CS-1575A

(DUAL TRACE OSCILLOSCOPE)

INSTRUCTION MANUAL

SAFETY

Symbol in This Manual

⚠ This symbol indicates where applicable cautionary or other information 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.

CONTENTS

FEATURES

1. High sensitivity of 10 mV/div or more and wide band-width of 5 MHz (−3 dB).
2. Dual-trace operation and X-Y operation can be achieved simultaneously by use of the PHASE DISPLAY switch.
3. Functions as a conventional dual-trace oscilloscope (DUAL-V) and stereoscope (DUAL-H).
4. Zero phase Lissajous' figure is displayed at the same time during X-Y operation, making it possible to measure phase difference accurately throughout the range of low and high frequencies.
5. Trigger source is selected automatically during single or dual trace operation with the use of dual triggering system.
6. CHOP and ALT are interlocked with time base switch to permit automatic selection.
7. X-Y selection allows CH1 amplifier to be used as Y axis amplifier and CH2 amplifier as X axis amplifier in X-Y operation mode.
8. Auto free-run system enables the trace to be checked even at no-signal.
9. The high voltage power for the CRT is fully established by the use of DC-DC converter, assuring reliable sensitivity and brightness against voltage fluctuation.
10. The adoption of ICs throughout the circuitry improves reliability.
11. Low power consumption (25 W) for cool and reliable operation.

SPECIFICATIONS

CATHODE RAY TUBE

Type :	130BEB31
Acceleration voltage :	2 kV
Useful measuring :	8 divx10 div (1 div = 1 cm)

VERTICAL AXIS (for both CH1 and CH2)

Sensitivity :	10 mV/div or higher
Attenuator :	1-3 steps, 1/1 to 1/300, 6 ranges, precisely adjustable between ranges. Inter-channel error is ±5%.
Input impedance :	1 MΩ±3% Approx. 30 pF
Frequency response :	
DC :	DC to 5 MHz (−3 dB), DC to 7 MHz (−6 dB)
AC :	5 Hz to 5 MHz (−3 dB), 5 Hz to 7 MHz (−6 dB)
Risetime :	70 nsec
Crosstalk :	Less than −40 dB (at 1 kHz)
Operating mode :	
CH1 :	Channel 1 only, single trace
CH2 :	Channel 2 only, single trace
DUAL-H :	Horizontal dual trace
DUAL-V :	Vertical dual trace
X-Y :	CH1 = Y axis, CH2 = X axis
Dual-trace selection :	Automatic selection of CHOP and ALT (Switched to CHOP at about 80 kHz when SWEEP RANGE is set to 10 -50 Hz and TRIG.SOURCE is in LINE, CH1, CH2 or EXT. Switched to ALT at other settings.)
Phase indication :	X and Y are simultaneously displayed by PHASE DISPLAY. Zero phase Lissajous' figure is displayed at the same time during X-Y operation.
⚠Maximum input voltage :	600 Vp-p or 300 V (DC + AC peak)

SWEEP

Sweep system :	Auto free-run sweep (free-run sweep at no-signal)
Sweep frequency :	10 Hz-50 Hz, 50 Hz-200 Hz, 200 Hz-1 kHz, 1 kHz-5 kHz, 5 kHz-20 kHz and 20 kHz-100 kHz Fine adjustment in 6 ranges.
Linearity :	Less than 5%

TRIGGERING

Source :	
LINE :	Fixed to supply frequency.
DUAL :	Source is automatically selected to the waveform of CH1 or CH2
CH1 :	Fixed to CH1 signal.
CH2 :	Fixed to CH2 signal.
EXT :	Fixed to external signal.
Triggering level :	Set by the TRIG.LEVEL switch.
Slope :	Positive only
Coupling :	AC only (inclusive of EXT)
External triggering :	
Input impedance :	Approx. 1 MΩ, approx. 50 pF
⚠Maximum input voltage :	100 Vp-p or 50 V (DC + AC peak)
Triggering range :	
Internal (DUAL, CH1, CH2) :	0.5 div (50 Hz-3 MHz) 1 div (20 Hz-5 MHz)
External (EXT) :	0.5 Vp-p (50 Hz-3 MHz) 1 Vp-p (20 Hz-5 MHz)

HORIZONTAL AXIS (CH2)

Operating mode :	X-Y mode is selected by DISPLAY MODE switch. CH1: Y axis, CH2: X axis
Sensitivity :	Same as vertical axis (CH1)
Input impedance :	Same as vertical axis (CH1)

SPECIFICATIONS

Frequency response :
DC : DC to 1 MHz (−3 dB), DC to 1.5 MHz (−6 dB)
AC : 5 Hz to 1 MHz (−3 dB), 5 Hz to 1.5 MHz (−6 dB)
X-Y phase difference : Less than 3° at 50 kHz
X-Y distortionless amplitude : More than 8 div × 8 div at 100 kHz (POSITION: Center)

CALIBRATION VOLTAGE :

0.6 Vp-p ±5%
Positive square wave of power supply frequency

POWER SUPPLY

Power supply voltage : AC100 V/120 V/220 V ±10%, 216 V − 250 V, 50/60 Hz
Power consumption : Approx. 25 W

DIMENSIONS

Width : 260 mm (260 mm)
Height : 190 mm (214 mm)
Depth : 375 mm (440 mm)
Figures in ( ) show maximum size.

WEIGHT : 8 kg

ACCESSORIES :

BNC cord : 2
AC cord : 1
Instruction manual : 1
Replacement fuse : 0.3A 2
0.7A 2

OPTIONAL ACCESSORIES :

PC-30 (attenuator probe)
Attenuation : 1/10, 1/1
Input impedance : 10 MΩ, 22 pF ±10% (1/10)
1 MΩ, 200 pF or less (1/1)

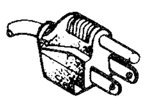
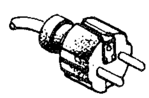
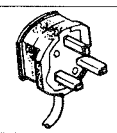
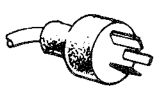
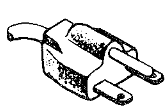
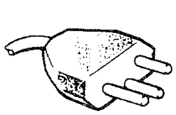
Plug configuration	Power cord and plug type	Factory installed instrument fuse	Line cord plug fuse	Parts No. for power cord.
	North American 120 volt/60 Hz Rated 15 amp (12 amp max; NEC)	0.7 A, 250 V Fast blow AGC/3AG	None	E30-1820-05
	Universal Europe 220 volt/50 Hz Rated 16 amp	0.3 A, 250 V T. lag 5×20 mm	None	E30-1819-05
	U.K. 240 volt/50 Hz Rated 13 amp	0.3 A, 250 V Fast blow 6×30 mm	0.3 A Type C	
	Australian 240 volt/50 Hz Rated 10 amp	0.3 A, 250 V Fast blow 6×30 mm	None	E30-1821-05
	North American 240 volt/60 Hz Rated 15 amp (12 amp max; NEC)	0.3 A, 250 V Fast blow AGC/3AG	None	
	Switzerland 240 volt/50 Hz Rated 10 amp	0.3 A, 250 V Fast blow AGC/3AG 6×30 mm	None	

Fig. 1 Power Input Voltage Configuration

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 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.

