MODELS VC-6523/VC-6023
VC-6524/VC-6024

DIGITAL STORAGE OSCILLOSCOPE

OPERATION MANUAL

WARNING

TO AVOID ELECTRIC SHOCK , DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

IMPORTANT

READ RULE FOR SAFE INSTALLATION, OPERATION AND INSTRUCTION CAREFULLY.

RETAIN THIS MANUAL FOR FUTURE REFERENCE.

Hitachi Denshi, Ltd.

CONTENTS

1. FEATURES

This oscilloscope is high-speed digital storage oscilloscopes provided with a high-speed A/D converter for each channel to enable the measurement, memory, and analysis of high-speed phenomena.

(1) High speed and wide bandwidth

A high-speed A/D converter is provided for each channel, and the inputsignal can be sampled at the sampling speed up to 20 Msps.If the signal has a complete repetition, the signal of up to 50 MHz (20 MHz for the VC-6523/VC-6023) can be stored. Further this oscilloscope can be used as a normal 50 MHz (20 MHz for the VC-6523/VC-6023) real-time oscilloscope.

(2) Memory of waveforms (save function)

Two 1 kilo-word save memories are provided, and up to two sets of the stored waveform can be saved.

(3) Multiple functions

Multiple functions to analyze signals are provided.

- Roll mode function:
  Facilitates the measurement of a low-speed signal.
- Average function:
  Removes a noise component from the signal including random noises.
- Smoothing function

(4) External interface functions

Various output functions are built in to analyze and record storage data.

- RS-232C interface
  Digital data is output to a personal computer, etc.
- Digital plot function:
  A hard copy of the display on the CRT is directly obtained by the X-Y plotter via the RS-232C.

(5) CRT readout and cursor measurement functions

The operation and the measurement can be made quickly.

- CRT readout function:
  Displays the characters of the setting information of the operation panel on the CRT.
- Cursor measurement function:
  Displays the voltage difference ($\triangle V$), the time difference (ΔT), and the frequency ($1/\Delta T$) between cursors alphanumerically.

2. COMPOSITION

(1) Oscilloscope 1 unit

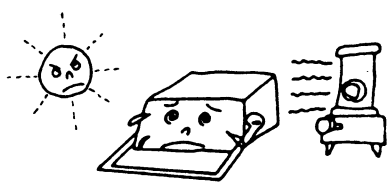
(2) Accessories

Probes, AT-10AK 1.5	2 pcs.
Fuse	1 pc.
Operation manual	1 copy
AC power cord, 3-conductor	1 pc.

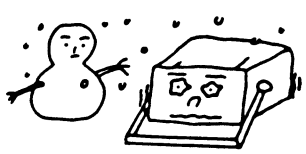
3. PRECAUTIONS

Installation

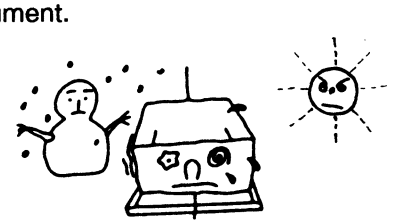
* Avoid installing the instrument in an extremely hot or cold place.
  - Avoid placing the instrument in a place exposed directly to sunlight for a long time, in a car in mid-summer, or near a room heating device.
  - The maximum operating ambient temperature is 40°C.



* Do not use the instrument outdoors for a long time on a cold winter day. The operating ambient temperature is 0°C or more.



* Avoid moving the instrument from a hot place to a cold place and vice versa, orcondensation may form inside the instrument.



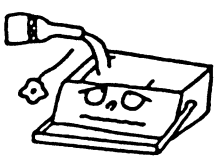
* Keep the instrument away from damp air, water, and dust.

Unexpected trouble may be caused when the instrument is placed in a damp ordusty place.

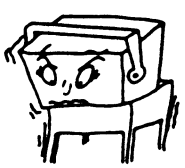
The operating ambient humidity is 45 to 85%.

Do not place a liquid-filled container on the instrument.

An accidental intrusion of liquid may also cause troubles.



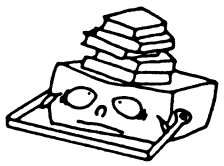
* Do not place or use the instrument in a place subject to vibration.



* Do not place the instrument near a magnet or a magnetic body. An oscilloscope uses electron beams. Therefore, do not bring a magnet close to the instrument or do not use the instrument near an equipment generating strong magnetic force.

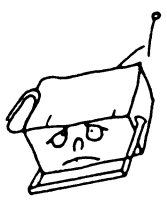
Operating considerations

* Do not put a heavy object on the instrument.
* Do not block ventilation holes.

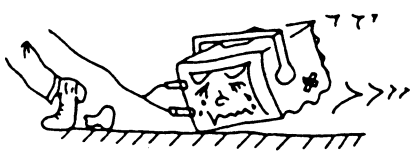


* Do not apply a heavy shock to the instrument.

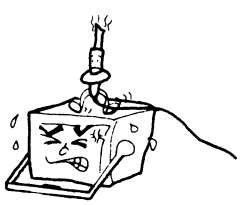
* Do not insert a wire, pin, etc. through ventilation holes.



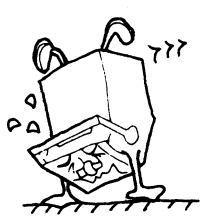
* Do not drag the instrument with a probe connected.



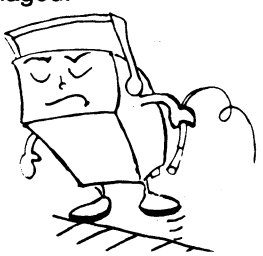
* Do not leave a hot soldering iron on or around the cabinet or the screen.



* Do not try to turn the instrument upside down. Otherwise, knobs may be broken.



* Do not use the instrument upright, leaving cables connected to terminals or connectors on the rear panel. Otherwise, the cables may be damaged.

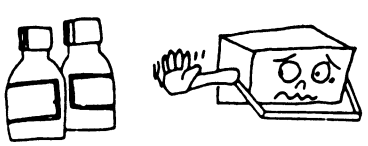


When not in use

When not in use, put the dust cover (optional accessory) on the instrument.

Care

* Removal of stain from the case
  - When the outside of the case is stained, wipe it lightly using a neutral detergent and then clean the surface with a dry cloth.
* Never use a volatile agent such as benzine and thinner.
  - When the panel surface is stained, remove the stain with a clean, soft cloth. When heavy stains are present, first use a diluted detergent or alcohol and then clean with a dry cloth.



Maintenance

(1) Use and store the instrument carefully to avoid damage to built-in precise components.

(2) Clean the scale plate from time to time with a clean soft cloth.
(3) The recommended ambient condition is 20°C, 65%.

Calibration interval

To maintain the instrument accuracy, perform the calibration after each 1000 hours of operation, or every six months if used infrequently.

Operating precautions

* Check the line voltage.
  The operating voltage range of this oscilloscope is as shown below. Check the line voltage without fail before turning on the power switch.

Rating	Line Voltage(50/60Hz)
AC100V	AC 90V - 110V
AC120V	AC108V - 132V
AC220V	AC198V - 242V
AC240V	AC216V - 264V

Nominal volts ±5% at 400Hz

Prior to shipment, the voltage selector is set properly. When the oscilloscope is intended to be used on a different voltage, relocate the voltage selector in the procedures which follow.

1) Disconnect the power connector.
2) Insert a screwdriver into the right side of the cap and remove the fuse holder cap.
3) Mount the fuse holder cap into the fuse holder so that the marking of the correct voltage faces up.
4) Connect the power connector.
   When setting the line voltage to 220VAC or higher, it is needed to replace the power cable and fuse. In this case, contact your local Hitachi Denshi sales representative.

* Do not increase the brightness too much.
  Do not increase the brightness of the spot and trace too much. Your eyes may be tired and the phosphor screen of the CRT may be burnt.
* Do not apply an excessive voltage.
  The input withstand voltage of each input connector and probe input is as follows. Never apply a voltage higher than specified.
  INPUT direct, 300V
  (DC + AC peak at 1 kHz)
  When x 10 probe is used 400V
  (DC + AC peak at 1 kHz)
  When x 1 probe is used 300V
  (DC + AC peak at 1 kHz)
  EXT TRIG INPUT 300V
  (DC + AC peak)
  EXT BLANKING 30V
  (DC + AC peak)

CAUTION:

Never apply a voltage higher than specified to avoid possible damage to the instrument.

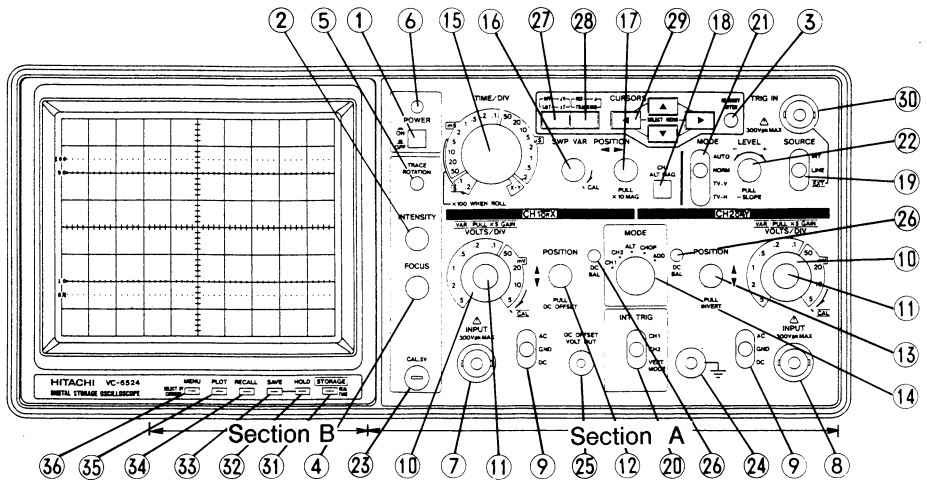
4. OPERATION PANEL

The digital storage oscilloscope is provided with the real time oscilloscopefunction and the digital storage function.The front panel is designed to offer ease of operation, and the panel is composed of the Section A for setting of measurement conditions and of the Section B for setting of operation modes.

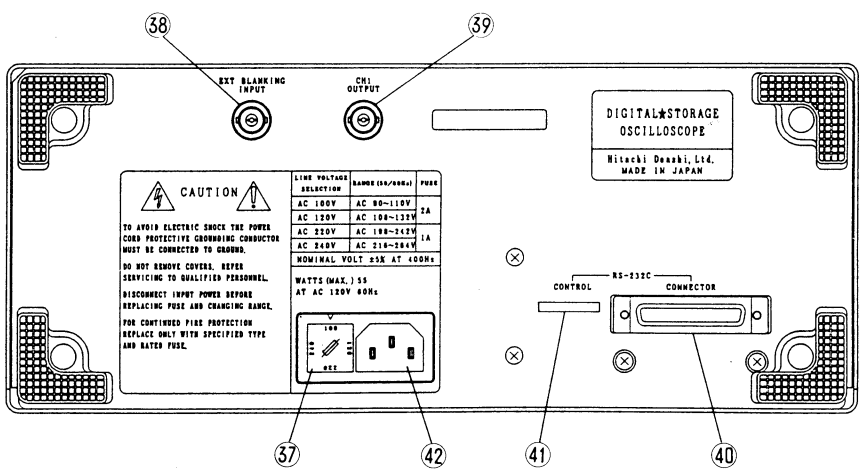
When the REAL TIME mode is selected (Green STORAGE LED goes off), the instrument functions as a real time oscilloscope.This mode is called the REAL TIME mode.

When the STORAGE mode is selected (Green LED lights or blinks), the instrument functions as a digital storage oscilloscope. This mode is called the STORAGE mode.

Refer to Item 5.2 for the operation mode selection.



Front panel (VC-6524)



Rear panel

5. PANEL DESCRIPTION

5.1 Front Panel Section A

(1) Power and CRT

① POWER switch

Power is ON in the pressed mode (⏤), and OFF in the released mode (⊔).

② INTEN control

A clockwise rotation increases the brightness of the waveform in the REAL-TIME mode.

③ READOUT INTEN control (screwdriver adjustment)

A clockwise rotation increases the brightness of the read-out. (REAL TIME mode only)

In the STORAGE mode, the brightness of the waveform on the screan and the readout increases.

④ FOCUS control

After obtaining an appropriate brightness by the INTEN control, adjust the FOCUS control until the trace has best definition. Though the focus is corrected automatically when the INTEN control is rotated, adjust the FOCUS control if necessary.

⑤ TRACE ROTATION control (screwdriver adjustment)

This control corrects the displacement of trace caused by external magnetic fields. Align the trace with the horizon graticule line with this control.

⑥ POWER lamp

This lamp lights in green when power is on.

(2) Vertical deflection system

⚠⑦ CHI INPUT connector

BNC connector for vertical axis input.

The signal input to this terminal becomes the X-axis signal when the instrument is used as an X-Y oscilloscope.

⚠⑧ CH2 INPUT connector

The same as CH1, but when the instrument is used as an X-Y oscilloscope, the signal input to this terminal becomes the Y-axis signal.

⑨ AC-GND-DC

The switches used to select the coupling system between the input signal and vertical axis amplifier.

AC: Input signal is capacitively coupled to the vertical amplifier. The DC component of the input signal is blocked.

DC: All frequency components of the input signal are coupled to the vertical deflection systems.

GND: At this setting the input to the vertical axis amplifier is grounded.

⑩ VOLTS/DIV switch

This is a step attenuator which selects the sensitivity.

Set to an appropriate range according to the incoming signal level.

⑪ VAR controls, PULL X5 GAIN

* These controls provide a continuous variable vertical deflection factor.

  Attenuation of down to 1/2.5 is obtained by turning in a counterclockwise

direction.

* These controls are useful when comparing two waveforms or when measuring the rise time of a square waveform.
* Normally set to the CAL position.
* When the knob is PULL position (pulled up state) the gain of the vertical axis is magnified 5 times and the maximum sensitivity becomes 1mV/DIV.

⑫ POSITION control PULL DC OFFSET

This knob used to adjusting the position of the vertical axis.

The trace rises with the clockwise rotation of this knob and falls with the counterclockwise ratation.

When the knob is pulled up, the adjustment range of the trace position of the vertical axis can be magnified by the DC OFFSET function.

Therefore, the peak value of an input waveform with large amplitude can be measured.

(Keep pushed-in for the normal operation.)

Note) DC OFFSET functions only when the VC-6524/VC-6024 is in the REAL-TIME mode.

⑬ POSITION control PULL INVERT

The same as CH1, but when the knob is at PULL position (pulled up state), this is used to inverse the polarity of the input signal applied to CH2.

This control is conveniently used in the comparison of two waveforms having different polarity or in the observation of the waveform of the difference signal (CH1) - (CH2) between CH1 and CH2 using ADD.

⑭ VERTICAL MODE switch

The vertical axis modes are selected as follows.

Vertical axis mode	REAL TIME mode	STORAGE mode
CH1	The signal connected to CH1 only is displayed on CRT.	The signal connected to CH1 only is displayed on CRT.
CH2	The signal connected to CH2 only is displayed on CRT.	The signal connected to CH2 only is displayed on CRT.
ALT	The signals connected to CH1 and CH2 are displayed alternately at each sweep or CRT.	The ALT mode is established for the sweep range of 0.5ms/DIV or faster. The CHOP mode is established for the sweep range of 1ms/DIV or slower Dnal storage waveforms aredisplayed on CRT.
CHOP	The signals connected to CH1 and CH2 are switched at 250kHz approx regardless of sweep and displayed simultaneously on CRT use this mode for the dual measurement of slow sweep signal.	
ADD	The algebraic sum of the signals connected to CH1 and CH2 are displayed on CRT.	The algebraic sum of the signals connected to CH1 and CH2 are displayed on CRT.

(3) Horizontal deflection system

⑮ TIME/DIV switch

The sweep time of the horizontal deflection system and the operation system in the STORAGE mode are selected.

(i) REAL TIME mode

Sweep time ranges are 19 steps from 0.2 μs/DIV to 0.2s/DIV.

(ii) STORAGE mode

(a) Modes other them ROLL mode

Sweep time ranges are 19 steps from 0.2 μs/DIV to 0.2s/DIV.

(b) ROLL mode

Sweep time ranges are from 0.2 μs/DIV to 2ms DIV.

For 5ms/DIV to 0.2 s/DIV, the ROLL mode is established, and the sweeptime becomes the setting value x 100, ie, 0.5 s/DIV to 20 s/DIV.

(iii) X-Y

This position is used when using the instrument as an X-Y oscilloscope.

In this position the X (horizontal) signal is connected to the input of CH1; the Y (vertical) signal is applied to the input of CH2 and has a deflection range from less than one millivolt to 5 volts/DIV at a reduced band-wide of 500 kHz.

The X-Y display is available only in the HOLD mode when the mstrument is in the STORAGE mode.

For detail, refor to 8.3 (11).

NOTES:

(a) In the STORAGE mode, the sampling method is changed automatically by the TIME/DIV.

0.2 μs/DIV to 2 μs/DIV

Equivalent sample

(Only a repetitive signal can be stored.)

5 μs/DIV to 0.2 s/DIV Normal sample

0.5 s/DIV to 20 s/DIV Roll mode

(the instrument must be set to the ROLL made)

(b) Only a completely repetitive signal can be stored in each range from 0.2 μs/DIV to 2 μs/DIV (equivalent sampling mode range).When a signal containing a non-repetitive component is stored in these ranges, the waveform different from the input signal may be displayed or the waveform on the CRT may not be updated with the STORAGE lamp (green LED) lit. In case of measuring a non-repetitive signal, set the range to 5 μs/DIV or slower.

⑯ SWP AVR

The TIME/DIV can be changed continuously in the REAL TIME mode. When this switch is rotateofully in the direction of arrow (CW), the CAL mode is established and the sweep is calibrated to the specified value. Normally set this switch to the CAL position. In the STORAGE mode, this switch is iqnored for the normal sampling. However in the equivalant sampling mode, this switch provides the same function as in the REAL TIME mode.

⑰ POSITION, PULL X10 MAG

The trace is moved horizantally in the REAL TIME mode. It is moved right when rotating the switch CW, while it is moved left when rotating the switch CCW.

Note) The trace can be moved horizontally in the STORAGE mode by pressing the CURSORS ◁ ▷ keys. It is moved left by the CURSORS ◁ key and right by the CURSORS ▷ key. This is effective only when the CURSORS display

is OFF or when the MENU is not selected.
The sweep can be magnified 10 times by pulling the POSITION, PULL X10 MA control.

⑱ CH1 ALT MAG

The sweep of the signal connected to CH1 is switched between X1 (NORM) and X10 (MAG) for each sweep. Therefore, the X1 and X10 waveforms can be measured simultaneously on the CRT.
Move the portion to be magnified to the center of the screan and press this switch (pushed state (⏤)).
The X10 waveform is displayed about 3div below the X1 waveform. This is effective only when the VC-6524/VC-6024 is in the REAL TIME mode. (Effective only for CH1 in the VERTICAL mode)

(4) Trigger system

⑲ SOURCE select switch

This switch is used to select the triggering signal source sweep.

INT The input signal applied to CH1 or CH2 becomes the triggering signal.

LINE This setting is used when observing a signal trigering with power supply line frequency.

EXT External triggering signal applied to TRIG INPUT becomes the triggering signal.
This setting is used when triggering with a special independently of the vertical axis signal.

⑳ INT TRIG select switch

This switch is used to select the internal triggering signal source sweep.

CH1 The input signal applied to CH1 becomes the triggering signal.

CH2 The input signal applied to CH2 becomes the triggering signal.

VERT MODE For observing two waveforms, the sync signal changes alternately corresponding to the signals on CH1 and CH2 to trigger the signal.

