20MHz COMPACT OSCILLOSCOPE

# CS-3035

# INSTRUCTION MANUAL

KENWOOD CORPORATION


90/12 11 10 9 8 7 6 5 4 3 2 1 89/12 11 10 9 8 7 6

# 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

# OVERVIEW AND CONFIGURATION

## Overview

This unit is a compact, light-weight, high performance portable oscilloscope equipped with rectangular CRT with internal graticule.
The frequency bandwidth of 20 MHz and selectable sweep time of 0.2 µs/div to 1 s/div for the vertical axis allows use for a wide range of applications. It is also equipped with magnification functions for the vertical and horizontal axis, HFREJ function allowing stable triggering with high frequency components blocks, and optional DC power supply for field use. These features make it the ideal oscilloscope for on-site servicing and maintenance.

## Configuration

The following items are contained in the packing case. When unpacking, make sure that all items have been included.

Oscilloscope ........................................ 1 pc.
Probe (PC-30) ........................................ 2 pcs.
Panel cover ........................................ 1 pc.
Instruction manual ........................................ 1 pc.
Replacement fuse 0.3 A ........................................ 2 pcs.
0.5 A ........................................ 2 pcs.

In addition, the following are also available as optional accessories (sold separately).

DC power supply (BP-70)
Carrying case (soft) MC-81
Carrying case (hard) MC-82
Carrying case (hard) MC-83 (for use when DC power supply is attached)

# SPECIFICATIONS

## CRT

Type....................................Rectangular high luminance CRT (with internal graticule)
Acceleration Voltage ...........Approx. 1.8 kV
Display Area........................8 × 10 div flat-face (1 div = 6.35 mm)

## VERTICAL AXIS

Operating Modes.................CH1, CH2, ALT, CHOP, ADD
Sensitivity..........................5 mV/div to 5 V/div, +/−3%
Sensitivity Magnification ...5 times +/−5% (×5 MAG used)
Attenuator...........................1-2-5 step sequence, 10 ranges, adjustable between ranges
Frequency Response
5 mV/div to 5 V/div..........DC: DC to 20 MHz, −3 dB
AC: 5 Hz to 20 MHz, −3 dB
×5 MAG used.................DC: DC to 4 MHz, −3 dB
AC: 5 Hz to 4 MHz, −3 dB
Input Impedance .................1 Mohm, approx. 40 pF
Rise Time...........................17.5 ns or less (20 MHz)
Crosstalk............................−40 dB minimum
Polarity Inversion ................CH2 only
Chop Frequency..................Approx. 50 kHz
⚠ Maximum Input Voltage.......800 Vp-p or 400 V (DC+AC peak)

## HORIZONTAL AXIS

Operating Modes.................X-Y operation selectable with sweep knob
CH1: X axis  CH2: Y axis
Sensitivity..........................Same as vertical axis (CH1)
Input Impedance .................Same as vertical axis (CH1)
Frequency Response............DC: DC to 200 kHz, −3 dB
AC: 5 Hz to 200 kHz, −3 dB
X-Y Phase Difference...........3° or less at 10 kHz
⚠ Maximum Input Voltage.......Same as vertical axis (CH1)

**SWEEP**

Sweep Type........................NORM: Triggering sweep
AUTO: Sweep free runs in absence of trigger
SINGLE: Single sweep

Sweep Time........................0.2 μs/div to 1 s/div +/− 3% in 21 ranges, 1-2-5 sequence, adjustable between ranges

Sweep Magnification...........5 times +/−5% (×5 MAG used)

**TRIGGERING**

Internal Sync......................INT, LINE

External Sync......................EXT

External Sync Input
Impedance.......................1 Mohm, 40 pF or less

⚠ Maximum External Trigger
Input Voltage.....................50 V (DC+ACpeak)

Sync Coupling.....................AC, HFREJ, DC

Polarity..............................+/−

Trigger Sensitivity..............

| Coupling | Frequency | Amplitude (Voltage) | |
|---|---|---|---|
| | | INT | EXT |
| DC | DC ~ 2 MHz<br>~ 20 MHz | 0.5 div<br>1 div | 0.1 Vp-p<br>0.2 Vp-p |
| HFREJ | Attenuation at more than 1.5 kHz | | |
| AC | 10 Hz ~ 2 MHz<br>~ 20 MHz | 0.5 div<br>1 div | 0.1 Vp-p<br>0.2 Vp-p |

AUTO: Same as above specification for above 50 Hz.

**CALIBRATION VOLTAGE**........Square wave (positive polarity)
0.25 Vp-p ±2%, 1 kHz ±2%

**POWER REQUIREMENTS**

Power Supply Voltage.........AC100/120/220/240 V ±10% 216 V~250 V 50/60 Hz

Power Consumption............Approx. 22 W (at 100 V AC)

**DIMENSIONS AND WEIGHT**

Dimensions.........................216 (width)×89 (height)×298 (depth) mm

Weight...............................Approx. 4 kg

**OPERATING TEMPERATURE AND HUMIDITY FOR GUARANTEED SPECIFICATIONS**

5 to 35°C, 85% maximum RH

**ACCESSORIES**.......................Probe (PC-30) 2 pcs.
Panel Cover 1 pc.
Instruction Manual 1 pc.
Power Cord 1 pc.
Fuse (0.5 A) 2 pcs.
(0.3 A) 2 pcs.