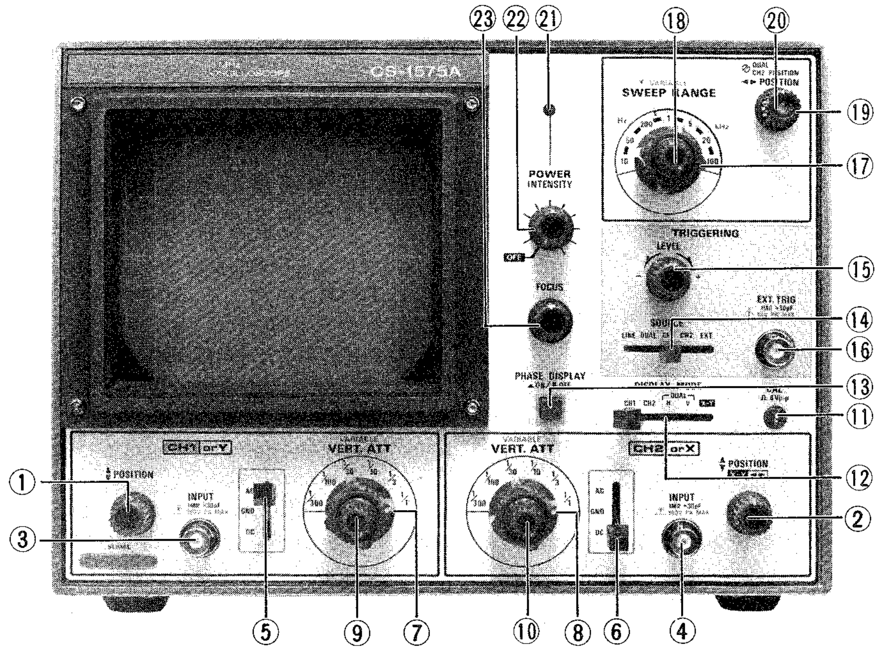
Line fuse

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: 600 Vp-p or 300 V (DC+AC peak)
   EXT. TRIG input jack: 100 Vp-p or 50 V (DC+AC peak)
4. Always connect a cable from the earth ground (GND) jack 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. 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.

CONTROLS AND INDICATORS



Front Panel:

① ▲▼ **POSITION**

This control adjusts vertical position during CH1 or X-Y operation. A right turn will shift the waveform upward.

② ▲▼ **POSITION, X-Y ◄►**

This control adjusts vertical position for CH2. It also adjusts horizontal position during X-Y operation. A right turn will shift the waveform upward, or to the right during X-Y operation.

③ **INPUT**

Input terminal for CH1 (or Y)

④ **INPUT**

Input terminal for CH2 (or X).

⑤ **AC-GND-DC**

Input selector for CH1 (or Y).

⑥ **AC-GND-DC**

Input selector for CH2 (or X).

⑦ **VERT. ATT**

Attenuator for CH1 (or Y). Selectable in 6 ranges from 1/1 to 1/300. Maximum sensitivity is obtained when VARIABLE ⑨ is turned fully clockwise.

⑧ **VERT. ATT**

Attenuator for CH2 (or X). It functions the same as VERT ATT ⑦.

⑨ **VARIABLE**

Attenuator for fine control of CH1 (or Y).

⑩ **VARIABLE**

Attenuator for fine control of CH2 (or X).

⑪ **CAL. 0.6 Vp-p**

Calibration voltage terminal. Calibration voltage is 0.6 Vp-p of square wave of power supply frequency.

⑫ **DISPLAY MODE**

Operation mode selector with the following functions.

CH1 :	Only the input waveform to CH1 is displayed.
CH2 :	Only the input waveform to CH2 is displayed.
DUAL-H :	Two input signals are displayed at the left and right.
DUAL-V :	Two input signals are displayed at the up and down positions.
X-Y :	X-Y operation where CH1 = Y and CH2 = X. CHOP and ALT are interlocked with SOURCE ⑭ and SWEEP RANGE ⑰ for automatic selection. Refer to SWEEP RANGE ⑰.

⑬ **PHASE DISPLAY**

Phase indicating switch. X and Y are simultaneously indicated when DISPLAY MODE ⑫ is set to DUAL-H or DUAL-V, and zero phase Lissajous' figure is indicated at the same time when DISPLAY MODE ⑫ is at X-Y.

⑭ **SOURCE**

Trigger signal selector with the following functions.

LINE :	Synchronized to the power supply frequency.
DUAL :	Source is automatically selected according to the waveform of CH1 or CH2.
CH1 :	CH1 signal becomes Trigger signal.
CH2 :	CH2 signal becomes Trigger signal.
EXT :	Input signal of EXT TRIG ⑯ becomes Trigger signal.

⑮ **LEVEL**

This control adjusts Triggering level. It determines the starting point of sweep on the slope of sync signal waveform.

⑯ **EXT.TRIG**

Input terminal for external Trigger signal.

⑰ **SWEEP RANGE**

Horizontal sweep time selector. It selects in 6 ranges from 10-50 Hz to 20 kH-100 kH. For dual-trace observation in the range of 10-50 Hz, both channels are switched to CHOP at about 80 kHz if SOURCE ⑭ is set to LINE, CH1, CH2 or EXT. In other cases, they are switched to ALT.

⑱ **VARIABLE**

Used for fine adjustment of sweep time.

⑲ **◄► POSITION**

Horizontal position adjuster. A right turn will shift waveform to the right. It does not function when DISPLAY MODE ⑫ is in X-Y position.

⑳ **DUAL-H CH2 POSITION**

This control adjusts horizontal position of CH2 only when DISPLAY MODE ⑫ is in DUAL-H position. A right turn will shift waveform to the right.

㉑ **LED PILOT LAMP**

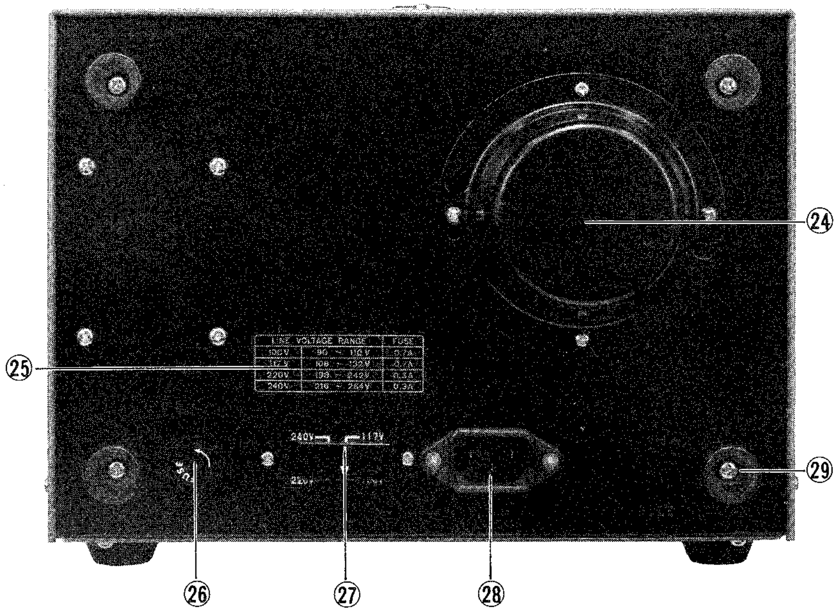
This lamp lights when POWER switch ㉒ is turned on.

㉒ **POWER/INTENSITY**

Functions as a power switch and intensity control. Turning fully counterclockwise will turn the power OFF. Turning clockwise will turn the power ON. Further turning will increase the brightness of waveform.

㉓ **FOCUS**

Spot focus control to obtain optimum waveform according to brightness.



REAR PANEL:

㉔ CRT cover

Used for adjustment of trace angle. Refer to "Maintenance".

㉕ VOLTAGE PLATE

Use only the voltages and fuses specified.

㉖ FUSE HOLDER

Fuse rated at 0.7 A is used for 100 V or 117 V operation. For operation on 220 V or 240 V, replace it with one rated at 0.3 A.

㉗ AC VOLTAGE SELECTOR

Before operating, set this selector to the AC power voltage used.

㉘ POWER CONNECTOR

For connection of the AC power cord supplied. Use the supplied AC cord.

