MS-1660

(DIGITAL MEMORY SCOPE)

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.

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
PREPARATION FOR USE 6
CONTROLS AND INDICATORS 7
  FRONT PANEL 7
  REAR PANEL 14
OPERATION 16
  OPERATION AS AN OSCILLOSCOPE 16
  (1) NORMAL SWEEP DISPLAY OPERATION 18
  (2) MAGNIFIED SWEEP OPERATION 18
  (3) X-Y OPERATION 18
  MEMORY SCOPE OPERATION 19
  (1) WAVEFORM OBSERVATION 19
  (2) READING TO PEN RECORDER 21
  (3) CONTROL BY GP-IB 21
APPLICATION 23
  APPLICATION AS AN OSCILLOSCOPE 23
  APPLICATION AS A DIGITAL MEMORY SCOPE 32
Power Input Voltage Configuration 34

FEATURES

The digital memory scope MS-1660 consists of a DC-20MHz bandwidth, dual-trace oscilloscope with a built-in digital memory. The memory features a capacity of 8 bits x 2048 words per channel and a maximum write speed of 1 μs/word. The unit provides the ability to store and reproduce sporadic, transient and repetitive events, and rear the stored signals out to a pen recorder, through simple operation.

The contents of the memory can be read out or written via GP-IB so that external data can be monitored on the CRT screen by storing the data in the memory. Since an independent sampling clock is provided for each channel, separate signals can be stored with separate clocks at the same time, and the same signals can be stored at a low speed and a high speed at the same time. A single trace can be used as 4K words.

1. For each trace, a memory space of 2k words is provided. The unit has two independent semiconductor memories of 8 bits x 2048 words each.
2. Dual channel
   Input consists of two events at a time, each allotted an independent memory space. Maximum write speed is 1 μs/word.
3. Dual clock
   Two completely independent sampling clocks are provided to allow simultaneous storage of two totally unrelated signals. Also, the same signal can be stored at low speed and high speed (equivalent of partial magnification) at the same time.
4. Minus delay function
   The unit is capable of storing the signals produced before a trigger pulse, which are not observable on oscilloscopes.
   The data after the delay set point can be observed on the other channel, by magnification or contraction. The delay set point is continuously variable with cursor indication.
5. Hard copy
   The pen recorder provided can be used to produce the hard copy of the displayed waveform from memory. In addition, pen free run function is provided for automatic repetition of signal storage and corresponding hard copy reproduction.
6. Two storage modes are selectable. The refresh mode initiates writing with a trigger signal. In the pretrigger mode, the termination of writing is controlled with a trigger signal. In either mode, the waveform following the cursor point can be viewed in magnified or contracted form in the other channel.
7. Free run function for automatic repetition of read/write operations
   Once written, the signals are held in a read state for up to 20 sec, then enter a writable state in which the signals wait for a trigger signal. This cycle is repeated automatically.
8. Memory backup function
   Signals stored remain unchanged in the memory even after turning power off. Thus waveforms may be analyzed at any time on later days.
9. With the GP-IB interface, the data within in memory can be sent out, and external data can be written in the memory for display on the screen.
10. Line synchronization facilitates the observation and storage of the signals that are triggered with the line frequency.
11. By setting the mode to X-Y, the unit changes to an X-Y oscilloscope with a one-button operation.
12. A rectangular, large sized CRT with wider display area provides full-screen signal observation.
13. The vertical axis provides a high sensitivity of 1 mV/div, plus a wide band range from 5mV/div to a desired setting.
14. The unit is capable of high-speed sweep of 20ns/div.
15. A 150mm rectangular CRT with internal graticule (domed mesh type, post-acceleration with 6kV acceleration voltage) provides easy waveform observation without parallax.
16. The 0, 10, 90, and 100% marks on the screen provides easy measurement of rise time.
17. The angle of horizontal trace can be easily corrected with trace rotation controls on the front panel.
18. The scale illumination facilitates measurement in a dark place, and also enables photographic recording of the on-screen waveform.
19. With the automatic free run function, the trace can be checked while no signal is fed.
20. CH1 OUTPUT terminals are provided to monitor the input signals on the CH1.

SPECIFICATIONS

CRT

Model: 150 FTM31: Rectangular, with internal graticule
Acceleration voltage: 6 kV
Display area: 8 X10 div (1 div = 10 mm)

VERTICAL AXIS (Common to CH1 and CH2)

Sensitivity: 1 mV/div to 5V/div ± 3%
Attenuator: 5 mV/div to 5V/div
1-2-5 sequence, fine adjustment between 10 ranges
Input impedance: 1 MΩ ± 2%, Approx. 25 pF
Frequence responce:
DC: DC to 20 MHz (Within – 3 dB at 5 mV/div to 5V/div)
DC to 10 MHz (Within – 3 dB at X5 GAIN)
AC: 5 Hz to 20 MHz (Within – 3 dB at 5 mV/div to 5 V/div)
5 Hz to 10 MHz (Within – 3 dB at X5 GAIN)
Rise time X1: Less than 17.5 ns
X5 GAIN: Less than 35 ns
Crosstalk: Less than –40 dB (CH1 & CH2 in same range)

Operating modes:
CH1 CH1, single trace
CH2 CH2, single trace
DUAL CH1 and CH2, dual trace
ADD CH1 + CH2 (added) display
ALT Dual or quad trace alternating
CHOP Dual or quad trace chopped
X-Y X-Y oscilloscope
CHOP frequency: Approx. 250 kHz
Polarity reversal: Available for CH2 only

Maximum input voltage: 500 V_{p-p} or 250V (dc + ac peak)

Maximum undistorted amplitude: 8 div, minimum (DC to 20 MHz)

HORIZONTAL AXIS (Channel 2 input, except X10MAG)

Modes: X-Y mode is switch selectable
CH1: Y axis
CH2: X axis
Sensitivity: Same as vertical axis (CH2)
Input impedance: Same as vertical axis (CH2)
Frequency response:
DC: DC to 1 MHz (Within –3 dB)
AC: 5 Hz to 1 MHz (Within –3 dB)
X-Y phase difference: Less than 3° at 100 kHz
Maximum allowable input voltage: Same as vertical axis (CH2)

SWEEP

Sweep: NORM; Trigger sweep
AUTO; Automatic free run function while signals are not fed
Sweep time: 0.2 µs/div. to 0.5 s/div ± 3%, in 1-2-5 sequence with in 20 ranges, fine adjustment between 20 ranges
Sweep magnification: X10 ± 5%
Linearity: ± 3% (0.2 µs/div ± 5% with X10 magnification)

TRIGGERING

CH1: Triggered with vertical input signal on CH1.
CH2: Triggered with vertical input signal on CH2.
EXT: Triggered with external synchronizing signal.
LINE: Triggered with line frequency
External triggering:
Input impedance: 1 MΩ ± 2%, Approx. 25 pF
⚠Maximum input voltage: 50 V (DC + AC peak)
Coupling modes: AC, HF_{REJ}, DC
Sync sensitivity

SYNC COUPLING	SYNC. FREQ. RANGE	MIN. SYNC AMPLITUDE (VOLTAGE)	
		INT	EXT
DC	DC ~ 20 MHz	1 div	0.1 V_{p-p}
AC	10Hz ~ 20 MHz	1 div	0.1 V_{p-p}
DC HF_{REJ}	At 1.5 kHz or over, min. amplitude (voltage) required for sync increases.		

PROBE CALIBRATING VOLTAGE

0.5V ± 2% of positive square wave, approx. 1 kHz

INTENSITY MODULATION

Input voltage: Intensity increases with TTL level.
Input impedance: Approx. 10 kΩ
Frequency range: DC to 5 MHz
Maximum input voltage: 50 V (DC + AC peak)

VERTICAL AXIS OUTPUT CH1 signal output

Output voltage: Approx. 50 mV/div (50Ω load)
Output impedance: Approx. 50Ω
Frequency response:
X1: 100 Hz to 20 MHz (within ± 3 dB), at 50Ω load
X5 GAIN: 100 Hz to 10 MHz (within ± 3 dB), at 50Ω load

GATE OUTPUT

Output waveform:	Positive pulse triggered to sweep
Output voltage:	TTL level
Series resistance:	Approx. 220Ω

DATA CONVERTER

Converting method:	Successive comparison, A/D converter
Conversion speed:	1 μs/word
Resolution:	8 bits (0.4%)
Frequency response:	DC to 250 kHz (within −3 dB)

MEMORY

Memory capacity:	8 bits X 2048 words/CH X2 (Full memory capacity of 4096 words)
Memory devices:	C-MOS static RAMs
Write speed:	1 μs to 100 ms/word, with 1-2-5 steps in 16 ranges (with independent channel setting)
Read speed	
INT:	MEMORY OUT: 1 μs/word (fixed) SCOPE: 1 μs/word (fixed) FOR PEN: 10, 20, 50 ms/word (3 ranges)
EXT:	TTL level, repetitive square wave of less than 1 MHz High-level pulse width; More than 500 ns Low-level pulse width; More than 500 ns Rise time; Less than 500 ns
FREEZE function:	Rewrite-protectable for each channel
Memory backup:	Full memory holding. Holding time of more than 200h.

OPERATING FUNCTIONS

REFRESH: (TRIG START)	Write is started with the trigger signal (or manually). Write prohibition variable time between 1 to 20 sec (DISPLAY TIME)
PRE TRIG: (MANUAL START)	A write is started manually. Performs pretrigger operation (negative delay) according to cursor setting. Automatic, repeated write/read operations are available (read time can be
DELAY:	set from approx. 1 to 20 sec). address is simultaneously displayed in other channel.
Cursor setting	Cursor is continuously movable within addresses between 2 and 2000 words. Shifting resolution 1 word (speed variable in 2 steps)

DATA OUTPUT

D/A converter:	8-bit resolution
Output level:	MEMORY OUT: 1.6Vp-p ± 3% relative to input full scale FOR PEN: 2.0Vp-p ± 3% relative to input full scale (Over 1 kΩ load)
Output impedance:	MEMORY OUT: Approx. 22Ω

CONTROL OUTPUT

READ GATE OUT

Output waveform:	Positive pulse equivalent to 1 word of last address
Output voltage:	TTL level (Common to both channels)
Series resistance:	Approx. 220Ω

READ GATE OUT FOR PEN

Control signal for PEN

Output signal:	Negative logic (activated about 2 sec after pen start ON)
Output voltage:	TTL level
Series resistance:	Approx. 220Ω

EXTERNAL CONTROL

The data in memory is controllable via GP-IB.

Governing standard:	IEEE STD 488-1978
Subsets to be used:	SH1, AH1, TE0, LE0, T6, L4, SR1, RL1, PP0, DC1, and DT0

POWER SOURCE

Line voltage	100/120/220/240Vac ± 10%, 50/60Hz
Power consumption	Approx. 70W

DIMENSIONS

Width	426 mm (433 mm)
Height	177 mm (190 mm)
Depth	411 mm (475 mm)
	Figures in ( ) includes projecting parts.

WEIGHT	Approx. 13 kg

ENVIRONMENT

Operating temperature and humidity for guaranteed specifications:	10 to 35°C, 85% RH max.
Full operating temperature and humidity range:	0 to 45°C, 85% RH max.

ACCESSORIES

Probe (PC-20)	2
Attenuation:	1/10, 1/1
Input impedance	1/10: 10 MΩ, below 18 pF 1/1 : 1 MΩ, below 100 pF
Instruction manual:	1
AC power cord:	1
Replacement fuse:	1
OPTION	GP-IB cable (CB-2420P)

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 right side of the power connector 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 memory scope at earth ground. Do not attempt to defeat the ground wire connection or float the memory scope 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. 40.

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. Before putting this instrument in use, make sure that the power source selector switch is set to the proper position that corresponds to the line voltage. If the selector switch is not properly set, this causes damage to the instrument. Connect the power cord to the power receptacle only after this confirmation is made.
2. The MS-1660 should be installed at a place meeting the following conditions:
   - o The MS-1660 is not exposed to direct sunlight.
   - o Temperature and humidity are not very high. The air does not contain many dust particles.
   - o The surrounding facilities and equipment do not produce intense mechanical vibration, magnetic force, or impulse voltage.
3. Never apply more than the maximum rated voltage to the oscilloscope input jacks.
   CH1, CH2 input jacks:
   500Vp-p or 250V (DC + ACpeak)
   ⚠EXT TRIG, Z AXIS input jacks:
   50V (DC + ACpeak)
   Never apply external voltage to the oscilloscope output terminals.
4. When desiring to retain the stored waveform while the instrument is powered off, push the FREEZE switch before turning off the power. Keep the FREEZE switch pressed while the power is turned off. It is desirable to keep the FREEZE switch pressed when the instrument is powered on again to reproduce the stored waveform. Note that, if input signal source is in connection with the instrument when the power is turned on, the stored waveform will be erased by the write operation started with an input signal.
   The upper 3 bits of the address switches for GP-IB must be set to the lower positions.
5. Do not increase the intensity more than required.
6. Never allow a small spot of high brilliance to remain on the screen for extended periods of time.
7. When using this instrument in X-Y mode, set the PULL-X10MAG switch to the PUSH position. If this switch is set to the PULL position, the waveform may be disturbed by noise.
8. Never cover the ventilating holes in the top of the scope, as this will increase the operating temperature inside the case.
9. When removing the case, observe the maintenance instruction contained in this manual to prevent a safety hazard because this instrument contains high voltage circuits.
10. Always ground the instrument using the FRAME side of the GND terminals on the rear panel to prevent a safety hazard.
11. 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.

CONTROLS AND INDICATORS

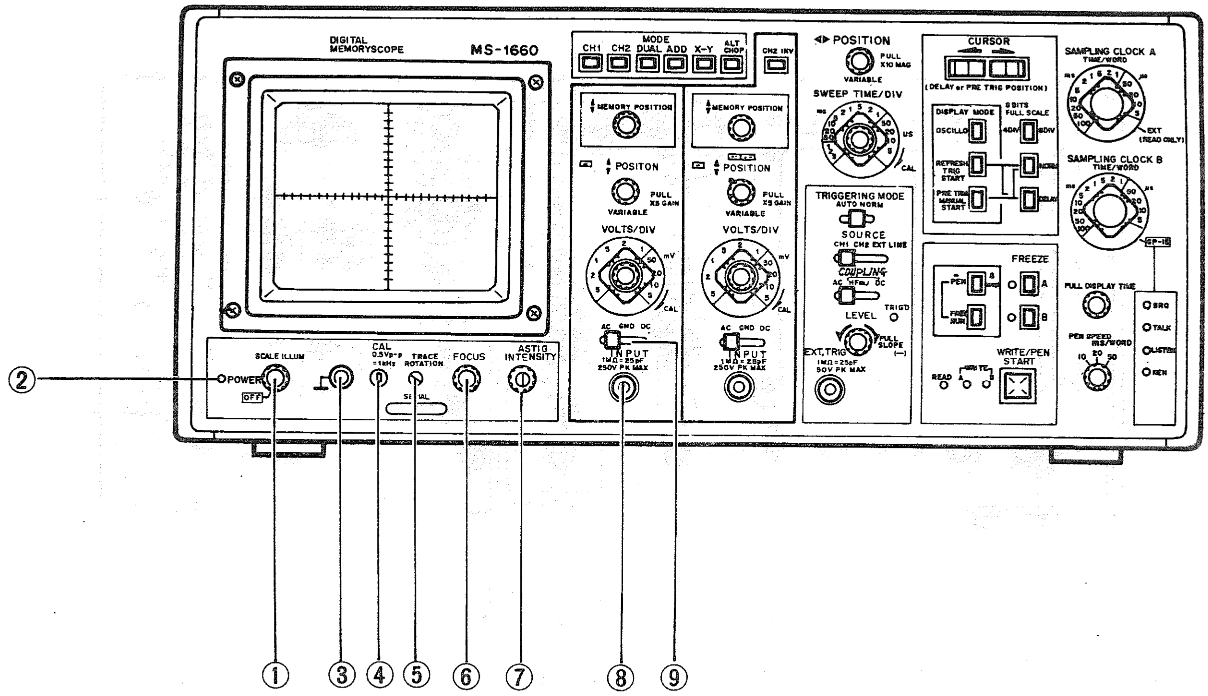


Fig. 1

FRONT PANEL

① POWER, SCALE ILLUM Control
Turns power on/off and varies graticule brightness.