# PREPARATION FOR USE

## SAFETY

Before connecting the instrument to a power source, carefully read the following information; then verify that the proper power cord is used and the proper line fuse is installed for power source. The specified voltage is shown at the left side of the power cord on the rear panel. If the power cord is not applied for specified voltage, there is always a certain amount of danger from electric shock.

### Line voltage

This instrument operates using AC-power input voltages that 100/120/220/240 V at frequencies from 50 Hz to 60 Hz.

### Power cord

The ground wire of the 3-wire AC power plug places the chassis and housing of the oscilloscope at earth ground. Do not attempt to defeat the ground wire connection or float the oscilloscope; to do so may pose a great safety hazard.
The appropriate power cord is supplied by an option that is specified when the instrument is ordered.
The optional power cords are shown as follows in Fig. 1.

### Line fuse

The fuse holder is located on the rear panel and contains the line fuse. Verify that the proper fuse is installed by replacing the line fuse.

## EQUIPMENT PROTECTION

1. Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may become permanently burned. A spot will occur only when the scope is set up for X-Y operation and no signal is applied. Either reduce the intensity so the spot is barely visible, switch back to normal sweep operation when no signal is applied, or set up the scope for spot blanking.
2. Never cover the ventilating holes on the top of the oscilloscope, as this will increase the operating temperature inside the case.
3. Never apply more than the maximum rating to the oscilloscope inputs.

   ⚠ CH1, CH2 INPUT jacks:

   800 Vp-p or 400 V (DC+AC peak)

   EXT TRIG INPUT jack:

   50 V (DC+AC peak)

   Never apply external voltage to the oscilloscope output terminals.
4. Always connect a cable from the earth ground (GND) terminal of the oscilloscope to the chassis of the equipment under test. Without this caution, the entire current for the equipment under test may be drawn through the probe clip leads under certain circumstances. Such conditions could also pose a safety hazard, which the ground cable will prevent.
5. Always use the probe ground clips for best results. Do not use an external ground wire in lieu of the probe ground clips, as undesired signals may be introduced.

6. Operation adjacent to equipment which produces strong AC magnetic fields should be avoided where possible.
This includes such devices as large power supplies, transformers, electric motors, etc., that are often found in an industrial environment. Strong magnetic shields can exceed the practical CRT magnetic shielding limits and result interference and distortion.
7. Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation of probe should be adjusted initially, then the same probe always used with the input of scope. Probe compensation should be readjusted whenever a probe from a different scope is used. (See page 20)
8. In X-Y operation, do not pull out the PULL×5 MAG switch. If pulled out it, noise may appeare on the waveform.

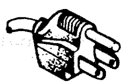
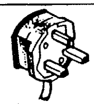
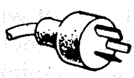
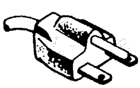
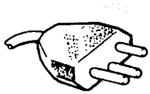
| **Plug configuration** | **Power cord and plug type** | **Factory installed instrument fuse** | **Line cord plug fuse** |
|---|---|---|---|
|  | North American<br>120 volt/60 Hz<br>Rated 15 amp<br>(12 amp max; NEC) | 0.5 A, 250 V<br>Fast blow<br>AGC/3AG | None |
|  | Universal Europe<br>220 volt/50 Hz<br>Rated 16 amp | 0.3 A, 250 V<br>Fast blow<br>5×20 mm | None |
|  | U.K.<br>240 volt/50 Hz<br>Rated 13 amp | 0.3 A, 250 V<br>Fast blow<br>6×30 mm | 0.3 A<br>Type C |
|  | Australian<br>240 volt/50 Hz<br>Rated 10 amp | 0.3 A, 250 V<br>Fast blow<br>6×30 mm | None |
|  | North American<br>240 volt/60 Hz<br>Rated 15 amp<br>(12 amp max; NEC) | 0.3 A, 250 V<br>Fast blow<br>AGC/3AG | None |
|  | Switzerland<br>240 volt/50 Hz<br>Rated 10 amp | 0.3 A, 250 V<br>Fast blow<br>AGC/3AG<br>6×30 mm | None |

**Fig. 1 Power Input Voltage Configuration**

# CONTROLS AND INDICATORS

## FRONT PANEL

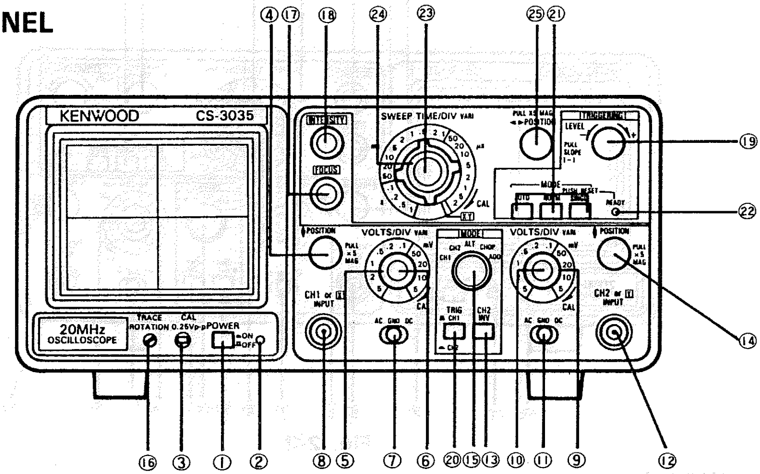


Fig. 2-1

### ① POWER

Power switch for the oscilloscope. Pressing this control once turns the power on and pressing it again turns the power off.

