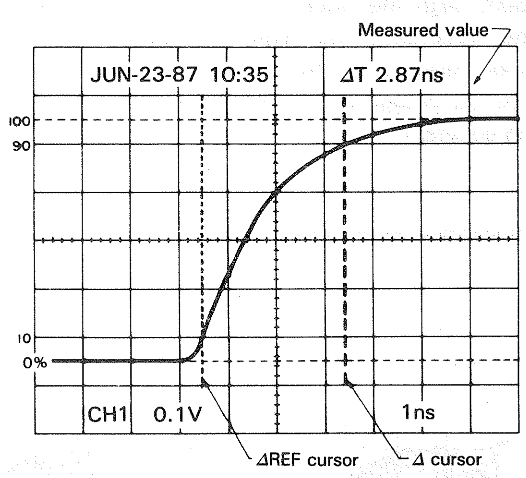


Fig. 42

NOTE: If the input signal frequency is low, the sampling rate drops making coarse dots noticeable.
The rise time measurement could sometimes be impossible in other ranges than the fastest range.

MAINTENANCE

REPLACING THE FUSE

In case the fuse has blown, locate the cause. If the fuse itself is the cause, replace it as follows:

1. Pull the plug of the power cord from the power outlet.
2. Remove the fuse holder in the rear panel using a standard screwdriver (see Fig. 43).
3. Take out the blown fuse, and in its place, insert a new fuse.
4. Set the label of your line voltage to the mark ▼, then plug the fuse holder containing the new fuse into the rear panel.

CHANGING THE SUPPLY VOLTAGE

Remove the fuse holder in the rear panel using a standard screwdriver. Then set the label of your line voltage to the mark ▼ and plug the fuse holder back into place. When changing the supply setting from 100/120 V to 220/240 V, change the 1.2 A fuse for a 0.8 A one. (see Fig. 43)

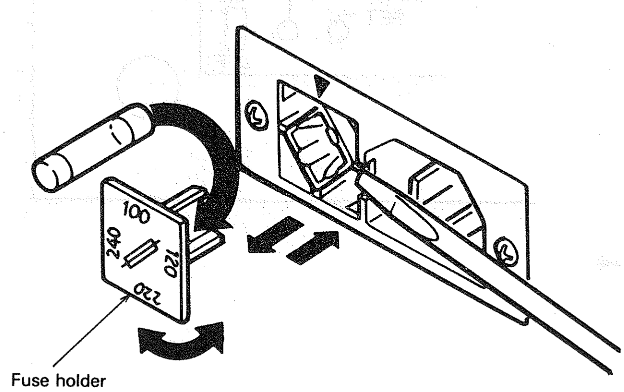


Fig. 43

RESETTING THE READOUT CALENDAR AND CLOCK DISPLAY

The readout calendar and clock display can be changed and reset with the DATE change switch located on the right end of the rear side on the bottom. (This can be performed without removing the case.)

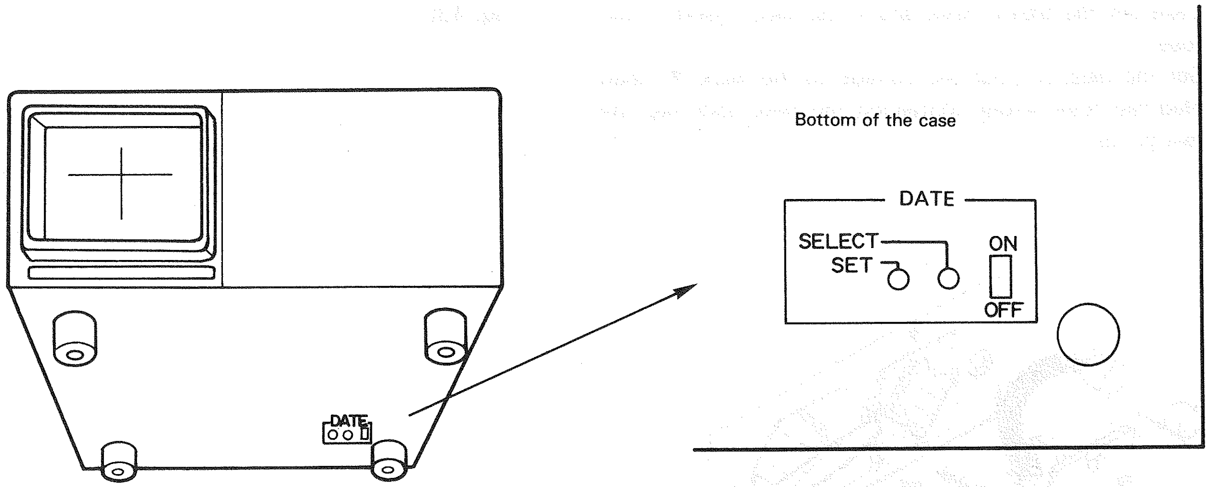


Fig. 44

NOTE: When performing the following operations, be sure to use an insulated stick.