② POWER LED Pilot Lamp
Indicates that the power supply has been turned on.

③ ⏚
Ground terminal.

④ CAL
Provides a positive 0.5V peak-to-peak square wave signal of approx. 1 kHz for probe compensation adjustment.

⑤ TRACE ROTATION Control
Electrically rotates the trace to horizontal position. Used as when the trace is tilted by terrestrial magnetism.

⑥ FOCUS Control
Used to adjust the trace for optimum focus.

⑦ INTENSITY/ASTIG Control
INTENSITY: Adjusts the trace intensity.

ASTIG: Astigmatism adjustment provides optimum spot roundness when used in conjunction with FOCUS control

⑧ INPUT Jack
Vertical input for channel 1 trace in normal sweep operation. Vertical input for X-Y operation.

⑨ AC-GND-DC Switch
Three-position switch which operates as follows:

AC: Input signal is capacitively coupled, blocking DC component.

GND: Opens the path between the input jack and vertical amplifiers so that the input of vertical amplifier is grounded. This allows the earth potential to be checked.

DC: Input signal is direct coupled, allowing observation of waveform containing DC component.

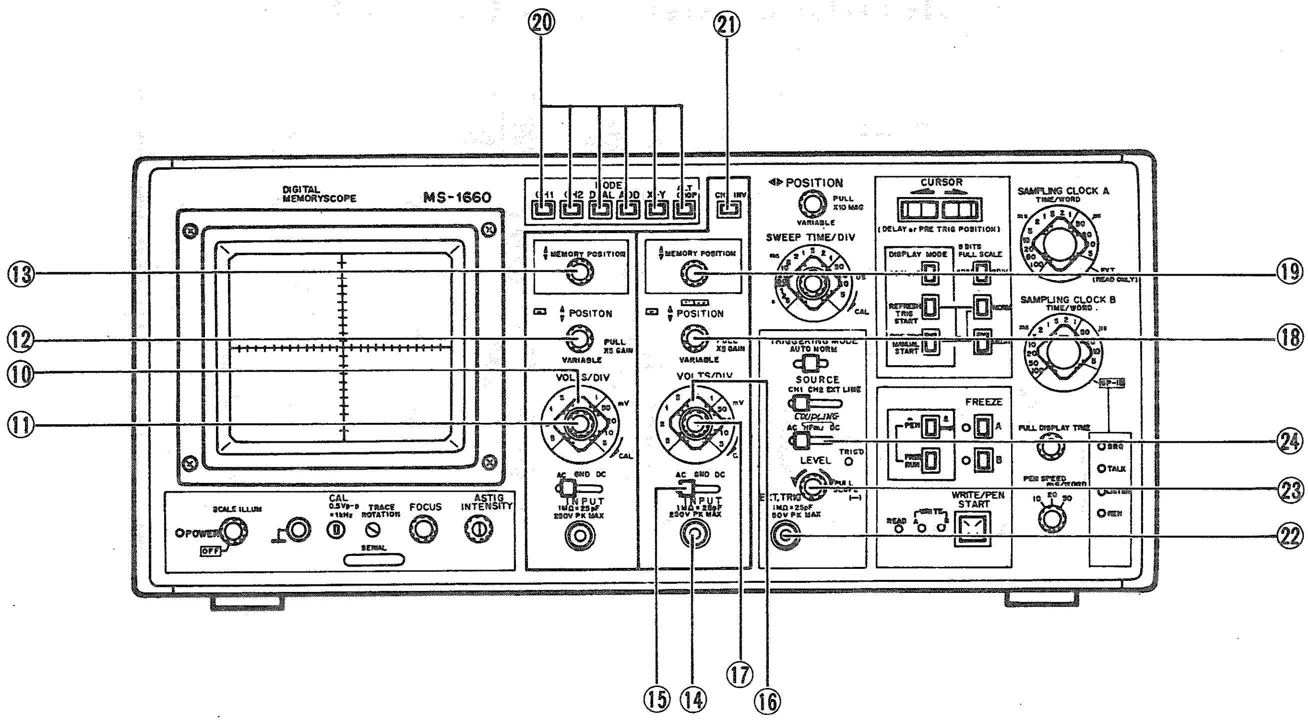


Fig. 2

⑩ **VOLTS/DIV Control**

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

⑪ **VARIABLE/PULL X5 GAIN Controls**

VARIABLE:

Rotation provides fine control of CH1 vertical sensitivity. In the fully clockwise (CAL) position, the vertical attenuator is calibrated. For X-Y operation, this control serves for X-axis attenuation fine adjustment.

PULL X5 GAIN:

When pulled out, the VOLTS/DIV setting is multiplied by five, and for X-Y operation, the X-axis sensitivity is multiplied accordingly. In X5 GAIN mode, increased vertical gain makes the trace thiker.

⑫ **⇕ POSITION Control**

Rotation adjusts vertical position of CH1 waveform on the screen. For X-Y operation, this control adjusts Y axis position.

In memory scope operation, the control provides DC OFFSET adjustment of CH1, superimposing the DC level over input signal.

Clockwise rotation of the control adds +DC level to the GND level. Counterclockwise rotation adds −DC level to the GND level.

⑬ **⇕ MEMORY POSITION Control**

Adjusts the vertical position of the stored waveform. With selection of the SAMPLING CLOCK A Control, this control adjusts the vertical position of the stored waveform. For memory operation in X-Y mode, the control adjusts Y-axis position.

NOTE:

This control has no effect on MEMORY OUT A ㊺ jack.

⑭ **INPUT Jack**

Receives CH2 vertical input, or X-axis input in X-Y operation.

⑮ **AC-GND-DC Switch**

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-DC⑨for CH1.

⑯ **VOLTS/DIV Control**

Vertical attenuator for CH2. Provides the same function as VOLTS/DIV Control ⑩ for CH1. In X-Y operation, the control serves as the X-axis attenuator.

⑰ **VARIABLE/PULL X5 GAIN Control**

Provides the fine control of the vertical attenuation for CH2 and increases the vertical sensitivity. The control performs the same function as VARIABLE/PULLX5 GAIN Control ⑪ for CH1. In X-Y operation, the control provides the fine adjustment of the X-axis attenuation and increases the X-axis sensitivity.

⑱ ⬍ **POSITION Control**

For CH2, the control provides the same function as ⬍ POSITION Control ⑫ for CH1. In X-Y operation, the control provides X-axis position adjustment. In memory scope operation, this control provides DC OFFSET adjustment for CH2.

⑲ ⬍ **MEMORY POSITION Control**

With selection of the SAMPLING CLOCK B control, this control adjusts the vertical position of the stored waveform. For memory operation in X-Y mode, the control adjusts the X-axis position.

NOTE:
This control does not work for MEMORY OUT B ㊺ jack.

⑳ **MODE Switch**

Selects the operation mode of the vertical axis.

CH1: Only the input signal to channel 1 is displayed on the screen. In memory operation, a different display is produced on the screen according to the selection of NORM/DELAY selector of DISPLAY MODE ㉜ switches.

NORM: The waveform stored with SAMPLING CLOCK A is displayed on the screen.

DELAY: The waveforms stored with SAMPLING CLOCK A and B are displayed as dual traces on the screen.

CH2: Only the input signal to channel 2 is displayed on the screen. In memory operation, a different display is produced on the screen according to the selection of NORM/DELAY selector.

NORM: The waveform stored with SAMPLING CLOCK B is displayed on the screen.

DELAY: The waveforms stored with SAMPLING CLOCK A and B are displayed as dual traces on the screen.

DUAL: The input signals to channel 1 and channel 2 are displayed on the screen. In memory operation, the waveforms stored with SAMPLING COCK A and B are displayed on the screen.

DELAY operation will not be produced but only NORM operation will be performed even if the NORM/DELAY selector is set to DELAY.

ADD: The algebraic sum of CH1 and CH2 signals is displayed on the screen. When the CH2 INV 21 button is engaged, the difference between CH1 and CH2 signals is displayed.

In memory operation, a different display is produced according to the selection of NORM/DELAY selector.

NORM: The screen displays the waveform which is stored with SAMPLING CLOCK B as the algebraic sum of CH1 and CH2 signals (or as the difference between CH1 and CH2 signals when CH2 INV is selected).

DELAY: The screen provides a dual trace display the wave forms which are stored with SAMPLING CLOCK A and B as the algebraic sum of CH1 and CH2 signals (or as the difference between CH1 and CH2 signals when CH2 INV is selected).

X-Y: The instrument operates as an X-Y oscilloscope with CH1 serving as Y-axis and CH2 as X-axis.

In memory operation, the waveform stored with SAMPLING CLOCK A is displayed as Y-axis input, and the waveform stored with SAMPLING CLOCK B is displayed as X-axis input.

The DELAY operation will not be produced but only the NORM operation will be produced even if the NORM/DELAY selector is set to DELAY.

▀ ALT/ ▄ CHOP Selector:

Selects the display mode for two traces in the DUAL mode.

▀ ALT: CH1 and CH2 aignals are alternately displayed.

▄ CHOP: CH1 and CH2 signals are displayed by chopping.

In memory operation, the alternate sweep mode is automatically selected regardless of the setting of this selector. Setting to display the stored waveform on the screen.

NOTE:
Each of the mode setting controls is related to the writing into memory. See the descriptions on DISPLAY MODE, REFRESH/PRE TRIG, NORM/DELAY, SAMPLING CLOCK A, B, and CURSOR.

㉑ **CH2 INV Button**

Inverts the polarity of CH2 signal.

㉒ **EXT TRIG Jack**

When the SOURCE control is set to the EXT position, the sweep is triggered by the input signal fed through this jack.

㉓ **LEVEL/PULL SLOPE (–) Control**

LEVEL: Adjusts the trigger level, i.e., the point on the trigger signal waveform slope where the sweep starts.

PULL SLOPE: Adjusts the polarity of the triggering. When the control is pulled out, the trigger occurs at the trailing edge of the input waveform.

㉔ **COUPLING Switch**

Selects the coupling for the triggering signal.

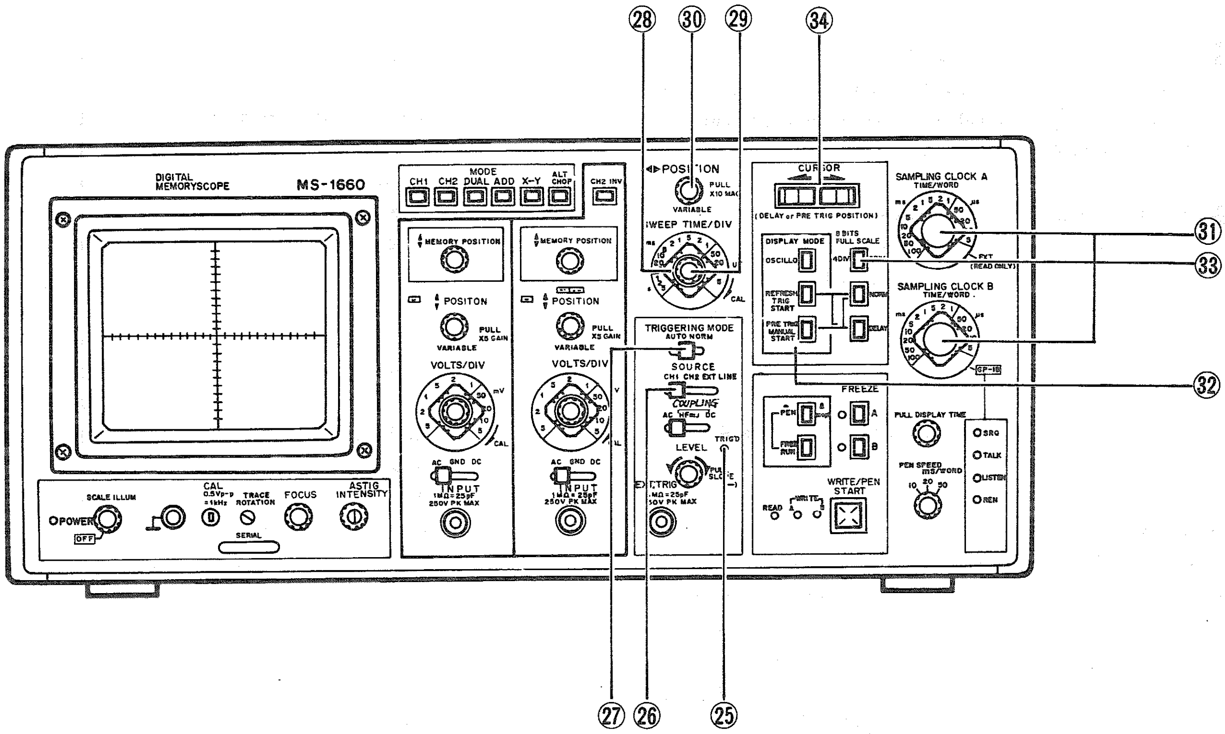


Fig. 3

AC: The trigger signal is capacitively coupled with the trigger circuit.
The DC component of input signal is blocked.

HF_{REJ}: Trigger signal is DC coupled with the trigger circuit.
AC components over 1.5 kHz are attenuated for stable triggering of low-frequency components.

DC: The trigger signal is DC coupled with the trigger circuit in such a way as to give a triggering which includes the effects of dc components.

(25) TRIG'D Lamp

Lights up when the triger signal is fed and reaches the triggering range set with the LEVEL control (23) .

(26) SOURCE Switch

Allows selection from three triggering modes.

CH1: CH1 vertical input signal becomes a trigger signal.

CH2: CH2 vertical input signal becomes a trigger signal.

EXT: Signal applied at EXT.TRIG (22) jack becomes a trigger signal.

LINE: Line frequency of the commercial source becomes a trigger signal.

(27) TRIGGERING MODE Switch

Selects triggering mode.

AUTO: Triggered sweep operation. Even without a trigger signal, the unit performs free run, showing a trace.

NORM: Normal triggered sweep operation. No trace will be presented when a proper trigger signal is absent.
While the stored waveform is displayed on the screen, only the stored waveform is displayed on the screen without performing the NORM operation.

(28) SWEEP TIME/DIV Control

Selects the sweep time in 20 steps from 0.2 μs/div to 0.5 s/div. The sweep time will be the indication value calibrated at the CAL position (full clockwise) of VARIABLE (29) . While the stored waveform is displated on the screen, the indication on this control has no effect.