### ② Pilot Lamp

Lamp lights when the oscilloscope is on.

### ③ CAL Terminal

Voltage terminal for calibration of probes. Provides an approximately 1 kHz square wave at 0.25 V with positive polarity.

### ④ ⬍ POSITION/PULL ×5 MAG

Rotation adjusts the vertical position of channel 1 trace on the display. Pulling this knob increases the vertical axis sensitivity 5 times.

### ⑤ VOLTS/DIV

Sets the vertical axis sensitivity using the vertical attenuator for channel 1. This knob can be switched in a 1-2-5 sequence. Setting the VARIABLE knob ⑥ to the CAL position provides calibrated vertical axis sensitivity.
During X-Y operation, this control serves as the attenuator for the X axis.

### ⑥ VARI (ABLE)

Rotation provides fine control of channel 1 vertical attenuation. Allows continuous adjustment between VOLTS/DIV ranges. In the fully clockwise (CAL) position, the vertical attenuator is calibrated. During X-Y operation, this control serves as the X axis attenuator fine adjustment.

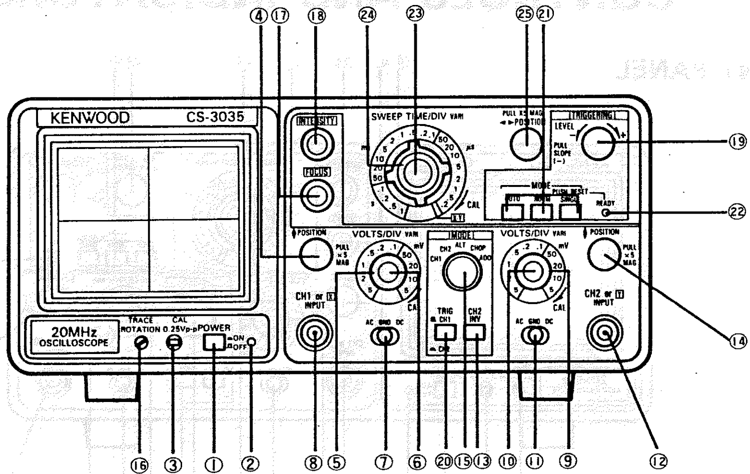



**Fig. 2-2**

### ⑦ AC-GND-DC

This lever selects the coupling method used for the CH1 vertical axis input signal.

**AC:** Input signal is AC coupled, and DC component is blocked.

**GND:** Input signal and vertical amplifier are separated and input to vertical amplifier is grounded. This allows for confirmation of the ground potential.

**DC:** Input signal is DC coupled allowing for measurement including DC component.

This lever servers as the X axis input selector during X-Y operation.

### ⑧ CH1 or X INPUT

Vertical axis input jack for channel 1. Serves as the X axis input jack during X-Y operation.

### ⑨ VOLTS/DIV

Vertical axis attenuator for channel 2. Performs the same function for channel 2 as the channel 1 VOLTS/DIV control. Serves as the X axis or Y axis attenuation adjustment control during X-Y operation.

### ⑩ VARI (ABLE)

Rotation provides fine control of channel 2 attenuation. Performs the same function for channel 2 as the channel 1 VARIABLE control. Serves as the Y axis attenuation fine adjustment control during X-Y operation.

### ⑪ AC-GND-DC

This lever selects the coupling method used for the channel 2 vertical axis input signal. Performs the same function as the channel 1 AC-GND-DC control. Serves as the Y axis input selector during X-Y operation.

### ⑫ CH2 or Y INPUT

Vertical axis input jack for channel 2. Serves as the Y axis input jack during X-Y operation.

⑬ **CH2 INV**

Inverts the polarity of the channel 2 signal.

⑭ **▲▼ POSITION/PULL ×5 MAG**

Performs the same function for channel 2 as the channel 1 ▲▼ POSITION control. Serves as the Y position adjustment control during X-Y operation.

⑮ **MODE**

This switch selects the vertical axis operation mode.

**CH1:** Channel 1 input signal is displayed on the CRT.
**CH2:** Channel 2 input signal is displayed on the CRT.
**ALT:** Channel 1 and channel 2 signals are displayed alternately on the CRT with each sweep.
**CHOP:** Channel 1 and 2 signals are displayed alternately on the CRT at a repetition rate of 50 kHz or more.
**ADD:** The algebraic sum of the channel 1 and 2 signal is displayed on the CRT. If CH2 INV ⑬ is engaged, the difference is displayed on the CRT.

**Note:**
**The ALT, CHOP, and ADD modes cannot be used during X-Y operation.**

⑯ **TRACE ROTATION**

Electrically rotates trace to horizontal position.
Adjust when strong magnetic fields cause the trace to be tilted.

⑰ **FOCUS**

Adjusts the trace for optimum focus.

⑱ **INTENSITY**

Adjusts the brightness of the trace.

⑲ **LEVEL/PULL SLOPE (−)**

**LEVEL:** Trigger level adjustment control. Determines point on trigger signal waveform where sweep starts.
**SLOPE:** Trigger polarity selector. Pulling the knob triggers the sweep at the falling slope of the input waveform.

⑳ **TRIG ■ CH1 / ▬ CH2 (TRIG switch)**

This button selects the trigger source when an internal trigger (INT selected by TRIG SOURCE ㉘) is selected.