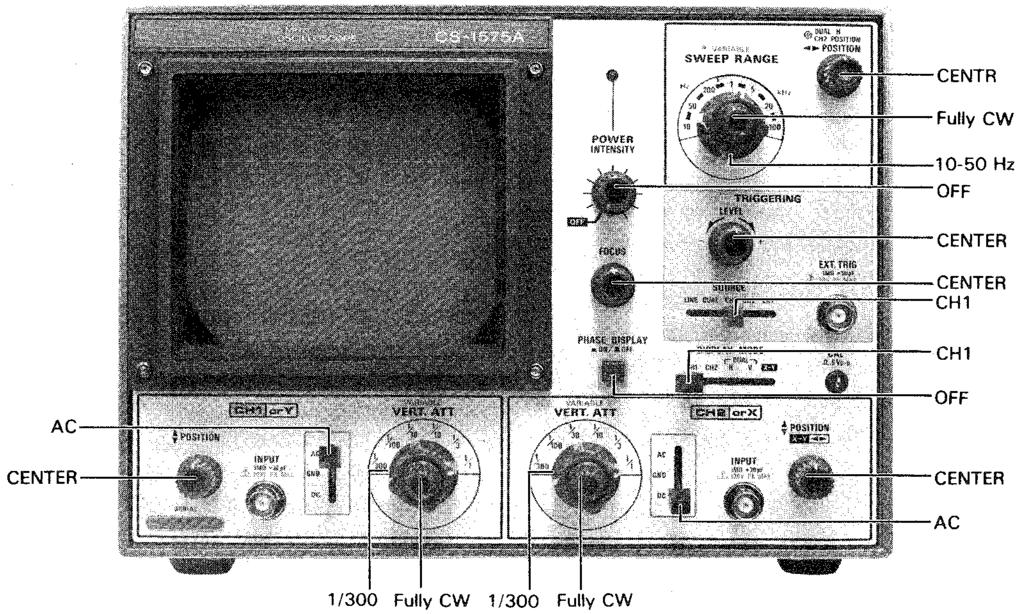
㉙ CORD WRAP

Used to wind the power cord when the oscilloscope is carried or stored. It also serves as a stand.

OPERATION

PRELIMINARY OPERATION

When operating the oscilloscope, refer to panel controls and their function. Before the power switch is turned on, set the controls as follows.



OPERATING PROCEDURES

(1) Turn POWER/INTENSITY ㉒ clockwise. The power is turned to ON and LED PILOT LAMP ㉑ lights. Turn POWER/INTENSITY further clockwise until the setting mark indicates the right horizontal position.

(2) Horizontal trace will be displayed. When trace does not appear at the center of the screen, adjust ⬍ POSITION ① or ◄► POSITION ⑲ to center. Adjust brightness by POWER/INTENSITY ㉒. If trace is unclear, adjust FOCUS ㉓.

(3) The oscilloscope is now ready for measurements. Apply a signal to be measured to INPUT ③ or ④. Turn VERT.ATT ⑦ clockwise to obtain the desired size of waveform.

(4) Set DISPLAY MODE ⑫ to CH1 → CH2 and the signal to INPUT ④ is displayed. At DUAL-H position, signals to INPUTs ③ and ④ appear at the left and right, and at DUAL-V position the signals appear at the up and down positions. At X-Y position, X-Y operation is effected using signals to ③ and ④ as Y and X axis, respectively.

(5) When the signal voltage is more than 10 mV and waveform fails to appear on the screen, the oscilloscope may be checked by feeding input from CAL. 0.6 Vp-p ⑪.

(6) When DC component is measured, set AC-GND-DC ⑤ or ⑥ to DC position. If, in this case, the DC component contains plus potential, the waveform moves upward and if it contains minus potential, the waveform moves downward. The reference point of "0" potential is checked at GND position.

Triggering operation

To observe a stationary input signal waveform, the sweep circuit must be triggered correctly. This can be accomplished either by input signal or by applying a signal with a specific relationship (a multiple of integer) with the input signal in terms of time to the external trigger terminal. The AC (capacitance) coupling trigger circuit input permits triggering by AC component only; DC component in trigger signal is cut off. When trigger signal is absent, the sweep circuit enters free-running state, permitting the check of GND level.

When a trigger signal is present, the trigger point can be determined by LEVEL ⑮ for observation as in the normal trigger signal.

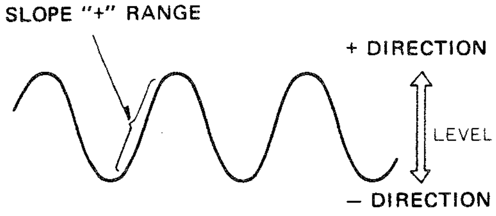


Fig. 6

Fig. 6 shows the relation between SLOPE and LEVEL at a trigger point. Since SLOPE is fixed to "+", the level of trigger point can be set within the range shown in Fig.6. When the triggering level exceeds the limit, the sweep circuit enters free-running state where the waveform starts running.

LINE

By setting SOURCE to LINE, the input signal can be synchronized with the power supply frequency. This function makes it easy to observe a ripple of power supply frequency contained in the signal. At that time, LEVEL can be changed by LEVEL ⑮ .

DUAL

The two channels are automatically selected for trigger sweep and free-run sweep by means of individual sync circuits, so even when the amplitude, frequency or vertical position of one channel is varied, it does not affect the other channel. In dual-trace operation, LEVEL ⑮ functions as a level adjuster for both CH1 and CH2, and both channels can be synchronized at the same level. In single-trace operation, only the sync circuit of the channel being used operates, so sync is effected without using SOURCE ⑭ .

Generally, SOURCE ⑭ is set to DUAL only when waveform is monitored where observation of time relation between two channels is not required, or when observing single-trace waveform.

CH1, CH2

When SOURCE ⑭ is set to CH1 during dual-trace or single-trace operation, the sweep circuit is driven using the input signal of CH1 as a trigger signal. When SOURCE ⑭ is set to CH2, the trigger signal becomes the input signal of CH2. With SOURCE set to CH1 or CH2, trigger level can be be adjusted by TRIG. LEVEL ⑮ .

By setting SOURCE to CH1 or CH2, the time relation between two channels can be observed on the screen.

EXT

External triggering is accomplished by setting SOURCE ⑭ to EXT position, provided a trigger signal is applied to EXT.TRIG ⑯ . Use LEVEL ⑮ to adjust trigger level in this case, too. External triggering is used when you wish to trigger with a signal different from the input signal. It should be noted, however, that the trigger signal must have a relationship with the input signal in terms of time. Fig. 7 shows that the sweep circuit is driven by the gate signal when the gate signal in the burst signal is applied to EXT TRIG ⑯ . Thus, accurate triggering can be achieved without regard to the input signal fed to INPUTs ③ and ④.

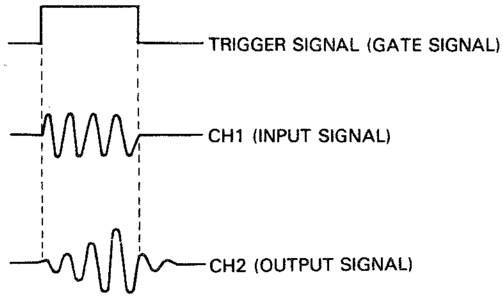


Fig. 7

USE OF DUAL-H, DUAL-V AND DUAL-H CH2 POSITION

DUAL-H

With DISPLAY MODE ⑫ set to DUAL-H, the signal of CH1 appears at the left half of the scale and the signal of CH2 at the right half. At this time, turn ◄► POSITION ⑲ and both signals of CH1 and CH2 will shift to the left and right. When DUAL-H CH2 POSITION ⑳ is turned, only the signal of CH2 will shift to the left and right. Generally, the start point of CH1 is set to the extreme left of the scale by ◄► POSITION ⑲ and the start point of CH2 set in the center of the scale by DUAL-H CH2 POSITION ⑳, (waveform is swept always from left to right). Since DUAL-H mode is used to compare the amplitude of waveform, SOURCE ⑭ should be set to DUAL, as stated in "Triggering Operation".