(29) VARIABLE Control

Provides fine sweep time adjustment continuously between the ranges of the SWEEP TIME/DIV Control (28) . The sweep time is calibrated in the CAL position (full clockwise). While the stored waveform is displayed on the screen, this control has no effect.

(30) ◀▶ POSITION/PULL X10 MAG Control

◀▶ POSITION:
Rotation adjusts horizontal position of the waveform.

PULL X10 MAG:
Provides 10 times faster sweep time when pulled out.

(31) **SAMPLING CLOCK A, B Controls**

Select a sampling frequency for the input signal in 16 ranges between 100 ms and 1 μs/word. Between the 100 ms and 1 μs/word range, the waveform can be observed during write operation because the input signal is read out while the input signal is written in memory. Between the 50 μs and 1μs/word range, a trace is displayed during write operation because the waveform is read out after the write in the memory (2 Kw) has completed.

Therefore, when a continuous trigger waveform is fed, the read time cannot be maintained, producing discontinued waveform or a trace on the screen, but the waveform will be stored normally. When such a condition is present, pull the PULL DISPLAY TIME knob 39 to maintain the read time.

When the DISPLAY MODE selector (32) is set to NORM, SAMPLING CLOCK A corresponds to the CH1 input signal, and the SAMPLING CLOCK B to the CH2 input signal. When the DISPLAY MODE selector is set to DELAY, SAMPLING CLOCK A and B correspond to the input signal of the main channel selected with the MODE selector (20). The DELAY position of that mode selector corresponds to NORM.

Fully clockwise rotation of the SAMPLING CLOCK A control makes a connection to the read only EXT CLOCK terminals; consequently, the contents of the memory are read out with the clock signal that is fed from the EXT CLOCK terminal (49) on the rear panel. This mode is used only for read operation so that the instrument is frozen for memory protection, with the FREEZE lamp being on. Fully clockwise rotation of the SAMPLING CLOCK B control provides connection with GP-IB, thereby allowing the reading and writing of memory contents by connecting the GP-IB controller to the unit. (For details, refer to the description on GP-IB.)

(32) **DISPLAY MODE Switches**

The MS-1660 operates as a dual-trace oscilloscope by the push of OSCILLO and as a memory scope when REFRESH or PRETRIG is selected.

Combinations of switch settings allow four modes of writing input signal into memory.

REFRESH-NORM:

A write to memory is started by a trigger signal or manually by the push of WRITE/PEN START (37). After 2048 words have been written, the write operation stops, and the unit waits in read state for the next trigger signal or manual start.

REFRESH-DELAY:

A write to memory is started by a trigger signal or manually by the push of WRITE/PEN START (37) and continues until 2048 words have been written. The data after the cursor point (delay setting point) are transferred to the other channel: according to the sampling clock of that channel, these data are written by 2048 words into the memory allocated to that channel. After completion of writing for both channels, the unit waits in read state for the next trigger signal or manual start.

This combination provides the same mode as REFRESH-NORM when MODE (20) is set at DUAL. When MODE (20) is at ADD, the data following the cursor point are written to CH1 according to the SAMPLING CLOCK A.

PRE TRIG-NORM:

A write to memory is initiated by pressing WRITE/PEN START button (37). The point set by CURSOR switch (34) becomes the memory's trigger address, and the write operation continues until the number of words "(2K words) – (words specified by cursor setting)" have been written after input of trigger signal. Then the unit waits in road state until WRITE/PEN START (37) is next pressed. (PULL DISPLAY TIME (39) must be OFF.) This mode permits observation of the waveform preceding the trigger signal.

When MODE (20) is set at DUAL, CH1 performs the above operation. CH2 terminates its write operation upon completion of CH1 write operation.

PRE TRIG-DELAY:

The channel specified by MODE (20) performs the same operation as in the PRE TRIG-NORM mode. The data after the cursor point (delay setting point) are transferred to the other channel; according to the sampling clock of that channel, these data are written by 2048 words into the memory allocated to that channel. After data are written for both channels, the unit waits in read state for the next push of the start button. (PULL DISPLAY TIME (39) must be OFF.)

The MODE (20) is set at DUAL, CH1 performs the same operation as in the PRE TRIG-NORM mode. CH2 starts a write to memory from the cursor point (i.e., trigger point for CH1) and stops the write operation when 2048 words have been written.

(33) **8 DIV/4 DIV Selector**

Provides a 1/1 and 1/2 output levels of the stored waveform which is displayed on the screen and taken at the MEMORY OUT jack on the rear panel.

With this button not pressed, the output level will be 1.6 Vp-p (at full input scale). With this button pressed, the output level will be halved to 0.8 Vp-p (at full input scale).

The selection does not change the resolution of the vertical axis.

Therefore, the waveforms of two events are conveniently observed by selecting the 4DIV position.

(34) CURSOR Switch

Displays the bright spot (cursor point) on the main channel side according the combinations of settings of MODE (20) and DISPLAY MODE (32). Cursor movement is in two speeds. That is, when the right or left button is pressed once, the cursor point moves to the right or left, respectively, by one word; holding the right or left button depressed moves the cursor continuously to the corresponding direction as far as the button is depressed. The cursor point will stop upon arrival at the right or left end. The cursor point is movable between 2 and 2000 words (memory address). The cursor point display mode is available to the following combinations:

Display mode / Mode	REFRESH		PRE TRIG	
	NORM	DELAY	NORM	DELAY
CH1	–	Cursor point on CH1 side	Cursor point on CH1 side	Cursor point on CH1 side
CH2	–	Cursor point on CH2 side	Cursor point on CH2 side	Cursor point on CH2 side
DUAL	–	–	Cursor point on CH1 side	Cursor point on CH1 side
ADD	–	Cursor point on CH2 side	Cursor point on CH2 side	Cursor point on CH2 side
X-Y	–	–	–	–

(35) PEN/SCOPE, FREE RUN Selectors

PEN/SCOPE:

Selects the output direction of the memory contents, to SCOPE or PEN. The read speed varies with each selection. Pressing the button sets the unit into the PEN mode (and the MEMORY OUT terminal on the rear panel will be switched accordingly).

When the PEN mode is selected, press PEN START (37), and after a preparatory period of about two seconds, the memory contents are fed out to FOR PEN (46) at the speed set with PEN SPEED (40) (10 ms t 50 ms/word). This switch should not be changed to the PEN mode during a write. If so changed, the proper waveform may not be obtained.

FREE RUN:

This mode automatically repeats a write to memory and a read to FOR PEN (46). As the write to memory, controlled by a trigger signal, is completed, the PEN mode is automatically selected. Then, in about two seconds of preparatory period, signals are outputted to FOR PEN (46), and after completion of the output, the unit again enters the trigger wait state.

NOTE:

The proper waveform may not be obtained if this switch is changed to the FREE RUN mode while the memory contents are fed out to the FOR PEN A, B jacks with PEN START button in the PEN mode. So, do not change the setting of this switch during output operation.

(36) FREEZE button

Freezes, i.e., suspends the write the into memory. Pressing the A side stops the write operation on the memory which is controlled by SAMPLING CLOCK A (31), with the result that the data will be retained in the memory. Pressing the B side stops the write operation on the corresponding memory. When this switch is pressed, the write A or B (38) lamp lights up, indicating that the write operation is apparently performed, but the write operation is actually suspended. With the push of the FREEZE switch, the green LED on the left will light up.

(37) WRITE/PEN START Button

When PEN/SCOPE switch (35) is set to the monitor mode, this button serves as a manual start button for write to memory. If DISPLAY MODE (32) is set to REFRESH, the push of this botton is interpreted as a trigger signal; if DISPLAY MODE (32) is set to PRE TRIG, the push of this button starts a write to memory, and after completion of the write, the unit enters the trigger signal wait state.

When PEN/SCOPE switch (35) is set to the pen mode, this button is pressed to output signals to FOR PEN (46). Actually, the signal output begins about two seconds after the button is pressed.

(38) WRITE A B, READ LEDs

These LEDs indicate whether the unit is in the WRITE or READ state. Normally, directory after the unit is powered on, the READ (green) LED lights up to indicate the READ state. When the WRITE/PEN START (37) button is pressed or the write operation is started by a trigger signal, the WRITE A or B (red) LED lamp lights up to indicate the write state.

(39) PULL DISPLAY TIME Knob

After being pulled, this knob is turned counterclockwise to make the time setting longer and clockwise to make it shorter. The time can be set from about 1 to 20 seconds. The unit performs different operations depending on whether DISPLAY MODE (32) is set at REFRESH or PRE TRIG.

REFRESH:

The read time period after a write is set by the PULL DISPLAY TIME knob in the range of about 1 to 20 seconds. During this period, the unit is in read-only state, that is, a write does not take place because any tigger signal is ignored. After the end of the set period, the unit enters the trigger wait state, ready to

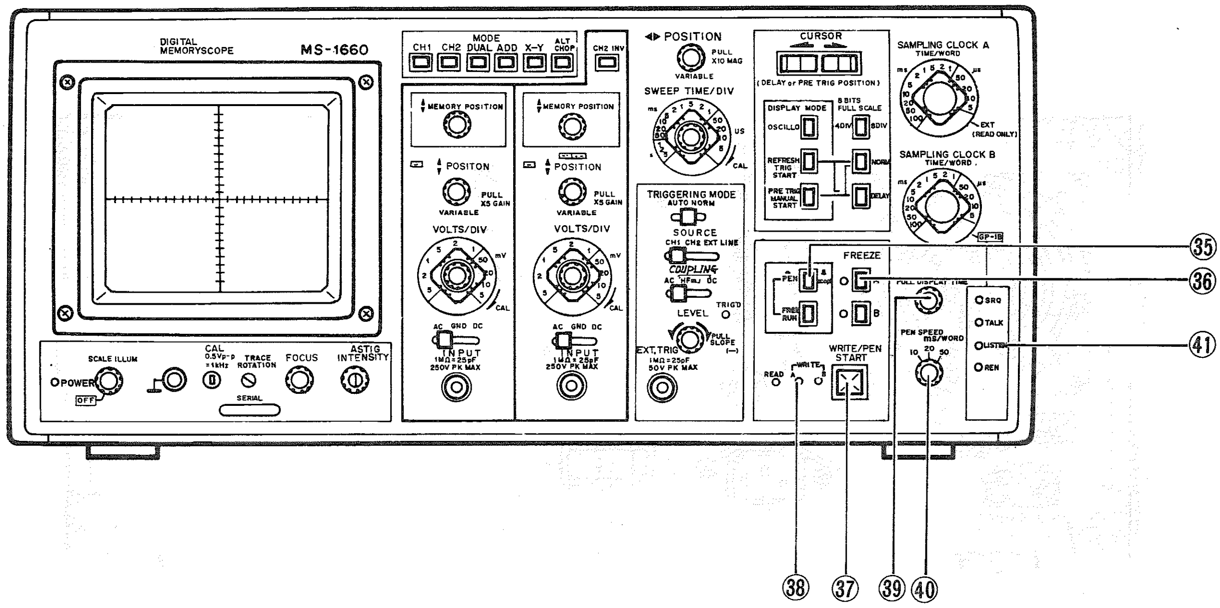


Fig. 4

execute the next write upon receipt of a trigger signal.

PRE TRIG:

A write to memory is started not by manual start but at the interval set by the PULL DISPLAY TIME knob. Upon receipt of a trigger signal, the unit performs a PRE TRIG operation, and after the elapse of the set interval, restarts a write to memory.

If, in this mode, WRITE/PEN START (37) is pressed, the write operation may stop. When using manual start, therefore, ensure that the PULL DISPLAY TIME button is OFF. In the event of an unwanted stop of write operation, the stop can be cancelled by simply pushing an then pulling the PULL DISPLAY TIME button.

(40) **PEN SPEED Selector**

With PEN/SCOPE (35) selector set to the PEN position, this switch becomes effective to select a read speed of the PEN output in 3 steps: 10, 20, and 50 ms/word.

(41) **GP-IB LEDs**

The four LEDs indicate the state of the unit when it is controlled by a GP-IB. When lit, each LED provides the following indication:

SRQ: The unit is in service request mode.
TALK: The unit is addressed as the talker.
LISTEN: The unit is addressed as the listener.
REN: The unit is in remote mode.

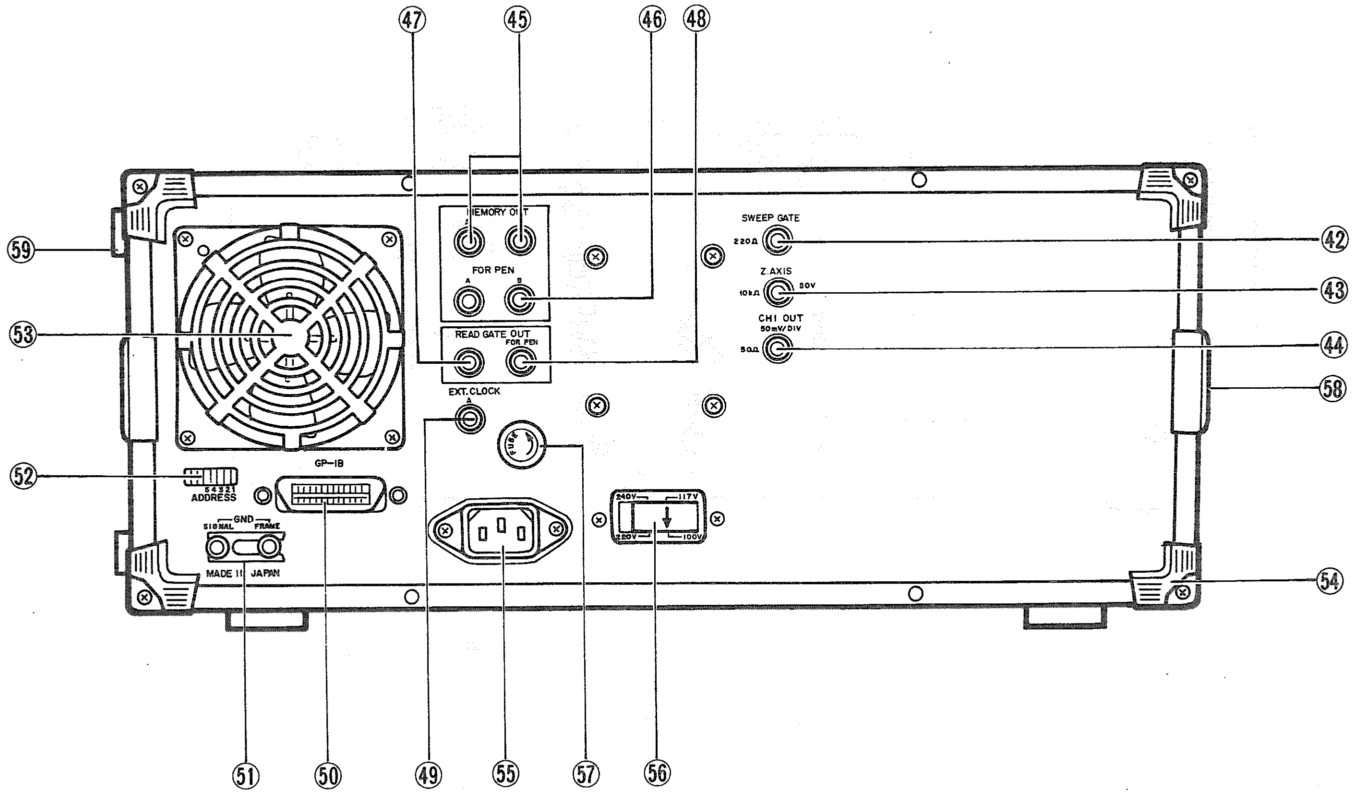


Fig. 5

REAR PANEL

(42) SWEEP GATE Jack
The positive-pulse gate waveform synchronized with the sweep is outputted here.