**CH1:** Channel 1 input signal serves as the trigger source.
**CH2:** Channel 2 input signal serves as the trigger source.

㉑ **TRIGGERING MODE (TRIG MODE)**

Knob for selecting the triggering mode.

**AUTO:** Triggered sweep operation when trigger signal is present, automatically generates sweep (free run) in absence of trigger signal.

**NORM:** Normal triggered sweep operation. Unlike AUTO, no sweep appears when the proper trigger signal is not applied.

**SINGLE/PUSH RESET:**

Pressing this knob selects the single sweep mode. The sweep is reset by pressing again, and is reset every time it is subsequently pressed. When there is no trigger signal, the READY lamp is illuminated and there is a single sweep at the next trigger signal.

㉒ **READY (LED)**

When the SINGLE (RESET) knob ㉑ is pressed in the SINGLE (single sweep) mode, this LED lights up and the oscilloscope waits for the next trigger signal. The LED goes out at the end of the sweep.

㉓ **SWEEP VARIABLE**

Provides fine adjustment of sweep time; continuous adjustment is possible between steps selected by SWEEP TIME/DIV ㉔. Sweep time is calibrated by in the extreme clockwise (CAL) position.

㉔ **SWEEP TIME/DIV**

Sweep time coarse selector. Selects sweep times between 0.2 $\mu$s/div and 1 s/div in 21 steps. Indicated values are calibrated when SWEEP VARIABLE ㉓ control is set to CAL position (fully clockwise). Oscilloscope is set to X-Y operating mode when this knob is rotated to fully counterclockwise (X-Y) position. In X-Y operation, sweeping stops and the channel 1 becomes X axis amplifier and the channel 2 becomes Y axis amplifier.

㉕ **◄ ► POSITION/PULL ×5 MAG**

Rotation adjusts the horizontal position of the trace on the display. Pulling this knob increases the sweep time five times. The SWEEP TIME/DIV value is 1/5 of the indicated value at this time. Serves as the X position adjustment control during X-Y operation.

## SIDE PANEL

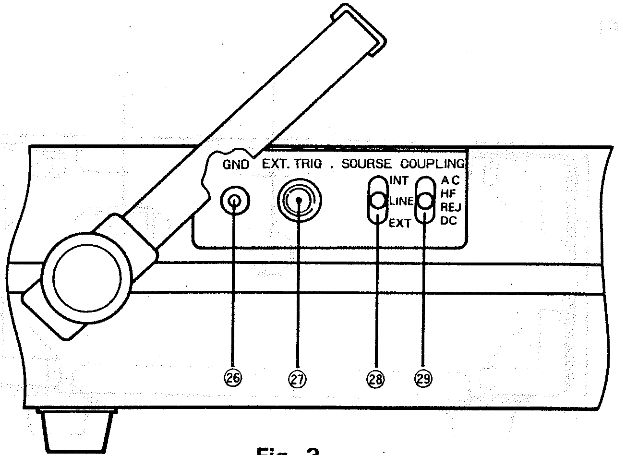



**Fig. 3**

㉖ **GND Terminal**

Chassis ground terminal used for establishing a common ground with other equipment.

㉗ **EXT. TRIG Jack**

Input terminal for external trigger signal. When the TRIG SOURCE ⑳ control is set to NORM and ㉑ is set to EXT, the signal input to this terminal becomes the trigger signal.

㉘ **SOURCE (TRIG SOURCE)**

Selects the trigger source (sync signal source). The following trigger sources can be selected.

**INT:** Internal triggering is selected and the sweep is triggered by the signal input for the vertical axis. Either the channel 1 or channel 2 signal can be selected as the trigger source using the TRIG switch ⑳.

**LINE:** The sweep is triggered by the line power frequency.

**EXT:** The trigger source is the signal applied to the EXT. TRIG Jack ㉗.

㉙ **COUPLING**

Selects the coupling method used for the trigger signal.

**AC:** Trigger signal is AC coupled to the sync circuit. Blocks DC component of input signal. Most commonly used position for waveform observation.

**HFREJ:** Trigger signal passes through a low pass filter before coupling to the sync circuit. High frequency components above about 1 kHz are attenuated allowing for stable triggering by the low frequency components.

**DC:** Trigger signal is DC coupled to the sync circuit. Sweep is triggered by signal including DC component.

## REAR PANEL

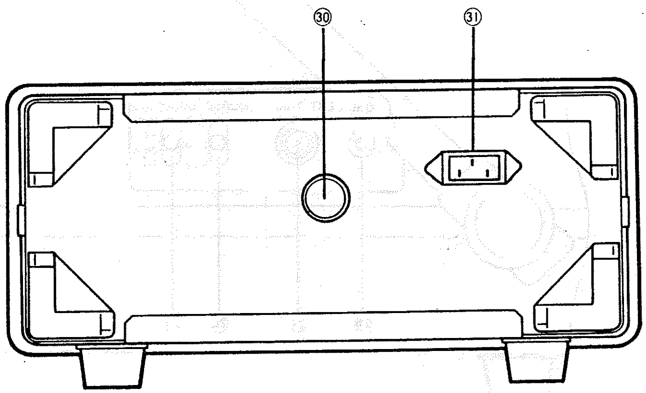



Fig. 4

⑳ **Fuse Holder**
Contains the line fuse. Verify that the proper glass fuse is installed when replacing the line fuse.
100 V to 120 V ........................................ 0.5A
200 V to 240 V ........................................ 0.3A

㉛ **Power Connector**
This is the connector for applying AC power. Use the supplied AC cord.

