MODEL VC-6050

DIGITAL STORAGE OSCILLOSCOPE

OPERATION MANUAL

Hitachi Denshi, Ltd.

MODEL VC-6050

DIGITAL STORAGE

OSCILLOSCOPE

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WARRANTY

This Hitachi Denshi, Ltd. product is warranted against defects in workmanship and materials. If any failure, resulting from a defect in either workmanship or material, shall occur under normal use within one year from the original date of purchase, such failure shall be corrected free of charge to the original purchase by repair or, at Hitachi Denshi's sole option, replacement of the defective part or parts. No charge shall be made for labor or services performed during said one year period providing the product is brought to our Authorized Service Station.

Hitachi Denshi, Ltd. will either repair or at its sole option, replace any part except for cathode ray tube, fuses, probes, lamps, batteries and other optional materials which are defective in either workmanship or material under normal and proper use.

This warranty does not cover equipment which has been tampered with in any way, or damage caused by accident, negligence, alteration, or misapplication.
This product must be returned transportation prepaid, properly packed and insured. This warranty applies only to the original purchaser.

NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED. Hitachi Denshi, Ltd. IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

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NOTE

- This instrument should be adjusted at an ambient temperature of +20°C for best overall accuracy.
  Allow at least 15 minutes warm-up before proceeding.

- To clean the enclosure or the front panel, use neutral detergent. Refrain from using thinner, benzine, alcohol or other chemicals.

- For safety operation, be sure to connect the ground lead of the GND (ground) terminal to earth ground, if a two-wire AC power system is used. Failure to complete the ground system may allow the chassis and cabinet of this instrument to be elevated above ground potential and pose a shock hazard.

1. INTRODUCTION

The Hitachi Digital Storage Oscilloscope VC-6050 is provided with the digital storage function. The VC-6050 can be used as a conventional oscilloscope, also used as a versatile oscilloscope featuring facilitated observation of a single shot, and offering the output port to feed out stored waveforms.

2. FEATURES

(1) Samples the signal at 40 MHz maximum.
(2) Stores a repetition frequency of 60 MHz.
(3) Stores a single shot signal of up to 10 MHz.
(4) A large memory capacity of 4 kilo-words x 2 channels.
(5) Saves the stored waveform of up to the two waveforms.
(6) Displays the saved waveform of up to the two waveforms.
(7) Offers analog output of the stored waveform in the PLOT mode to an external terminal.
(8) Facilitates the observation of the low-speed signal by the roll mode function.
(9) Averages the sweeps of up to 256 times.
(10) Feeds out the waveform data to the external computer through GPIB.
(11) Reads out the setting values on the CRT.
(12) Facilitates the observation of the voltage difference, the time difference, and the frequency with the two line cursors.
(13) Works as the triple trace oscilloscope of 60 MHz with the cursor function.

3. COMPOSITION

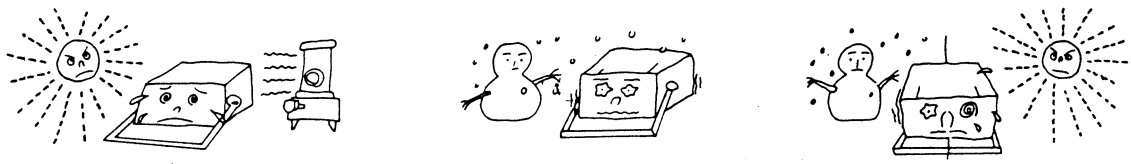
(1) Oscilloscope (VC-6050) ..... 1 unit
(2) Probes (AT - 10 AP 1.5)..... 2 pcs.
(3) Fuse (Fuse 1 or Fuse 2) ..... 1 set
(4) Dust proof cover ..... 1 pc.
(5) AC power cord ..... 1 pc.
(6) Operation manual ..... 1 copy

4. PRECAUTIONS

Installation site

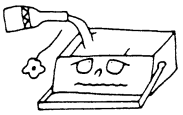
* Avoid installing the instrument in an extremely hot or cold place.
  - o Avoid placing the instrument in a place exposed directly to sunlight for a long period of time, in a car in midsummer, or near a room heating device.
  - o The maximum operating ambient temperature is 40°C.

* Do not use the instrument that has been left outdoors on a cold winter day. The operating ambient temperature is 0°C or more.



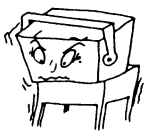
* Avoid moving the instrument from a hot place to a cold place and vice versa, or condensation may form inside of the instrument.