㉑ TRIGGER MODE switch

AUTO: A sweep is performed automatically. When a trigger signal is applied, the normal sweep operation is performed and the waveform is stationary.
The instrument will automatically display a trace without an input signal being applied or out of trigger. This setting is convenient in most cases.
Normal trigger will be established by setting trigger level when a signal is applied to the input. In the STORAGE mode, a waveform displayed on the CRT continues to be updated regardless of the presence of a trigger signal.

NORM: Trace will appear when a sweep is triggered. Trace will not appear when a signal is not applied or when a signal is triggered properly.
Use this MODE when effecting synchronization to a very low frequency signal (25 Hz or less). When the signal is not triggered properly in the STORAGE operation, a waveform is not updated and the traces are held.

TV-V: Used when measuring the vertical TV signal.

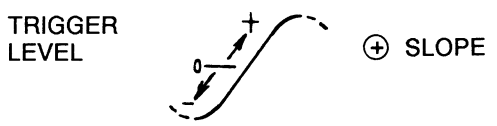
TV-H: Used when measuring the horizontal TV signal.

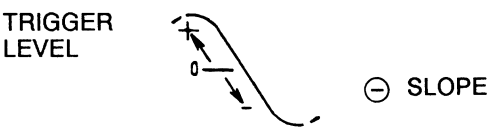
Note: TV-V and TV-H are sychranized only when the sync signal is negative.

㉒ TRIGGER LEVEL control, PULL (–)SLOPE

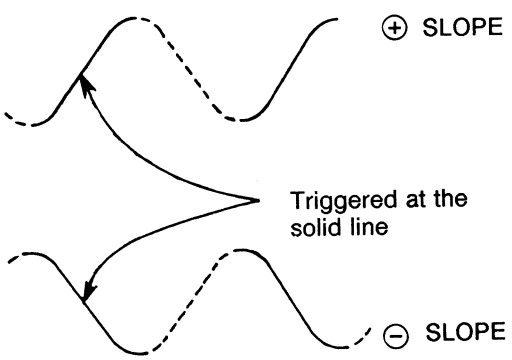
This knob is used to decide at which portion of the waveform should the sweep be started by setting trigger level.

This knob is also enabled to switch SLOPE. Depressed position (normal state) is for (+) SLOPE and PULL position (state in which the knob is protruding) is for(–) SLOPE.





Explanation of synchronization level



Explanation of synchronization polarity

(5) Miscellaneous

㉓ CAL 0.5V tip

Output terminal of calibration square wave of about 1kHz and 0.5V. It has a tip terminal. It is used to calibrate the probe combination.

㉔ GND terminal

Earth terminal of the oscilloscope.

㉕ DC OFFSET connector (VC-6524/VC-6024 only) VOLT OUT

This is the output connector to readout the voltage measurement with a digital multimeter, etc., when the instrument is set to the DC OFFSET mode.

(Except : x5 GAIN, out of CAL)

㉖ DC adjustment controls BAL

There are used for the ATT balance adjustment.

㉗ △V→△T→1/△T

By this Switch, △V, △T and 1/△T can be selected and displayed in turn on the CRT by pressing this switch, and measurements by cursors are available.

△V: Two horizontal cursors appear. The voltage between the two cursors is calculated according to the setting of VOLTS/DIV, and displayed with △V on the upper side of the CRT.

△T: Two vertical cursors appear. The time between the two cursors is calculated according to the setting of TIME/DIV, and displayed with △T on the upper side of the CRT.

1/△T: Two vertical cursors appear. The reciprocal of the time (frequency) between the two cursors is calculated with 1/△T on the upper side of the CRT.

㉘ REF→⊿→TRACKING

REF,⊿and TRACKING can be selected by this key. Each pressing this key moves the cursor in sequence.

REF: Moves the reference cursor on the CRT. (▽or ▷ is displayed on the reference cursor.)

⊿: Moves the measuring cursor on the CRT. (▽or ▷ is displayed

on the measuring cursor.)

TRACKING: Simultaneously moves the reference cursor and the measuring cursor with the interval between the two cursors unchanged. (▽or ▷ is displayed at the two cursors.)

㉙ CURSOR

The cursor (the cursor displayed by ▽or ▷) specified by the REF-△-TRACKING key can be moved by this key.

△
▽ Moves the △V cursor up or down.
◁ ▷ Moves the △T or V△T cursor left or right.

⚠㉚ TRIG INPUT connector

Input terminal for use for external triggering signal of sweep.

5.2 Front Panel Section B

㉛ STORAGE switch

When this LED goes off, the instrument functions as the normal real-time oscilloscope, the switches ㉜ thru ㊱ are all invalid, and all the LED's go off.

When this switch is pressed once, the LED lights, resulting in the STORAGE mode. In this case the switches ㉜ thru ㊱ are all valid.

When this switch is pressed again in the STORAGE mode, the REAL TIME mode is established again. In the STORAGE mode, the LED blinks in synchronism with sampling.

㉜ HOLD switch

Pressing this switch stops sampling, resulting in the hold state, and the LED lights.

Further pressing this switch releases ights. hold state and sampling starts.

㉝ SAVE switch

This is the switch to store the display waveform in the save memory. This switch is valid only in the hold state (HOLD LED lights).

When this switch is pressed, the LED lights to indicate that the waveform is stored in the save memory.

㉞ RECALL switch

This is the switch to display the saved waveform on the CRT again. When this switch is pressed, the LED lights.

The RECALL state is released by pressing this switch.

㉟ PLOT

Press this switch to output the display waveform to the X-Y plotter connected externally. Then data starts to be transmitted and the LED lights. This switch is valid only in the hold state (HOLD LED lights).

㊱ MENU

Press this switch to change the ROLL, the number of average, the interpolation method, the on-off of smoothing and the selection of save memory. The selection of PROBE X10 and X1 can also be made. Each pressing changes the setting mode and the present setting mode is displayed at the top right on the CRT. The settings in each mode are changed by the SELECT MENU ◁ ▷.

5.3 Rear Panel

㊲ FUSE

The fuse is inside the fuse holder.

CAUTION: When the fuse is blown out, contact your nearest Hitachi

Denshi representative.

(38) EXT BLANKING INPUT terminal

This is a terminal for applying a blanking signal from an external source. This terminal is DC-coupled. The intensity is lowered by a positive signal, while it is increased by a negative signal.

(39) CH1 OUTPUT connector

Output connector providing a sample of the signal applied to the CH1 connector.

(40) RS-232C connector

Connect to the plotter or other equipment with the RS-232C interface.

(41) RS-232C switches

The eight switches set the address of the instrument with the binary data.(Refer to item 9.2 Specifications of plot.)

(42) AC input connector

Connect the AC power source.

6. HOW TO PRODUCE THE TRACE

Before turning ON the POWER switch, insure the power supply voltage is within the range of 108-132/V for AC 120V set, 198-242V for AC 220V set, and 216-264V for AC 240V set. Insert the plug of the power cord on the rear panel into the power supply wall socket and set the controls as follows.

POWER	OFF
INTEN	Counterclockwise to the full
FOCUS	Midrange
AC-GND-DC	GND
⫞⫟POSITION	Midrange (the knob is in the depressed)
MODE	CH1
TRIG MODE	AUTO
TRIG SOURCE	INT
INT TRIG	CH1
TRIG LEVEL	Midrange
TIME/DIV	0.5 ms/ DIV
⇌POSITION	Midrange

Set all the levers of the switches to the upper side. After ending all the setting mentioned above, turn ON the POWER and, 15 second later, rotate the INTEN knob clock-wise. Then the sweep bright line will appear. If the observation is to be started immediately, set the FOCUS control at a point where the bright lineis sharpest. If the instrument is not used with the power supply turned on rotate the INTEN counterclockwise to reduce the brightness and also blur the FOCUS.

NOTE:

For usual observation, leave the following non-calibrating function section set to "CAL" position.

VARIABLE	Rotate in the direction of arrow. In this case the VOLTS/DIV is calibrated to its indicating value.
SWP VAR	Leave the knob in depressed state. In this case the TIME/DIV is calibrated to its indicating value.

Align the bright line with the horizontal scale line at the center of the screen by operating CH1 POSITION. In some cases the bright line may be oblique to the scale slightly by the effect of earth magnetism. In this case, bring the bright line until it lies on the horizontal scale line at the center of the screen by properly adjusting the semi-fixed variable resistor TRACE ROTATION on the front panel.

7. METHOD FOR CONNECTING SIGNALS

The first step of measurement is to connect the signal to the instrument properly. Do it with utmost care.

WARNING:

When connecting the probe or the signal input cable to the circuit to be measured, be sure to connect the ground side of the probe or the signal input connector to the ground side of the signal source. If not, potential difference between the instrument and other equipment or earth ground may result in shock hazard and damage the instrument, the probe, and other equipment.

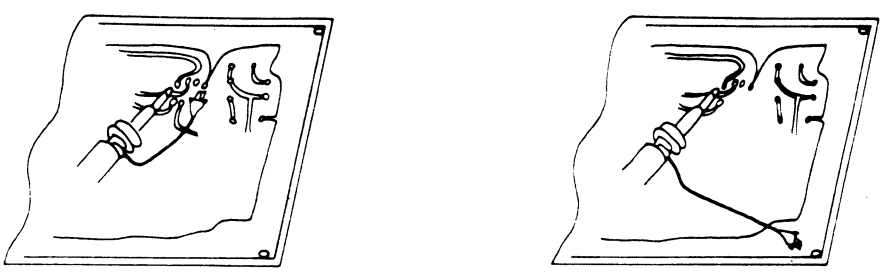
(1) Using probes

Use the attached probe, when measuring a high frequency wave with high accuracy.
It should be noted, however, that since the input signal is attenuated by this prove to 1/10 before it is input to the oscilloscope the use of the probe is disadvantageous for low level signals, and that at the same time the measuring range is extended by that amount for high level signals.

NOTES:

a) Do not apply a signal in excess of 400 V (DC + peak AC at 1 kHz or less) to the input.

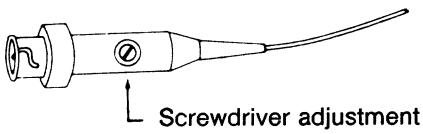
b) Connect the probe ground lead as close as possible to the point being measured especially when measuring a signal with a fast rise time or a high frequency signal. Long probe ground leads may cause waveform distortions, such as ringing and overshoot.

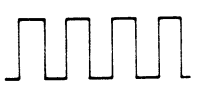


(a) Proper (b) Improper

Connection of ground lead

c) To avoid a measurement error, probe compensation must be done especially when probes are changed.
Connect the probe tip to the CAL 0.5 V output terminal and the probe ground lead to the GND terminal.
A 1 kHz square wave should be displayed with flat tops. Any distortion in the presentation is caused by incorrect probe compensation.
If overshoot or undershoot is present, turn the screwdriver adjustment in the probe for a flat-top presentation.





(a) Optimum

(b) Capacity too small

(c) Capasity too large

(2) Direct connections

When connecting signals without using the supplied probe, pay attention to the following points in order to minimize a measurement error.

- When using an unshielded lead, there should be no trouble, provided the circuit under measurement is of low impedance source and high level. However, in most cases, measurement errors may be caused by stray coupling with other circuits or power line interference. This can cause errors even at low frequencies. In general, avoid measuring with an unshielded lead.
- When using a shielded wire, it is desirable to use a coaxial cable with a BNC type connector. If a BNC type connector is not available, connect one end of the shield to the ground terminal of the instrument and the other end to the ground of the circuit to be measured.
- The following precautions must be observed when performing a wide bandwidth measurement. It is necessary to terminate the cable with a characteristic impedance, when measuring a fast rise waveform or a high frequency wave. The absence of a termination resistor will result in a measurement error due to a ringing phenomenon when a long cable is used. Some measuring circuits require a termination resistor equal to the characteristic impedance of the cable. (A BNC type termination resistor is recommended for this purpose).
- In order to perform measurements with the circuit in a proper operating state, it is sometimes necessary to terminate the cable with an impedance which corresponds to the circuit being measured.
- The stray capacity of the shield wire must be taken into account when performing measurements with a long shield wire. Since a shield wire has a capacity of about 100 pF per meter, its effect on the test circuit cannot be ignored. Use a X10 probe to minimize the effect on the circuit.
- When a sheld wire or a non-terminated cable is used, and the cable length reaches 1/4 the wave length or its ultiples (1/4 the wave length is about 1.5 meter [3.8meter] when using a coaxial cable at 50 MHz[20 MHz]), oscillationmay be caused in the 2 to 5

mV/DIV ranges. This is caused by the resonance between the externally connected high-Q inductance and the input capacity. Reduce the Q by connecting the cable or shield wire to the input connector by the resistors from 100 Ω to 1 kΩ connected in series, or by performing measurements at another VOLTS/Dlv range.

8. BASIC OPERATIONS AND MEASUREMENT PROCEDURES

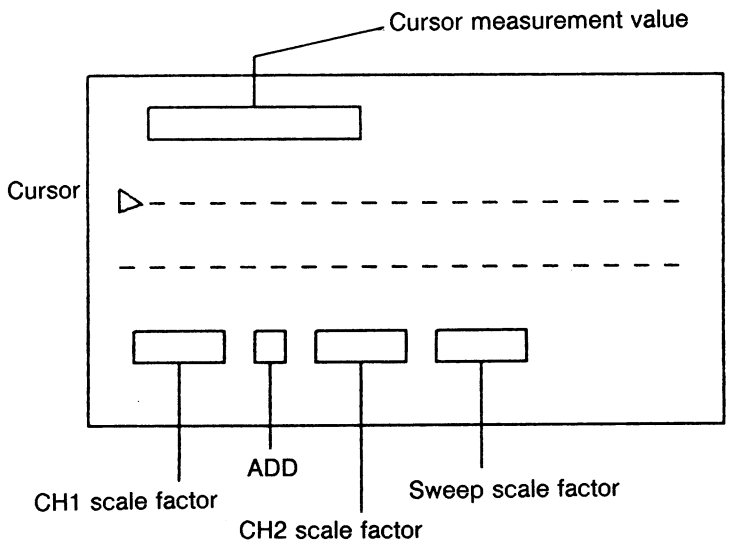
The measurement is provided with the REAL TIME mode function and the STORAGE mode function, and the selection of the modes can be made by the switches of the STORAGE MODE section. The basic operations are described below.

NOTE:
Prior to measurements, allow 20 minutes of warmup time.

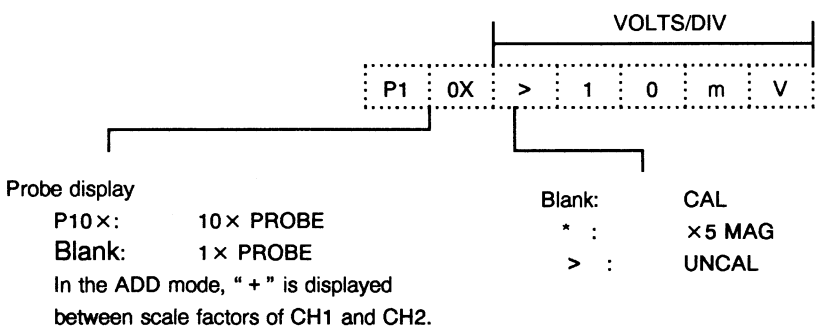
8.1 Data Display

(1) REAL TIME mode display

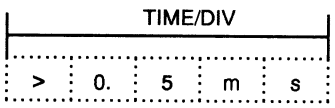
Data display positions on the CRT



① CH1 and CH2 scale factor displays



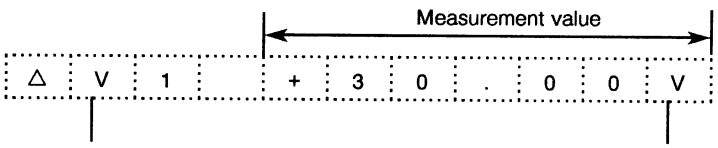
② Sweep scale factor display



Blank: ×1 CAL
* : ×10 MAG
> : UNCAL

③ Display of cursor measurement value in the X-Y mode.
The read-out and the cursor become in the OFF state in the X-Y operation mode.

④ Cursor measurement value display
A measurement value between cursors is displayed.



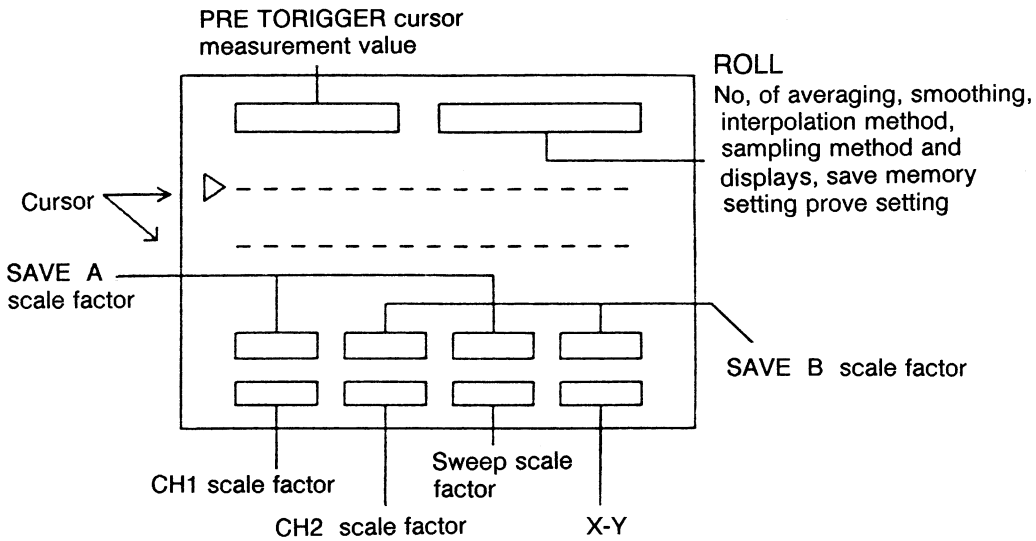
ΔV1: CH1
ΔV2: CH2
ΔV 1_2: ADD
ΔT: Time difference between Two cousors for TIME/DIV
1/ΔT: Reciprocal number of ΔT

ΔV: +, -, mV, V, div
ΔT: +, -, ns, μs, ms, div
1/ΔT: mHz, Hz, kHz, MHz, ?, div
"div" is displayed in the following cases :

- The measurement value in the channel selected by the VERTICAL MODE switch is not in the CAL state.
- The VERTICAL MODE is set to ADD, and the VOLTS/DIV settings of CH1 and CH2 are not equal.
- SWP VAR (UNCAL state, CRT display : >)

(2) STORAGE mode display

Data display positions on the CRT



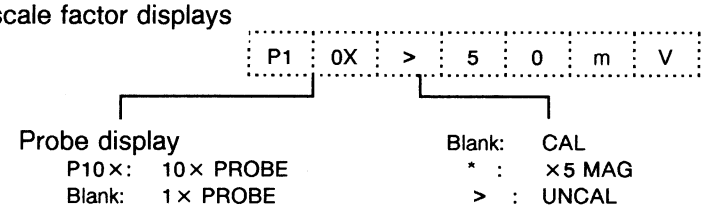
NOTE:

In the STORAGE MODE, the waveform can be displayed while the input signal is stored. Moreover, the waveform previously stored can be displayed.

The instrument stores the scale factor and the setting conditions related to the waveforms as far as the waveform is stored. When the waveform is displayed, these values can be displayed at any time.