(43) Z AXIS INPUT Jack
External intensity modulation input; TTL compatible. Positive voltage increases the intensity.

(44) CH1 OUTPUT Jack
CH1 vertical output connector, providing a capacitively coupled signal. Used as in frequency measurement by connecting a frequency counter. Cascade connection for CH1 and CH2 is not allowed.

(45) MEMORY OUT A, B Jacks
The data for A and B stored in their memories are taken at these jacks after being converted into analog form.
When the MODE switch is set to ADD and the DISPLAY MODE selector is set to NORM, the added output signal is fed only to the B jack.

(46) FOR PEN A, B Jacks
Output (analog) signal connectors for a pen recorder. The data stored by using the SAMPLING CLOCK A control is fed to the A connector, and the data stored by using the SAMPLING CLOCK B is fed to the B connector. These connectors are only effective in PEN mode.

NOTE:
It is impossible to set a PEN SPEED value and ON/OFF state for either jack independently of the other.

(47) READ GATE OUT Jack
The positive pulse corresponding to the one word of the last address in the memory is fed to this connector. The output signal from this connector can be used as a trigger signal when reading via the EXT CLOCK connector.

(48) READ GATE OUT FOR PEN Jack
This connector is used to control a pen recorder or other device. This connector is effective in PEN mode. With the PEN START button pressed, the signal is fed at low level (TTL level).

(49) EXT CLOCK Jack
External clock input connector for read only. This connector is used with the SAMPLING CLOCK A switch set to EXT.

(50) GP-IB Connector
When connecting this instrument to the GP-IB interface the piggyback cable is connected here. Connection or disconnection must be done only after the GP-IB controller is powered off.

(51) **GND Terminal**

The ground terminals for GP-IB connection. When the short bar (metal fitting) is connected between these terminals, the GND line in the GP-IB connector will be grounded to the case.

(52) **ADDRESS Selector**

GP-IB address setting switch, representing address bits 1 through 5 from the right. This switch is used to set the GP-IB address with five binary bits. Each bit becomes "1" when the corresponding switch position is set to the upper side. The three other bit positions on the left must be held on the lower side. If any of these three is on the upper side, memory backup when the power is off cannot be made.

(53) **FAN**

Exhausts air to carry the heat out of the case.

(54) **Cord Wrap**

The power cord is wrapped here when the unit is transported or kept in storage. The cord wraps also serve as the feet.

(55) **Power Connector**

The power cord provided is plugged here.

(56) **Voltage Selector**

Provides a selection of AC line voltages 100/120/220/240 V by insertion of an appropriate plug.

(57) **Fuse Holder**

Accommodates a time-lag fuse of 1 A for 100/120V supply or 0.5 A 220/240V supply.

(58) **Handle (Belt Type)**

Used when transporting the unit.

(59) **Side Legs**

Useful when installing the unit in a narrow spaces or for temporary resting during transport.

OPERATION

Before turning on the scope, set the front panel controls shown below. For a detailed description of controls, see "CONTROLS AND INDICATORS".

When using a probe, refer to its instruction manual, as well as the paragraph "PROBE COMPENSATION" under "APPLICATION".

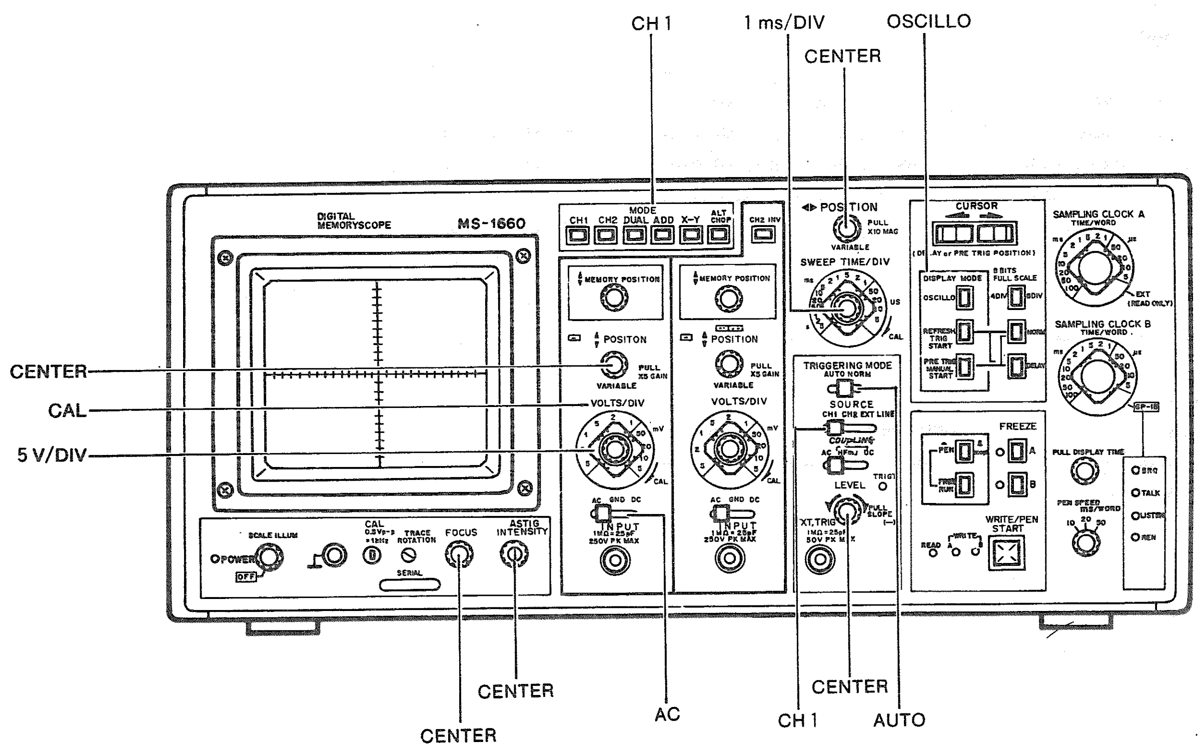


Fig. 6

OPERATION AS AN OSCILLOSCOPE

[1] NORMAL SWEEP DISPLAY OPERATION

1. Turn the POWER switch (1) clockwise – the power supply will be turned on and the pilot lamp will light.

   Set these modes as follows:
   Vertical MODE (20) : CH1
   TRIGGERING MODE (27) : AUTO
   DISPLAY MODE (32) : OSCILLO

2. The trace should appear in the center of the CRT display. If not, center it with POSITION (12). Next, adjust the INTENSITY (7) and, if necessary, the FOCUS (6) for ease of observation.
3. Apply an input signal to channel CH1 INPUT jack (8) and adjust VOLTS/DIV (10) for a suitable size display of the waveform.
   When MODE switch (20) is set to CH2 and an input signal is applied to CH2 INPUT (14) as well, the input signal for CH2 is displayed on the screen through operations similar to CH1.
   When MODE (20) is set to ADD, the screen displays the waveform representing the algebraic sum of CH1 + CH2. If CH2 INV (21) is then pressed, the display changes to the algebraic difference of CH1 – CH2.
   The sensitivity will be the value of VOLTS/DIV setting if both channels are set to the same VOLTS/DIV setting.
   When MODE (20) is set to DUAL or ALT, the sweep alternates between CH1 and CH2.
4. If the waveform to be displayed cannot be triggered or the trigger point is to be shifted, follow the triggering instructions given below.

TRIGGERING

For the waveform of input signal to be observed, it must be held stationary by properly triggering the sweep circuit. Trigger may be internal where the circuit is triggered by the input waveform to be observed, or it may be external where a signal having a certain time-relationship with the input signal is applied to the external trigger terminal.

(1) The selection of a signal that serves as the trigger signal is made using the SOURCE selector. In observation of some waveform, the DC component or high-frequency component such as noise may not be required as the trigger signal. Therefore, the COUPLING control should be adjusted to the specific purposes.

INTERNAL TRIGGERING

By setting SOURCE selector (26) to CH1, CH2, or LINE, the input signal in the triggering circuit is connected to the internal trigger source.

Any input signal can be easily triggered, because the input signal fed to INPUT (8) or (14) is branched in the vertical amplifier to the trigger circuit so that it acts to create trigger signal synchronized with the input signal, thus driving the sweep circuit.

With the SOURCE selector set to CH1 or CH2, a trigger is developped by the CH1 or CH2 signal regardless of the MODE setting. With the SOURCE selector set to LINE, triggering is delivered from the commercial line frequency.

EXTERNAL TRIGGERING

With the SOURCE selector set to EXT, a trigger signal applied to the EXT TRIG jack (22) serves as the external trigger. External triggering should be used when a signal different from the input signal for the vertical axis is used for triggering. In this case, the trigger signal must have a certain time relation with the vertical input signal.

Fig. 7 shows input and output signals observed when a gate signal is fed to EXT TRIG jack (22) as a trigger signal (the sweep circuit is driven with the gate signal) and, at the same time, the burst signal produced by the gate signal is fed to the sample circuit.

As shown in the figure, external triggering produces the proper trigger regardless of the input signal to INPUT jacks (8) and (14). Thus there is no need of triggering adjustment even if the input signal varies.

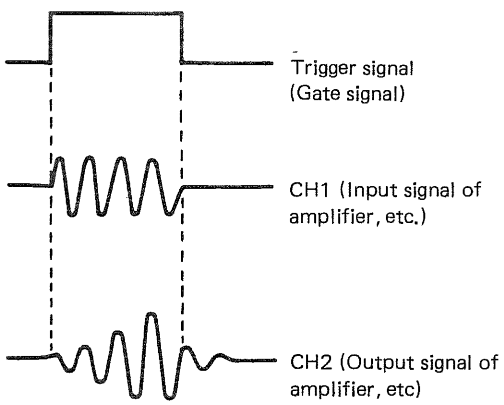


Fig. 7

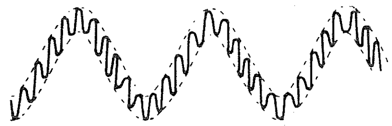
(2) Setting of coupling switch

AC

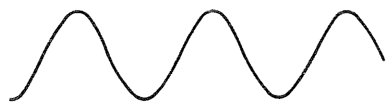
The trigger signal is capacitively coupled, so its DC component is cut, giving a stable trigger which is not affected by the DC component. With this advantage, this position of the coupling switch is conveniently selected for ordinary applications. However, if the trigger signal is lower than 10 Hz, 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 1.5 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.



Waveform with high-frequency noise superimposed



Trigger signal processed in HF_{REJ} mode

Fig. 8

DC

The trigger signal and the trigger circuit are directly coupled to allow triggering from DC components. This mode is usefull for the triggering with a low-frequency waveform below 10 Hz or with a slowly repetitive, sharp edge signal such as lamp waveform.

(3) After the SOURCE has been set, the trigger point can be set by rotating LEVEL/SLOPE control (23).

TRIGGER LEVEL

The trigger point of waveform is set with the LEVEL and SLOPE controls. Fig. 9 shows the relation between LEVEL and SLOPE with respect to trigger point. Set the level of the trigger point as required.

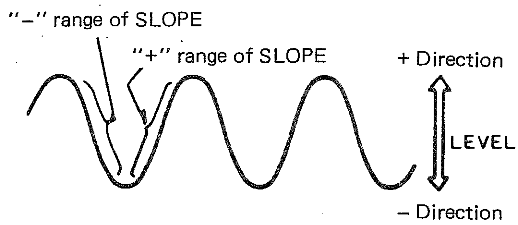


Fig. 9

AUTO TRIGGER

With the TRIGGERING MODE selector (27) set to AUTO, the sweep circuit is set in the free run mode while the trigger signal is not present. So, auto triggering is useful for GND level confirmation.

When trigger signal is fed, the trigger point can be set by using the LEVEL and SLOPE controls as in the case of normal triggering. When the trigger point exceeds the trigger range, the unit enters the free run mode and the waveform will flow.

Normally (with TRIGGERING MODE set to NORM), when no trigger signal is present or the trigger range is exceeded, the sweep is deactivated and no trace is generated.

5. Adjust the SWEEP TIME/DIV control (28) to give a suitable display.
   Adjust the VARIABLE control (29) as required. By doing this, normal sweep display is produced.

[2] MAGNIFIED SWEEP OPERATION

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

Procedure:

Using the ◂▸ POSITION control (30), adjust the desired portion of waveform to the center of the CRT. Then this control can be pulled out 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

Phase difference measurements may be made by use of the X-Y display mode.

Procedure:

Set the MODE switch (20) to X-Y. In this mode the channel 1 or Y input becomes the Y-axis input, and the channel 2 or X input the X-axis input for X-Y display.

The vertical position is adjusted with ▴▾ POSITION (12) of CH1, and the horizontal position is with ▴▾ POSITION (18) of CH2.

X and Y sensitivity are set by using the channel 2 and channel 1 VARIABLE and VOLTS/DIV controls respectively.

MEMORY SCOPE OPERATION

[1] WAVEFORM OBSERVATION

Set each control to display the waveform as in the case of an ordinary oscilloscope.

(1) Set each control as follows:

MEMORY POSITION	: Center
PULL DISPLAY TIME	: OFF
FREEZE	: OFF
PEN/SCOPE	: SCOPE

(2) Set SAMPLING CLOCK so that it corresponds to the input frequency. (If the SAMPLE CLOCK setting is lower than the input frequency, an aliasing error occurs).

(3) Set DISPLAY MODE to REFRESH or PRE TRIG.

REFRESH mode:

When a signal is fed to the INPUT connector on this unit and exceeds the trigger level setting, the WRITE LED lamps A, B will light up to indicate that the write operation is being performed.

These LED lamps relate to SAMPLING CLOCK A and B; their lighting time varies with the setting range (the time consumed for writing one word into memory) of the SAMPLING CLOCKs.

When SAMPLING CLOCK is set to a CLOCK position which is slower than 0.1ms/word while the WRITE LED lights and the write operation is performed, the write and read operations are simultaneously performed. On the screen, the input signals appear sequentially from the left.

When SAMPLING CLOCK is set to a CLOCK position faster than 0.1 ms/word, the signals disappear just for moment (less than approx. 100 ms) during write operation, but the waveform is displayed in an almost stable condition because the write operation will be instantly completed and the read operation will be immediately started.

If the input signal is a continuous waveform with shorter period (sine wave, triangular wave, rectangular wave, etc.), the write operation is restarted by the next trigger pulse immediately after the write operation is completed. Therefore, if the SAMPLING CLOCK is set to a CLOCK position faster than 0.1 ms/word, the write and read operations are cyclically performed, with the result that the trace during the write operation may appear on the screen, producing flicker. If to observe the waveform in such a condition, perform the following adjustment:

By pulling the PULL DISPLAY TIME control and turning it clockwise, the restart time can be changed by controlling the successive trigger pulses. Fully clockwise rotation of the control disables the next write operation for about 20 seconds, maintaining the read state (the adjustment is variable between approx. 1 to 20 seconds.)