DUAL-V

With DISPLAY MODE ⑫ set to DUAL-V, the oscilloscope functions just the same as a dual-trace oscilloscope. If it is required to measure the time relation between two signals in DUAL-V mode, SOURCE ⑭ should be set to CH1 or CH2. If not required, it may be set to DUAL.

USE OF PHASE DISPLAY AND PHASE MEASUREMENT

The oscilloscope is designed for single-trace and dual trace operation; it displays signals of both channels on left and right or up and down positions of the screen where CH1 is displayed as Y axis and CH2 as X axis. The dual-trace and X-Y observations can be made simultaneously by using PHASE DISPLAY. With the PHASE DISPLAY set to ON in X-Y mode, "zero phase Lissajous' figure (trace inclined 45° from upper right to lower left of the screen)" when the same waveform without phase difference is applied to X and Y axes is displayed. So waveforms of current phase difference can be observed by comparing the Lissajous' figure due to signals of both channels with "zero phase Lissajous' figure" even on the high frequency band that causes a phase shift in X and Y amplifiers.

Fig. 8 shows Lissajous' figures when 1 kHz sine waves of 0°, 90° and 180° of phase difference are applied to X and Y axes. In Fig. 9, the frequency is changed to 50 kHz where the zero phase Lissajous' figure has about 3° of phase shift in X and Y axes of the oscilloscope. When it is compared with X-Y waveform, a correct phase difference can be checked (refer to Fig. 10).

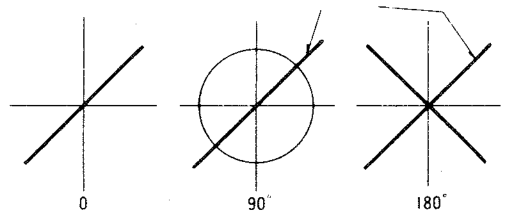


Fig. 8

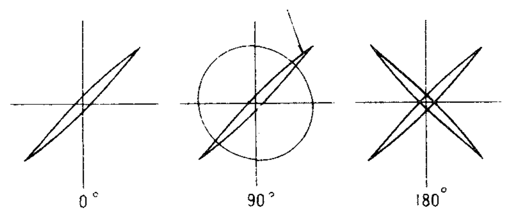
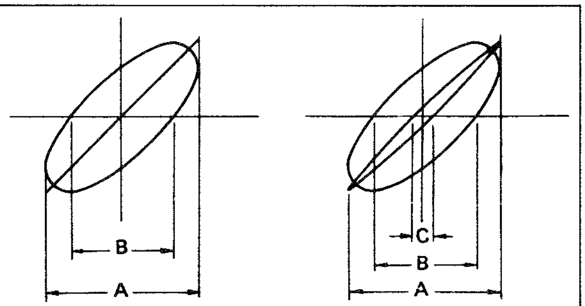


Fig. 9

Actual phase difference can be obtained according to Fig. 10.



PHASE ANGLE $\phi = \text{SINE}^{-1}\frac{B}{A}$
NO PHASE SHIFT IN X AND Y AMPLIFIERS OF OSCILLOSCOPE

PHASE ANGLE ϕ
$= \text{SINE}^{-1}\frac{B}{A} - \text{SINE}^{-1}\frac{C}{A}$
PHASE SHIFT IS PRESENT IN X AND Y AMPLIFIERS OF OSCILLOSCOPE

Fig. 10

WAVEFORM SETTING WITH PHASE DISPLAY AND CONTROL KNOBS:

(In the examples below, 1 kHz sine wave with 90° phase difference is applied to X-Y, with SWEEP RANGE set to 50-200 Hz and trigger SOURCE to DUAL.)

[EXAMPLE 1]

Fig. 11 shows the waveform when DISPLAY MODE is set to DUAL-H and PHASE DISPLAY to ON. Fig. 12 shows the waveform when the control knobs are set as follows:

◄► POSITION: Move 2 div to the left.

DUAL-H CH2 POSITION: Turn to the right to shift the waveform of CH2 by 2 div to the right.

SWEEP VARIABLE: Adjust by observing the screen.

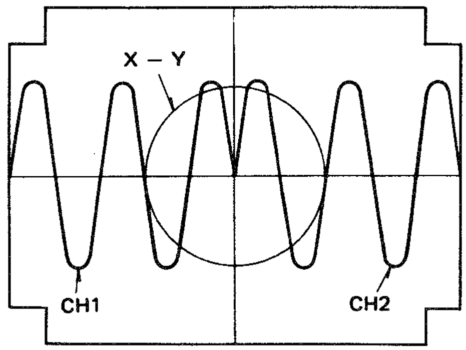


Fig. 11

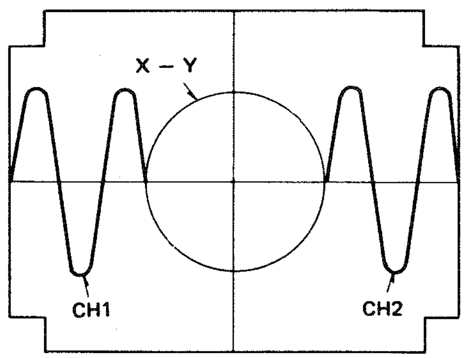


Fig. 12

[EXAMPLE 2]

Fig. 13 shows the waveform when DISPLAY MODE is set to DUAL-V, PHASE DISPLAY to ON, and CH1 and CH2 are separated by 2 div with ▲▼ POSITION. Fig. 14 shows the waveform when the control knobs are set as follows:

◄► POSITION: Turn to the right to set the start point of waveform in the center position.

SWEEP VARIABLE: Adjust by observing the screen.

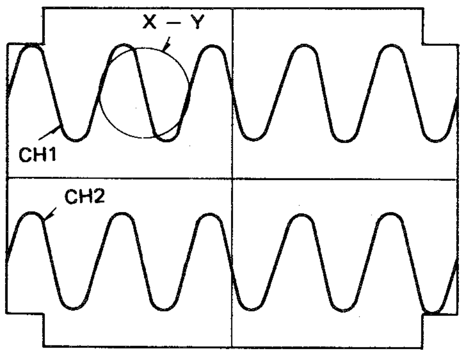


Fig. 13

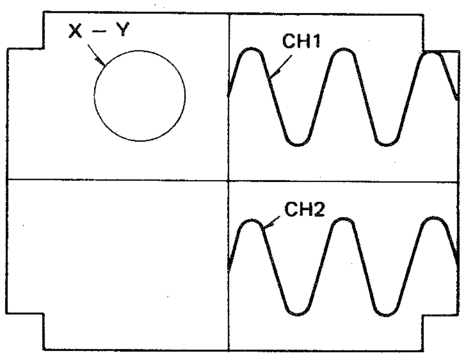


Fig. 14

[EXAMPLE 3]

In Example 2, if the positions of CH1 and CH2 are reversed, the waveforms displayed are as shown in Fig. 15. Fig. 16 shows the waveforms when ◄► POSITION is turned to the left.