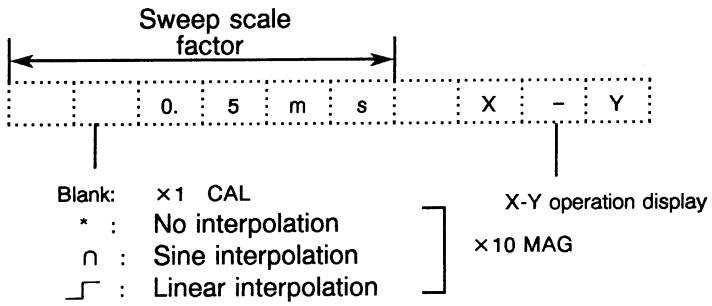
- CH1, CH2 and sweep scale factors
  When the waveform of CH1 or CH2 is displayed, the scale factors corresponding to the waveform are displayed.
- The cursor measurement value of the sweep waveform corresponding to the function selected by the PRE TRIGGER, cursor measurement value and VERTICAL MODE switches is displayed.
- SAVE A and SAVE B scale factors
  The VOLTS/DIV and TIME/DIV are displayed when the waveform is saved in the save memory.
  This scale factor is displayed only when the save waveform is displayed on the CRT by pressing the RECALL switch.

① CH1 and CH2 scale factor displays

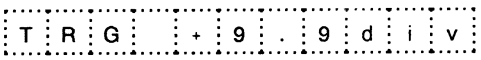


In the ADD made " + "is displayed between factors of CH1 and CH2,

② Sweep scale factor display and X-Y display

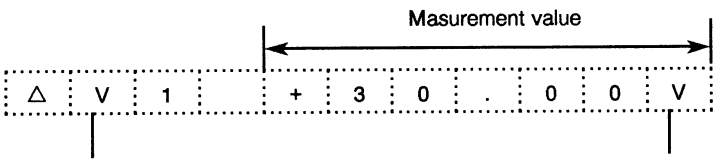


③ PRE TRIGGER setting display
Triggering point of the waveform

Example: 

④ Displays of ROLL setting, No. of averaging, interpolation method, smoothing, save memory setting, probe factor setting and sampling method. For these displays, refer to items 8.3 (9).

⑤ Cursor measurement value display
A measurement value between cursors is displayed.



ΔV1: Voltage difference between two cursors for the CH1 sweep waveform
ΔV2: Voltage difference between two cursors for the CH2 sweep waveform
$\Delta v\,{}_{1_2}$: Voltage difference between two cursors for the ADD sweep waveform
ΔT: Time difference between two cursors for the sweep waveform
1/ΔT: Reciprocal number of ΔT

ΔV: +, -, mV, V, div
ΔT: +, -, ns, μs, ms, div
1/ΔT: mHz, Hz, kHz, MHz, ?, div

Voltage difference between "div" is displayed in the following cases:

- The measurement value in the channel selected by the VERTICAL MODE switch is not in the CAL state.
- The VERTICAL MODE is set to ADD, and the VOLTS/DIV setting of CH1 and CH2 are not equal.
- The TIME/DIV is set to 0.2μs/div to 2μs/div and SWP VAR mode (CRT display in UNCAL mode) is established.

NOTES:

Readout display appears when the power is turned on. If this display is not needed, press the ◁ switch, while pressing the △V / △T / 1 / △T and REF / △ switches sinultaneously. Then, the read-out display disappears. To obtain the readout display again. Press the ▷ switch, while pressing the △V / △T / 1 / △T and REF /△ switches sinultaneously.

8.2 REAL TIME Mode

The instrument works as a conventional oscilloscope.

(1) Normal sweep display

① Set the switches, and controls as shwn in Table 8-1.
Check that the green LED of the STORAGE switch goes off. If not, press this switch to establish the REAL TIME mode.

Table 8-1 Initial setting of basic display

Vertical axis	VOLTS/DIV VAR AC-GND-DC POSITION VERTICAL MODE	Set according to the amplitude of the applied signal. CAL (Fully clockwise) AC Mid-position CH1
CRT	INTEN FOCUS	Proper position Mid-position
Horizontal axis	X10 MAG	off
Trigger	TRIGGER LEVEL TRIGGER MODE TRIGGER SOURCE INTERNAL TRIGGER	Mid-position AUTO INT CH1

② Connect the signal to CH1 INPUT connector using a probe or a coaxial cable which meets the input impedance. Refer to Section 7 for connection.

③ Adjust the INTEN control for proper illumination.

④ Adjust the VOLTS/DIV of CH1 and the vertical POSITION control so that the trace is displayed within the screen.

⑤ Adjust the TRIGGER LEVEL control for stable display.

⑥ Adjust the TIME/DIV switch so that the trace is displayed at a proper cycle. Use the FOCUS control, if necessary.

(2) In the case of measuring a single waveform

Use CH1 or CH2 when measuring a single waveform. Make the following settings when using CH1.

VERTICAL MODE switch: CH1
TRIGGER SOURCE switch: INT
TRIGGER MODE switch: AUTO
INT TRIG switch: CH1
AC-GND-DC switch: AC or DC

Under these settings, almost all the repetitive signals of approximately 25 Hz or more supplied to CH1 can be triggered and measured by adjusting the TRIG LEVEL control.

Since the TRIGGER MODE of the

horizontal axis is at AUTO, the trace appears even when no signal is present or when the GND switch is at GND. This means that the DC voltage can be measured. The following switching is needed when measuring low frequency signals of approximately 25 Hz or less.

TRIGGER MODE switch : NORM

Triggering can be effected by operating the TRIG LEVEL control under this setting.

When using CH2 only, use the instrument after making the following settings.

VERTICAL MODE switch:	CH2
TRIGGER SOURCE switch:	INT
INT TRIG switch:	CH2

(3) In the case of measuring two waveforms

Measurement of two waveforms can be made easily by setting the VERTICAL MODE select switch to ALT or CHOP. At ALT, the two waveforms of high repetitive frequency can be measured. At CHOP, the two waveforms of low repetitive frequency can be measured. For measurement of phase difference, apply trigger by the phase advanching signal.

(4) In the case of measuring a waveform in the X-Y mode

When the TIME/DIV switch is set to X-Y, this instrument operates as an X-Y oscilloscope.

Connect each input as follows.

X-axis signal	CH1 INPUT
Y-axis signal	CH2 INPUT

Push in the X10MAG switch (PULL·X10MAG knob) of the horizontal axis.

(5) ADD mode

The sum of the two waveforms can be measured by setting the VERTICAL MODE switch to ADD.

8.3 Digital Storage Functions

The operating procedures of the digital storage functions are described below.

(1) Normal storage mode (NORM)

① Display the waveform to be stored in the REAL TIME mode.

② Press the STORAGE switch, and light green LED.

③ In this mode, a waveform is swept every trigger according to the setting state of controls on the front panel, the waveform to be stored is displayed on the CRT as it is. The slower the sweep rate, the longer the time is required for the acquisition and display of the waveform. It takes approximately 3 seconds until a waveform is acquired at the sweep range of 0.1 s/DIV. The trigger signal is generated thereafter. Therefore, when the sweep rate is slow, the waveform is not displayed on the CRT immediately after the controls on the front panel have been adjusted.

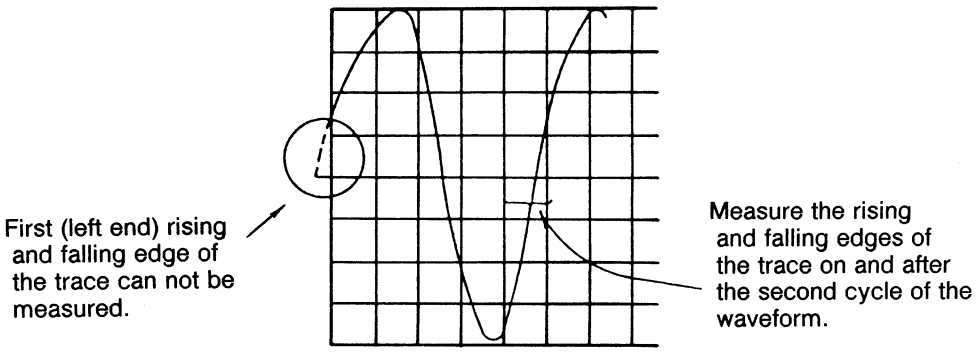
④ When the TIME/DIV control is from 5 μs/div to 0.2 s/div, both the single and the repetitive waveforms can be stored.

⑤ When the HOLD switch is pressed in the normal storage mode, the updating operation of the CRT display stops, and the CRT display at that time can be held. Precautions for the repeat mode range are shown below.

(2) Equivalent sampling mode (EQUIV)

When the TIME/DIV switch is set to 0.2 μs/div to 2 μs/div (4 steps), only the repetitive waveform can be stored in the equivalent sampling mode. Note the following items in this mode.

a) The first (left end) rising and falling edges of the trace may not be displayed in the repeat mode range. In this case, measure the rising or falling edge on the second or later cycles of the waveform.



Display in the equivalent sampling mode

b) It takes 5 seconds or more to store the input signal of 1 kHz or lower (for the 200 Hz input).

c) When the low frequency signal is stored, noise can be mixed. It is recommended to use a sine wave of 1 MHz or higher or a square wave with the rise time which is faster than 0.3 μs.

NOTE: The sampling rate in the STORAGE mode

In the normal display without horizontal magnification in the STORAGE mode, the horizontal full scale of 10 div on CRT consists of 1000 sampling data.

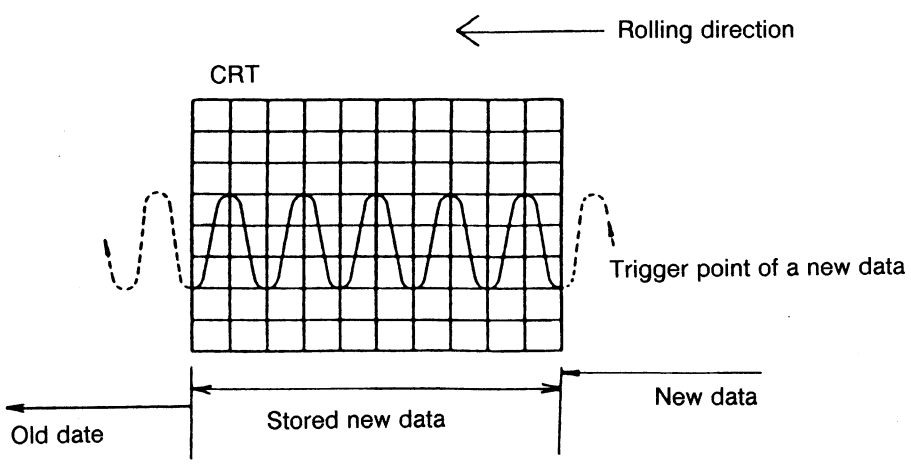
(3) ROLL mode

The displayed waveform is rolled from right to left (0.5 s/div to 20 s/div). The right end of each trace is the updating point of a new data.

The ROLL mode facilitates measurement of a signal of approximately 100 Hz or lower.

Press the HOLD switch to stop the ROLL mode and hold the final waveform on the CRT.

For the procedure of the ROLL mode selection, refer to 8.3(a).



NOTES:

a) Aliasing

When measuring the signal in such STORAGE mode as NORM, AVG, etc., aliasing can occur when an input signal which has more than half of the frequency with respect to the sample clock frequency at the sweeping range is added.

When aliasing occurs, the waveform of the input signal frequency minus the sample clock frequency will be displayed. It is possible that this display is judged a correct waveform. If aliasing is suspected, select the REAL TIME mode and check if the display is the same as that in the actural operation mode. In case aliasing occurs, the waveform of (input frequency – sample clock frequency) is displayed in the STORAGE mode, and the waveform with flat top and bottom portions in the REAL TIME mode. Therefore, judge aliasing with the difference of two displays.

b) Updating of the roll waveform

The roll mode at the high speed ranges (up to 0.5 s/div) is available. For some input signal, the movement of its waveform may not be seen smoothly at the range 0.5 s/div. This phenomena is caused by the relationship between the updating of the waveform data and the display speed. Actually the waveform data itself is correct.

(4) HOLD mode

When the HOLD switch is pressed in the EQUIV, NORM, or ROLL mode, the HOLD mode is set. In this mode, the sampling operation in each operation mode is interrupted, the waveform display data at the time when the mode was changed to the HOLD mode is continued to display. After HOLD, the displayed waveform data can not be moved up and down.

(5) Save operation (SAVE)

The waveform data which is sampled and displayed in the STORAGE MODE can be stored in the save memory. The data stored in the save memory can be displayed on the CRT by the RECALL operation.

SAVE operation

a) The sampling data is displayed in the STORAGE MODE. When the HOLD switch is pressed, the waveform is held.

b) The held waveform data is stored in the save memory by pressing the SAVE switch. (The SAVE switch functions only in the HOLD mode.)

c) The save switch LED lights momentarily to indicate that the saved waveform data is cleared when a new waveform data is stored by the above operation or when power is off.

d) When the VERTICAL MODE switch is set to CH1, CH2 or ADD, each pressing the SAVE memory saves the waveform in the save memories A and B alternately. When the VERTICAL MODE switch is set to ALT or CHOP, the CH1 waveform is saved in the save memory A, and at the same time, the CH2 waveform is saved in the save memory B.

The memory saved in the MANU mode can be fixed either the same memory A or B. For operation, refer to 8.3ca).

(6) Display of the save memory (RECALL)

The contents of the save memory stored by the save operation in the HOLD mode are displayed on the CRT by the following

operation, and can be compared with a current waveform.

① When the VERTICAL MODE switch is set to CH1, CH2, or ADD pressing the RECALL switch displays the waveform stored in the save memory A, and the setting values (V/DIV and TIME/DIV). Further pressing the switch displays the waveform stored in the save memory B. When the switch is pressed again, the save waveform disappear.

② When the VERTICAL MODE switch is set to ALT or CHOP, Pressing the RECALL switch displays the waveform stored in the save memories A and B. When the switch is pressed again, the save waveform disappears. As the waveform data displayed in the save mode is saved in the save memories, the save waveform can not be moved up or down.

③ When the RECALL switch is pressed while the SIN or LIN interpolation is performed, the SAVE waveform may not be displayed. To display the save waveform while the interpolation is performed, establish the HOLD made first, and then press the RECALL switch.

(7) Output to the X-Y plotter (PLOT)

The waveform displayed in the HOLD mode is fed out to the X-Y plotter via the RS-232C by pressing the PLOT switch. (The PLOT switch functions only in the HOLD mode.) Press the PLOT switch again to interrupt plotting. For details, refer to section 9.

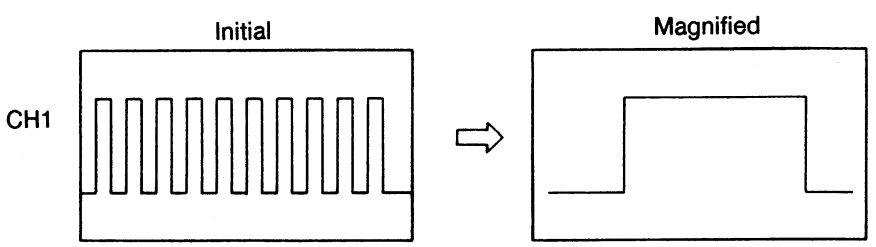
(8) Hrizontal magnifying display (magnification of time axis)

A storage waveform displayed on the CRT is magnified by 10 times from the center of the CRT. Waveform stored in the save memory can not be magnified.

a) Move the position to be magnified to the center of the screen. Use the SELECT MENU switches (◁ ▷) to move the position.

b) When the X10 MAG switch is pulled, the data at 1 div at the center of the screen is magnified by 10 times.

NOTE: When the initial waveforms of CH1 and CH2 are both displayed, both the waveforms are magnified from the center position.



c) Push in the X10 MAG switch again. The initial waveform will be displayed.

NOTE:

When the sampling is made in the ROLL mode, the horizontal magnification by the above operation can not be performed. However, the horizontal magnification in the HOLD state is possible.

(9) MENU mode

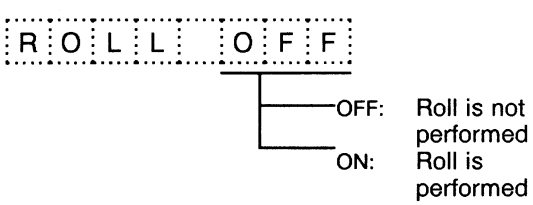
The on-off settings of the roll, the number of average, the interpolation method in the horizontal magnification mode, the waveform smoothing, the save memory and the probe can be made by the MENU switch.

Each pressing the MENU switch displays the [ROLL], [AVG], [INTRPL], [SMOOTH], [SAVE] and [PROBE] in sequence.

at the top right of the CRT and each LED lights. Further pressing the switch releases the MENU mode and the LED goes off.

① ROLL setting mode

When the MENU LED lighds and the [ROLL] is displayed the on-off setting can be done.



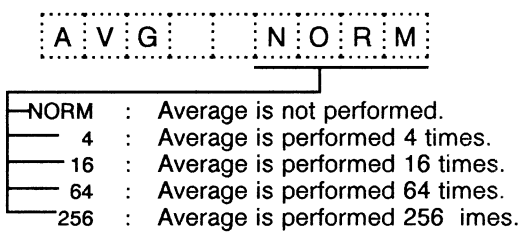
The setting can be done by the SELECT MENU [◁] [▷] keys. OFF changes to ON by the [▷] key, and ON changes to OFF by the [◁] key.

When the ROLL is set to ON by the above procedure, the ROLL mode is established for 5 ms/DIV to 0.2 s/DIV. (The sweep time is the setting value X100, i.e, 0.5 s/DIV to 20 s/DIV.)

When the ROLL is ON in the range from 0.2 μs/DIV to 2 ms/DIV, the normal sampling mode or the equivalent sampling mode is established according to the setting value.

② AVG setting mode

When the MENU LED lights and the [AVG] is displayed at the top right of the CRT, the number of average can be set.



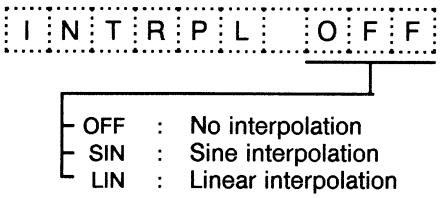
The number of average is selected by the SELECT MENU [◁] [▷] keys. ressing the [▷] key changes the number from NORM to 4 to 16 to 64 to 256 to NORM. Pressing the [◁] key changes the number in the reverse order. The averaged waveform is displayed after the data of the set sweep number has been acquired. When the number of average is 16, data is acquired 16 times (the STORAGE LED blinks 16 times). Then the data is averaged and the average waveform display is updated.

Thus, the nun-repetitive signal affected by asynchronous noise can be picked up. The average operation is performedby the set number of average. In the ROLL mode, the average operation is not performed.

③ Interpolation method selection mode

When the MENU LED lights and the [INTRPL] is displayed at the top right of the CRT, the interpolation method can

be selected.



The mode selection is made by the SELECT MENU ◁ ▷ keys. Pressing the ▷ key changes the mode from OFF to LIN to SIN to OFF. Pressing the ◁ key changes the mode in the reverse order.

The interpolation method is how to interpolate the magnified data when magnifying the display waveform in the horizontal direction (except for the save waveform).

In case of OFF, the waveform is magnified as is in the horizontal direction.

In case of SIN, the SIN operation is performed, so that the initial waveform is shaped to be a waveform close to a sine wave. This is effective for a sine wave.

When a square wave is connected in this state, ringing becomes remarkable, and the displayed waveform seems to be different from the input waveform.

In this case, change the setting to OFF or LIN.

In case of LIN, data is interpolated linearly, and the waveform is displayed smoother than at OFF.

NOTE:

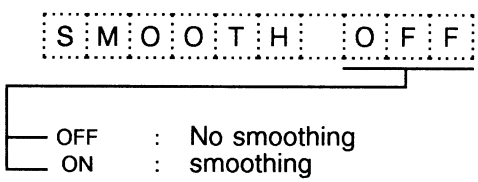
In case of SIN, set the amplitude of the input signal to less than 8 div on the CRT.