* Keep the instrument away from damp air, water, and dust.
  Unexpected trouble may be caused when the instrument is placed in a damp or dusty place.
  The operating ambient humidity is 35 - 85 %.
  Since an accidental intrusion of liquid may also cause troubles, do not place a liquid-filled container on the instrument.



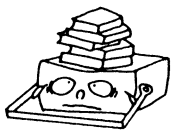
* Do not place or use the instrument in a place subject to vibration.

* Do not place the instrument near a magnet or 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.

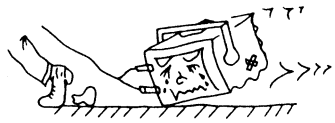


Handling

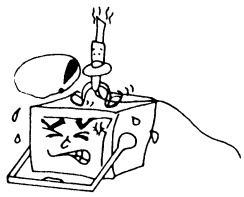
* Do not put a heavy object on the instrument.
* Do not block ventilation holes.
* Do not apply a heavy shock to the instrument.

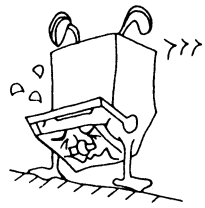


* Do not insert a wire, pin, etc. through ventilation holes.
* Do not drag the instrument with a probe connected.

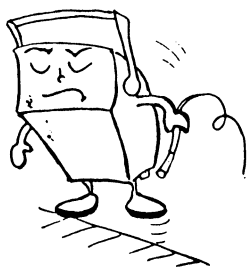


* Do not leave a hot soldering iron on the cabinet or the screen.
* Do not try to turn the instrument upside down. Otherwise, knobs may be broken.





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

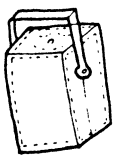


Handle

The handle can be positioned for carrying or as a tilt-stand for the instrument. To position the handle, press in at both pivot points and turn the handle to the desired position. Thirteen positions are provided for convenient carrying or viewing.

When not in use

When not in use, put the dust-proof cover on the instrument.



Power supply

Allow more than 3 seconds before turning on the power switch after the switch has been set to off.
The built-in microprocessor may not function normally if AC power failure occurs. In this case, pull the INITIAL SET (DLY/CURSOR) switch or set the POWER switch to OFF and then to ON. Then, the microprocessor restores the normal operating condition.
If a problem persists, contact your local Hitachi Denshi service station.

This instrument performs the internal initial processing, with the LED's on the front panel lit, for 3 seconds after the power on. During this period, the instrument does not function. This is not trouble.

Care and repair

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

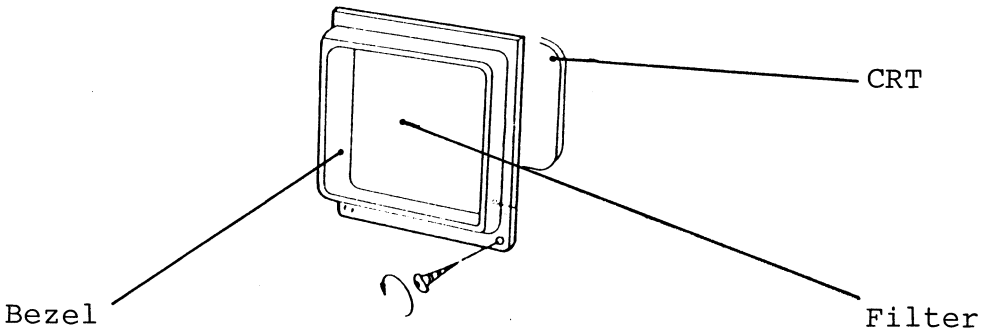
  - o When dust has accumulated inside, remove dust in the cabinet by a dry brush, or by a compressor or a vacuum cleaner.

Note:
When opening the case, disconnect the power supply plug without fail.
When cleaning the inside, make sure that no charge remains on the capacitors of the power supply circuit.

* Cleaning of CRT

To ensure correct observation, keep the surface of the CRT screen or the screen filter clean. Remove the stains on the CRT or the filter with a clean and soft cloth, paying attention not to impair it. When the stain is extremely heavy, clean it with a neutral washing agent and then leave it as is until the moisture is removed naturally.

o If the filter is installed while it is moistened, water rings may be formed and the waveform may be blurred to become hard to observe. Pay attention not to leave finger prints on it.