## TOP CASE SURFACE

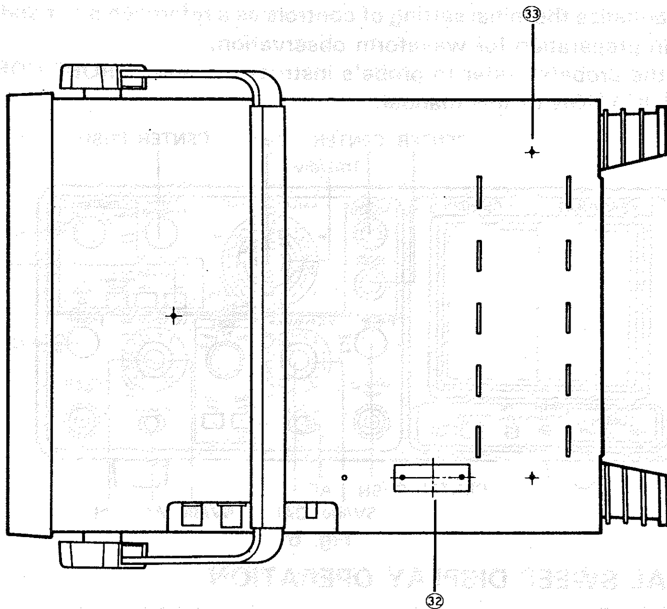



Fig. 5

㉜ **Connector Cover**

Used when option BP-70 (DC power supply) is used. This cover protects the connector for supplying power. Loosen the screws on the front panel, remove the rear panel screws, rotate 180 degrees, and tighten the screws again to hold the cover in place. Damage to the unit is liable to occur if used with the cover removed. When the optional power supply is in use, attach the cover to protect the connectors.

㉝ **Screw Hole for Option Attachment**

Screw hole used to attach optional BP-70 unit to this oscilloscope.

# OPERATION

## INITIAL STARTING PROCEDURE

Until you familiarize yourself with the use of all controls, the following procedure may be used to standarize the initial setting of controls as a reference point and to obtain trace on the CRT in preparation for waveform observation.
When using the probe(s), refer to probe's instructions and "PROBE COMPENSATION" listed in APPLICATION of this manual.

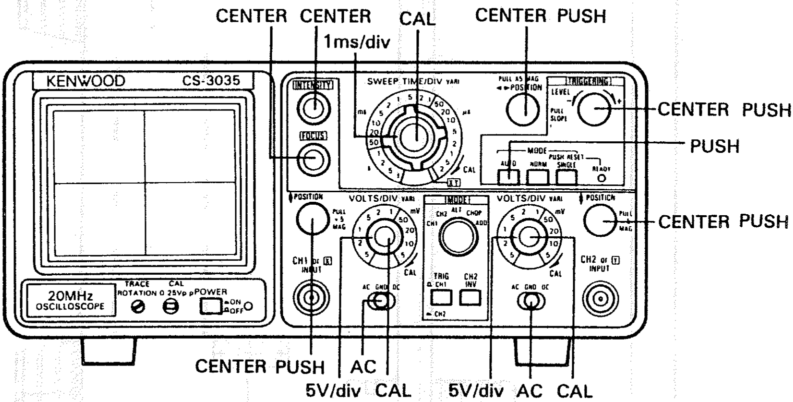



Fig. 6

## (1) NORMAL SWEEP DISPLAY OPERATION

1. Push the POWER switch ① – the power supply will be turned on and the pilot lamp will light.
   Set these modes as follows;
   MODE ⑮: CH1
   TRIG MODE ㉑: AUTO
   SOURCE ㉘: INT
   COUPLING ㉙: AC
2. The trace will appear in the center of the CRT display and can be adjusted by the CH1 ⬍ POSITION ④ and ◄► POSITION ㉕ controls. Next, adjust the INTENSITY ⑱ and, if necessary, the FOCUS ⑰ for ease of observation.
3. Vertical Modes
   With vertical MODE ⑮ set to CH1, and TRIG ⑳ switch set to CH1, apply an input signal to the CH1 INPUT ⑧ jack and adjust the VOLTS/DIV ⑤ control for a suitable size display of the waveform. If the waveform does not appear in the display, adjust the VOLTS/DIV and ⬍ POSITION controls to bring the waveform into the center portion of the CRT display. Operation with a signal applied to the CH2 INPUT ⑫ jack and the vertical MODE set to CH2 is similar to the above procedure.
   In the ADD mode, the algebraic sum of CH1 + CH2 is displayed. If the CH2 INV ⑬ switch has been engaged, the algebraic difference of the two waveforms, CH1 – CH2 is displayed. If both channels are set to the same VOLTS/DIV, the sum or difference can be read directly in VOLTS/DIV from the CRT. In the ALT mode, one sweep displayes the channel 1 signal and the next sweep displays the channel 2 signal in an alternating sequence.

In the CHOP mode, the sweep is chopped at an approximate 50 kHz rate and switched between CH1 and CH2. Note that in the CHOP mode of operation with the SOURCE switch set to INT, TRIG ⑳ switch set to CH1 or CH2, the trigger source becomes the chopping signal itself, making waveform observation impossible. Use ALT mode instead in such cases, or select a trigger SOURCE of CH1 or CH2.
If no trace is obtainable, refer to the following TRIGGERING procedures.