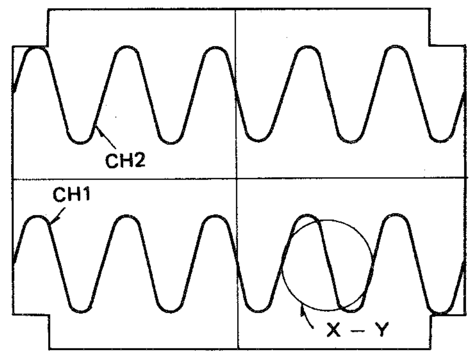


Fig. 15

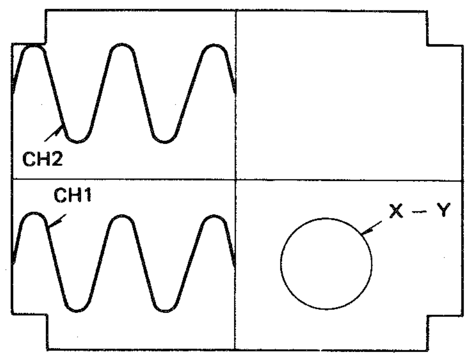


Fig. 16

APPLICATIONS

APPLICATIONS OF PHASE DISPLAY

By using the method shown in Fig. 12, audio systems can be checked and tested. For waveform analysis, refer to Fig. 20. In the waveforms shown in Fig. 20, DUAL-H mode and zero phase Lissajous' figure are simultaneously displayed for convenience. It should be noted that the zero phase Lissajous' figure is displayed only when PHASE DISPLAY is set to ON in X-Y mode.

Adjustment of Head Azimuth of Tape Deck

Use a standard tape (400 Hz or 315 Hz) and set the oscilloscope to 1/10 sensitivity (Fig. 17). Since the output frequency response of a tape deck is 30 Hz to 20 kHz, there is no phase shift in 400 Hz or 315 Hz. Adjust the head azimuth so that the phase difference in the Lissajous' figure is eliminated.

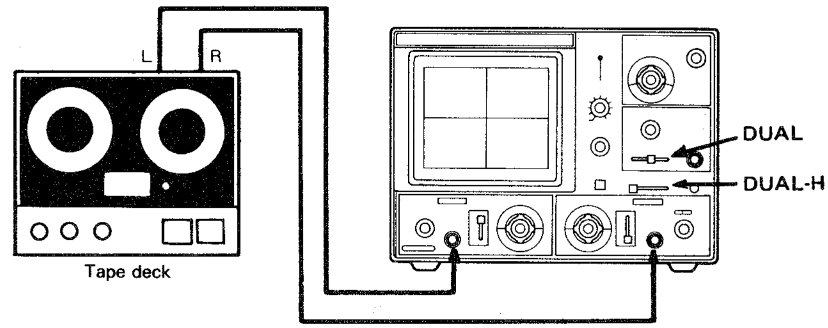


Fig. 17

Test of Output Amplifier

Apply the outputs of a sine wave signal generator to both channels of the amplifier under test. Connect the amplifier output to the oscilloscope input using the same dummy load and adjust the sensitivity of the oscilloscope so that optimum amplitude is obtained according to the output of the amplifier (Fig. 18). For testing the square waveform of the amplifier, refer to the paragraph below.

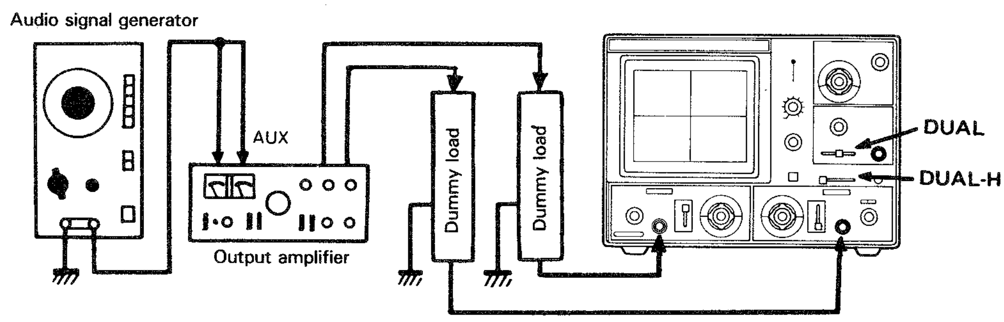


Fig. 18

Test of Propagation Characteristic of Listening Room

In a listening room the sound from the speaker is sometimes hear louder. This happens when certain frequencies of the sound are resonated with the natural vibration of listening room.

The resonance frequency can be detected by using the oscilloscope. Connect the output of a sine wave signal generator to the AUX input of a pre-main amplifier and place a high output dynamic microphone at the listening position. Connect the output of the microphone to CH1 and a part of the output of the signal generator to CH2 to compare the levels. Adjust the volume of the amplifier observing the oscilloscope and increase the frequency from about 50 Hz to about 20 kHz gradually with the output of the signal generator maintained constant. If, at this time, the listening room is resonated, the amplitude on the screen becomes maximum at the resonance point. This frequency is about 100 Hz to 1 kHz (Fig. 19).

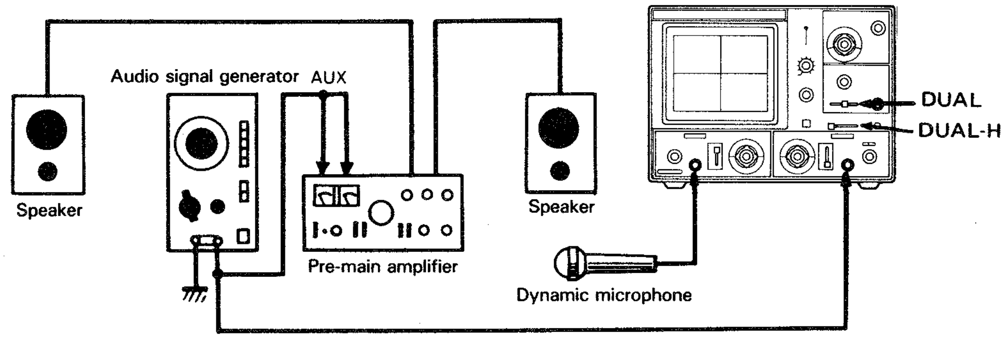


Fig. 19

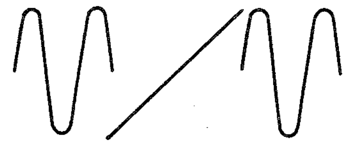
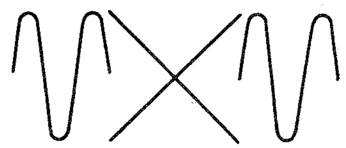
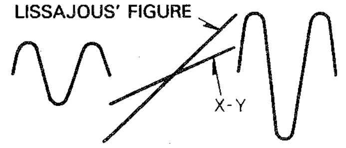
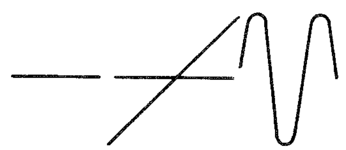
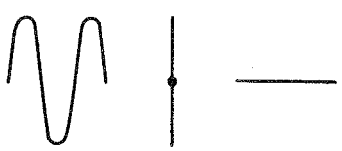
No.	Wave form	Judgement	Trouble	Remarks
1		No phase shift. No amplitude distortion. No distortion between channels.		The same signal is applied to CH1 and CH2.
2		180° out of phase. No amplitude distortion.	* Incorrect input connection (signal and earth connected in reverse. * Incorrect circuit wiring.	Locate the cause of trouble referring to the normal waveform shown in No. 1.
3		Phase shift. No amplitude distortion.	Improper azimuth adjustment.	
4	ZERO PHASE LISSAJOUS' FIGURE  X-Y	No phase shift. Amplitude distortion (CH1 amplitude is narrow.	* Outputs not balanced. * ATT and VARIABLE of oscilloscope not balanced.	The inclination of zero phase Lissajous' figure is always 45°. If the inclination of X-Y is the same as that of this figure, there is no amplitude distortion in both channels. If it is smaller, CH1 amplitude becomes narrow.
5		No phase shift. Amplitude distortion (CH2 amplitude is narrow.		
6		No phase shift. No amplitude distortion between channels.	Stylus pressure, inside force canceler, overhang and arm height of record player are not properly adjusted, or stylus is dirty.	Compare zero phase Lissajous' figure with X-Y to locate the cause of distortion. Checking the sine wave is not sufficient.
7		No signal in CH1.	Disconnection or poor connection of signal.	
8		No signal in CH2.		If there is no signal in CH2, zero phase Lissajous' figure becomes a spot.