Maintenance

(1) Use and store the instrument carefully. Avoid giving 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 instrument is as shown below. Check the line voltage without fail before turning on the power switch.

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

Nominal volts ±5% at 400 Hz.

When the line voltage is lower than the operating range, the displayed waveform may be discontinuous or the displayed characters may be not even in brightness. In this case, check the line voltage.

Before shipment, the voltage selector is properly set. When the instrument is intended to be used on a different rated voltage, change the voltage selector position. (Rated voltages are indicated on the rear panel of the oscilloscope.)

* **Use only specified fuses**

In order to protect the circuit against overcurrent, two fuses listed in FUSE 1 and FUSE 2 are used on the primary side of the power supply. When the fuse is blown out, thoroughly check for the cause, repair any faults present, and then replace with a specified fuse. Do not try to use a fuse other than the specified. Otherwise, fault may be caused or danger may be invited.

(Particularly, do not use a fuse different from the specified one in current capacity and in length.) The standards of the fuses are as follows.

FUSE 1

Line voltage	Capacity	Dimensions (Diameter x length) mm	Type
AC 100V AC 120V AC 220V AC 240V	2A	5.2 ϕ x 20	MT4-2A (250V 2A)

FUSE 2

Line voltage	Capacity	Dimensions (Diameter x length) mm	Type
AC 100V AC 120V AC 220V AC 240V	3A	6.35 ϕ x 31.8	MF61M3 (250V 3A)

*** Do not increase the brightness too much.**

Do not increase the brightness of the spot and trace too much. Your eyes may be strained and the phosphor screen of the CRT may be burnt.

*** Do not apply an excessive voltage.**

The input withstand voltages of connectors and probe are as follows. Never apply a voltage higher than specified.

INPUT direct	400V (DC + AC peak at 1 kHz)
When x 10 probe is used	500V (DC + AC peak at 1 kHz)
EXT INPUT	400V (DC + AC peak at 1 kHz)
EXT BLANKING	50V (DC + AC peak)

*** Confirm the setup value.**

When the oscilloscope is powered again, the initial set value is set as shown in table below:

Item	Initial set value
A time	1 ms
B time	0.5 ms
Delay time	Equivalent to 1 division
Probe compensation	X10 (P_{10X})
Cursor value	ΔV : 6 DIV ΔT : 8 DIV 1/ΔT : 8 DIV
Cursor menu selection	No cursor
A/B TIME selection (ALT mode)	B
Storage functions	
SWP X10 MAG POINT	0.0 DIV
PRE TRIG	0.0 DIV
NO. OF SWEEPS	2 CNT
ROLL MODE TIME	0.5 s
Initial data of display memory	Displays a trace at the middle point on the CRT.
Initial data of SAVE memory	Displays a trace at the middle point on the CRT.

* **Check that NON STORE, NORM, ROLL, or AVG key is pressed.**
  One of the NON STORE, NORM, ROLL, AVG and HOLD keys is required to be pressed during operation.
  Before measuring, check that a required key is pressed. When none of them are pressed, press one of the keys to reset the oscilloscope to the normal operation.

5. PANEL DESCRIPTION

The digital storage oscilloscope VC-6050 is provided with the real time oscilloscope function 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 NON STORE key of the Section B is selected, the VC-6050 functions as a real time oscilloscope. This mode is called the NON STORE mode.

When a key other than the NON STORE key of the Section B is selected, the VC-6050 functions as a digital storage oscilloscope. This mode is called the STORAGE mode.

See Item 5.2 (1) for description of the STORAGE modes.
Section A, Section B, and Rear panel are described below.