4. After setting the SOURCE switch, adjust the SLOPE control.
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.
The SOURCE switch selects the input signal that is to be used to trigger the sweep, with INT sync possibilities (CH1, CH2, LINE) and EXT sync possibility.

### ★ 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 ⑧ or ⑫ 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.
When the vertical MODE selection is in ALT, the ALT position is very convenient for measuring the time duration of the waveform. However, for phase or timing comparisons between the channel 1 and channel 2 waveforms, both traces must be triggered by the same sync signal.
When the SOURCE selection is in INT TRIG ⑳ switch set to CH1, the input signal at the channel 1 INPUT ⑧ jack becomes trigger regardless of the position of vertical MODE. When the SOURCE selection is in INT, TRIG ⑳ switch set to CH2, the input signal at the channel 2 INPUT ⑫ jack becomes trigger regardless of the position of vertical MODE. When the SOURCE selection in LINE, the ac line voltage powering the oscilloscope is used as sync triggering.

### ★ External Sync

When the SOURCE selection is in EXT, the input signal at the EXT TRIG INPUT ㉗ 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. Fig. 7 also 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 ⑧ or ⑫ jack so that no further triggering is required even when the input signal is varied.

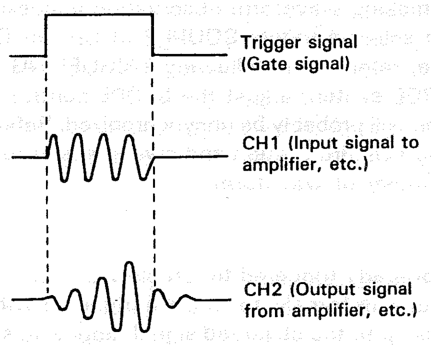



Fig. 7

★ **Triggering Level**

Trigger point on waveform is adjusted by the LEVEL/PULL SLOPE ⑲ control. Fig. 8 shows the relationship between the SLOPE and LEVEL of the trigger point. Triggering level can be adjusted as necessary.

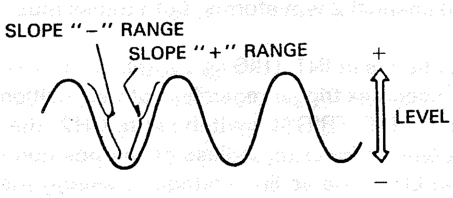



Fig. 8

★ **Auto Trigger**

When the TRIG MODE ㉑ 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 also becomes free-running where the waveform starts running. When the LEVEL control is pushed in and/or, when the trigger signal is absent or the triggering level exceeds the limit there is no sweep.

## (2) MAGNIFIED SWEEP OPERATION

Since merely shortening the sweep time to magnify a portion of an observed waveform can result in the desired portion disappearing off the screen, such magnified display should be performed using the MAGNIFIED SWEEP.

Using the ◄► POSITION control, adjust the desired portion of waveform to the CRT. Pull out the PULL × 5 MAG control to magnify the display 5 times. For this type of display the sweep time is the SWEEP TIME/DIV setting divided by 5.

## (3) X-Y OPERATION

For some measurements, an external horizontal deflection signal is required. This is also referred to as an X-Y measurement, where the Y input provides vertical deflection and X input provides horizontal deflection.
X-Y operation permits the oscilloscope to perform many types of measurements not possible with conventional sweep operation. The CRT display becomes an electronic graph of two instantaneous voltages. The display may be a direct camparison of two voltages such as during phase measurement, frequency measurement with Lissajous waveforms.
To use an external horizontal input, use the following procedure;

1. Set the SWEEP TIME/DIV control to the X-Y position.
2. Use the channel 1 probe for the vertical input and the channel 2 probe for the horizontal input.
3. Adjust the amount of horizontal deflection with the CH2 VOLTS/DIV and VARIABLE controls.
4. The CH2 (vertical) POSITION ⑭ control now serves as the horizontal position control, and the ▲▼ POSITION control is disabled.
5. All sync controls are disconnected and have no effect.

# APPLICATION

## PROBE COMPENSATION

To obtain an accurate measurement result, the probe must be adjusted correctly before measurement.

1. Connect the probe to the INPUT terminal and set the control for a normal sweep display.
2. Connect the probe to the CAL terminal on the front panel, and adjust the SWEEP TIME/DIV control to display a few cycles of the signal output from it.
3. Adjust the trimmer on the probe to obtain the following correct compensation waveform.

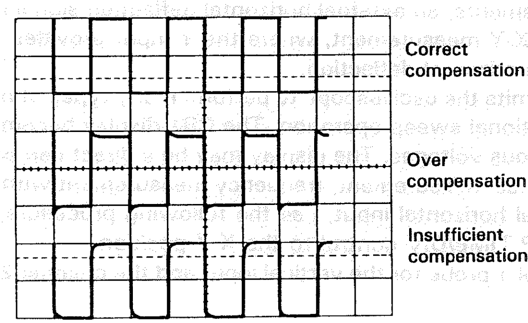



Fig. 9

## 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 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.

## DC VOLTAGE MEASUREMENTS

This procedure describes the measurement procedure for DC waveforms.