When the signal having a large amplitude on the CRT is connected. waveform distortion is observed at the upper and lower portions of the waveform.

When the interpolation method is changed in the ROLL mode, the ROLL waveform is held and the interpolation becomes effective in the MAG X10 mode. The MAG X10 mode is not valid when the ROLL waveform is not held.

④ Smoothing selection mode

When the MENU LED lights and the SMOOTH is displayed at the top right of the CRT, the smoothing is made on and off.



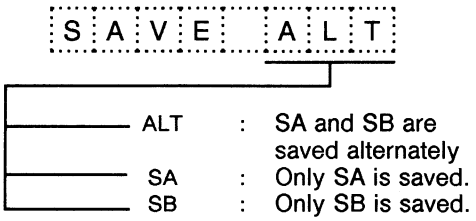
In case of OFF, the storage waveform is displayed by dots. When changed to ON, the sots are connected smoothly, resulting in the smooth waveform display.

When the sampling frequency is low with respect to the input signal frequency(when the signal having more than 5 cycles per division is connected), the amplitude may be displayed small.

In this case, set the smoothing mode to OFF to display the waveform of the similar amplitude with the input signal.

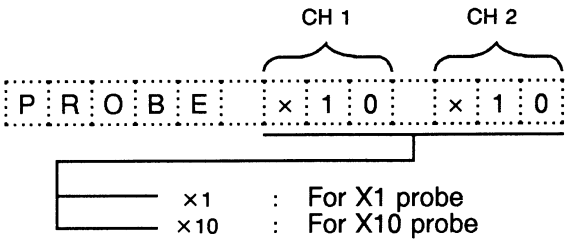
The setting can be done by the SELECT MENU ◁ ▷ keys, OFF changes to ON by the ▷ key , and ON changes to OFF by the ◁ key.

⑤ Save memory setting mode When the MENU LED lights and the SAVE is displayed, at the top right of the CRT the save memory can be selected.



The setting can be done by the SELECT MENU ◁ ▷ keys.
The mode changes from ALT to SA to SB to ALT by the ▷ key.
The mode changes from ALT to SB to SA to ALT bu the ◁ key.
When the VERTICAL MODE switch is ALT or CHOP, the CH1 waveform is saved in the save memory A and at same time ,the CH2 waveform is saved in the save memory B without this mode.

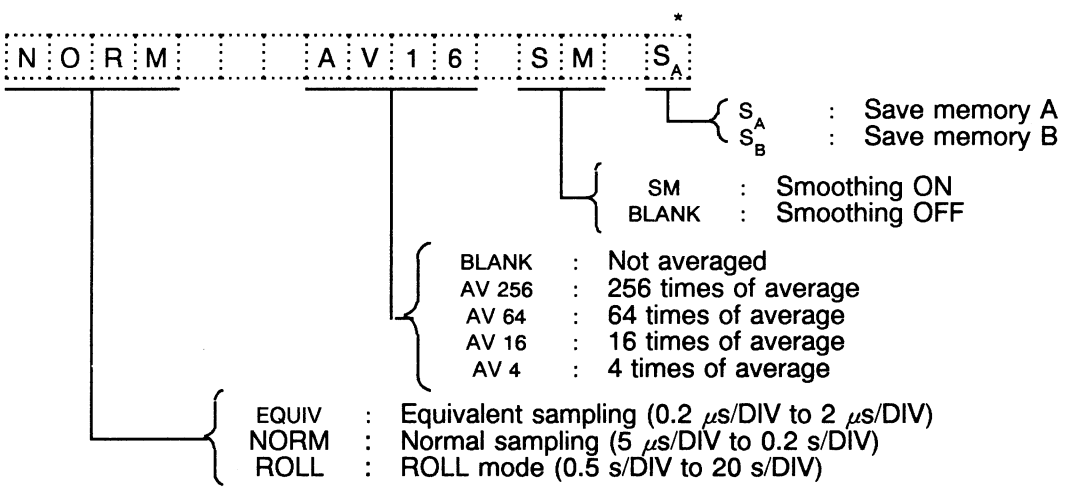
⑥ Probe factor setting mode
When the MENU LED lights and the PROBE is displayed at the top right of the CRT, the probe factor can be selected



The setting can be done by the SELECT MENU ◁ ▷ keys.
The probe factor changes from X10 to X1 by the ◁ key.
The probe factor changes from X1 to X10 by the ▷ key.

(10) Menu display in the modes other than MENU

In the modes other than MENU, the setting information of the number of average, the interpolation method and the smoothing is displayed as follows.



*When SA is displayed, save memory A saves the waveform, and when SB is displayed, save memory B saves the waveform.

(11) Measurement of X-Y waveform

1. Set the VERTICAL mode to CHOP or ALT.
2. Connect the X-axis signal (horizontal axis signal) and the Y-axis signal (vertical axis signal) to CH1 INPUT and CH2 INPUT, respectively.
3. Display the sampling waveform on the screen.
4. Hold the waveform by the HOLD switch.
5. Set the TIME/DIV switch to X-Y. The X-Y waveform in the STORAGE mode is now measured.

Notes:

1. Push in the horizontal axis X10 MAG switch (PULL X10 MAG knob).
2. The X-Y mode is not established when the HOLD mode is not established or when the VERTICAL mode is set to a mode other than CHOP or ALT (sampling is beld).
3. When the TIME/DIV switch is switched between X-Y and S/DIV quickly at the horizontal ×10MAG mode and at SIN or LIN intepolation mode, it may take 2 or 3 seconds until the corresponding mode is established.

8.4 General Measurement

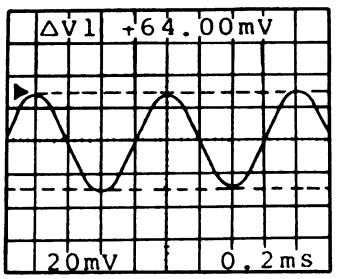
(1) Voltage measurement

① △V cursor measurement

The measurable area by the △V cursors is 3 divisions above and below the center horizontal graticule line.

Set the VOLTS/DIV switch so that a waveform is within the area.

When a signal including a DC component is measured in the DC coupling mode, adjust the POSITION control so that the GND trace is within the measurable area.



△ cursor

REF cursor

When the △V is selected by the △V-△T-1/△T switch, two horizontal cursors appear on the CRT. The voltage between the reference cursor and the △ cursor is displayed with "△V" on the upper side of the CRT. The voltage becomes "+" when the △ cursor is above the reference cursor, while it is "−" when the △ cursor is below the reference cursor.

The cursor selected by the REF.△. TRACKING switch is moved up or down by the SELECT MENU △ ▽ keys.

Pressing the △ key moves the cursor (displayed by ▷) up.

Pressing the ▽ key moves it down. Therefore, the voltage between two cursors can be measured. To measure the voltage from the GND line, press the GND switch to display the GND line, and align the reference cursor with the GND line.

Switch the input coupling mode to DC, and align the △ cursor with the level to be measured.

NOTES:

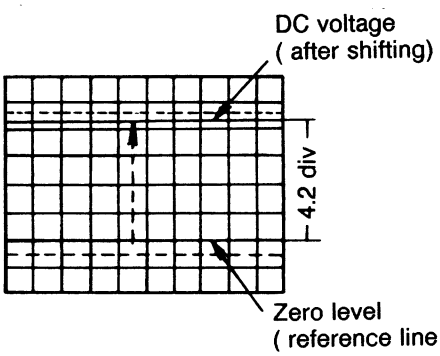
a) When the ALT mode or the CHOP mode is selected in the REAL TIME mode, the measurement value of CH1 (△V1) is displayed.

b) The measurement value is displayed in divisions when the VAR function is used. (UNCAL state, CRT display: >)

c) In X-Y mode, the △V cursor can not be selected.

d) The resolution of the △V cursor is 100 points/div in the REAL TIME mode and 25 points/div in the RECALL mode. Consequently, the measured data is slightly different from the REAL TIME mode to the STORAGE mode.

② Visual measurement



Set the AC-GND-DC switch to GND and obtain the base-line trace.

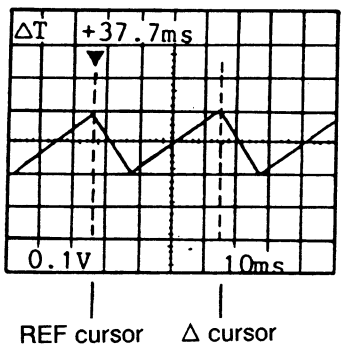
Set the AC-GND-DC switch to DC and set the VOLTS/DIV switch to obtain an optimum amplitude waveform. Since the trace shifts by the amount of DC voltage, the DC voltage of the signal can be obtained by multiplying the shift by the indicated value of VOLTS/DIV. When VOLTS/DIV is 50 mV/DIV, then 50 mV/DIV x 4.2 = 210 mV (However, if the 10X probe is in use, the true value of the signal becomes 10 times the value, it will be 50 mV/DIV x 4.2 x 10 = 2.1 V).

(2) Time and frequency measurement

① △T cursor measurement

When the △V, △T, 1/△T key is pressed, the △V cursor appears on the CRT.

When the key is pressed again the △T can be selected, △T cursor measurement value will be displayed with vertical cursors on the upper side of the CRT.



The measurable area by the △T cursor is 4 divisions to each side from the center vertical graticule line.

Set the TIME/DIV switch so that the desired portion of a waveform is as large as possible.

The cursor selected by the REF ·△· TRACKING switch can be shifted left or right by the SELECT MENU ◁ ▷ keys. Pressing the ▷ key moves the cursor right and pressing ◁ key moves it left.

NOTES:

a) In the X-Y mode, the △T cursor measurement can not be selected.

b) The measurement value is displayed in divisions when the SWP VAR function is need. (UNCAL state, CRT display: >)

② 1/△T cursor measurement

When the △V, △T, 1/△T key is pressed, two cursors will appear on the CRT.

Then, press the key twice, and 1/△T is displayed on the upper side of the CRT.

When the two cursors are set to the one period position of the measured waveform by the SELECT MENU ◁ ▷ key, the reciprocal number of the time between two cursors is displayed with 1/△T on the upper side of the CRT.

NOTES:

a) In X-Y mode, the 1/△T cursor measurement cannot be selected.

b) The measurement value is displayed in divisions when the SWP VAR function is vsed. (UNCAL state, CRT display: >)

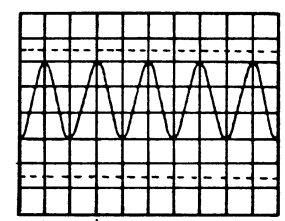
③ Visual time measurement

The illustration shows one period of time between A and B, which represents 2.0 DIV.

When the sweep time is 1 ms/DIV, the period is given by

1 ms/DIV x 2.0 = 2.0 ms

(2.0 x 10^{-3}s)



Time A Time B

④ Visual frequency measurement

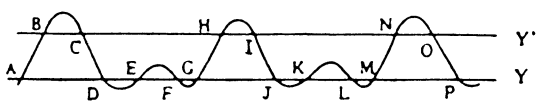
The above result, 2.0 ms (2.0 x 10-3s), is converted so that the frequency is given by 1/ (2.0 × 10^{-3}) = 500Hz

(3) How to trigger

① Operation of the TRIGGER LEVEL control

In the case shown in Fig. (a) where waveforms are greatly different in amplitude, the waveform is doubled if the TRIGGER LEVEL control is not set properly. In the case where the trigger level is selected by line Y, two waves, one starting with A, advancing to B, C, D, E, F, . . . and the other starting with E, advancing to F, G, H, I . . . , will appear alternately on the screen. They will be doubled as shown in Fig. (b).

In such a case, rotate the LEVEL control clockwise until the trigger level comes to Y' line. Then the waveform on the screen becomes the one as shown in Fig. (c) which starts with B and advances to C, D, E, F, . . . and allows triggering.



Y' Trigger level

Y Setting line

(a) Signal waveform

(b) When the trigger setting level is Y

(c) When the trigger setting level is Y'

Triggering of complex waveforms

② Synchronization of observing two waveforms

a) When two signals of CH1 and CH2 have same frequencies or the frequencies of an integral number or the frequencies in a relation of a specific time difference, the INT TRIG switch selects either CH1 or CH2 as a reference signal. CH1 position selects CH1 signal as a reference, and CH2 position selects CH2 signal.

b) For an observation of signals of different frequencies, set the INT TRIG switch to the VERT MODE. The sync signal switches at each alternation of channels, and the waveform of the each channel is stably triggered.

SELECTION OF A TRIGGER SOURCE ON THE VERT MODE

A. Trigger signal is obtained in the following steps.

1) Set the SOURCE switch ⑲ to INT.

2) Set the INT TRIG switch ⑳ to VERT MODE.

3) Select the MODE switch ⑭.

Table 8-2

SOURCE		INT			LINE	EXT
INT TRIG		CH1	CH2	VERT MODE	Line	External
V MODE	CH1	CH1	CH2	CH1		
	CH2	CH1	CH2	CH2		
	ALT	CH1	CH2	CH1 CH 2(ALT)		
	CHOP	CH1	CH2	ADD		
	ADD	CH1	CH2	ADD		

When the SOURCE swich to INT, INT TRIG switch to VERT MODE, and MODE switch to ALT, the input signals applied to CH1 and CH2 become trigger source alternatively at each sweep.

Consequently, even for an observation of two waveforms of different frequencies, the waveform of the each channel is stably triggered. In this case, the signal should be applied to both CH1 and CH2, and the two signals have the same level portion in excess of the rated amplitude each other. There should be a common portion of levels available that is above the rated amplitude of CH1 and CH2.

When a sinewave is applied to CH1, and a square wave is applied to CH2, "A"s in Fig. 8-1 are the levels possible for synchronization.

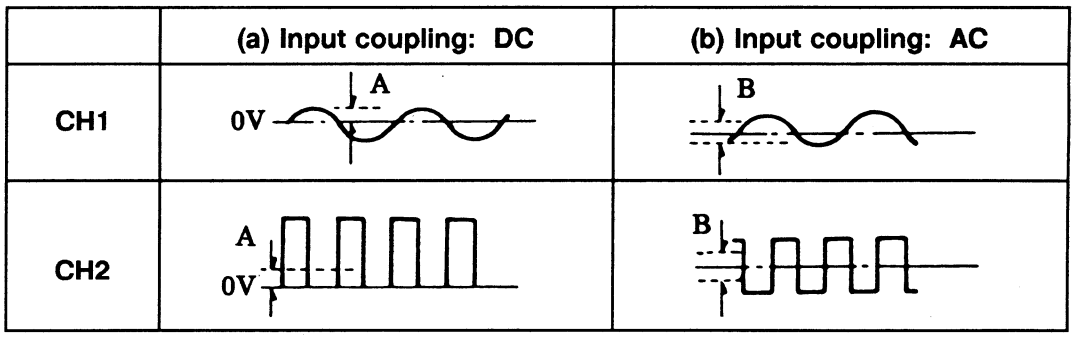


Fig. 8-1

In order to expand the synchronization range, AC coupling is applied to the CH2 side.

When either the CH1 or CH2 input signal is smaller as shwon in Fig. 8-2, adjust the VOLTS/DIV switche ⑩ to obtain sufficient amplitudes.

The VERT MODE triggering requires 1.5 div more than the amplitude required for an observation of CH1 or CH2.

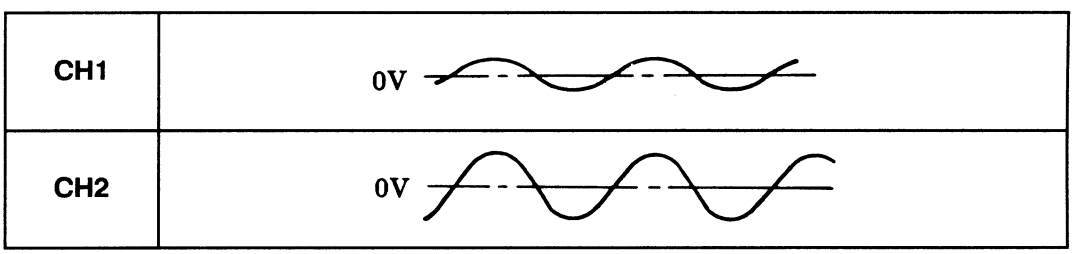


Fig.8-2

The VERT MODE triggering is not possible when the signal is applied only one channel as illustrated on Fig.8-3.

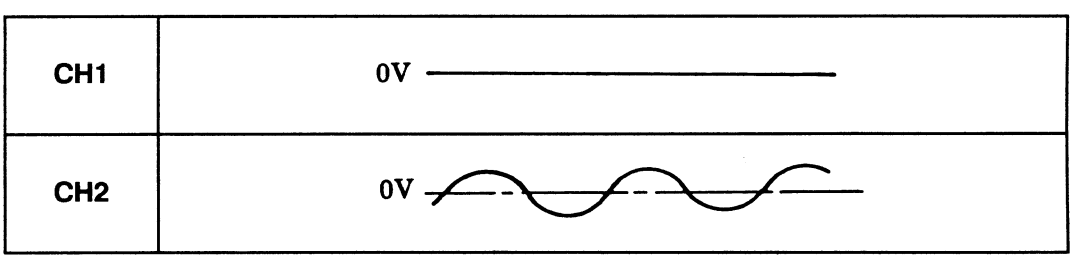


Fig.8-3

Note:

Do not use the INT TRIG to the VERT MODE when PULL x5 GAIN 11 is in the pulled out position (x5 GAIN mode).

ALTERNATE TRIGGER

Jittering wave may appear on the screen when a gently-sloping signal is displayed by approximately 10 cycles or less, with the

VERT MODE for the INT TRIG switch and the ALT position for the MODE select switch. For detailed and clear observation of each signal, set the MODE select switch to the CH1 or CH2.

③ How to use TV exclusive synchronization

a) On the image waveform of TV

In the work concerned with TV, complexed signals containing videosignal, are often measured. However, since the waveform is complexed, a special circuit is needed to effect a stable synchronization with vertical waveform.

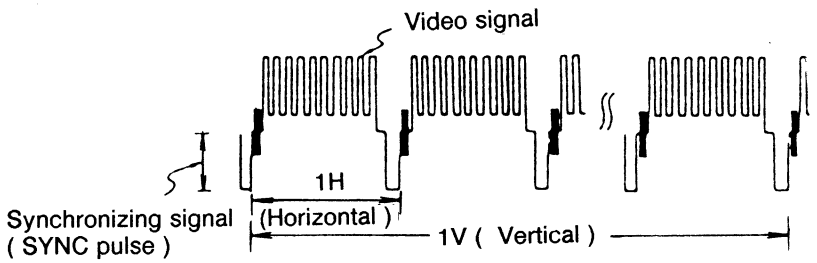
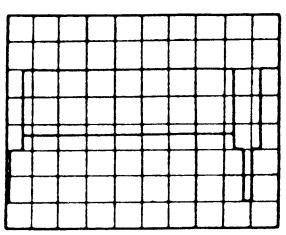


Fig. 8-4

b) Operation

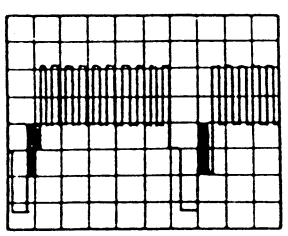
To observe vertical signal



MODE : TV-V
TIME / DIV
0.1ms/DIV~0.2s/DIV

Fig. 8-5

To observe horizontal signal

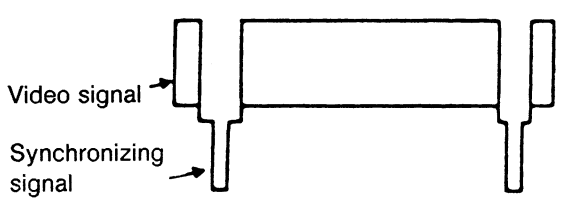


MODE : TV-H
TIME / DIV
50μs/DIV~0.2μs/DIV

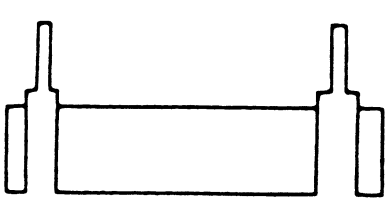
Fig. 8-6

Note: This oscilloscope synchronizes with only (–) synchronizing signal.