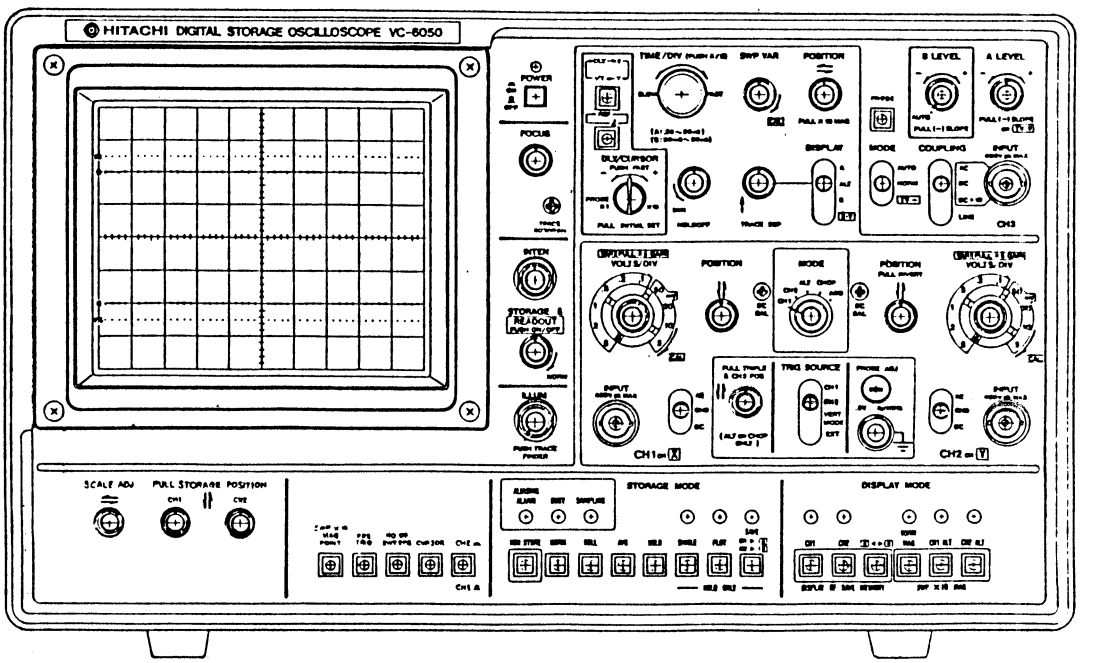


Fig. 5-1 Front View

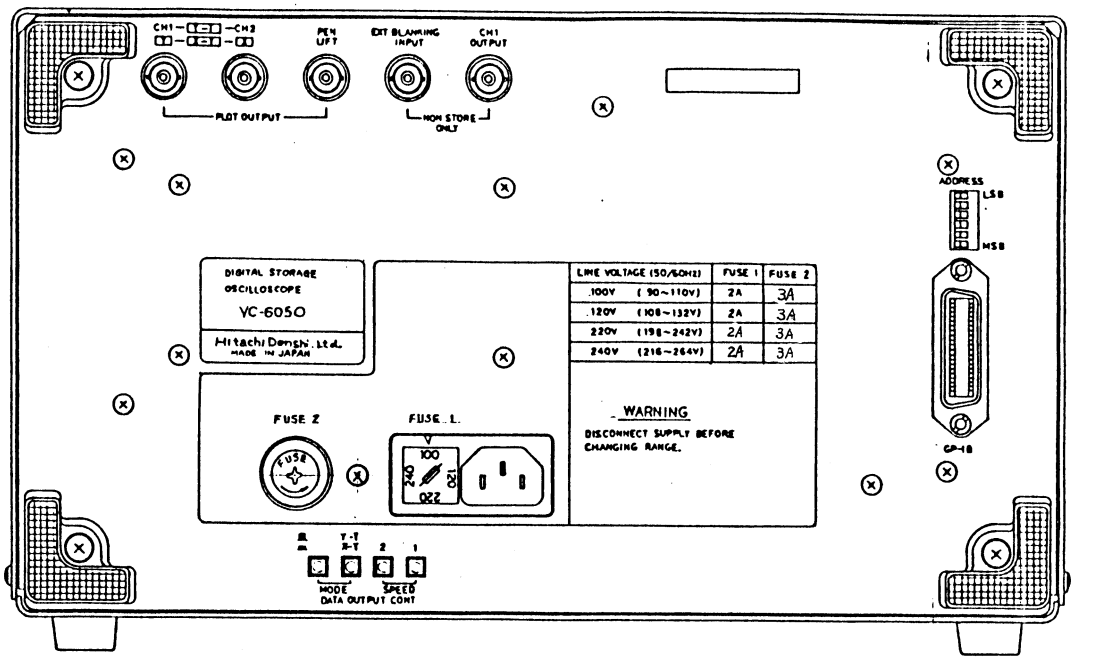
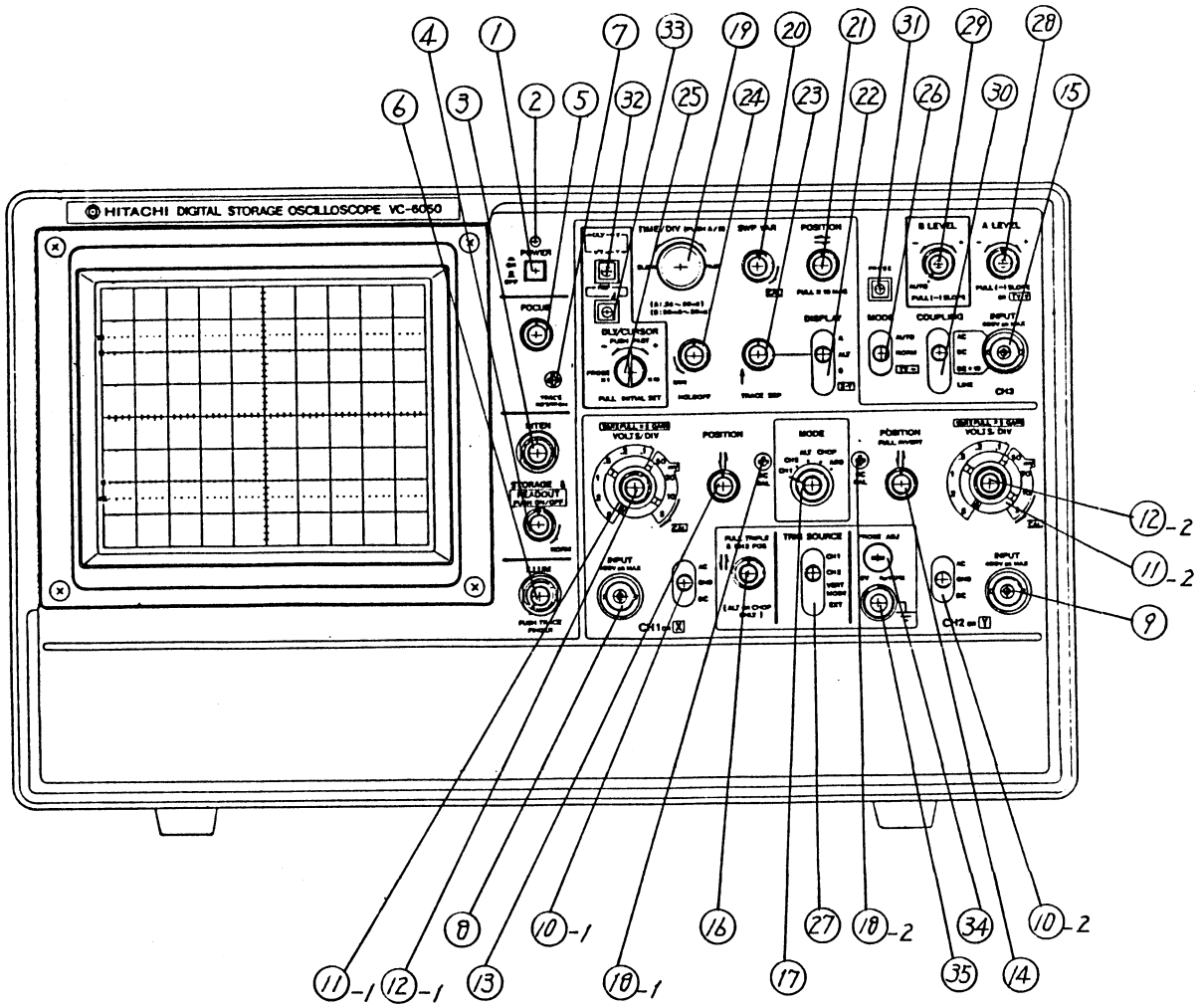


Fig. 5-2 Rear View

5.1 Front Panel Section A



(1) CRT

① **POWER switch**

Sets ON in the depressed mode (▬), and OFF in the released mode (■).

② **POWER lamp**

Lights in green when the POWER switch is set to ON.

③ **INTEN control**

Adjusts the trace brightness. A clockwise rotation increases brightness.

④ **STORAGE & READOUT PUSH ON/OFF control**

Normally set this control to the fully clockwise position (NORM) to obtain the optimum focus.

If the brightness of characters and waveform in the storage mode needs to be decreased, set the INTEN control to the mid-point and rotate this counterclockwise. In this case, either of characters or waveform may be out of focus, but it is not a fault. For optimum focus, control the FOCUS control ⑤.

At each press of control characters disappear and are displayed.

⑤ **FOCUS control**

After obtaining an appropriate brightness by operating INTEN, adjust FOCUS until the display is clearest.

Although the focus is also corrected automatically when INTEN is rotated, the focus is sometimes slightly shifted.

In this case, adjust the FOCUS control.