Procedure:

1. Connect the signal to be measured to the INPUT jack. Set the vertical MODE to the channel to be used. Set the VOLTS/DIV and SWEEP TIME/DIV switch to obtain a normal display of the waveform to be measured. Set the VARIABLE control to the CAL position.
2. Set the TRIG MODE to AUTO and AC-GND-DC to the GND position, which established the zero volt reference. 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). Multiply the distance measured above by the VOLTS/DIV setting and the probe attenuation ratio as well. Voltages above and below the reference level are positive and negative values respectively.

Using the formula:
DC level = Vertical distance in divisions × (VOLTS/DIV setting) × (probe attenuation ratio).

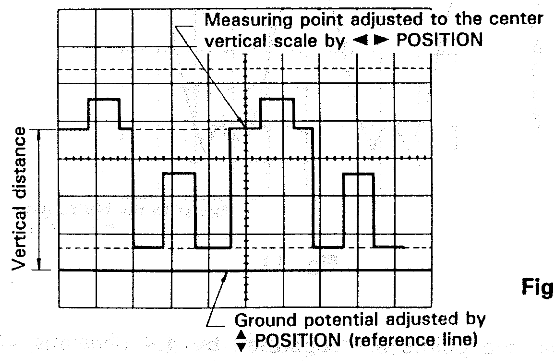



Fig. 10

**[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. 10)

Substituting the given values:
DC level = 3.8 (div) × 0.2(V/div) × 10 = 7.6 V

## MEASUREMENT OF THE VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM

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

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 AC, adjusting VOLTS/DIV and SWEEP TIME/DIV for a normal display. Set the VARIABLE to CAL.
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.
   If a probe is used, further multiply this by the attenuation ratio.

Using the formula:
Volts Peak-to-Peak
=Vertical distance (div)×(VOLTS/DIV setting)×(probe attenuation ratio)

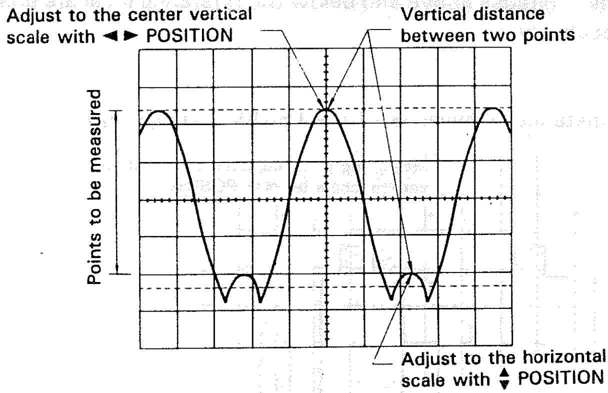



**Fig. 11**

**[EXAMPLE]**
For the example, the two points are separated by 4.4 divisions vertically. Set the VOLTS/DIV setting be 0.2 V/div and the probe attenuation be 10:1. (See Fig. 11)

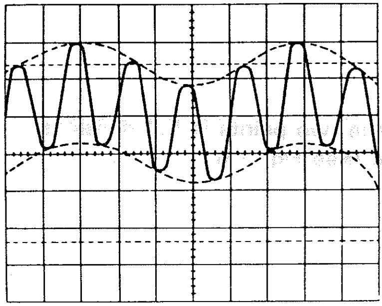
Substituting the given value:
Voltage between two points=4.4 (div)×0.2(V/div)×10=8.8V

## 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.

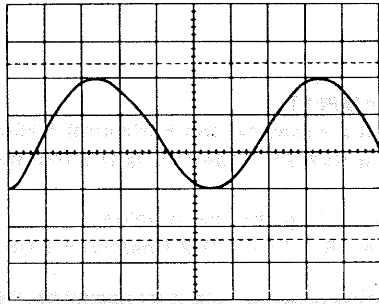
Procedure:
1. Apply the signal containing an undesired component to the CH1 INPUT jack and the undesired signal itself alone to the CH2 INPUT jack.
2. Set the vertical MODE to CHOP and SOURCE to CH2. Verify that CH2 represents the unwanted signal in reverse polarity. If necessary reverse polarity by setting CH2 to INV.
3. Set the vertical MODE to ADD 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.

a)



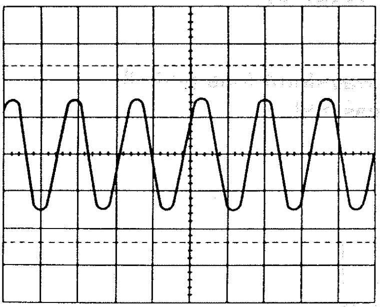
Signal containing undesired component
(Broken lines undesired component envelope)

b)



Signal without undesired component

c)



Undesired component signal

**Fig. 12**

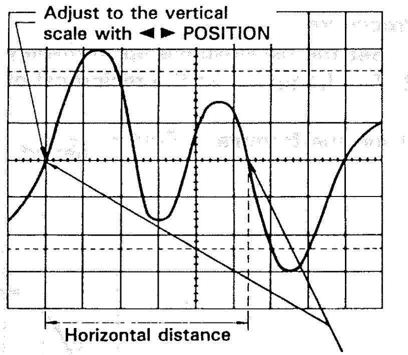



**Fig. 13**

## TIME MEASUREMENTS

This is the procedure for making time measurements between two points on a waveform. The combination of the SWEEP TIME/DIV and the horizontal distance in divisions between the two points is used in the calculation.