(Reference)



(a) Example of (–) synchronization signal



b) Example of (+) synchronization signal

(4) Measurement of the waveform before the trigger point (PRETRIGGER)

Although a conventional oscilloscope displays the trigger point only at the left end of the screen since the sweep starts at the trigger point of the signal, the instrument can display the trigger point anywhere on the scren in 0.1 div steps, using the PRETRIGGER function in the STORAGE mode so that it is possible to measure the waveform before trigger point precisely.

(a) When the MENU mode is OFF, the position of the trigger point is displayed (div)

(b) The position of the trigger point is set by the SELECT MENU◁ ▷keys.

(c) Example:

In the case of 4.0 div setting, the signal before the rising edge of the waveform (the triggered point) can be observed as shown below.

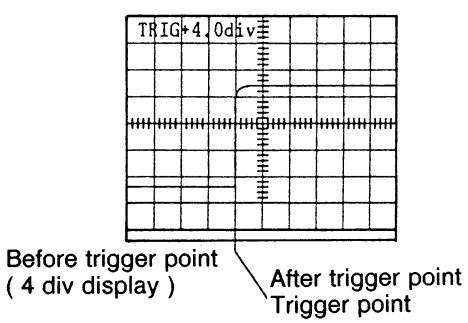


Fig. 8-7

(5) DC OFFSET

① Ptinviplr og DC OFFSET

The ocilloscope (VC-6024 only) provides the DC offset voltage display of ±1 to ±100V according to the range. An output terminal for voltage reading. (Except : x5 GAIN, out of CAL) See Fig. 8-8 for the function of the DC OFFSET.

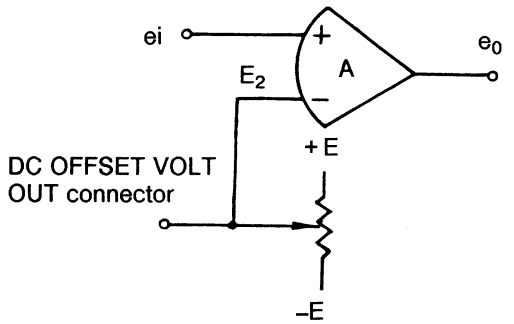


Fig. 8-8 Principle of DC OFFSET

There if following relation among the differential amplifier output voltage eo, the input voltages ei and E2.

$e_o = A (e_i - E_2)$

$e_i = E_{DC} + e_{AC}$

(Where E_{DC} is a DC input and e_{AC} is an AC input)

Set the controls so that $E_2 = E_{DC}$ is attained. Then $e_o = A \times e_{AC}$ is obtained.

The DC component can be removed for an observation.

OFFSET voltage ranges

VOLTS/DIV	DC OFFSET voltage
5mV/DIV~50mV/DIV	more than ±1V (×1)
0.1V/DIV~0.5V/DIV	more than ±10V (×10)
1V/DIV~5V/DIV	more than ±100V (×100)

When measured with a DMM connection, multiply the DMM reading by the multiplier written above in indentaion ( ).

② Measurement by the DC OFFSET function

In order to readout the voltage level digitally, connect a DMM (digital multimeter) to the DC OFFSET output terminal and set the oscilloscope to the

DC OFFSET mode. See Fig. 8-9.

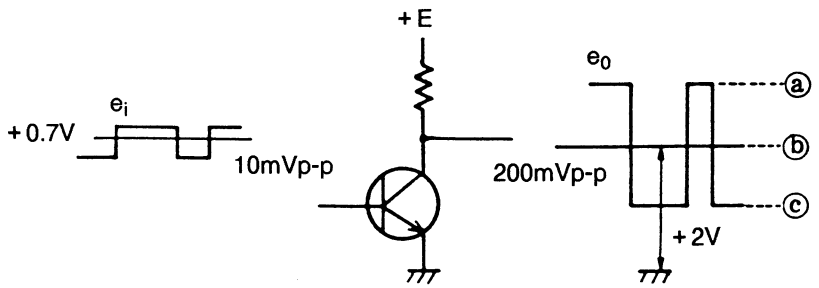


Fig. 8-9 Transistor amplifier

(a) Measuring DC component

Align level ⓑ with the center graticule and read the DMM digital value. (+2V should be displayed.)

(b) Measuring AC component

When the above is performed with an input sensitivity of 50mV, then 4 div of amplitude must be present on the oscilloscope screen.

The AC component is observable on the oscilloscope screen where as the DC component is measurable an a DMM, and there is no need for any complicated switching as such needed for conventional oscilloscopes.

Moreover, the DC OFFSET function provides readings of peak to peak value (p-p) of e_0 on a DMM.

Align level ⓐ with the center graticule line on the screen, read the DMM value and name it V(a). Then align level ⓒ with the graticule line and readout V(c). The p-p the difference between V(a) and V(c), and the value can be read digitally on the DMM.

As explained above, the DC OFFSET function with DC OFFSET output terminal offers an improved operational convenience and a highly accurate measurement in detaild waveform portions.

9. DIGITAL PLOT OUTPUT TO THE X-Y PLOTTER

All the data displayed on the screen is output to the X-Y plotter only by connecting this instrument and the X-Y plotter with the RS-232C cable.

The operation of the instrument is described below.

For the operation of the X-Y plotter, refer to the operation manual attached to the plotter.

9.1 Applicable X-Y Plotter

Hitachi Graphic Plotter 681-XA (RS-232C specifications) or completely compatible unit.

9.2 Specifications of Plot

(1) Letters and cursor

All the letters and cursor displayed on the screen are plotted.

(2) Waveform data

All the waveform data displayed on the screen is plotted.

The waveforms of the horizontal axis of 10 divisions and the vertical axis of 10 divisions are plotted. In the magnification mode, the magnified portion only is plotted.

(3) Grids and scale

The grids of the horizontal axis of 10 divisions and the vertical axis of 8 divisions are plotted. The scale of 0.2 div unit on the horizontal and verticalcenter greds is plotted.

(4) Screen mode

The four screen modes are selectable by setting the DIP switches on the rear.

For details, refer to item 9.4 setting.

(5) Pen replacement

Replacement of pens can be designated by the DIP switches on the rear.

For details, refer to item 9.4 setting.

(6) Examples of plot

Figs. 9-1(a) thru 9-1(d) illustrate examples of the plot output.

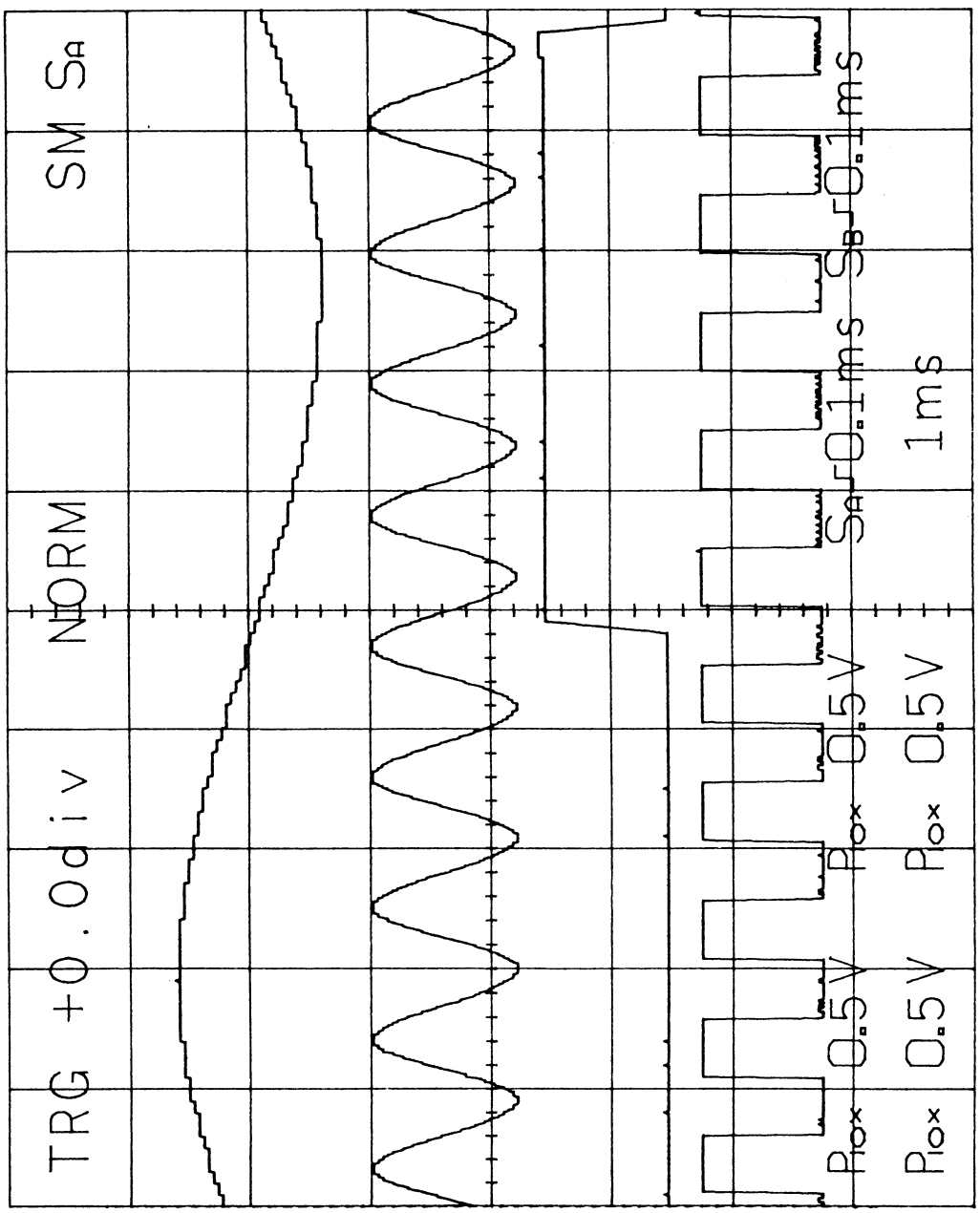
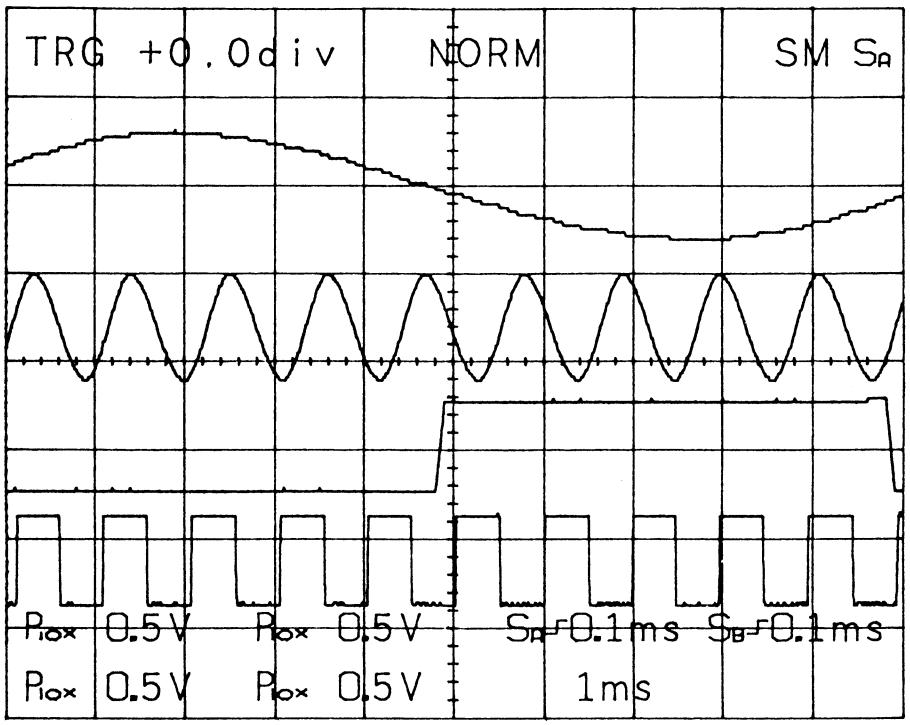


Fig. 9-1(a) Plot output display 1



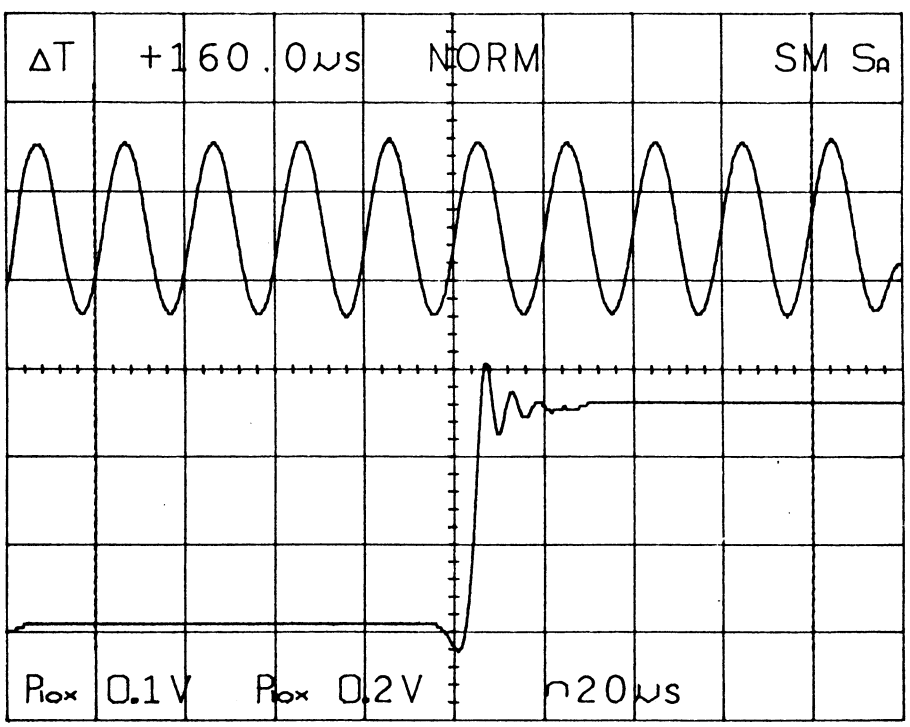


Fig. 9-1(b) Plot output display 2

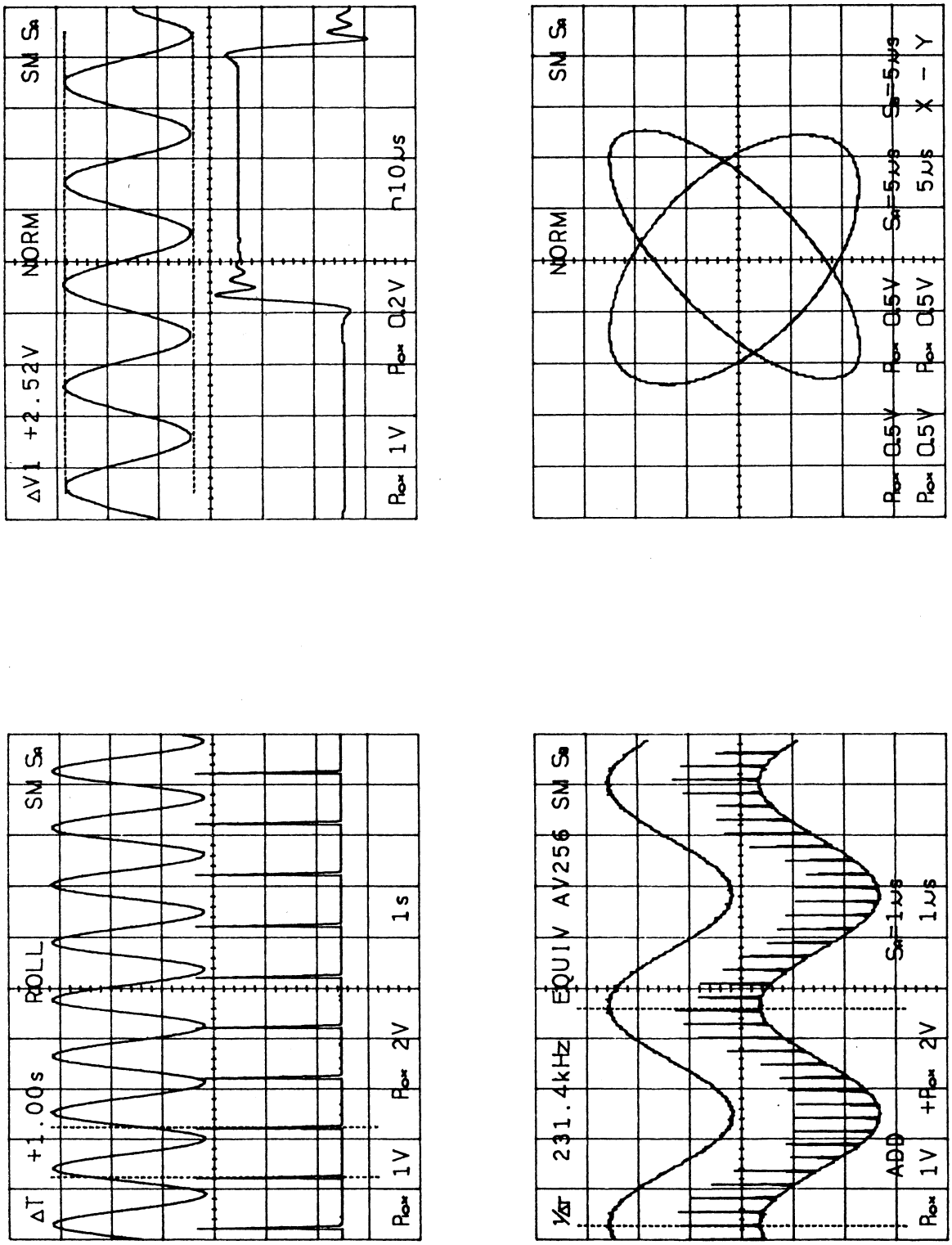
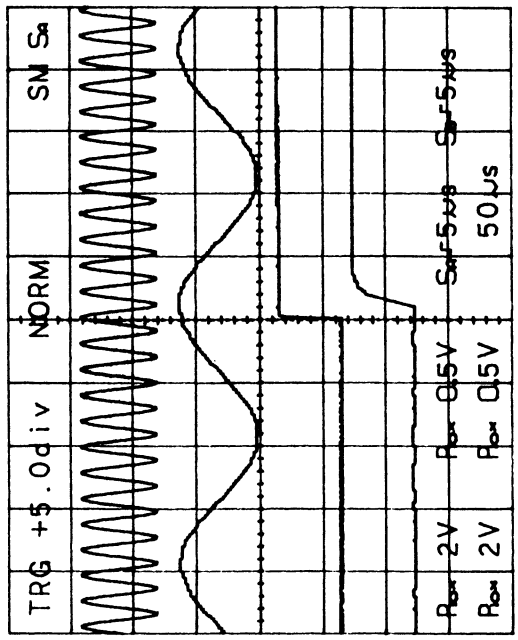


Fig. 9-1(c) Plot output display 3



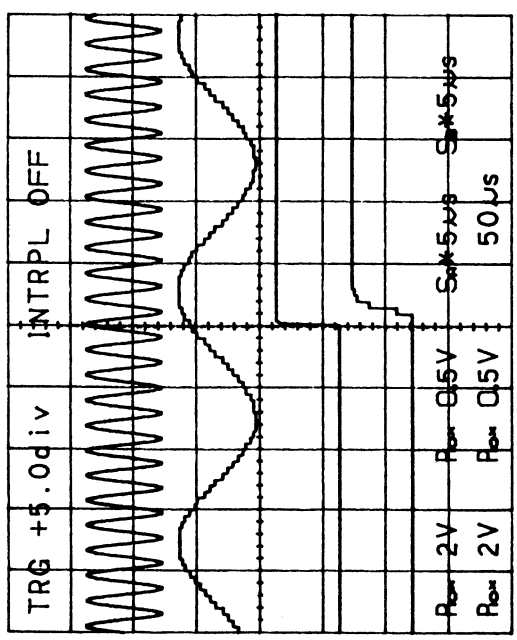


Fig. 9-1(d) Plot output display 4

9.3Connection

Connect the connector on the rear with a X-Y plotter by the RS-232C interface cable.