(1) ON/OFF
This switches the calendar and clock display on and off. When switched on, the display will appear on the CRT, and will go out when switched off.

(2) SELECT
This is used to select the section of the calendar and clock display to be corrected. When this button is pressed, correction mode is activated and the "month" indication will blink. Pressing the button again will move the blinking position to the 10's column, for the "date" indication. In this way, each time the button is pressed, the blinking position is shifted to the right one column sequentially. Once the blinking position reaches the "minutes" indication and the button is pressed again, all indications will be lit steadily to show that correction mode has finished.

NOTE: During correction mode (when there is a blinking section within the calendar or clock display), when the control knobs on the front panel are operated, a correct readout display will not be obtained. Be sure to complete correction mode before operating the control knobs.

(3) This is used to correct the calendar and clock display.
When this button is pressed, the blinking figure subject to correction is changed. Press the button to set the calendar or clock display as desired. The "minutes" indicator will be set to "0" when the correction mode is released.

ACCESSORIES

STANDARD ACCESSORIES INCLUDED

Probe (PC-31) .... 2 pcs.
Instruction Manual 1
Replacement Fuse
  1.2 A .... 2 pcs.
  0.8 A .... 2 pcs.
Power supply cable 1

OPTIONAL ACCESSORIES

Probe Pouch (MC-78) 1

This soft vinyl pouch attaches to the top side oscilloscope housing and provides storage space for two probes and the operators manual. Install the probe pouch as follow;

1. Unsnap the probe pouch from the retainer plate.
2. Align the retainer plate with 4 holes on the top side of the case, with 4 snaps at the top.
3. Attach the 4 corners of the retainer plate to the oscilloscope case with the 4 nylon rivets supplied.
4. Attach the pouch to the retainer plate using the snap fastener.

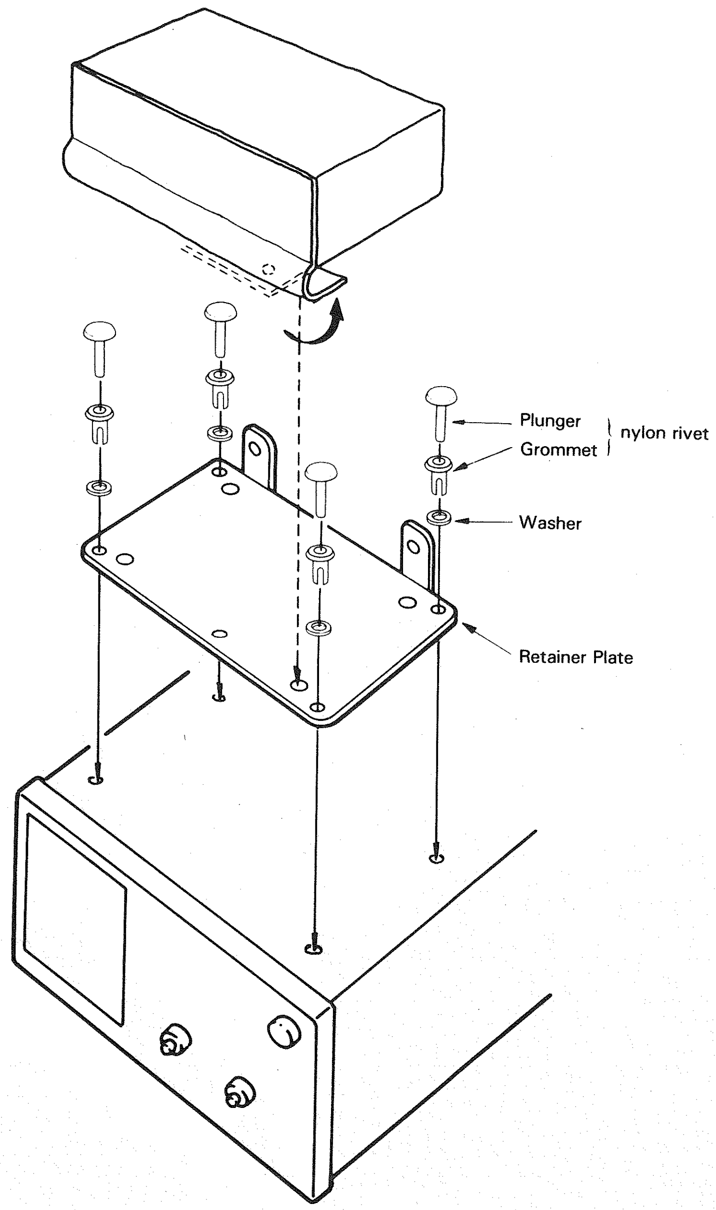


Fig. 45

MEMO

MEMO

A product of
KENWOOD CORPORATION
17-5, 2-chome, Shibuya, Shibuya-ku, Tokyo 150, Japan