Procedure:

1. Apply the signal to be measured to the INPUT jack. Set the vertical MODE to the channel to be used. Adjust the VOLTS/DIV and SWEEP TIME/DIV for a normal display. Be sure that the VARIABLE control is set to CAL.
2. Using the ▲▼ POSITION control, set one of the points to be used as a reference to coincide with the horizontal centerline. Use the ◄► POSITION control to set this point at the intersection of any vertical graduation line.
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 "×5 MAG" is used, multiply this further by 1/5.

Using the formula:

Time = Horizontal distance (div) × (SWEEP TIME/DIV setting) × "×5 MAG" value$^{-1}$ (1/5)

[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. 13)

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

## 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. Set the oscilloscope up to display one cycle of waveform (one period).
2. The frequency is the reciprocal of the period measured.

Using the formula: $\text{Freq} = \frac{1}{\text{period}}$

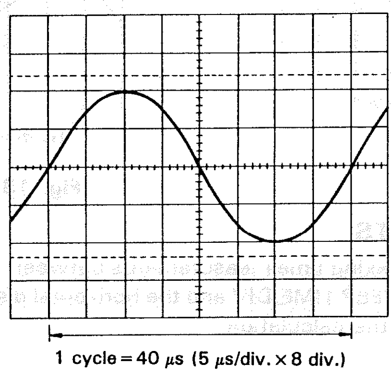



Fig. 14

[EXAMPLE]
A period of 40 μs is observed and measured. (See Fig. 14)

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

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 to CAL.

2. Count the number of cycles of waveform between a chosen set of vertical graduation lines.
   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 "×5 MAG" is used multiply this further by 5.
   Note that errors will occur for displays having only a few cycles.

Using the formula: $$\text{Freq} = \frac{\#\text{ of cycles} \times \text{"}\times 5\text{ MAG" value}}{\text{Horizontal distance (div)} \times \text{SWEEP TIME/DIV setting}}$$

[EXAMPLE]
For the example, within 7 divisions there are 10 cycles.
The SWEEP TIME/DIV is 5 $\mu$s/div. (See Fig. 15)

Substituting the given value: $$\text{Freq} = \frac{10}{7\text{ (div)} \times 5\ (\mu\text{s/div})} = 285.7\text{ kHz}$$

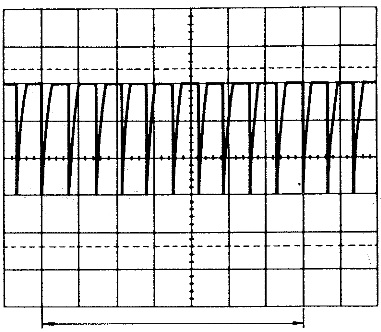


Fig. 15

Count cycles between this portion

## 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 votating SWEEP TIME/DIV control clockwise to 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. 17.
   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 sift 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. 16.

$$\text{SINE } \phi = \frac{A}{B}$$

Where $\phi$ = phase angle

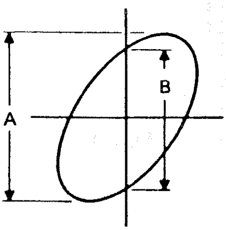



Fig. 16 Phase shift calculation

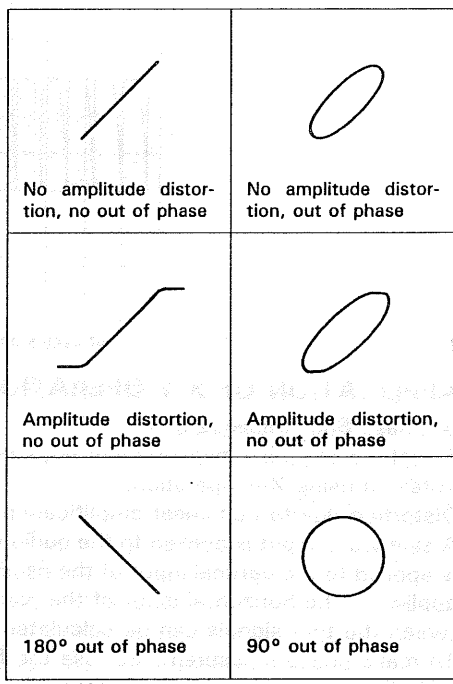



Fig. 17 Typical phase measurement oscilloscope displays

# MAINTENANCE

## ⚠ Caution : Read this page carefully to keep your safety.

**For Electric Shock Protection:**
**Be sure to disconnect the power cable from the socket before conducting the following operation.**

## MAINTENANCE

There is high voltage used inside this unit. Never open the case.

## REPLACEMENT OF FUSES

This oscilloscope will not function if the fuse has blown. If the fuse blows, determine the cause, and contact your dealer if the cause lies in this equipment.
If the cause was external to this equipment, remove the cause, detach the fuse holder from the rear panel using a flatblade screwdriver, and insert a new fuse.

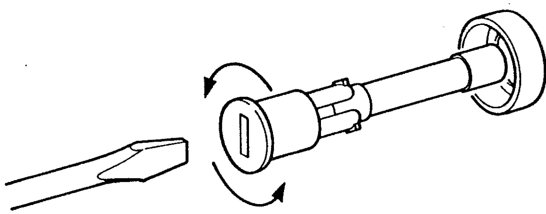



Fig. 18

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KENWOOD CORPORATION

17-5, 2-chome, Shibuya, Shibuya-ku, Tokyo 150, Japan