Fig. 20 Waveform analysis

Note:
Zero phase Lissajous' figure can be observed only with PHASE DISPLAY set to ON in X-Y mode. Thus, the waveforms shown above differ from those actually obtained on the screen.

AMPLIFIER SQUARE WAVE TEST

Introduction

A square wave generator and oscilloscope can be used to display various types of distortion present in electric circuits. A square wave of a given frequency contains a large number of odd harmonics of that frequency. If a 500 Hz square wave is injected into a circuit, frequency components of 1.5 kHz, 2.5 kHz, 3.5 kHz are also provided.

Since transistors are non-linear, it is difficult to amplify and reproduce a square wave which is identical to the input signal.

Junction capacitance, stray capacitances as well as narrow band devices and transformer response are the factors which prevent faithful response of a square wave signal. A well-designed amplifier can minimize the distortion caused by these limitations. Poorly designed or defective amplifiers can introduce distortion to the point where their performance is unsatisfactory. As stated above, a square wave contains a large number of odd harmonics. By injection of a 500 Hz sine wave into an amplifier, we can evaluate amplifier response at 500 Hz only, but by injecting a square wave of the same frequency we can determine how the amplifier would response to input signals from 500 Hz up to the 15th or 21st harmonic.

The need for square wave evaluation becomes apparent if we realize that some audio amplifiers will be required during normal use to pass simultaneously a large number of different frequencies. With a square wave, we can evaluate the quality of input and output characteristics of a signal containing a large number of frequency components such as complex waveforms of musical instruments or voices. The square wave output of the signal generator must be extremely flat. The oscilloscope vertical input should be set to DC as it will introduce the least distortion, especially at low frequencies. Because of the harmonic content of the square wave, distortion will occur before the upper end of the amplifier bandpass. It should be noted that the actual response check of an amplifier should be made using a sine wave signal. This is especially important in an limited bandpass amplifier such as a voice amplifier. The square wave signal provides a quick check of amplifier performance and will give an estimate of overall amplifier quality. The square wave will also reveal some deficiencies not readily apparent when using a sine wave signal. Whether a sine wave or square wave is used for testing the amplifier, it is important that the manufacturer's specifications on the amplifier be known in order to make a better judgement of its performance.

Testing Procedure (refer to Fig. 21)

(1) Connect the output of the square wave generator to the input of the amplifier being tested.
(2) Connect the CH2 of the oscilloscope to the output of the amplifier.
(3) If the DC component of the amplifier output is low, set the AC-GND-DC switch to DC position to allow both the AC and DC components to be viewed. However, the AC position may be used to observe the AC component only, though this will reduce the audio frequency of contents of less than 5 Hz.
(4) Adjust the vertical gain controls for a convenient viewing height.
(5) Adjust the sweep time controls for one cycle of square wave display on the screen.

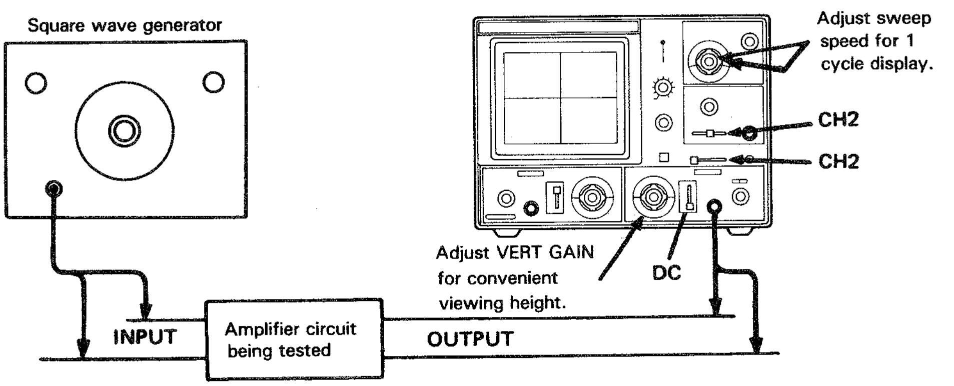


Fig. 21 Equipment set-up for square wave testing of amplifiers

Analysis of Waveforms

The short rise time which occurs at the beginning of the half-cycle is created by the in-phase sum of the medium and high frequency sine wave components.

The same holds true for the drop time.

The reduction in high frequency components should produce a rounding of the square corners at all four points of one square wave cycle (see Fig. 22).

Distortion can be classified into the following three categories:

1. The first is frequency distortion and refers to the change in the amplitude of a complex waveform. In other words, the introduction in an amplifier circuit of resonant network or selective filters created by combination of relative components will create peaks or dips in an otherwise flat frequency response curve.
2. The second is non-linear distortion and refers to a change in waveshape produced by application of the waveshape to non-linear elements such as transistors, an iron core transformer or a clipper network.
3. The third is delay or phase distortion, which is distortion produced by a shift in phase between some components of a complex waveform.

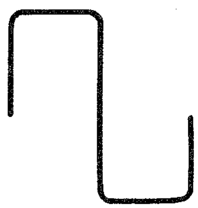


Fig. 22 Square wave response with high frequency loss

In actual practice, a change in amplitude of a square wave component is usually caused by a frequency selective network which includes capacity, inductance or both. The presence of the C or L introduces a difference in phase angle between components, creating phase distortion or delay distortion. Therefore, in square wave testing of practical circuitry, we usually find that the distorted square wave includes a combination of amplitude and phase distortions. In a typical wide band amplifier, a square wave check reveals many distortion characteristics of the circuit. The response of an amplifier is indicated in Fig. 23, revealing poor low frequency response along with overcompensated high frequency boost. The response of 100 Hz square wave applied to the amplifier will appear as in Fig. 24A. The figure indicates satisfactory medium frequency response (approximately 1 kHz to 2 kHz) but shows poor low frequency response. Next, a 1 kHz square wave applied to the input of the amplifier will appear as in Fig. 24B. This figure displays good frequency response in the region of 1000 to 4000 Hz but reveals a sharp rise at the top of the leading edge of the square wave because of overcompensation at frequencies of more than 10 kHz.

As a rule of thumb, it can be safely said that a square wave can be used to reveal response and phase relationships up to the 15th or 20th odd harmonic or up to approximately 40 times the fundamental of the square wave. It is seen that wide-band circuitry will require at least two frequency check points to properly analyze the entire bandpass. In the case illustrated by Fig. 23, a 100 Hz square wave will encompass components up to about 4 kHz.

To analyze above 4 kHz and beyond 10,000 Hz, a 1 kHz square wave should be used. Now, the region between 100 Hz and 4000 Hz in Fig. 23 shows a rise from poor low-frequency (100 Hz to 1 kHz) response to a flattening out from beyond 1000 and 4000 Hz. Therefore, we can expect that the higher frequency components in the 100 Hz square wave will be relatively normal in amplitude and phase but that the low-frequency components "B" in this same square wave will be modified by the poor low-frequency response of this amplifier (see Fig. 24).