PRE TRIG mode

This mode provides the PRE TRIG (– DELAY) operation which is preculiar to the digital memory scope.

In this mode, write operation is usually started manually (by pressing the WRITE START button).

Write operation can also be started repeatedly at regular time intervals by using the PULL DISPLAY TIME control.

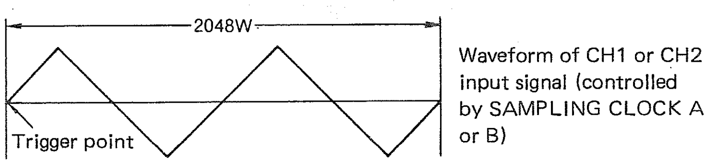
If the signal applied to the unit is not a continuous wave but is sporadic, the trace develops a flickering bright spot on its left end. The position of the bright spot is the guide point that represents the trigger point after write (i.e., the address position on the screen). The bright spot is moved to the right or left by pressing the CURSOR switch.

When the waveform prior to the trigger point is to be displayed on the left hald of the screen, press the CURSOR switch until the bright spot is positioned to the center of the screen. After this positioning, the push of the WRITE START button (manual start in this case) causes lighting of the LED of WRITE A or B (depending on MODE switch setting), which indicates the writing operating is being performed. The lighting of the LED is independent of the input signal. If the input signal comes to exceed the TRIG LEVEL setting, as indicated by lighting of the TRIG'D lamp, the writing operation is terminated after writing of the following input waveform, and the WRITE A, B LEDs go off. Upon this termination of writing, the trigger point for the waveform just stored moves to the bright spot positioned with the CURSOR switch. The unit is then held in read state, with a still waveform on the screen. The result is that the waveform before the trigger point is displayed to the left of the bright spot on the screen, and the waveform after the trigger point is to the right of the bright spot.

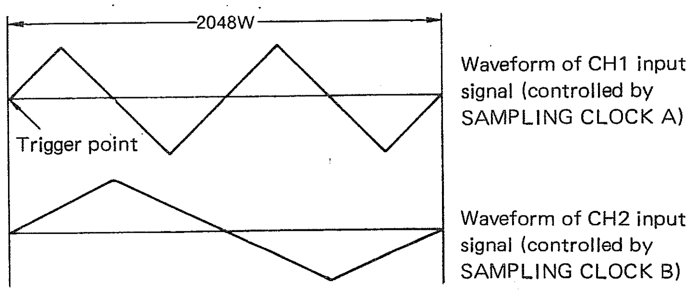
Given below are examples of output waveform obtained in various modes.

(1) DISPLAY MODE: REFRESH–NORM

1 MODE: CH1 or CH2

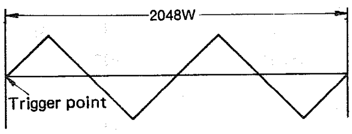


(2) MODE: DUAL



CH1 and CH2 input signals are same, but SAMPLING CLOCK A is set to twice the SAMPLING CLOCK B setting.

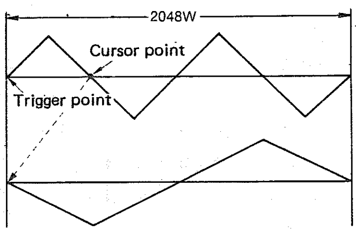
3 MODE: ADD



Synthesized waveform of CH1 and CH2 input signals (controlled by SAMPLING CLOCK B)

(2) DISPLAY MODE: REFRESH-DELAY

1 MODE: CH1 or CH2



Waveform of CH1 or CH2 input signal (controlled by SAMPLING CLOCK A or B)

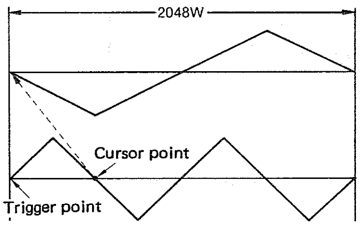
Waveform of CH1 or CH2 input signal (controlled by SAMPLING CLOCK B or A)

SAMPLING CLOCK A (or B) is set to twice the SAMPLING CLOCK B (or A) setting.

2 MODE: DUAL

Same operation as in DUAL mode of REFRESH-NORM mode.

3 MODE: ADD



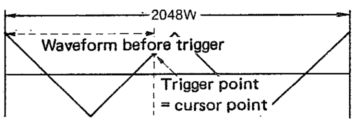
Synthesized waveform CH1 and CH2 input signals (controlled by SAMPLING CLOCK A)

Synthesized wave of CH1 and CH2 input signals (controlled by SAMPLING CLOCK B)

SAMPLING CLOCK B is set twice the SAMPLING CLOCK A setting.

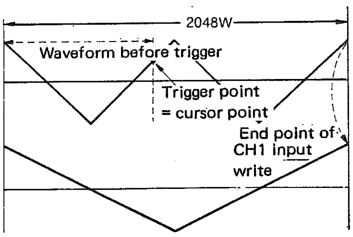
(3) DISPLAY MODE: PRE TRIG-NORM

1 MODE: CH1 or CH2



Waveform of CH1 or CH2 input signal (controlled by SAMPLING CLOCK A or B)

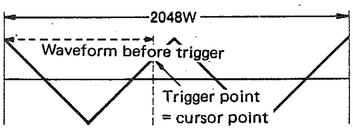
2 MODE: DUAL



Waveform of CH1 input signal (controlled by SAMPLING CLOCK A)

Waveform of CH2 input signal (controlled by SAMPLING CLOCK B)

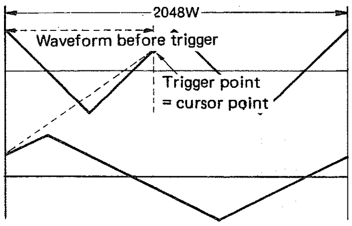
CH1 and CH2 input signals are same, but SAMPLING CLOCK A is set to twice the SAMPLING CLOCK B setting.



Synthesized waveform of CH1 and CH2 input signals (controlled by SAMPLING CLOCK B)

(4) DISPLAY MODE: PRE TRIG-DELAY

1 MODE: CH1 or CH2

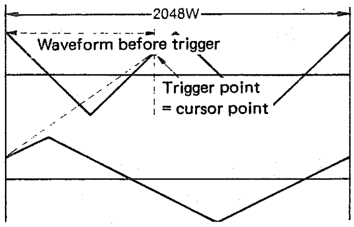


Waveform of CH1 or CH2 input signa (controlled by SAMPLING CLOCK A or B)

Waveform of CH1 or CH2 input signal (controlled by SAMPLING CLOCK B or A)

SAMPLING CLOCK A (or B) is set to twice the SAMPLING CLOCK B (or A) setting.

2 MODE: DUAL

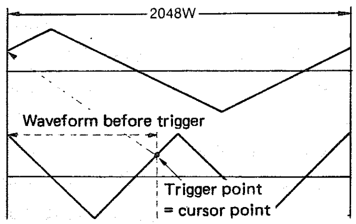


Waveform of CH1 input signal (controlled by SAMPLING CLOCK A)

Waveform of CH2 input signal (controlled by SAMPLING CLOCK B)

CH1 and CH2 input signals are same, but SAMPLING CLOCK A is set to twice the SAMPLING CLOCK B setting.

3 MODE: ADD



Synthesized waveform of CH1 and CH2 input signals (controlled by SAMPLING CLOCK A)

Synthesized waveform of CH1 and CH2 input signals (controlled by SAMPLING CLOCK B)

SAMPLING CLOCK B is set to twice the SAMPLING CLOCK A setting.

Fig. 10

[2] READING TO PEN RECORDER

When recording the output waveform on a pen recorder, follow the procedure below.

1 Set PEN/SCOPE (35) to the SCOPE mode, and write the input signal to be recorded into the unit.
2 Being sure that the WRITE LED (38) has gone off, change PEN/SCOPE (35) to the PEN mode.
3 Connect the jack A or B under "FOR PEN" (46) to the input jack on the pen recorder.
4 Adjust PEN SPEED (40) to the pen speed of the pen recorder.
5 Press WRITE/PEN START (37). Then, in about two seconds, the waveform stored in the MS-1660 is outputted. After output of 2048 words, the reading completes. Pressing WRITE/PEN START (37) once again causes restart of reading.
In the free run mode, the unit enters the trigger wait state after reading to FOR PEN (46). Upon receipt of a trigger signal, the unit starts writing and, after completion of the writing, restarts reading to FOR PEN.

NOTE-1. When performing the FREE RUN operation, press the FREE RUN (35) instead of WRITE/PEN START (37) button in step 5 above.

NOTE-2. 0V adjustment of pen-recorder:
After setting the INPUT selector to GND, adjust the ⬍ POSITION control so that the MEMORY OUT will be 0V. Then, set the PEN/SCOPE to PEN mode, and press the PEN START to feed 0V from the FOR PEN jack. Now, adjust the DC OFFSET on the pen recorder so that this voltage will be the 0 volt of the pen-recorder.

[3] CONTROL BY GP-IB

The MS-1660 has GP-IB communication capabilities to send out data from the memory or receive data from outside into the memory for display on the monitor. The interface with GP-IB conforms with IEEE Std. 488—1978.

1. Connector

1 Connector
Use the 24-pin cable designed specifically for connection to the GP-IB connector. The illustration below shows the pin numbers and signals, as viewed from the rear panel.

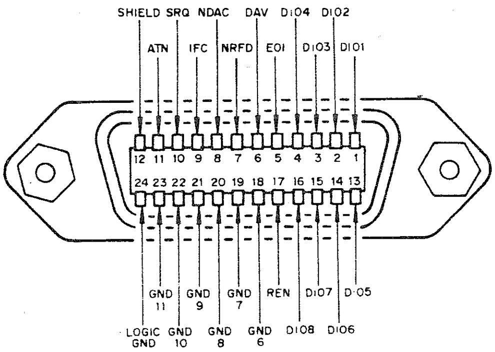


Fig. 11

2 Connector pin configuration

Signal Pin No.	Signal Name	Signal Pin No.	Signal Name
1	DIO 1	13	DIO 5
2	DIO 2	14	DIO 6
3	DIO 3	15	DIO 7
4	DIO 4	16	DIO 8
5	EOI	17	REN
6	DAV	18	GND
7	NRFD	19	GND
8	NDAC	20	GND
9	IFC	21	GND
10	SRQ	22	GND
11	ATN	23	GND
12	SHIELD	24	GND

3 Input/output signals

a) DIO 1–8
Data input/output lines. Also used for input/output of address information and command information; the two kinds of information are identified by the ATN line.

b) DAV (Data valid)
Signifies that the signal sent from the talker or controller to DIO is effective.

c) NRFD (Not ready for data)
Signifies that the listener is ready to receive the DIO line signals.

d) NDAC (Not data accepted)
Signifies that the listener has already received data.

e) ATN (Attention)
A signal from the controller. Indicates whether the signals on DIO lines are data, address information, or command information.

f) REN (Remote enable)
A signal from the controller, for switching each device into remote or local control mode.

g) IFC (Interface clear)
A signal from the controller, for clearing the GP-IB interface of each device.

h) SRQ (Service request)
A call from the talker or listener to the controller.

i) EOI (End or identify)
A data completion signal from the talker.

4 Interface circuit
The electrical specifications of input/output signals are shown below.

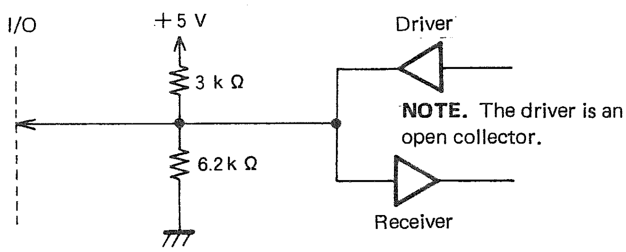


Fig. 12

2. Device commands

R1: Sends 2K bytes of data (binary) from memory A to the controller in 2-digit hexadecimal ASCII representation.

R2: Sends 2K bytes of data (binary) from memory B to the controller in 2-digit hexadecimal ASCII representation.

W1: Transfers 2K bytes of data (bindary) from the controller to memory A in 2-digit hexadecimal ASCII representation.

W2: Transfers 2K bytes of data (binary) from the controller to memory B in 2-digit hexadecimal ASCII representation.

NOTE:

The commands must be given in uppercase characters. Lowercase characters are assumed to be different characters.

3. Delimiters

1 During talk
Sends CR LF+EOI.

2 During listen
Receives CR LF or CR LF+EOI

4. Data format

All data is coded in ASCII representation, using two bytes of ASCII notation to express one byte of binary data, except for status bytes. This requires a 4K-byte area for the controller to fetch the ASCII code data as they are. The controller must therefore provide a 4K-byte area. (An example of such a controller is the HP-9826).

[EXAMPLE]

Send/receive data contents: 000102 .... FF
Transfer data contents: 303030313032 4646

5. SRQ status byte (hexadecimal notation)

1 40: Command line overflow
The message "LINE OVER" is sent.

2 41: Non-existing command sent
The message "NO COMMAND" is sent.

3 44: Number sent not in hexadecimal
The message "NUMBER ERROR" is sent.

4 48: Transfer data to controller upon receipt of R1 or R2.

6. Remote operation

To set the MS-1660 into remote operation, follow these steps:

1 Check to be sure that the WRITE LEDs are off and the READ LED is on.
2 Set MODE ⑳ to a position other than X-Y.
3 Set SAMPLING CLOCK B ㉛ to GP-IB.

NOTE:

The local mode is restored simply by turning SAMPLING CLOCK B ㉛ off the GP-IB position, unless the MS-1660 is in local lockout state.

7. Address switch

ADDRESS switch (52) (on rear panel) has eight bit positions but only uses the low-order five bit positions for address setting. The high-order three bits must always be held on the lower side. Each bit position is "1" when set to the upper side.

8. Programming

ASCII characters are used for all commands and data. For example, the procedure for sending the contents of memory A to the controller is as follows:

1 In the controller, a 2K-byte area is reserved. (A 1-byte data requires 2 bytes because the ASCII notation is used.)
2 IFC is sent to the MS-1660.
3 DCL is sent to the controller.
4 MLA is sent to the MS-1660.
5 The "R1" command is sent to the controller.
6 The controller checks receipt of SRQ and confirms that the SRQ has a status byte of 48 (hex). After sending MTA to the MS-1660, the controller is then designated as the listener to accept the data in the area reserved in step 1.

When the controller sends data to the MS-1660. steps 1 through 4 area the same as above. If the data is to be written into memory A, however, the following steps are taken:

5 The "W1" command is sent from the controller to the MS-1660.
6 2K bytes of data are transferred from the controller using the ASCII notation.

When writing data into memory B, steps 5 and 6 are the same as above, except for the commands: "R2" instead of "R1", and "W2" instead of "W1".

Note that all data are in ASCII notation.

APPLICATION

APPLICATIONS AS OSCILLOSCOPE

PROBE COMPENSATION

For accurate measurement, the probe should be compensated before starting measurement, as follows:

1) Connect the probe to the INPUT jack and adjust each control for normal display of sweep. VOLTS/DIV should be set to 10mV/div and the probe switch to 10X.
2) Connect the probe to the CAL jack on the front panel. Adjust SWEEP TIME/DIV so that a few cycles of the signal from CAL are displayed.
3) Adjust the probe trimmer to obtain optimum compensation for the waveform on the screen.