Prior to connection of a plotter, read the related manual carefully and use the appropriate interface cable, because interface is changed in accordance with types of plotter.

Fig. 9-2 illustrates the wiring of the RS-232C interface cable used for the connection of the Hitachi Graph Plotter 681-XA and the instrument.

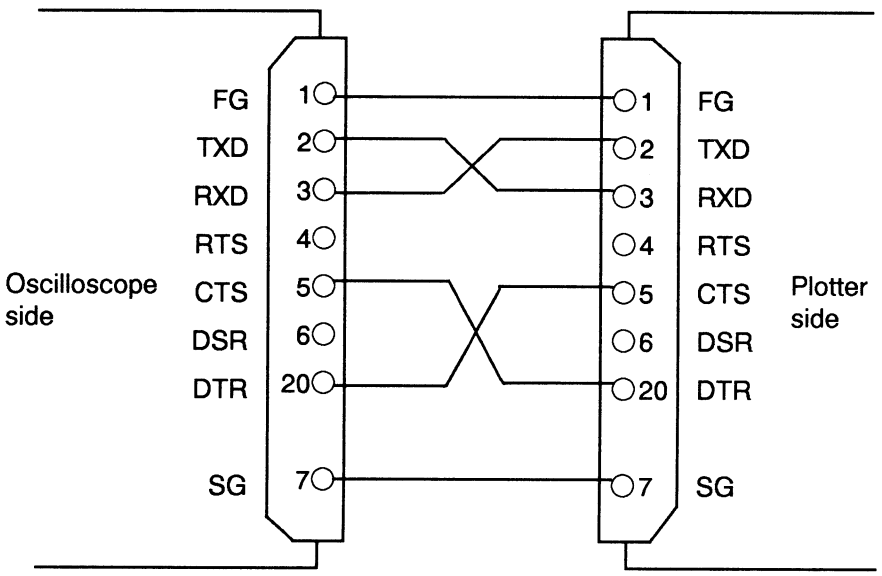
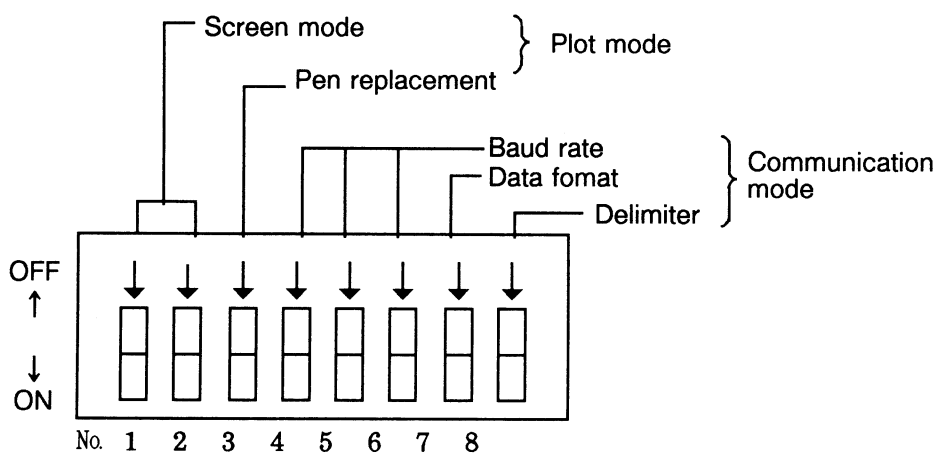


Fig. 9-2 Wiring diagram of the RS-232C interface cable

9.4Setting

Set the plot mode and the communication mode by the DIP switches on the rear.



(1) Plot mode

(a) Screen mode setting

The screen size can be set by Nos. 1 and 2 of the DIP switches, and one of the modes listed in Table 9-1 is selected.

Table 9-1 Screen mode setting

Screen mode	DIP switches No.1	DIP switches No.2	Content	Screen size (mm)
1	ON	ON	One screen is plotted on a sheet of A4 size paper.	170mm × 170mm (Refer to Fig. 9-1(a).)
2	ON	OFF	Two screens are plotted on a sheet of A4 size paper.	120.8mm × 120.8mm (Refer to Fig. 9-1(b).)
3	OFF	ON	Four screens are plotted on a sheet of A4 size paper.	85mm × 85mm (Refer to Fig. 9-1(c).)
4	OFF	OFF	Two screens are plotted on a sheet of A4 size paper.	85mm × 85mm (Refer to Fig. 9-1(d).)

(b) Pen replacement setting

The pen replacement can be set as listed in Table 9-2 by No. 3 of the DIP switches.

Table 9-2 Pen replacement setting

DIP switches No. 3	Pen replacement
ON	No
OFF	Yes

When No. 3 of the DIP switches is OFF, six kinds of colors can be used for the contents of plot.

Table 9-3 lists the contents of plot and the corresponding pen numbers.

For the plotter whose usable pens are six or less, the corresponding pen numbers are different. In case of the Hitachi graph plotter 681-XA the pen numbers are listed in parentheses.

Table 9-3 Contents of plot and corresponding pen

Contents of plot			Pen number
Grid and scale			1
Wave-form		CH1	3
		CH2	4
		SAVE A	5 (1)
		SAVE B	6 (2)
Cursor			2
Characters	VOLTS DIV	CH1	3
		CH2	4
		SAVE A	5 (1)
		SAVE B	6 (2)
	Time range	sweep	1
		SAVE A	5 (1)
		SAVE B	6 (2)
	Others		1

(2) Communication mode

Set the baud rate and the data format according to the specifications and applications of the plotter.

The same baud rate and data format must be set to the instrument and the plotter.

(a) Baud rate setting

The baud rate of the RS-232C interface can be set as listed in Table 9-4 by Nos. 4-6 of the DIP switches.

Table 9-4 Baud rate setting

DIP switches			Baud rate
No.4	No.5	No.6	
ON	ON	ON	300 baud
ON	ON	OFF	600 baud
ON	OFF	ON	1200 baud
ON	OFF	OFF	2400 baud
OFF	ON	ON	4800 baud
OFF	ON	OFF	9600 baud
OFF	OFF	ON	9600 baud
OFF	OFF	OFF	9600 baud

(b) Data format setting

The data format of the RS-232C can be set as illustrated in Table 9-5 by No. 7 of the DIP switches.

Table 9-5 Data format setting

DIP switches	Data format
No. 7	
ON	START BIT + 8BIT + 1STOP BIT
OFF	START BIT + 8BIT + 2STOP BIT

(c) Setting of delimiters

The delimiters needed for the data transfer with the personal computer through the RS-232C can be set, as listed in Table 9-6, by changing the No. 8 of the DIP switches. As the delimiters are not added in the digital plot output mode, this setting is not needed.

Table 9-6 Setting of delimiters

DIP switches	Delimiters
No. 8	
ON	C/R L/F
OFF	C/r

NOTE:

As for the communication mode setting, check the settings of the DIP switches before turning on the instrument.

When changing the settings of the DIP switches for the communication mode, change the settings first and then turn on the instrument.

9.5 Operation

(1) Execution of plotting

When the instrument is in the HOLD mode, press the [PLOT] switch. Then, the plotting starts immediately. While the plotting is being executed, the red lamp lights.

When the plotting finishes, the lamp goes off.

(2) Release of plotting operation

When the [PLOT] switch is pressed again during the plotting operation, the plotting operation stops in the course of plotting.

Thus an unnecessary plotting operation can be stopped.

9.6 RS-232C Interface

The instrument is provided with the RS-232C as a standard function. With this function, it is possible to perform the control by a personal computer, and input and output the waveform data to the computer. These communication functions can not be used with the output function to the X-Y plotter.

Do not execute the X-Y plotter output function (plot output by the PLOT switch) when using the communication function.

9.7 Major Causes of Troubles

When the X-Y plotter does not operate normally, check the above items.

(1) Cable is poorly connected or not connected.

(2) The power of the X-Y plotter if off.

(3) The X-Y plotter is not in the LISTEN ONLY mode, or in the error state. (See the operation manual of the X-Y plotter.)

(4) The instrument is not in the HOLD mode.

(5) The baud rate and data format are not set correctly. (Turn off the power and set them correctly. See item 9.4 (2).)

(6) The interface cable in use is not correct.
(See item 9.3.)

(7) Notes on plot interruption
To prevent a possible mis-operation of the plotter, the instrument transmits the initialize commands the instrument transmits the initialize commands ("ESC.K", "ESC.R") of the X-Y plotter prior to the start of plot.
When the plotter which does not accept these commands is used, mis-operation may be caused. If plotting is interrupted, turn off the X-Y plotter, and then turn on it to initialize the plotter. Thus proceed the plot.

NOTE: Be sure to use the X-Y plotter applicable to the HP-GL commands.

10. RS-232C

10.1 General

The RS-232C is the serial communication interface standardized by the Electronic Industries Association in the United States of America. This instrument and receive digital data through the RS-232C interface.

10.2 Specifications

(1) Electrical: conforms to the EIA RS-232C
(2) Type of transmission: Asynchronous
(3) Length of stop bit: 1 bit/2 bits
(4) Character length: 8 bits
(5) Party bit: Inhibit
(6) Delimiter: C/R L/F or C/R
(7) Transmission rate: 300, 600, 1200, 2400, 4800, or 9600 baud
(8) Communication protocol: Hard-wired handshake

10.3 Connector Pin Arrangement and Signal Description

(1) Fig. 10-1 illustrates the pin arrangement of the RS-232C connector, and Table 10-1 lists the pin functions.

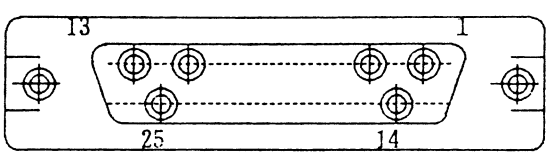


Fig. 10-1 Pin arrangement

NOTE: Connector DB-25P (female) applicable for connection cable is used.

Table 10-1 Terminals of the RS-232C connector

Pin No.	Signal	Function	Direction of signal
1	FG (AA)	Frame GND	
2	TXD (BA)	Transmit data	OUT
3	RXD (BB)	Receive Data	IN
4	RTS (CA)	Request to Send	OUT
5	CTS (CB)	Clear to Send	IN
6	NC	Non Connect	
7	SG (AB)	SignaL GND	
8	NC	Non Connect	
9	〃	〃	
10	〃	〃	
11	〃	〃	
12	〃	〃	
13	〃	〃	
14	〃	〃	
15	〃	〃	
16	〃	〃	
17	〃	〃	
18	〃	〃	
19	〃	〃	
20	〃	〃	
21	〃	〃	
22	〃	〃	
23	〃	〃	
24	〃	〃	
25	NC	Non Connect	

(2) Each signal of the RS-232C interface is described below.

① FG: Frame Ground
Ground line for chassis.

② TXD: Transmit Data
Transmit data output signal.
Normally in the mark state *1
*1 -9 V level "0" (space)
+9 V level "1" (mark)

③ RXD: Receive Data
Receive data input signal.
Normally in the mark state *1

④ RTS: Request To Send
This output signal indicates the request-to -send state.
This signal is used to control the transmission function of data transfer at the modem transmission section.
"0" (space): Carrier transmission request
"1" (mark): Carrier stop request

⑤ CTS: Clear To Send
This input signal controls the modem transmission section.
This signal becomes in the mark state when the modem transmission section is in the Clear-To-Send state.

⑦ SG: Signal Ground
Ground line for signal.

10.4 Connection

Connect the instrument with a personal computer by the RS-232C interface cable. Prior to connection of a personal computer, read the related manual carefully and use the appropriate interface cable, because interface is changed in accordance with types of personal computers.

Fig. 10-2 illustrates the wiring of the RS-232C interface cable used for the connection of the Hitachi personal computer B-16 and the instrument.

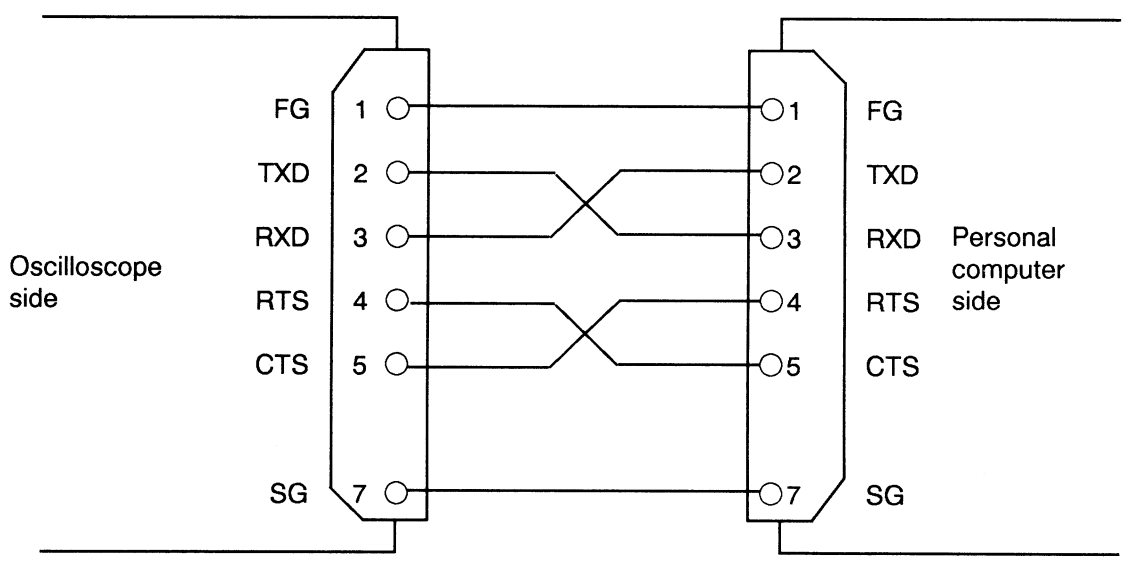


Fig. 10-2 Wiring diagram of the RS-232C interface cable

10.5 Operating Functions and Function Commands

Various operations can be performed under an appropriate program on a personal computer when the instrument is connected with the personal computer, using the RS-232C interface.

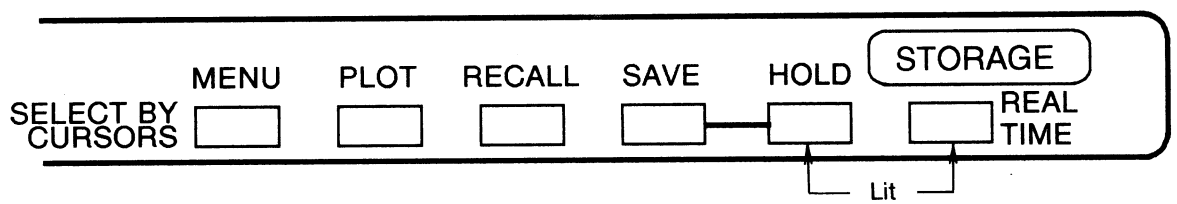
Function commands are the commands which designate operations to be executed by the instrument from the program.

A highly versatile automatic measuring system can be constituted by programming the operations in sequence at the personal computer.

Functions and function commands available through the RS-232C are described below.

(1) Panel setting

To operate the instrument from the personal computer, set the instrument to the STORAGE mode and the HOLD state. Check that the STORAGE mode setting switch LED and the HOLD LED on the front panel are lit.



(2) Operating functions

① Sampling start function

The controller can start the following sampling operation.

The single operation of the normal sampling is performed only once.

However, the single operation is not performed in the ROLL mode.

When receiving this command, the instrument makes the normal sampling of the waveform data equivalent to the data of one whole picture.

When all the data is prepared, the waveform on the CRT is updated and the instrument returns to the HOLD state.

Also, the sampled waveform data acquired by the above procedure can be transferred to the controller using the waveform data transmitting function ②.

② Waveform data transmission function

The instrument has the following six data memories:

CH1 acquisition memory which stores the CH1 waveform data

CH2 acquisition memory which stores the CH2 waveform data

Two save memories (SAVE A and SAVE B)

CH1 display memory

CH2 display memory

Each of the CH1 and CH2 acquisition memories has the capacity of loading 1024 or 2048 data in accordance with the sample mode. Each of the two save memories, and CH1 and CH2 display memories has the capacity of loading 1024 data.

The waveform data can be transmitted to the personal computer from any of these memories. The data in the CH1 and CH2 acquisition memories can not

be read in the average mode. The acquisition memory which is invalid in the HOLD mode, eq. the CH2 acquisition memory at the time when the VERTICAL MODE switch is set to CH1, can not be read.

Table 10-2 Sampling mode and acquisition memory capacity

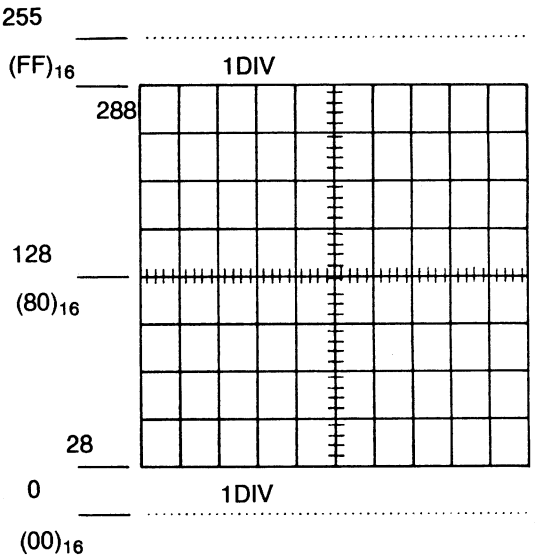
Input mode	Sample mode	Acquisition memory capacity
V MODE = DUAL or H MODE = X-Y	ROLL *1	2048
	NORM	2048
	EQUIV	1024
Other than above	ROLL *1	2048
	NORM	2048
	EQUIV	1024

Note 1: Average is not executed in the ROLL mode.

The number of the data which is transferred at one time can be selected appropriately whthin the range of the memory capacity. Either the decimal ASCII system or the binary system can be selected as the data transfer format.

The waveform data of each memory is 8 bits, i.e., 0 to 255 for the decimal system and (00)16 to $(FF)_{16}$ for the hexadecimal system. These data ranges correspond to 10 vertical divisions of the CRT screen.

The data of the center horizontal graticule line is 128 ((80)16 for the hexadecimal system). The data zero ((00)16 for the hexadecimal system) corresponds to the position one division lower than the bottom graticule line. The data 255 ((FF) 16 for the hexadecimal system) is equal to the position one division higher than the top graticule line.