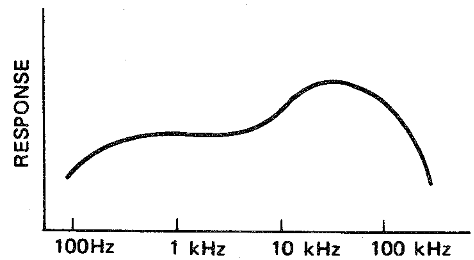


Fig. 23 Response curve of amplifier with poor low and high ends

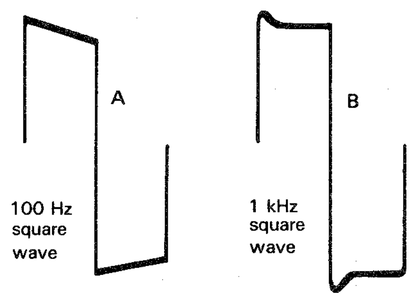


Fig. 24 Resultant 100 Hz and 1 kHz square waves from amplifier in Fig. 23

If the amplifier were such as to only depress the low frequency components in the square wave, a curve similar to Fig. 25 would be obtained. However, reduction in amplitude of the components is usually caused by a reactive element, causing, in turn, a phase shift of the components, producing the tilt as shown in Fig. 24A. Fig. 26 reveals a graphical development of a similarly tilted square wave. The tilt is seen to be caused by the strong influence of the phase-shifted 3rd harmonic. It also becomes evident that very slight shifts in phase are quickly shown up by tilt in the square wave.

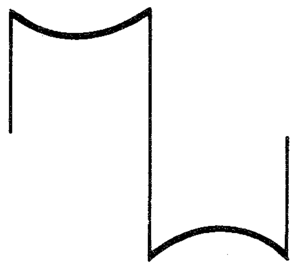


Fig. 25 Reduction of square wave fundamental frequency component in a tuned circuit

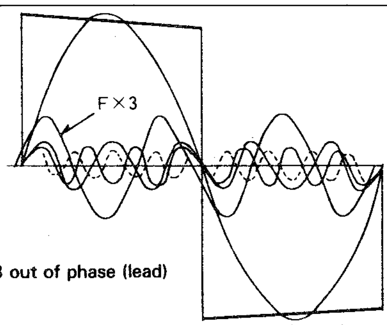


Fig. 26 Square wave tilt resulting from 3rd harmonic phase shift

Fig. 27 indicates the tilt in square wave produced by a 10° phase shift of a low frequency element in a leading direction. Fig. 28 indicates a 10° phase shift in a low frequency component in a lagging direction. The tilts are opposite in the two cases because of the difference in polarity of the phase angle in the two cases as can be checked through algebraic addition of components.

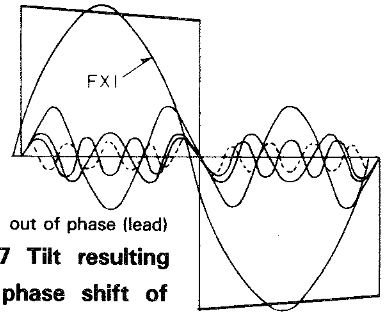


Fig. 27 Tilt resulting from phase shift of fundamental frequency in a leading direction

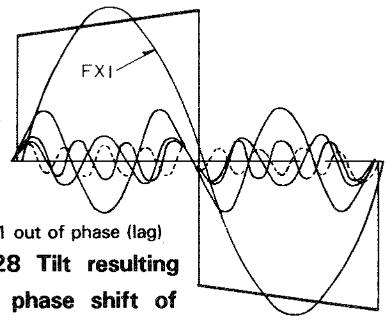


Fig. 28 Tilt resulting from phase shift of fundamental frequency in a lagging direction

Fig. 29 indicates low frequency components which have been reduced in amplitude and shifted in phase. It will be noted that these examples of low frequency distortion are characterized by change in shape of the flat portion of the square wave.

Fig. 24B shows a high frequency overshoot produced by rising amplifier response at the high frequencies.

It should again be noted that this overshoot makes itself evident at the top of the leading edge of the square wave. The sharp rise of the leading edge is created by the sum of a large number of harmonic components. If an abnormal rise in amplifier response occurs at high frequencies, the high frequency components in the square wave will be amplified larger than the other components, creating a high algebraic sum along the leading edge.

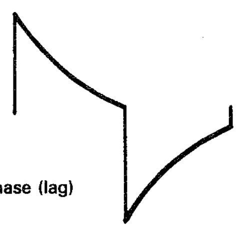


Fig. 29 Low frequency component loss and phase shift

Fig. 30 indicates high frequency boost in an amplifier accompanied by a lightly damped "shock" transient.
In this case, when the sudden transition in the square wave potential from a sharply rising, relatively high frequency voltage, to a level value of low frequency voltage, provided that the energy for oscillation in the resonant network in the amplifier is reasonably damped, then a single cycle transient oscillation may be produced as illustrated in Fig. 31. Fig. 32 summarizes the preceding explanation and serves as a handy reference.