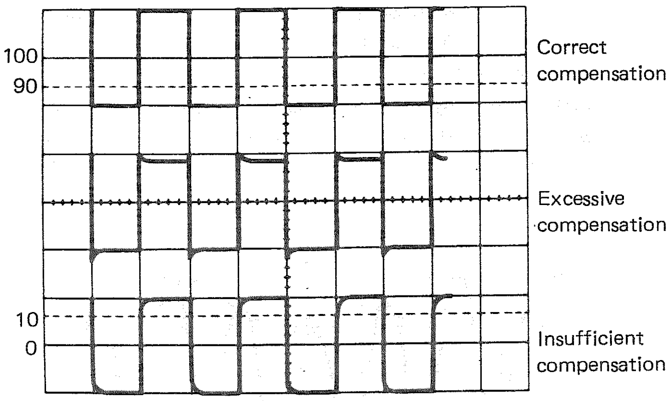


Fig. 13

TRACE ROTATION COMPENSATION

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

Adjust controls for a normal display. Set the AC-GND-DC switch to GND and TRIG MODE switch to AUTO.

Adjust the ▲▼ POSITION control such that the trace is over the center horizontal graduation line. If the trace appears to be rotated from horizontal, align it with the center graduation 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 and select the vertical MODE to the channel to be used. Set controls to obtain a normal display of the waveform to be measured. Set the VARIABLE control to the CAL.
2. Select the TRIGGERING MODE switch to AUTO and AC-GND-DC switch to GND, which establishes a trace at the zero volt reference. Using the ▲▼ POSITION control, adjust the trace position to the desired reference level position. Do not to disturb this setting once made.
3. Set the AC-GND-DC switch to DC to observe the waveform including its dc component. If an inappropriate reference level position or an inappropriate VOLTS/DIV setting was made, the waveform may not be visible on the CRT. If so, set VOLTS/DIV and / or the ▲▼ POSITION control once again.
4. Use the ◀▶ POSITION control to bring the point of the waveform to be measured to the center vertical graduation line of the graticule scale.
5. Measure the vertical distance from the reference level to the point to be measured. (The reference level can be rechecked by momentarily returning the AC-GND-DC switch again to GND).

   Multiply the distance measured above by the VOLTS/DIV setting to gain the voltage to be determined. When the probe is used, also multiply the probe's attenuation ratio.

   Voltages above and below the reference level are positive and negative voltages, respectively.

Dc level=(Vertical distance in divisions) x (VOLTS/DIV setting) x (probe attenuation ratio)

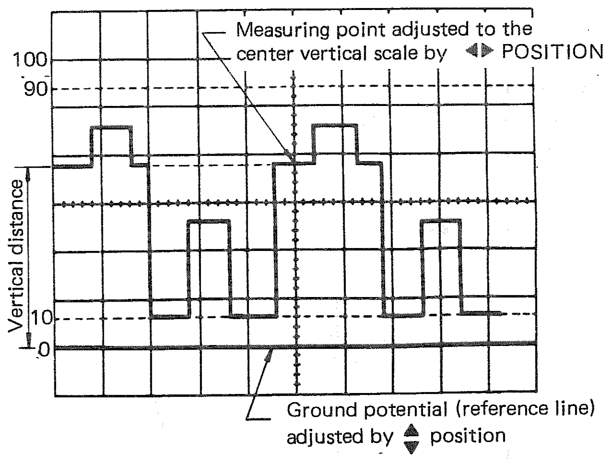


Fig. 14

[EXAMPLE]

For the example shown in Fig. 14 ,the point being measured is 3.8 divisions from the reference level (ground potential). If VOLTS/DIV is 0.2V and a 10 : 1 probe is used, then the voltage to be determined is:

Dc level=3.8 (div) x 0.2 (V) x 10 = 7.6V

MEASUREMENT OF VOLTAGE BETWEEN TWO POINTS ON A WAVEFORM

This procedure may be used to measure the peak-to peak voltages, or the voltage difference between any two points, on a waveform.

Procedure:

1. Apply the signal to be measured to the INPUT jack, select the vertical MODE to the channel to be used and set the AC-GND-DC switch to AC, to provide for normal sweep. Adjust VOLTS/DIV and SWEEP TIME/DIV controls for a normal display. Set the VARIABLE control to CAL.
2. Using the ▲▼ POSITION control, align one of the points to be measured with a horizontal graticule line and bring the second point into the screen area.
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 the number of divisions by the setting of the VOLTS/DIV control.
   If a probe is used, further multiply this by the probe attenuation ratio.

Voltage between two points
= Vertical distance (div) x (VOLTS/DIV setting)
x (probe attenuation ratio)

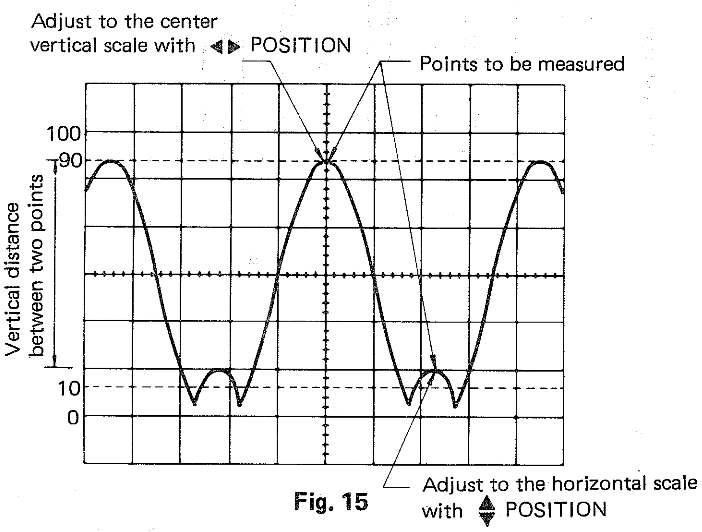


Fig. 15

[EXAMPLE]

For the example shown in Fig. 15, the two points are separated by 4.4 divisions vertically. Let the VOLTS/DIV setting be 0.2V/div and the probe attenuation be 10 : 1.

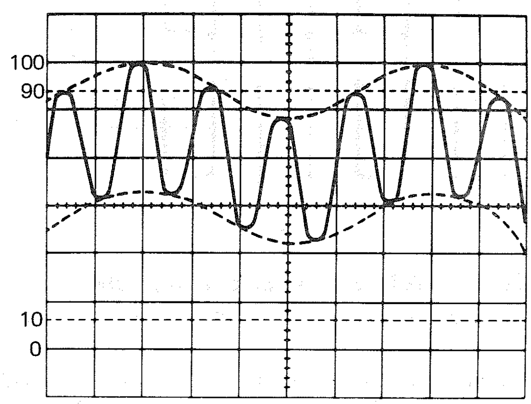
Voltage between two points = 4.4 (div) x 0.2 (V) x 10
= 8.8V

ELIMINATION OF UNDESIRED SIGNAL COMPONENTS

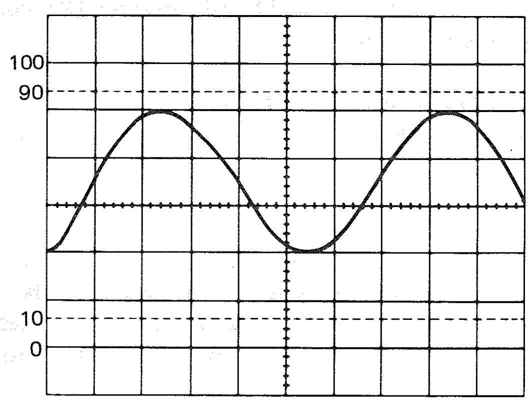
The ADD feature can be conveniently used to cancel out the effect of an undesired signal component.

Procedure:

1. Apply the signal containing an undesired component to the channel 1 INPUT jack and the undesired signal iteslf alone to the channel 2 INPUT jack.
2. Select the vertical MODE switch to DUAL (CHOP) and SOURCE switch to CH2. Confirm that channel 2 represents the envelope of the unwanted signal in reverse polarity. If necessary, reverse the polarity by setting CH2 to INV.
3. Select the vertical MODE switch to ADD and adjust the channel 2 VOLTS/DIV and VARIABLE controls 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.

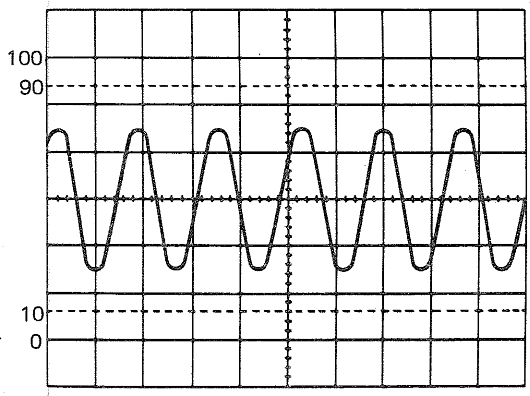


Signal containing undesired component
(Broken lines: undesired component envelope)



Undesired component signal

Fig. 16



Signal without undesired component

Fig. 16

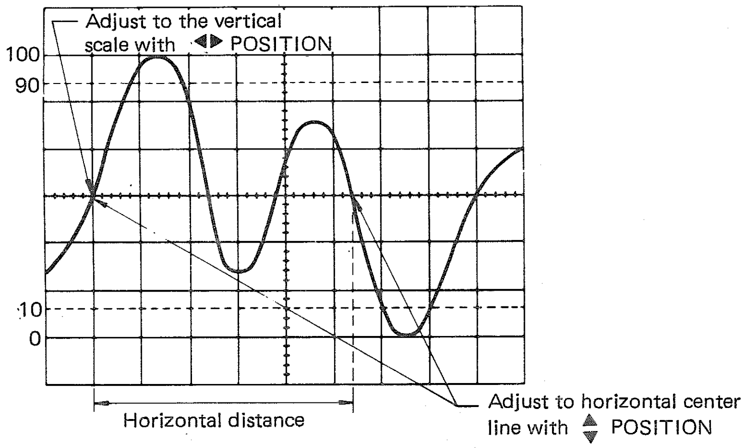


Fig. 17

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 and select the vertical MODE switch to the channel to be used. Adjust each control for a normal display. Adjust VOLTS/DIV and SWEEP TIME/DIV controls so that the waveform can be easily measured.
   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. If horizontal "x 10 MAG" is used, multiply this further by 1/10.

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

[EXAMPLE]

For the example shown in Fig. 17, the horizontal distance between the two points is 5.4 divisions.
If the SWEEP TIME/DIV is 0.2 ms/div, then
Time = 5.4 (div) x 0.2 (ms) = 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. Measure the time of one period by the procedure under the preceding paragraph "TIME MEASUREMENT".
2. The frequency is the reciprocal of the period measured.

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

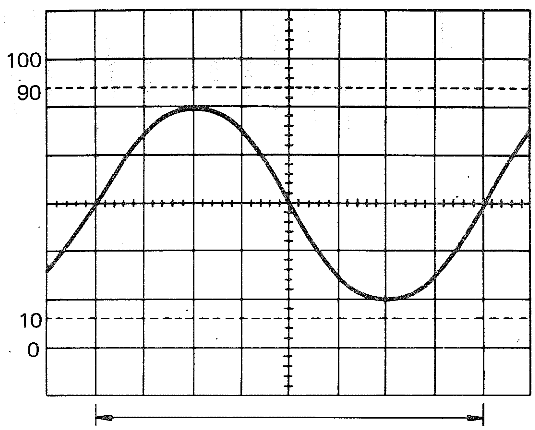


Fig. 18

[EXAMPLE]

For the example shown in Fig. 18, suppose that a period of 40 μs was observed and measured. Then the frequency is:

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

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

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. Set the VARIABLE control 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 setting, the time span for the cycles can be calculated. Multiply the reciprocal of this value by the number of cycles present in the given time span. If "x 10 MAG" is used, multiply this further by 10.
   Note that errors will occur for a display having only a few cycles.

$$Freq = \frac{\text{No. of cycles} \times \text{"x 10 MAG" value (10)}}{\text{Horizontal distance (div)} \times \text{SWEEP TIME/DIV setting}}$$

[EXAMPLE]

For the example shown in Fig.19, there are 10 cycles within 7 divisions.

Suppose that the SWEEP TIME/DIV setting is 5 μs.

$$Freq = \frac{10}{7 \times 5\,(\mu s)} \doteqdot 285.7\,kHz$$

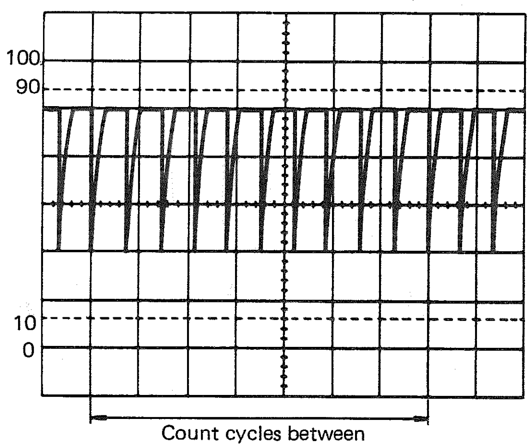


Fig. 19

PULSE WIDTH MEASUREMENTS

Pulse width can be measured as follows:

Procedure:

1. Apply the pulse signal to INPUT jack and select the vertical MODE switch to the channel to be used.
2. Use VOLTS/DIV, VARIABLE and ▲▼ POSITION controls to adjust the waveform such that the pulse is easily observed and such that the center horizontal graticule on the screen is at the middle of the pulse amplitude.
3. Measure the distance between the horizontal distance between the two points on the pulse waveform which cross the center horizontal line. Be sure that the VARIABLE control is in the CAL position. Multiply this distance by the SWEEP TIME/DIV control. Multiply further by 1/10 if "x 10 MAG" is used.

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

[EXAMPLE]

For the example shown in Fig. 20, the distance (width) of the center horizontal line segment crossing the pulse waveform is 4.6 divisions. Suppose the SWEEP TIME/DIV setting is 0.2 ms.

Pulse width = 4.6 (div) x 0.2 ms = 0.92 ms

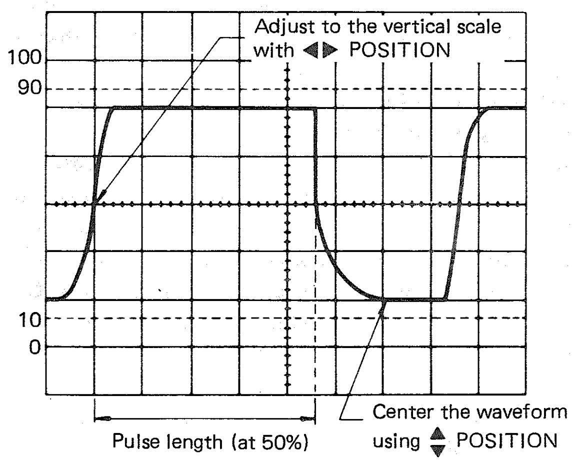


Fig. 20

PULSE RISETIME AND FALLTIME MEASUREMENTS

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 INPUT jack and select the vertical MODE switch to the channel to be used.