③ Transmission function of the measuring condition data

The instrument stores the data of the measuring conditions under which the data loaded in the memories was sampled. By the command from the personal computer, the measuring condition of a waveform in a certain memory can be transmitted.

Data is transmitted as a whole at a time of transfer. A specific data alone cannot be transmitted. The data format of the measuring conditions conforms to the ASCII system.

④ Reception function of the waveform data

The contents of the SAVE memory A and the SAVE memory B can be changed by the waveform data from the personal computer.

Set the RECALL switch to ON so that the rewritten data is displayed on the CRT.

⑤ Reception function of measuring condition data

The measuring condition data from the personal computer can be registered as the data for the waveform of the SAVE memory A or the SAVE memory B.

When the RECALL switch is turned to on, the data on VOLTS/DIV and TIME/DIV is displayed on the CRT.

⑥ Parameter calculation function

The following parameters can be calculated for any of the four memory waveform data CH1 acquisition memory, CH2 acquisition memory, SAVE A and SAVE B.

a) Maximum value

b) Minimum value

c) Mean value

⑦ Transmission function of parameters

The calculated results of the above calculation can be transmitted.

10.6 Format of Transfer Data

The arrangement format of the transferred data according to the function command is shown below. (Each function command and format are shown in Table 10-3.)

(1) Transmitting format of the waveform data

After reveiving the Ri command (i = 1 to 6), the instrument transmits the waveform data according to the following format. For details of each item, refer to Table 10-4.

- ASCII system

#	i	@	,	m	m	m	m	,	n	n	n	n	,	D1	,	D2	,	D3	,			,	DN	,	S.C	DEL

- Binary system

#	i	@	,	m	m	m	m	,	n	n	n	n	,	D1	D2	D3		DN	S.C	DEL

(2) Receiving format of the waveform data

After reveiving the Ri command (i = 1 to 4), the instrument transmits the waveform data according to the following format. For details of each item, refer to Table 10-4.

- ASCII system

#	i	@	,	m	m	m	m	,	n	n	n	n	,	D1	,	D2	,	D3	,			,	DN	,	DEL

- Binary system

#	i	@	,	m	m	m	m	,	n	n	n	n	,	D1	D2	D3		DN	DEL

The comma (,) is a delimiter code.

The format of DEL is C/R L/F or C/R. For the setting, refer to item 9.4 (2). In the binary system, D1 to DN and S.C are the binary data and the others are ASCII code data. A delimiter code is not used among each data from D1 to DN. Do not add the sum check to the receiving format of the waveform data.

(3) Transmitting and receiving format of measuring condition data

After the instrument receives the R0 command, the measuring condition data of the prescribed memory waveform is sent according to the following format.

For details of each item, refer to Table 10-5.

Also, when the instrument receives the W0 command, it receives and registers the data sent according to the following format as the measuring condition data of the prescribed SAVE memory.

#	i	@	,	V.M	,	H.M	,	A.T	,	B.T	,	V.C	,	P.F	,	V.D	,	D.T	,	N.S	,	S.C	DEL

"i" indicates the memory number which is the same as "i" of the commands R0(i).
Do not add the sum check to the receiving format of the measuring condition data.

(4) Transmitting format of parameters

When the instrument receives the commands G1 to G3, the parameters of the waveform data of the prescribed memory is sent according to the following format.

- Minimum value

#	i	@	,	M	A	X	,	X	X	X	,	S.C	DEL

"i" is the memory number. The instrument transmits the parameters by adding the i data designated by the G1 (i) command.

XXX is the ASCII code data with the maximum value data of 3 digits in the decimal system.

- Minimum value

#	i	@	,	M	I	N	,	X	X	X	,	S.C	DEL

"i" is the memory number. The instrument transmits the parameters by adding the i data designated by the G2 (i) command.

XXX is the ASCII code data with the minimum value data of 3 digits in the decimal system.

- Mean value

#	i	@	,	A	V	R	,	X	X	X	,	S.C	DEL

"i" is the memory number. The instrument transmits the parameters by adding the i data designated by the G3 (i) command.
XXX is the ASCII code data with the mean value data of 3 digits in the decimal system.

The sum check (S.C) and the delimiter (DEL) are the same as the transmission of the measuring condition data. Refer to Table 10-5.

Table 10-3 Function Commands (1/3)

<table>
<tr><th>No.</th><th>Function</th><th>Commands</th><th>Contents</th><th>Transmitting format</th></tr>
<tr><td>1</td><td>Sampling Norm single</td><td>S1 command</td><td>●Performs the single operation under the measuring condition which is previously set, and orders the command to retain the waveform data on the display memory.</td><td>S | 1 | DEL</td></tr>
<tr><td>2</td><td>Waveform data transmission</td><td>Ri command</td><td>●Designates the transfer of the waveform data stored in the Memory i by the data number (nnnn) with the address data (mmmm) at the head.
●Either the ASCII system or the binary system can be designated as the transmission method by X in the right column.
●The personal computer receives the prescribed data after transmitting this command.
●For the acquisition memory capacity, refer to Table 10-2.</td><td>R | i | (| m | m | m | m | , | n | n | n | n | , | x |) | DEL
●“i” indicates the memory number.
<table><tr><th>i</th><th>Memory</th></tr><tr><td>1</td><td>CH1 acquisition memory</td></tr><tr><td>2</td><td>CH2 acquisition memory</td></tr><tr><td>3</td><td>Save memory A</td></tr><tr><td>4</td><td>Save memory B</td></tr><tr><td>5</td><td>CH1 display memory</td></tr><tr><td>6</td><td>CH2 display memory</td></tr></table>●mmmm: Leading address in memories
Four-digit integer: 0～0999, 1999, (CH1 and CH2 acquisition memories)
0～0999 (Save memories, CH1 and CH2 display memories)
●nnnn: Number of transferred data
Four-digit integer: 1～1024, 2048 (CH1 and CH2 acquisition memories)
1～1024 (Save memories, CH1 and CH2 display memories)
●x = A: ASCII system
B: Binary system</td></tr>
</table>

Table 10-3 Function Commands (2/3)

<table>
<tr><th>No.</th><th>Function</th><th>Commands</th><th>Contents</th><th>Transmitting format</th></tr>
<tr><td>3</td><td>Transmission of measuring condition data</td><td>R0 command</td><td>●Designates the transfer of the measuring condition data at the time of sampling the waveform that Memory i stores.
●The personal computer receives the prescribed data after transmitting this command.</td><td>R | 0 | (| i |) | DEL
●i (= 1 to 4) indicates the same</td></tr>
<tr><td>4</td><td>Receiving of waveform data</td><td>Wi command</td><td>●Transmits the waveform data from the personal computer to the instrument to designate the SAVE memory A and B to write the data in sequence beginning with the leading address mmmm.
●The ASCII system or the binary system can be designated as the transmission method by X in the right column.
●The personal computer transmits the waveform data after transmitting this command.</td><td>W | i | (| m | m | m | m | , | n | n | n | n | , | x |) | DEL
●“i” indicates the memory number.
“i” must be 3 or 4.
<table><tr><th>i</th><th>Memory</th></tr><tr><td>3</td><td>Save memory A</td></tr><tr><td>4</td><td>Save memory B</td></tr></table>●mmmm: Leading address written in four-digit integer: 0000 to 0999
●nnnn: Number of transferred data Four -digit integer: 0001 to 1024
●x = A: ASCII system
B: Binary system</td></tr>
<tr><td>5</td><td>Receiving of measuring condition data</td><td>W0 command</td><td>●Transmits the measuring condition from the personal computer to the instrument, and designates the instrument to register the measuring condition data of the waveform that the SAVE memory A or B stores.
●The personal computer transmits the measuring condition data after transmitting this command.</td><td>W | o | (| i |) | DEL
●“i” indicates the memory number.
“i” must be 3 or 4.
<table><tr><th>i</th><th>Memory</th></tr><tr><td>3</td><td>Save memory A</td></tr><tr><td>4</td><td>Save memory B</td></tr></table></td></tr>
</table>

Table 10-3 Function Commands (3/3)

<table>
<tr><th>No.</th><th>Function</th><th>Commands</th><th>Contents</th><th>Transmitting format</th></tr>
<tr><td>6
i)
ii)
iii)</td><td>Parameter calculation
The maximum value
The minimum value
The mean value</td><td>
E1 command
E2 command
E3 command</td><td>
●Designates the calculation of the maximum value of the waveform data that the memory i stores.
●Designates the calculation of the minimum value of the waveform data that the memory i stores.
●Designates the calculation of the mean value of the waveform data that the memory i stores.</td><td>E 1 (i) DEL
E 2 (i) DEL
E 3 (i) DEL
●“i” indicates the memory number.
<table><tr><th>i</th><th>Memory</th></tr><tr><td>1</td><td>CH1 acquisition memory</td></tr><tr><td>2</td><td>CH2 acquisition memory</td></tr><tr><td>3</td><td>Save memory A</td></tr><tr><td>4</td><td>Save memory B</td></tr></table></td></tr>
<tr><td>7
i)
ii)
iii)</td><td>Transmitting function of parameter
The maximum value
The minimum value
The mean value</td><td>
G1command
G2command
G3command</td><td>
●Designates the transmission of the maximum value calculated from the waveform data of Memory i.
●Designates the transmission of the minimum value calculated from the waveform data of Memory i.
●Designates the transmission of the mean value calculated from the waveform data of Memory i.
●The waveform data must be calculated previously by the commands E1 to E3.
●The personal computer receives the prescribed data after transmitting this command.</td><td>G 1 (i) DEL
G 2 (i) DEL
G 3 (i) DEL
●“i” (= 1 to 4) indicates the memory number as shown in item 6.</td></tr>
</table>

Table 10-4 Format of Transmission of the waveform Data

No.	Item	Name	Format	ASCII system		Binary system	
				Data code	Bytes	Data code	Bytes
1	#i@	Memory number	"i" is 1 to 6 (NOTE 4)	ASCII	3	ASCII	3
2	mmmm	Leading address	Decimal, four digits 0000 to 999, 1999,3999 (NOTE 5)	ASCII	4	ASCII	4
3	nnn	Data number	Decimal. four digits 0001 to 1024, 2048, (NOTE 5)	ASCII	4	ASCII	4
4	Di	Data	◦ ASCII system Decimal, three digits / 1 data 000 to 255 ◦ Binary system 8-bit binary data	ASCII	3	Binary	1
5	S.C	Sum check (NOTE 1) (NOTE 2)	◦ ASCII system Hexadecinal ASCII data 00 to FF ◦ Binary system 8-bit binary data	ASCII	2	Binary	1
6	DEL		C/R L/For C/R (NOTE 3)	ASCII	1 to 2	—	1 to 2

NOTE 1 : The Sum check data adds all the former data (including symbols like a comma, etc,) by the binary system, and uses the least significant 8 bits of the data obtained as a result.

NOTE 2 : Do not add S.C in the receiving mode.

NOTE 3 : The format of a delimiter data is C/R L/F or C/R.
For the setting, refer to 9.4 (2).

NOTE 4 : In the receiving mode, only 3 or 4 can be designated.

NOTE 5 : For details, refer to Table 10-2.

Table 10-5 Transmitting and receiving format of measuring condition data

No.	Item	Name	Format	Binary system (Note 3)	
				Trans-mitting	Receiving
1	#i@	Memory number	"i" is 1, 2, 3 or 4 (Note 2)	3	3
2	V.M	Vertical mode	One of CH1, CH2, PUAL, ADD (Right justify)	4	4
3	H.M	Horizontal mode	A	1	1
4	A.T	A TIME/DIV (Note 3)	A TIME range value ; F3.1 (Note 4) Unit ; S, MS, MICS (Right justify)	9	9
5	B.T	B TIME/DIV (Note 3)	Space	9	9
6	V.C	Volt CAL	CAL or UNCAL (Right justify)	5	5
7	P.F	Probe factor	P1X or P10X Right justify)	4	4
8	V.D	Volts/DIV	VOLT range value : F3.1 (Note 4) Unit : V, MV (Right justify)(Note 5)	7	7
9	D.T	Delay amount	0.000DIV (NOTE 6)	9	9
10	N.S	No. of sweeps	1, 4, 16, 64, 256 (Note 7)	3	3
11	S.C	Sum check	Hexadecimal ASCII data 00 to FF	2	0 (Note 8)
12	DEL	Del imiter	C/R L/F or C/R (Note 9)	1 to 2	1 to 2

NOTE 1 : "Transmitting" and "Receiving" are described, viewed from the instrument.

NOTE 2 : In the receiving mode, only 3 or 4 can be designated.

NOTE 3 : This instrument is not provided with the delay sweep function therefore, only the data on A TIME/DIV is transferred.
Aspace is transferred to B TIME/DIV for convenient purpose.

NOTE 4 : For example, F3.1 is indicated as 50.0.
A space symbol of over one word is placed between the value and the unit.

NOTE 5 : When the VOLTS/DIV setting of CH1 and CH2 are different in the ADD mode, the data is transmitted with ADD only.

NOTE 6 : This instrument is not provided with the delay sweep function therefore, 0.000 DIV is transferred as the delay amount for convenient purpose.

NOTE 7 : Setting of the number of average the five modes, 1, 4, 16, 64 and 256 (1: NORM, 4: 4 times, 16 : 16 times, 64 : 64 times and 256 : 256 times)

NOTE 8 : Do not add a sum check data in the receving mode.

NOTE 9 : The format of a delimiter data is C/R L/F or C/R.
For the setting, refer to 9.4 (2).

10.7 Delimiter

For the transmission of the waveform data the function command message, the controller sends a delimiter to indicate the end of data to the instrument. The delimiter can select C/R L/F or C/R. For the settinf, refer to item 9.4 (2).

10.8 Processing of Abnormal Operation

The instrument sends return code in order to respond to a message command, or to inform the personal computer of the status. The following is the format and the meaning of these status bytes.

No.	Status byte	Description
1	41	Processing for a command is completed normally.
2	61	Command error
3	62	Data error
4	63	Data content error
5	64	Excessive data number
6	65	Insufficient data number
7	67	Protocol error

The return codes of the command error are transmitted when there is a format error in the message command.

10.9 Connect of the RS-232C Interface Cable and the Activation of the Instrument

(1) Connect the RS-232C cable between the instrument and the personal computer.

(2) Set the communication mode of the instrument and the personal computer according to item 9.4 (2).

(3) Set the instrument power to on, set the front panel controls and set the instrument in the HOLD mode (STORAGE mode). Now, the data transfer is possible. Perform the operation according to the commands form the personal computer.

10.10 Creation of Programs for Data Transfer

To facilitate programming, first execute a simple test program, send the function command to the instrument by the simple program, and check the resultant data received from the instrument. This simple test program will check the system validation and then a complete program can be written. The following program statement depends on the employed personal computer. Befor transmission, read carefully the employed personal computer manual, because the personal computer may require preparation such as data buffer area reservation and delimiter setting.

10.11 Major Causes of Abnormal Data Transfer

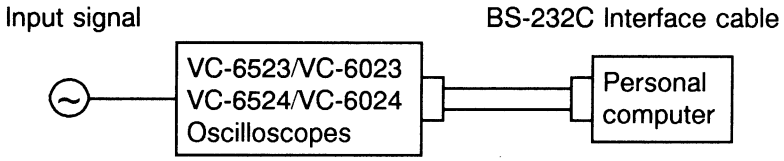
Check the below items when data transfer is not executed properly.

(1) A cable is not connected power of any equipment in the system is not turned on.
(2) The instrument is not in the HOLD mode. Verify that the panel setting are as specified in item 10.5 (1).
(3) The trigger mode is in the NORM trigger mode, and the trigger signal is not connected. (When the single sweep is executed by the S1 command from the personal computer.)
(4) The function command does not correspond to that of the instrument.
(5) The instrument does not correspond to the setting of the communication mode of the personal computer.
(6) The format of delimiter does not correspond to that of the instrument.
(7) The instrument is not initialized after the communication mode changed. When the instrument is turned on, the instrument reads the DIP switch settings and memorizes the data. Consequently, the communication mode can not be changed while the power is on.
(8) The function with which the instrument is not provided is executed, (PPC, GET, TCT, etc.)
(9) The buffer area of the data is not provided. (Transmission of a large amount of data is requested for the instrument though a listener has a small amount of buffer area.)
(10) There is an error in program. Use of decimal and hexadecimal system is not proper.

10.12 Programing Example

The following is an example of the programs executed when the instrument and the personal computer are connected. Prior to the connection with the personal computer, set the instrument, referring to the communication mode described in item 9.4 (2).

In this section, the GW-BASIC program of IBM.ST is used as an example for each function command.



The followinf communication mode is used of the example of the aobve program.

(a) Baud rate : 9600 baud
(b) Data format : START BIT + 8 BIT + STOP BIT
(c) Deliniter : C/R

(1) Program example 1 "S1" command

The NORMAL SINGLE mode is activated by the "S1" command. This is a program for observing the operation until the sampling is completed. The program example 1 is the program for the IBM XT (GW-BASIC).

Program example 1

```
10  ' *** S1 COMMAND (GW-BASIC) ***          · Comment
20  OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1    · RS-232C OPEN
30  PRINT #1,"S1"                            · S1 Command transmit
40  LINE INPUT #1,RTN$                       · Return code receive
50  RTN=ASC(RTN$)
60  IF RTN<>&H41 THEN 110                    · Return code check
70  , **********************               · As the time range is set,
80  , ** ANOTHER PROGRAM **                  · another progresss can be
90  , **********************               · executed.
100 GOTO 120                                 ·
110 PRINT "ERROR STATUS=";HEX$(RTN)          · Return code display
120 CLOSE #1                                 · RS-232C CLOSE
130 END                                      ·
```

(Explanation)

The instrument activates the sampling by "S1" command. When the sampling is completed, the return code inform that the operation is completed satisfactory. The lines from 40 to 60 observe the return code. In the return code is 65 (41 for hexadecimal), the operation is completed with a satisfactory result and it is possible to proceed another program (e.g., a prlgram to read a waveform data).

(2) Program example 2 "Ri" command

This is a program to receive 50 words of the CH1 waveform data from the 0 address by the "Ri" command.

Program example 2-1 : ASCII code transfer, for IBM XT (GW-BASIC)

Program example 2-2 : Binary code transfer, for IBM XT (GW-BASIC)

Program example 2-1

```
10  ·***Ri(mmmm,nnnn,x) COMMAND (GW-BASIC) ***   · Comment
20  OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1        · RS-232C OPEN
30  PRINT #1,"R1(0000,0050,A)"                   · Ri Command transmit
40  LINE INPUT #1,RTN$                           · Waveform data receive
50  PRINT "R1 RETURN=";RTN$                      · Waveform data display
60  CLOSE #1                                     · RS-232C CLOSE
70  END
```

Program example 2-2

```
10  ·***Ri(mmmm,nnnn,x) COMMAND (GW-BASIC) ***      · Comment
20  OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1          · RS-232C OPEN
30  PRINT #1,"R1(0000,0050,B)"                     · Ri Command transmit
40  RTN$=INPUT$(14,1)                              · Waveform data receive
50  FOR I=1 TO 52                                  ·
60      WRK$=INPUT$(1,1)                           ·
70      RTN$=RTN$+MID4(STR$(ASC(WRK$)),2)+","      ·
80  NEXT I                                         ·
90  PRINT "R1 RETURN=";RTN$                        · Waveform data display
100 CLOSE #1                                       · RS-232C CLOSE
110 END
```

(3) Program example 3 "R0" command

This is a program to receive the measuring condition data of CH1 by the "R0" command and display the data. The program example 3 is the program for the IBM-XT (GW-BASIC).