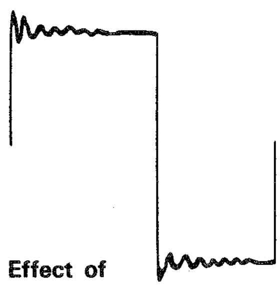


Fig. 30 Effect of high frequency boost and poor damping

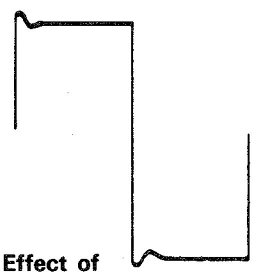


Fig. 31 Effect of high frequency boost and good damping

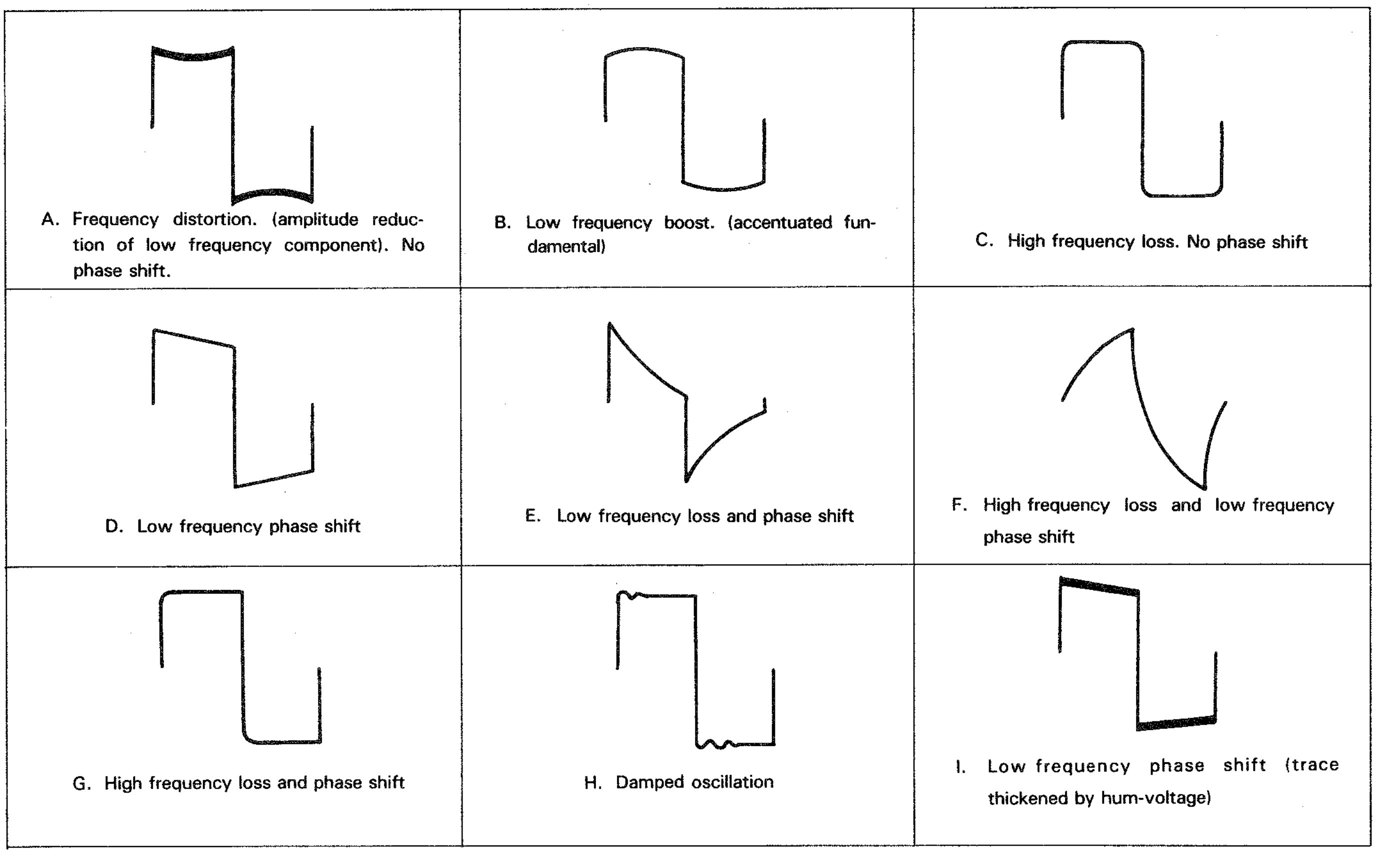


Fig. 32 Summary of waveform analysis for square wave testing of amplifiers

OTHER APPLICATIONS

Amplifier Phase Shift Measurement

In the square wave testing section of this manual, square wave distortion is explained in terms of phase shift of the signal components which comprise the square wave. These phase shifts can be verified directly by providing a sine wave input signal to the amplifier and observing the phase of output signal with respect to the input signal. In all amplifiers, a phase shift is always associated with a change in amplitude response. For example, at the −3 dB response point, a phase shift of 45° occurs.

Fig. 33 illustrates a method of determining amplifier phase shift directly. In this case, the measurements are being made at approximately 5000 Hz. The input signal is used as a reference and is applied to the Channel 1 input. The VARIABLE control is adjusted as required to provide a complete cycle of the input waveform displayed on 8 div horizontally, while the waveform height is set to 2 div. The 8 div display represents 360° at the displayed frequency and a centimeter represents 45° of the waveform.

The VER. ATT controls of Channel 2 are adjusted as required to produce a peak-to-peak waveform of 2 div. The Channel 2 POSITION control is then adjusted so that the Channel 2 waveform is displayed on the same horizontal axis as the Channel 1 waveform. The distance between the two waveforms then represents the phase shift between the two waveforms. In this case, the zero crossover points of the two waveforms are compared. The illustration shows a phase difference of 1 div which means a phase shift of 45°.

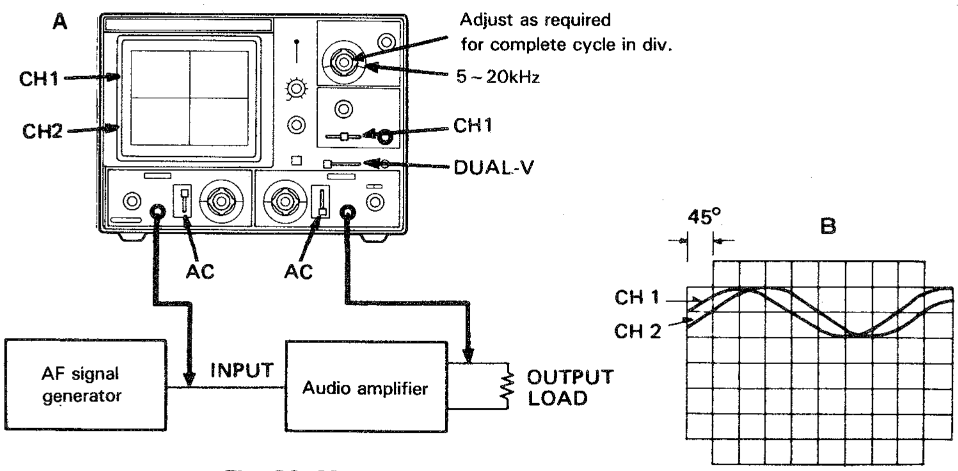


Fig. 33 Measuring amplifier phase shift

Stereo Amplifier Servicing

Another convenient use of dual-trace oscilloscope is in trouble-shooting of stereo amplifiers. If identical amplifiers are used and the output of one is weak, distorted or otherwise abnormal, the dual-trace oscilloscope can be effectively used to localize the defective state. With an identical signal applied to the inputs of both amplifiers, a side-by-side comparison of both units can be made by progressively sampling identical signal points in both amplifiers.

When the defective or malfunctioning stage has been located, it can be immediately observed and analyzed.

Frequency measurement

(1) Connect the sine wave of known frequency to the CH2 input of the oscilloscope and set the DISPLAY MODE switch to X-Y.
(2) Connect the CH1 to the signal to be measured.
(3) Adjust the CH1 and CH2 for proper amplitude.
(4) The resulting Lissajous' pattern shows the ratio between the two frequencies (see Fig. 34).

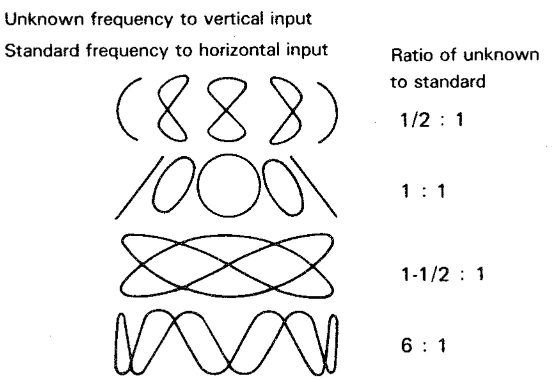


Fig. 34 Lissajous' waveforms used for frequency measurement

MAINTENANCE

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

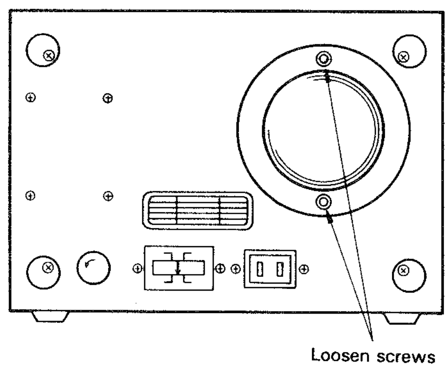
For Electric Shock Protection:
Be sure to disconnect the power cable from the socket before conducting the following operation.

VOLTAGE CONVERSION

For operation on AC 100 V, 110 V or 220 V, be sure to set the AC voltage selector switch on the rear panel to the correct position. For operation on AC 100 V or 117 V, replace the 0.3 A fuse on the rear panel with 0.7 A fuse.

TRACE ANGLE ADJUSTMENT

1. Loosen the 2 screws from the CRT cover at the rear panel.
2. Turn the CRT cover and CRT will rotate together. Turn CRT until the trace is aligned with the horizontal line of the scale.
3. Tighten firmly the 2 screws, making sure that the trace is not deviated from the horizontal line of the scale.
   Note: For adjustment, loosen the screws on the cover.
   Do not remove from the cover.



Trace angle adjustment

Fig. 35

ACCESSORIES

STANDARD ACCESSORIES INCLUDED

Instruction Manual B50-7549-20
Replacement Fuse
0.7 A F05-7011-05
0.3 A F05-3011-05

OPTIONAL ACCESSORIES

Probe (PC-30) W03-2308-05
Attenuation...1/10, 1/1
Input Impedance
1/10 ....10 MΩ, 22pF ±10%
1/1 ....1 MΩ, 200pF or less

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

PRINTED IN JAPAN B50-7549-20 (T) 91/12 11 10 9 8 7 6 5 4 3 2 1 90/12 11 10 9 8 7 6