Use the VOLTS/DIV and VARIABLE controls to adjust the waveform peak-to-peak height to six divisions.

2. Set each control for a normal display, and adjust the ♦ POSITION control such that the waveform is centered vertically in the display. Set the SWEEP TIME/DIV control to the maximum speed to the extent the 10% and 90% points are observable. Set the VARIABLE control to CAL.
3. Use the ◀▶ POSITION control to adjust the 10% point to coincide with a vertical graduation line, and measure the horizontal distance in divisions between the 10% and 90% points on the waveform. Multiply this by the SWEEP TIME/DIV setting, and also by 1/10 if "x10 MAG" is used.

NOTE:
The CRT screen has graduation lines representing 0, 10, 90 and 100%, where 6 div = 100%. These lines should be used for this measurement.

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

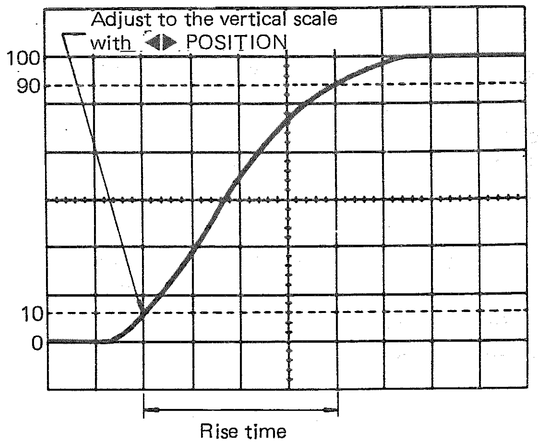


Fig. 21

[EXAMPLE]
For the example shown in Fig. 21, the horizontal distance is 4.0 divisions.
Suppose the SWEEP TIME/DIV setting is 2 μs.

Risetime = 4.0 (div) x 2 (μs) = 8 μs

Risetime and falltime can also be measured by changing step 3 above as follows:

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 that crosses the center horizontal line. Let this distance be D_1. Next adjust the waveform position such that the 90% point coinsides with the vertical centerline, and measure the horizontal distance from that line to the point that crosses horizontal centerline. Let this distance be D_2.

The total horizontal distance is then D_1 plus D_2. Multiply the total distance by the SWEEP TIME/DIV setting and the reciprocal of "x 10 MAG" setting.

Risetime = (D_1 + D_2) (div) x (SWEEP TIME/DIV setting) x "x 10 MAG" value^{-1} (1/10)

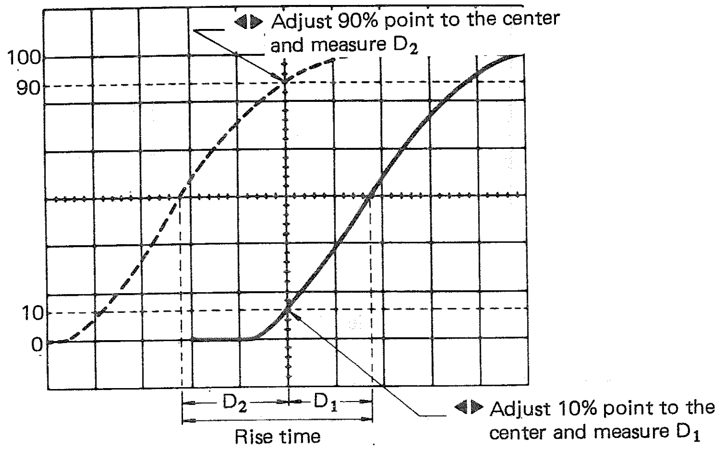


Fig. 22

[EXAMPLE]
For the example shown in Fig. 22, the measured D_1 is 1.8 divisions while D_2 is 2.2 divisions. If SWEEP TIME/DIV setting is 2 μs, then

Risetime = (1.8 + 2.2) (div) x 2 (μs) = 8 μs

TIME DIFFERENCE MEASUREMENTS

This procedure is useful in measurement of the time differences between two signals that are synchronized to each other.

Procedure:

1. Apply the two signals to channel 1 and channel 2 INPUT jacks, and select the vertical MODE switch to DUAL by choosing either ALT or CHOP mode.
   Generally, CHOP is chosen for low frequency signals with ALT used for high frequency signals.
2. Set each control for a normal display. Select the faster of the two signals as the SOURCE, and use the VOLTS/DIV and SWEEP TIME/DIV controls to obtain an easily observable display.
   Set the VARIABLE control to CAL.
3. Using each ♦ POSITION control, set the waveforms to the center of the CRT display. Then 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 "x 10 MAG" is used, multiply this further by 1/10.

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

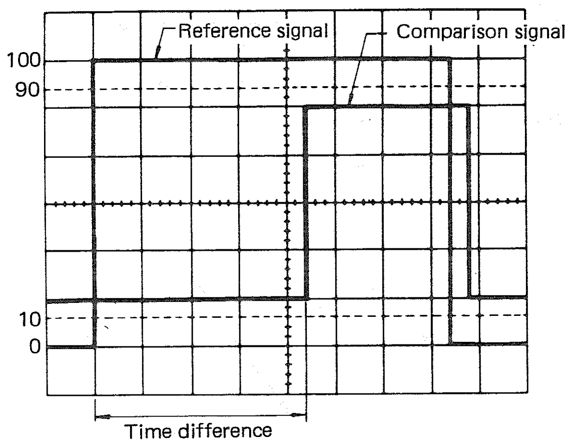


Fig. 23

[EXAMPLE]
For the example shown in Fig. 23, the horizontal distance measured is 4.4 divisions. If the SWEEP TIME/DIV setting is 0.2 ms, then

Time = 4.4 (div) x 0.2 (ms) = 0.88 ms

PHASE DIFFERENCE MEASUREMENTS

This procedure is useful in measuring the phase difference of signals (sinusoidal, for example) of the same frequency.

1. Apply the two signals to channel 1 and channel 2 INPUT jacks. Select the vertical MODE switch to DUAL, and choose either CHOP or ALT mode.
2. Set each control for a normal display. Set the SOURCE switch to the signal which is leading in phase, and use VOLTS/DIV control to adjust the signals such that they are equal in amplitude.
3. Use the SWEEP TIME/DIV and VARIABLE controls to adjust the display such that one cycle of the signals occupies 8 divisions of horizontal display.
   Use each ▲▼ POSITION control to bring the signals to the center of the screen. Having set up the display as above, one division now represents 45° (360°/8 div). So, the sweep coefficient is given as a multiple of the angle 45°/div.
4. Measure the horizontal distance between the corresponding points on the two waveforms, and multiply the sweep coefficient (45°/div).

Phase difference (deg) = Horizontal distance (div) x 45°/div

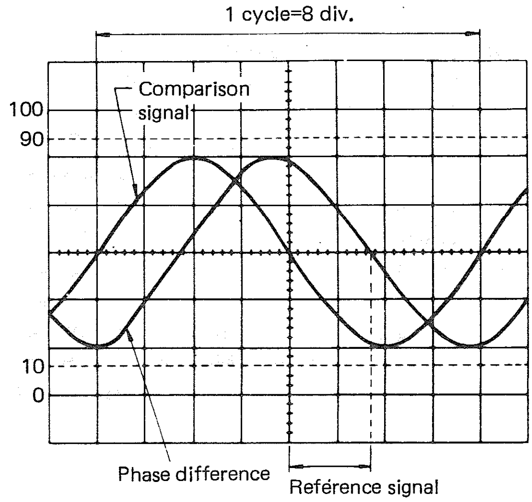


Fig. 24

[EXAMPLE]
For the example shown in Fig. 24, the horizontal distance is 1.7 div, which gives

Phase difference = 1.7 (div) x 45°/div = 76.5°

The above setup allows 45° per division, but if more accuracy is required, the SWEEP TIME/DIV setting may be changed to magnify the waveform without touching the VARIABLE control. If necessary, the TRIGGER LEVEL control can be readjusted.

With this method, the phase difference can be determined from the relationship between the SWEEP TIME/DIV setting for 8 div per cycle and the new SWEEP TIME/DIV setting made for better accuracy.

$$\text{Phase difference} = \text{horizontal distance of new sweep range (div)} \times 45°/\text{div} \times \frac{\text{New SWEEP TIME/DIV setting}}{\text{Original SWEEP TIME/DIV setting}}$$

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

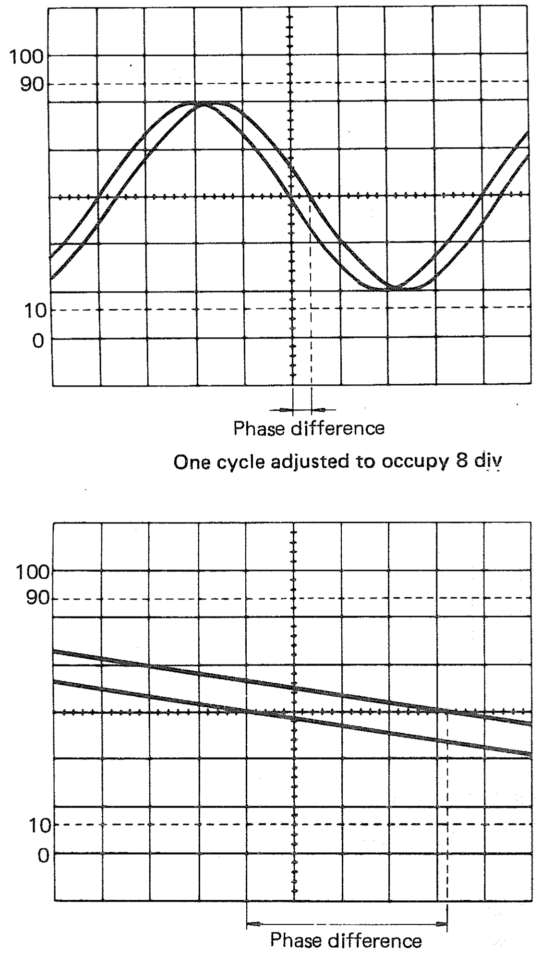


Fig. 25

RELATIVE MEASUREMENTS

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

⋆ Vertical Sensitivity

Setting the relative vertical sensitivity using a reference signal:

1. Apply the reference signal to INPUT jack, and adjust the display for a normal waveform display.
   Adjust the VOLTS/DIV and VARIABLE controls so that the signal amplitude coincides with a few divisions of graticule. After adjusting, do not to disturb the setting of the VARIABLE control.
2. Divide the voltage amplitude of the reference signal by the product of the vertical amplitude and VOLTS/DIV settings given in step 1 above.
   Vertical coefficient
   $$= \frac{\text{Voltage of reference signal (V)}}{\text{Vertical amplitude (div) x VOLTS/DIV setting}}$$
3. Remove the reference signal and apply the unknown signal to INPUT jack. Set the VOLTS/DIV control to for eacy observation. Measure the amplitude of the displayed waveform, and use the following relationship to calculate the voltage of the unknown waveform.

   Amplitude of unknown signal (V)
   = Vertical distance (div) x Vertical coefficient
   x VOLTS/DIV setting

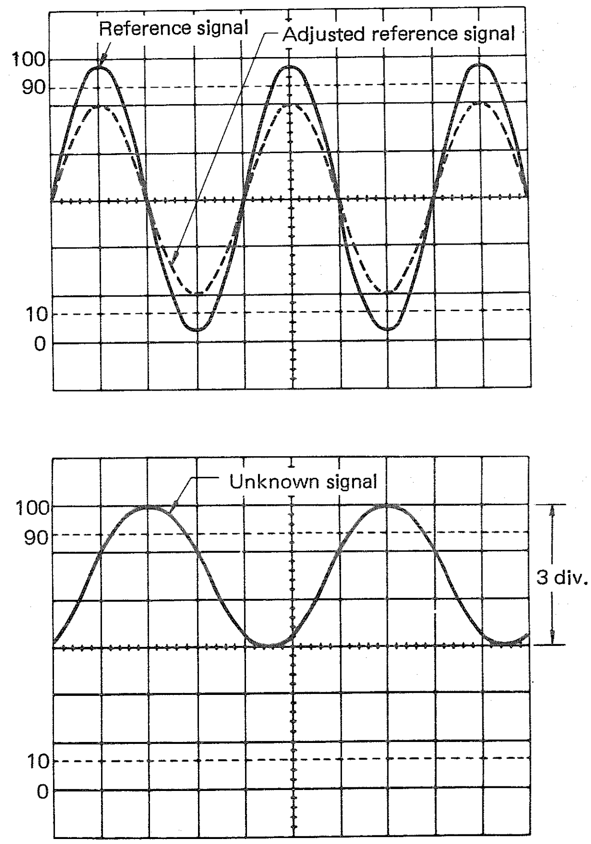


Fig. 26

[EXAMPLE]

For the example shown in Fig. 26, the VOLTS/DIV setting is 1V. The reference signal is 2 Vrms. Using the VARIABLE control, adjust so that the amplitude of the reference signal is 4 div. Then we have

$$\text{Vertical coefficient} = \frac{2\ \text{Vrms}}{4\ \text{(div)} \times 1\ \text{(V)}} = 0.5$$

Then, measure the unknown signal. Suppose that VOLTS/DIV setting is 5V and vertical amplitude is 3 div, then we have

Effective value of the unknown signal = 3 (div)x0.5x5(V)
= 7.5 Vrms

★ Period

Setting the relative sweep coefficient with respect to a reference frequency signal:

1. Apply the reference signal to INPUT jack and set each control for a normal display. Adjust the VOLTS/DIV and VARIABLE controls to obtain an easily observed waveform display. Adjust the SWEEP TIME/DIV and VARIABLE controls so that one cycle of the reference signal occupies exactly a few scale divisions. After this, do not to disturb the setting of the VARIABLE control.
2. Divide the period of the reference signal by the product of the horizontal distance (in divisions) and SWEEP TIME/DIV given in step 1 above.