Program example 3

```
10  · *** R0(i) COMMAND (GW-BASIC) ***             · Comment
20  OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1          · RS-232C OPEN
30  PRINT #1,"R0(1)"                               · RO Command transmit
40  LINE INPUT #1,RTN$                             · CH1 setting condition receive
50  PRINT "RO RETURN=";RTN$                        · Display
60  CLOSE #1                                       · RS-232C CLOSE
70  END                                            ·
```

(4) Program example 4 "Wi" command

This is a program to write data in the save memory A by the "Wi" command. The lines 30 to 200 set the waveform data to be transmitted to the instrument to the letter variable A$. Set the waveform data according to application. "Wi" command is transmitted by the line 220, and the waveform data set to A$ is written in the save memory A by the lines 270 to 310. The waveform data from the 0 address to the 999 address is written in the save memory A as shown in Fig. 10-3.

Program example 4-1 : ASCII code transfer, for IBM XT (GW-BASIC)

Program example 4-1 : Binary code transfer,. for IBM XT (GW-BASIC)

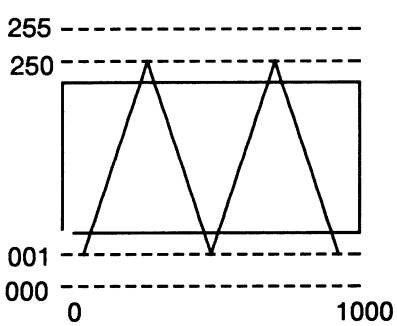


Fig. 10-3

Program example 4-1

```
10  ' *** Wi(mmmm,nnnn,x) COMMAND (GW-BASIC) ***      ' Comment
20  DIM A$(1000)                                      ' Set waveform data to the
30  CNT=0                                             ' character variable A$.
40  FOR I=1 TO 2                                      ' (Set the triangle wave
50      FOR B=1 TO 250                                ' (001-250, 250-001) shown
60          IF B>=100 THEN B$=MID$(STR$(B),2,3)       ' in Fig. 10-3 by the
70          IF B<100 THEN B$="0"+MID$(STR$(B),2,2)    ' 1000-word ASCII code.)
80          IF B<10 THEN B$="00"+MID$(STR$(B),2,1)    '
90          A$(B+CNT*250)=B$","                       '
100     NEXT B                                        '
110     CNT=CNT+1                                     '
120     FOR B=1 TO 250                                '
130         C=251-B                                   '
140         IF C>=100 THEN B$=MID$(STR$(C),2,3)       '
150         IF C<100 THEN B$="0"+MID$(STR$(C),2,2,)   '
160         IF C<10 THEN B$="00"+MID$(STR$(C),2,1)    '
170         A$(B+CNT*250)=B$+","                      '
180     NEXT B                                        '
190     CNT=CNT+1                                     '
200 NEXT I                                            '
210 OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1             ' RS-232C OPEN
220 PRINT #1,"W3(0000,1000,A)"                        ' Wi Command transmit
230 LINE INPUT #1,RTN$                                ' Return code receive
240 RTN=ASC(RTN$)                                     '
250 IF RTN<>&H41 THEN 360                             ' Return code check
260     PRINT "Wi COMMAND PASS"                       '
270 PRINT #1,"#3@,0000,1000,";                        ' Waveform data transmit
280 FOR I=1 TO 999                                    '
290     PRINT #1,A$(I);                               '
300 NEXT I                                            '
310 PRINT #1,A$(I)                                    '
320 LINE INPUT #1,RTN$                                ' Return code receive
330 RTN=ASC(RTN$)                                     '
340 IF RTN<>&H41 THEN 360                             ' Return code check
350 GOTO 370                                          '
360 PRINT "ERROR STATUS=";HEX$(RTN)                   '
370 CLOSE #1                                          ' RS-232C CLOSE
380 END                                               '
```

Program example 4-2

```
10  ' *** Wi(mmmm,nnnn,x) COMMAND (GW-BASIC) ***      ' Comment
20  DIM A$(1000)                                      ' Set waveform data to the
30  CNT=0                                             ' character variable A$.
40  FOR I=1 TO 2                                      ' (Set the binary data
50      FOR B=1 TO 250                                '  of the triangle wave
60          B$=CHR$(B)                                '  shown in Fig. 10-3.)
70          A$(B+CNT*250)=B$                          '
80      NEXT B                                        '
90      CNT=CNT+1                                     '
```

```
100     FOR B=1 TO 250                              ·
110         C=251-B                                 ·
120         B$=CHR$(C)                              ·
130         A$(B+CNT*250)=B$                        ·
140     NEXT B                                      ·
150     CNT=CNT+1                                   ·
160 NEXT I                                          ·
170 OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1           · RS-232C OPEN
180 PRINT #1,"W3(0000,1000,B)"                      · Wi Command transmit
190 LINE INPUT #1,RTN$                              · Return code receive
200 RTN=ASC(RTN$)                                   ·
210 IF RTN<>&H41 THEN 320                           · Return code check
220     PRINT "Wi COMMAND PASS"                     ·
230 PRINT #1,"#3@,0000,1000,";                      · Waveform data transmit
240 FOR I=1 TO 999                                  ·
250     PRINT #1,A$(I);                             ·
260 NEXT I                                          ·
270 PRINT #1,A$(I)                                  ·
280 LINE INPUT #1,RTN$                              · Return code receive
290 RTN=ASC(RTN$)                                   ·
300 IF RTN<>&H41 THEN 320                           · Return code check
310 GOTO 330                                        ·
320 PRINT "ERROR STATUS=";HEX$(RTN)                 ·
330 CLOSE #1                                        · RS-232C CLOSE
340 END                                             ·
```

(5) Program example 5 "W0" command

This is a program to register the measuring condition data in the save memory A by the Wo command.

The program example 6 is the program for the IBM XT (GW-BASIC).

Program example 5

```
10  · *** WO(i) COMMAND (GW-BASIC) ***              · Comment
20  DAT$ = DAT$+"#3@,"                              · Set the setting condition data
30  DAT$ = DAT$+" CH1,"                             · registered to the character
40  DAT$ = DAT$+"A,"                                · variable DAT$.
50  DAT$ = DAT$+"  50.0 MS,"                        ·
60  DAT$ = DAT$+"  20.0 MS,"                        ·
70  DAT$ = DAT$+"  CAL,"                            ·
80  DAT$ = DAT$+"P10X,"                             ·
90  DAT$ = DAT$+"50.0 MV,"                          ·
100 DAT$ = DAT$+"10.00 DIV,"                        ·
110 DAT$ = DAT$+"  1,"                              ·
120 OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1           · RS-232C OPEN
130 PRINT #1,"WO(3)"                                · W0 command transmit
140 LINE INPUT #1,RTN$                              · Return code receive
150 RTN=ASC(RTN$)                                   ·
160 IF RTN<>&H41 THEN 230                           · Return code check
170     PRINT "WO COMMAND PASS"                     ·
180 PRINT #1,DAT$                                   · Setting condition data transmit
190 LINE INPUT #1,RTN$                              · Return code receive
```

```
200 RTN=ASC(RTN$)                                  ·
210 IF RTN<>&H41 THEN 230                          · Return code check
220 GOTO 240                                       ·
230 PRINT "ERROR STATUS=";HEX$(RTN)                ·
240 CLOSE #1                                       · RS-232C CLOSE
250 END                                            ·
```

(6) Program example 6 "E1", "E2", "E3", "G1", "G2", and "G3" commands

Program 6-1 shows processes from the calculation of the maximum value to the reception and display of the maximum data.

The "E1" command is calculated by the line 30 and the calculation of themaximum value of CH1 is designated.

The lines 40 to 60 are for the observation of the return code and the check that the calculation of the maximum value is completely normally. The lines 80 and 90 input the maximum data by the "G1" command.

The program example 6-1 is the program for the program IBM XT (GW-BASIC).

Program example 6-1

```
10  · *** E1(i) G1(i) COMMAND (GW-BASIC) ***       · Comment
20  OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1          · RS-232C OPEN
30  PRINT #1,"E1(1)"                               · E1(i) Command transmit
40  LINE INPUT #1,RTN$                             · Return code receive
50  RTN=ASC(RTN$)                                  ·
60  IF RTN<>&H41 THEN 120                          · Return code check
70      PRINT "E1 COMMAND PASS"                    ·
80  PRINT #1,"G1(1)"                               · G1(i) Command transmit
90  LINE INPUT #1,RTN$                             · Maximum data receive
100 PRINT "MAX DATA=";RTN$                         · Display
110 GOTO 130                                       ·
120 PRINT "ERROR STATUS=";HEX$(RTN)                ·
130 CLOSE #1                                       · RS-232C CLOSE
140 END                                            ·
```

The program example 6-2 shows a process from the calculation of the minimum value to the reception and display of the minimum data. The program example 6-2 is the program for the IBM XT (GW-BASIC).

Program 6-3 shows a process from the calculation of the mean value to the reception and display of the mean data. The program example 6-3 is the program for the IBM XT (GW-BASIC).

The contents of the programs are the same as that of program example 6-1.

Program example 6-2

```
10  ' *** E2(i) G2(i) COMMAND (GW-BASIC) ***      ' Comment
20  OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1         ' RS-232C OPEN
30  PRINT #1,"E2(1)"                              ' E2(i) Command transmit
40  LINE INPUT #1,RTN$                            ' Return code receive
50  RTN=ASC(RTN$)                                 '
60  IF RTN<>&H41 THEN 120                         ' Return code check
70      PRINT "E2 COMMAND PASS"                   '
80  PRINT #1,"G2(1)"                              ' G2(i) Command transmit
90  LINE INPUT #1,RTN$                            ' Minimum data receive
100 PRINT "MIN DATA=";RTN$                        ' Display
110 GOTO 130                                      '
120 PRINT "ERROR STATUS=";HEX$(RTN)               '
130 CLOSE #1                                      ' RS-232C CLOSE
140 END                                           '
```

Program example 6-3

```
10  ' *** E3(i) G3(i) COMMAND (GW-BASIC) ***      ' Comment
20  OPEN "COM1:9600,N,8,1,CS,DS,CD" AS #1         ' RS-232C OPEN
30  PRINT #1,"E3(1)"                              ' E3(i) Command transmit
40  LINE INPUT #1,RTN$                            ' Return code receive
50  RTN=ASC(RTN$)                                 '
60  IF RTN<>&H41 THEN 120                         ' Return code check
70      PRINT "E3 COMMAND PASS"                   '
80  PRINT #1,"G3(1)"                              ' G3(i) Command transmit
90  LINE INPUT #1,RTN$                            ' Average value data receive
100 PRINT "MIN DATA=";RTN$                        ' Display
110 GOTO 130                                      '
120 PRINT "ERROR STATUS=";HEX$(RTN)               '
130 CLOSE #1                                      ' RS-232C CLOSE
140 END                                           '
```

The examples of the programs for function commands are illustrated above. It is recommended to create your own programs, using the above programs, according to the specific system application.

11. ADJUSTMENT

The ATT balance of the vertical axis can be adjusted easily in this oscilloscope.

(1) Set the AC-GND-DC switches of CH1 and CH2 to GND, the TRIG MODE switch to AUTO, and then display the trace at the center of the screen.

(2) Adjust the DC BAL controls ㉖ of CH1 and CH2 with a screwdriver so that the trace does not move even if the VOLTS/DIV switch is set to 5 mV/DIV and 10 mV/DIV alternately.

12. Specifications

12.1 Functions and performance

The following specifications are applicable to the VC-6523, VC-6023, VC-6524, and VC-6024 oscilloscopes unless otherurise noted.

(1) Functions common to the real-time and storage modes (Items marked * are only for the real-time mode)

CRT

CRT	6", with internal graticule and % scale
Acceleration voltage	12kv approx [2kv approx for the VC-6523/VC-6023]
Effective range	8DIV × 10DIV (10mm/DIV)
Brightness adjustment	Provided
Focus adjustment	Provided (with focus correction circuit)
Trace rotation	Available

External intensity modulation

Voltage	Trace becomes dark with the positive signal of 5V or more.
Bandwidth	DC-2MHz
Input impedance	33kΩ (typ) [47kΩ (typ) 5 or the VC-6523/VC-6023]
Withstand voltage	30V (DC + AC peak)

Vertical axis

Input sensitivity	×1 5mv/DIV to 5v/DIV (10 steps in 1-2-5 sequence) ×5 1mv/DIV to 1v/DIV
Sensitivity error ratio	×1 ± 3% ×5 ± 5%

Continuously variable sensitivity	Attenuated more then 2.5 times ×5 the indicated value for each range (With lock)
Frequency bandwidth	×1 DC-50MHz (20 MHz for the VC6523/VC-6023) +1, −3 dB (at 6DIV as reference) ×5 DC-7MHz +1, −3 dB (at 6DIV as reference)
Rise time	7ns approx [17.5ns approx for the VC-6523/VC-6023] ×5 : 50ns approx
Signal delay line	Leading edge is measurable. (VC-6524/VC-6024 only)
Input impedance	Direct 1MΩ approx, 25pF approx
Input withstand voltage	500V p-p or 300V (DC + AC peak at 1kHz)
Input coupling	AC-GND-DC
Magnifying function	×5 available
Operation modes	CH1, CH2, ALT, CHOP (Switching frequency 250kHz approx.) ADD (DIFF mode can be established when CH2 is in INV mode.)
Dynamic range	More than 6DIV
DC	±1 to ±100V (direct)
OFFSET function	Provided (not calibrated in V.UNCAL and V.MAG mode) [VC-6524/VC-6024 only]
Voltage read terminal	Voltage can be read by connecting a digital multimeter. (VC-6524/VC-6024 only)

X-Y Operation

X input	CH1
Y input	CH2
Sensitivity	Same as the vertical axis
X bandwidth	DC-500kHz
Phase error	Less than 30° (DC-50kHz)

Horizontal axis

Sweep system	Trigger sweep, auto trigger sweep, TV-V, TV-H
Sweep time	0.2μs/DIV~0.2s/DIV (19 steps in 1-2-5 sequence)
Maximum sweep time	20ns/DIV (at MAG ×10) [100ns/DIV (20ns/DIV~50ns/DIV is not calibrated) for the VC-6023]
Fine adjustment of sweep time	More than 2.5 times (with lock) sweep time
* Sweep time error	± 3%
* Sweep magnification	X10, error ±5%

* ALT MAG function	Provided (VC-6524/VC-6024 only)
* Position adjustment	Available

Trigger system

Trigger modes	AUTO, NORM, TV-V, TV-H
Trigger coupling	AC
Trigger source	INT (CH1, CH2, V-MODE), LINE, EXT
Trigger slope	±

Trigger sensitivity and frequency

	Frequency	Internal	External
VC-6524 VC-6024	20 Hz ~ 5 MHz	0.5 DIV (2.0 DIV)	200 mV
	5 MHz ~ 40 MHz	1.5 DIV (3.0 DIV)	800 mV
	40 MHz ~ 50 MHz	2.0 DIV (3.5 DIV)	1 V
VC-6523 VC-6023	20 Hz ~ 2 MHz	0.5 DIV (2.0 DIV)	200 mV
	2 MHz ~ 20 MHz	1.5 DIV (3.0 DIV)	800 mV

Note: ( ): V-MODE trigger mode

TV sync	Internal 1 DIV or more (vertical sync signal)
	External 200 mVp-p or more (vertical sync signal)
AUTO low band	25 Hz
External trigger input	Provided
Impedance	1 MΩ approx. 25 pF approx.
Input withstand voltage	300 V (DC + AC peak at 1 kHz)

Readout function

<Panel setting display>	
Vertical axis	V/DIV, UNCAL, MAG (converted value)
Sweep speed	S/DIV, UNCAL, MAG (converted value)
<Cursor readout function>	
Voltage difference △V	△-REF
Time difference △T	△-REF
Frequency 1/△T	△-REF
Cursor measurement effective range	From center of CRT
	Vertical within ±3 DIV
	Horizontal within ±4 DIV

CH1 OUTPUT

Output voltage	20 mV/DIV or more
Frequency response	50 Hz to 5 MHz (-3 dB)
Output impedance	50 ohms approx.

Calibrator

Waveform	1 kHz ±20%, square wave (duty 48:52 or more)
Voltage	0.5 V ±3%

(2) Digital storage functions

Waveform data storage

Memory capacity	
Display memory	1000 words × 4
Save memory	1000 words × 2
Acquisition memory	5 μs/DIV to 20 μs/DIV --- 2000 words/CH × 2
	0.2 μs/DIV to 2 μs/DIV --- 1000 words/CH × 2
Vertical resolution	250 points/10 DIV
Horizontal resolution	100 points/DIV
Maximum sampling rate	20 Mcps (alternate sample in 2-channel mode)
	Sampling rate depends on the time range.
Maximum storage frequency	
A single-shot signal	
(Maximum amplitude error:	
30% or less)	5 MHz (4 samples/cycle)
A repetitive signal	
VC-6523/VC-6023	20 MHz (17 MHz at Y axis × 5 MAG)
VC-6524/VC-6024	50 MHz (7 MHz at Y axis × 5 MAG)

Data acquisition

NORM storage mode	Updates data at each triggering.
AVG mode	Averages input signals by the selected number of average and displays the result after the averaging has reached the selected number. (Number of average: 4, 16, 64 and 256)
ROLL mode	Adds new data to the right of the CRT and shifts data from right to left continuously on the CRT.
HOLD mode	Holds the waveform displayed on the CRT.
SINGLE sweep	Performs an operation of the NORM storage, or AVG mode once at each by receiving the Si command from the personal computer through the

RS-232C interface, and updates a picture.

Data save

Up to two waveforms can be saved.
Two stored waveforms can be displayed with the two sampling waveforms.

Pretrigger

Variable (in 0.1 DIV steps)

Plotter output

Hard copy is available by the HP-GL through RS-232C.
6 colors are switchable.

External input/output

Provided with the RS-232C interface as standard.

Magnifying display

A storage waveform can be magnified up to 10 times in the horizontal direction.

X-Y operation

Single trace X-Y	X-axis = CH1, Y-axis = CH2
Dual trace X-Y	X-axis = CH1, Y-axis = CH2 X-axis = SA, Y-axis = SB
Sensitivity	X axis: CH1 1 mV to 5 V/DIV ± 5% Y axis: CH2 1 mV to 5 V/DIV ± 5%
Phase error	3° or less from DC to 50 kHz

Horizontal deflection system

Sweep time	0.2 μs/DIV to 20s/DIV 0.2 μs/DIV to 2μs/DIV is effective only for repetitive waveform. 0.5 μs/DIV to 20 s/DIV is only for roll mode. 0.2 μs/DIV to 0.5 ms/DIV: ALT sampling 1 ms/DIV to 20 s/DIV: CHOP sampling

Readout function

< Panel setting display >

Vertical axis:	V/DIV, UNCAL, MAG and probe conversion of CH1 and CH2
Sweep speed:	S/DIV, UNCAL, MAG (converted value)
Others:	X-Y, TRIGGER POINT No. of averaging, roll mode, smoothing, interpolation

method, save memory information, probe setting

< Cursor readout >

Voltage difference △V:	△-REF
Time difference △T:	△-REF
Frequency 1/△T:	△-REF

External output

RS-232C	Adaptable to HP-GL

12.2 Dimensions, environments, etc.

Power supply

Voltage	100/120/220/240 V AC
Frequency	50/60/400 Hz
Power consumption	50 W approx.

Environment

Operating temperature	0° to 40°C
Operating humidity	35 to 85%
Specification guaranteed temperature	10 to 35°C
Specification guaranteed humidity	45 to 85%
Safe storage temperature	–20 to +70°C
Safe storage humidity	35 to 85% (70% or less in the ambient temperature of 50°C)

Construction

Dimensions	310(W) × 130(H) × 370(D) mm approx. (excluding prefections)
Weight	8 kg. approx.