   Sweep coefficient

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

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

Period of the unknown signal = Horizontal distance of 1 cycle (div) x Horizontal sweep coefficient x SWEEP TIME/DIV setting

[EXAMPLE]
For the example shown in Fig. 27, SWEEP TIME/DIV setting is 0.1 ms and a reference signal of 1.75 kHz is applied. Adjust the variable control so that the distance of one cycle is 5 divisions.

$$\text{Horizontal coefficient} = \frac{\frac{1}{1.75\ (\text{kHz})}}{5 \times 0.1\ (\text{ms})} = 1.142$$

The unknown signal was then measured. If the SWEEP TIME/DIV setting was 0.2 ms and the distance is 7 div, then

Pulse width = 7 (div) x 1.142 x 0.2 (ms) ≑ 1.6 ms

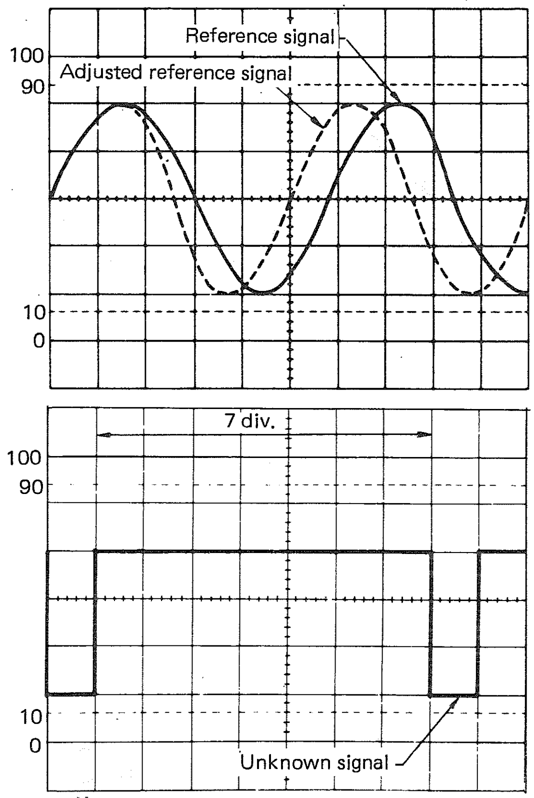


Fig. 27

X-Y OPERATION

PHASE MEASUREMENT

Phase measurements may be made with X-Y operation. Typical applications include the circuits designed to produce a certain phase shift, and the measurement of phase shift distortion in audio amplifiers.
Distortion of amplitude can be measured at the same time.
To make phase measurements, use the following procedure:

1. Apply a sine wave of small distortion to the audio circuit to be tested.
2. Set the signal generator output to the normal operating level of the circuit under test. Observe the circuit's output on the screen. If the test circuit is overdriven, the sine wave display is clipped and the signal level must be lowered.
3. Connect the CH1 probe to the output of the test circuit.
4. Set the MODE selector to X-Y.
5. Connect the probe to the input of the circuit under test.
6. Adjust the channel 1 and 2 gains for a suitable size of the Lissajous' pattern.
7. Some typical results are shown in Fig. 29. If the two signals are in phase, the Lissajous' pattern 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 circuliar Lissajours' pattern.
   Phase shift of more than 90° produces an elliptical Lissajours' pattern. The amount of phase shift is calculated from the measurement, using the following formula:

   Formula for phaze difference calculation:

$\text{Sine } \phi = \frac{B}{A}$ where ϕ = phase angle

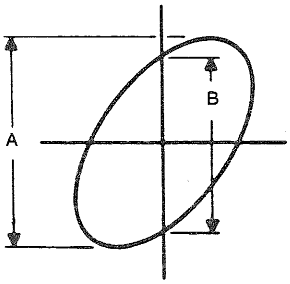


Fig. 28

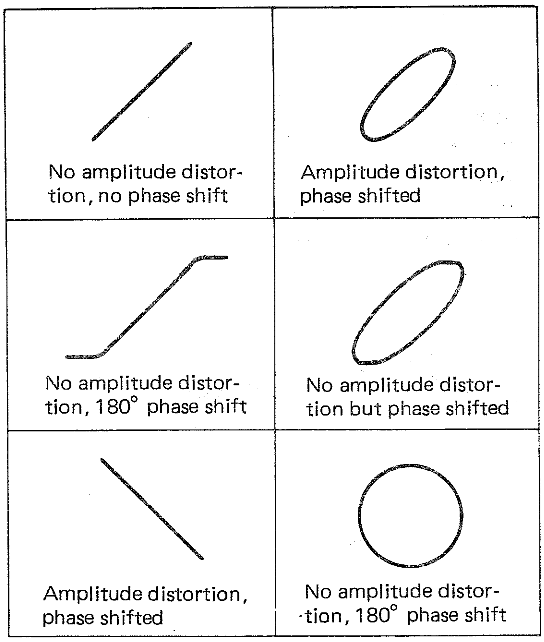


Fig. 29 Typical displays in phaze measurement

FREQUENCY MEASUREMENT

In addition to phaze measurement, frequency can be measured from the Lissajous' pattern.

Procedure:

1. Connect a sine wave of known frequency to the channel 2 INPUT jack of the oscilloscope, and set the MODE selector to X-Y.
2. Connect the CH1 probe to the unknown frequency.
3. Adjust the channel 1 and 2 gains.
4. The resulting Lissjous' pattern shows the ratio between the two frequencies.

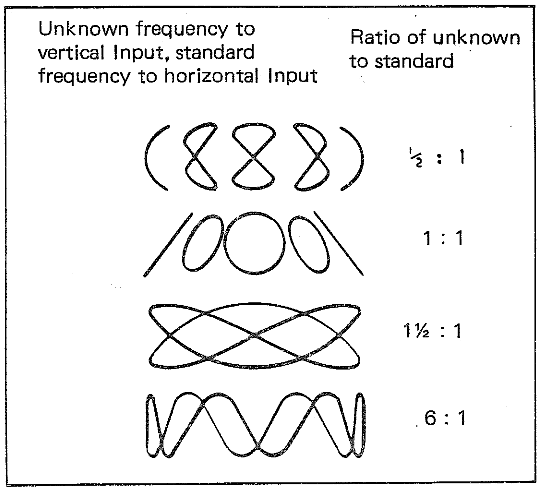


Fig. 30 Lissajous' patterns used for frequency measurement

APPLICATION AS A DIGITAL MEMORY SCOPE

With combination of a pen-recorder, GP-IB controller, etc, the MS-1660 memory scope provides the capability of easier waveform observation and data processing, allowing applications in a wider range.

As an illustration of such applications, the determination of response to a shock wave will be described.

(1) Using the memory as 4K words.

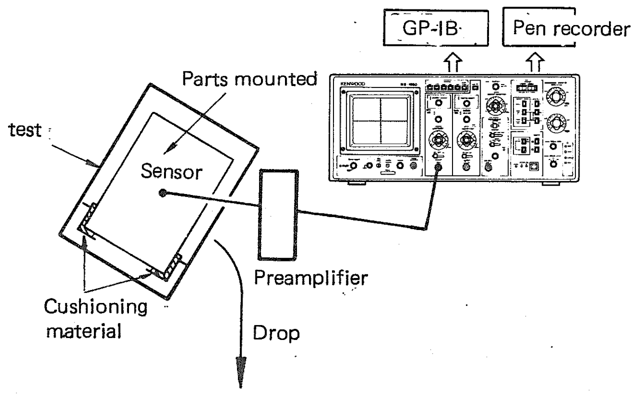


Fig. 31

1 To use the data after the trigger point as 4K words:
DISPLAY MODE: REFRESH-DELAY
CURSOR: Right end
PULL DISPLAY TIME: ON

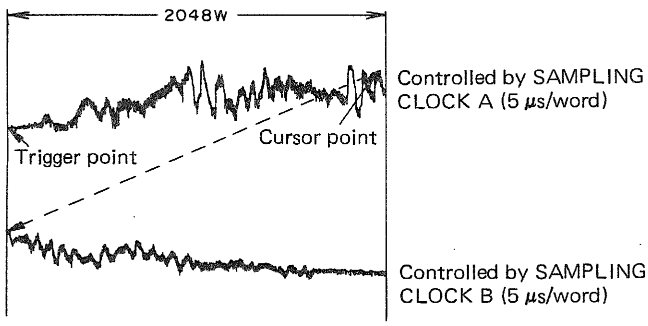


Fig. 32

(2) Magnifying a part of waveform using the dual-clock function

1 When the portion following the trigger point is required and the triggered portion is to be magnetified:
DISPLAY MODE: REFRESH-DELAY
CURSOR POSITION: The portion to be magnified
PULL DISPLAY TIME: ON

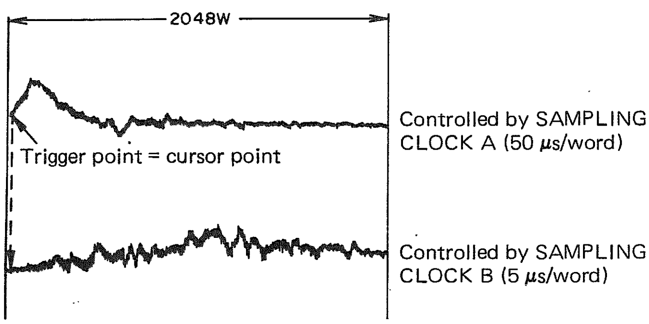


Fig. 33

2 When the portion around the trigger point is required and the waveform following the trigger point is to be magnified:
DISPLAY MODE: PRE TRIG-DELAY
CURSOR: Center
PULL DISPLAY TIME: OFF

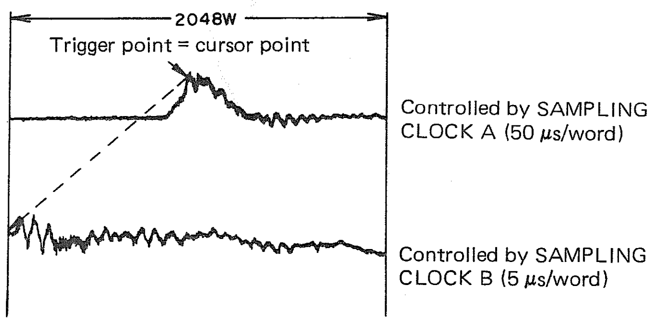


Fig. 34

3 When the portion around the trigger point is required and the end of the waveform is to be magnified:
DISPLAY MODE: PRE TRIG-NORM
MODE: DUAL
INPUT: Same signal input to CH1 and CH2
PULL DISPLAY TIME: OFF

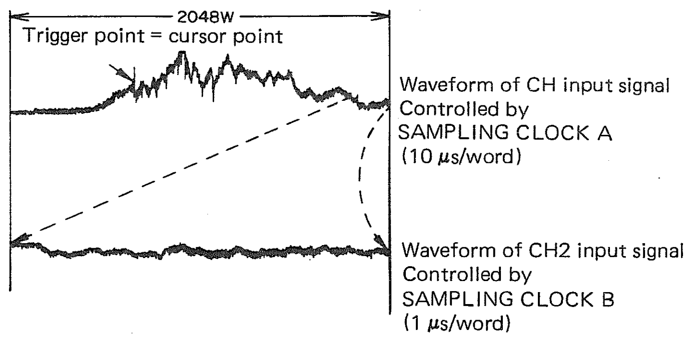


Fig. 35

4 To use the memory as 4K words symmetrical about the trigger point:
DISPLAY MODE: PRE TRIG-DELAY
CURSOR POSITION: Right end
PULL DISPLAY TIME: OFF

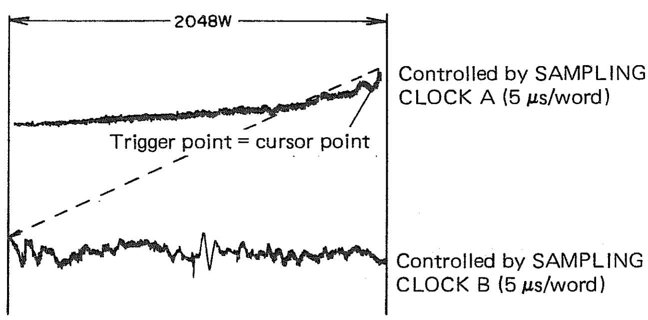


Fig. 36

(3) Observing different waveforms using dual-channel and dual-clock functons

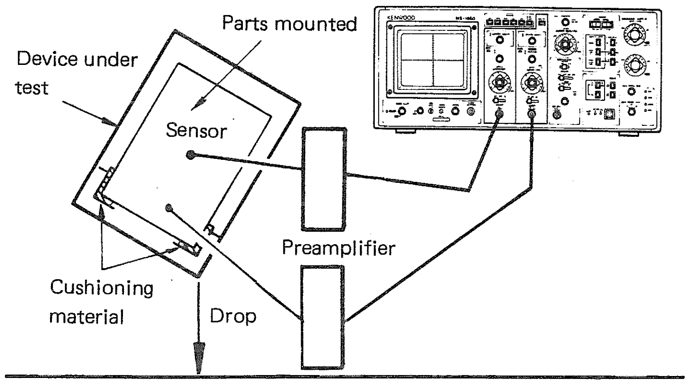


Fig. 37

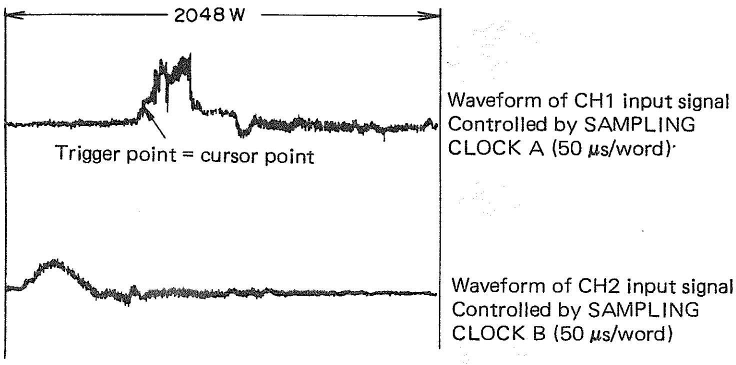


Fig. 39

1 To observe the portion following the trigger point:
DISPLAY TIME: REFRESH-NORM
MODE: DUAL
PULL DISPLAY TIME: ON

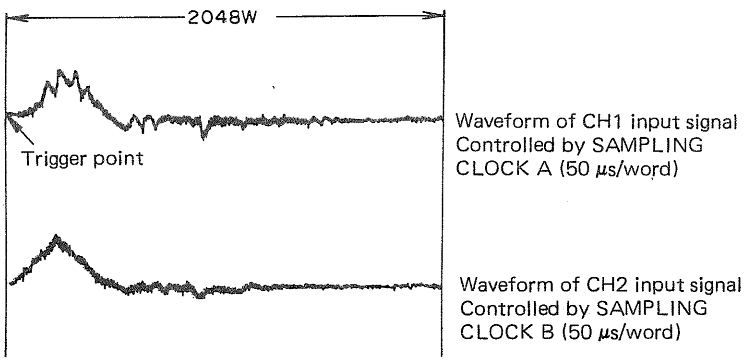


Fig. 38

2 To observe the portion around the trigger point:
DISPLAY MODE: PRE TRIG-DELAY
MODE: DUAL
PULL DISPLAY TIME: OFF

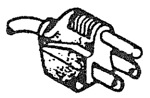
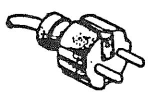
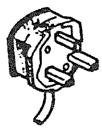
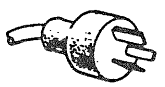
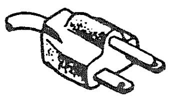
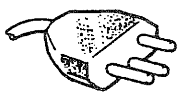
Plug configuration	Power cord and plug type	Factory installed instrument fuse	Line cord plug fuse
	North American 120 volt/60 Hz Rated 15 amp (12 amp max; NEC)	1 A, 250 V Time lag 5 x 20 mm	None
	Universal Europe 220 volt/50 Hz Rated 16 amp	0.5 A, 250 V Time lag 6 x 30 mm	None
	U.K. 240 volt/50 Hz Rated 13 amp	0.5 A, 250 V Time lag 6 x 30 mm	0.5 A Type C
	Australian 240 volt/50 Hz Rated 10 amp	0.5 A, 250 V Time lag 6 x 30 mm	None
	North American 240 volt/60 Hz Rated 15 amp (12 amp max; NEC)	0.5 A, 250 V Time lag 6 x 30 mm	None
	Switzerland 240 volt/50 Hz Rated 10 amp	0.5 A, 250 V Time lag 5 x 20 mm	None

Fig. 40 Power Input Voltage Configuration

MEMO

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

© 65704 PRINTED IN JAPAN B50-7559-10 (N)