⑥ **Scale ILLUM control (PUSH TRACE FINDER)**

Controls graticule illumination. Adjust illumination when viewing in a dark area or photographing. When this control is pushed in, the TRACE FINDER mode is available and the trace out of screen can be displayed on the effective screen area.

⑦ **TRACE ROTATION control**

Used to align a horizontal trace with the horizontal CRT graticule when the trace is affected by earth magnetism.

(2) Controls of vertical deflection system

⑧ **INPUT (CH1 or X) connector**

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

⑨ **INPUT (CH2 or Y) connector**

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

⑩ **AC-GND-DC switch**

Selects the manner in which the input signal is connected to the vertical deflection system.

AC: A capacitor is connected between the input connector and the vertical attenuator. The capacitor prevents DC component of the input signal from being applied to the vertical section but allows the AC voltages to be passed to the vertical section.

GND: The input of the vertical amplifier is grounded to provide a ground reference.

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

⑪ **VOLTS/DIV switches**

Vary the sensitivity of the vertical section so that the signal can be displayed and measured in an appropriate amplitude.

The deflection factor set by these switches is shown on the lower left side of the CRT.

The deflection factor corresponding to probes can be displayed by following the procedure of Item 6.4 (3).

⑫ **VAR PULL X5 GAIN switches**

* Vary the vertical deflection factor continuously. Attenuation of less than 1/2.5 is obtained at a fully counterclockwise position.
* Used when comparing the amplitudes of two waveforms or when measuring the rise time of a square wave. Set these switches to a fully clockwise position for normal measurements.
* When the switches are pulled, the vertical deflection factor at each range of VOLTS/DIV is magnified to five times. The maximum sensitivity is 1 mV/DIV.

NOTES:

1. Use the PULL X5 GAIN knob only when the VOLTS/DIV is set to 5 mV/DIV or 10 mV/DIV. Usually use the PULL X5 GAIN switch at the pressed state.
   When the knob is pulled, the signal to noise ratio and frequency bandwidth of the instrument will be reduced.
2. When the measurement is performed in the high-sensitivity range of 1 mV or 2 mV/DIV in the CHOP mode, it is sometimes difficult to obtain a stable trigger.
   Apply a high level signal synchronized with the signal measured into a channel not used and use the channel as the trigger signal source.

⑬ **POSITION ↕ control**

Sets the vertical position of the CH1 signal display.
Clockwise rotation moves the trace up and counterclockwise rotation moves it down.

⑭ **POSITION PULL INVERT ↕ control**

Sets the vertical position of the CH2 signal display.
Clockwise rotation moves the trace up and counterclockwise rotation moves it down.
When the control is pulled, the polarity of the Channel 2 signal is inverted.
It is useful for the comparison of two signals of opposite polarities and for the observation of the difference (CH1-CH2) of the two input signals in the ADD mode.
Normally set this knob in the pressed mode.

⑮ **CH3 INPUT connector**

The BNC connector provides an external trigger signal to Channel 3.

⑯ **PULL TRIPLE & CH3 POS ↕ control**

Sets the vertical position of the Channel 3 signal display.
When the control is pulled in the ALT or CHOP mode, the triple mode is established and the signal applied to Channel 3 is displayed.
The triple traces are available only in the NON STORE mode.

⑰ **MODE select switch**

Selects the operation mode of the vertical axis.

CH1: The signal only applied to CH1 is displayed.
In the HOLD mode, the waveform stored in the CH1 memory is displayed.
In the PLOT output mode, the CH1 signal only is fed out.

CH2: The signal only applied to CH2 is displayed.
In the HOLD mode, the waveform stored in the CH2 memory is displayed.
In the PLOT output mode, the CH2 signal only is fed out.

ALT: In the NON STORE mode, the signals which are applied to CH1 and CH2 are alternately displayed. This is used for the dual trace observation when the sweep rates are fast.
In the STORAGE mode, each of the signals applied to CH1 and CH2 is sampled at the same timing and, the stored waveforms of the dual trace are displayed.

Note:
When the 10 μs/DIV is selected in the STORAGE mode, CH1 and CH2 signals continue to be sampled alternately, but can be displayed simultaneously.

CHOP: In the NON STORE mode, the signals applied to CH1 and CH2 are switched at each 250 kHz, and both the signals are displayed simultaneously.
This is used for dual trace observation, and slower trace time.
In the STORAGE mode, the CHOP mode functions as the ALT.

ADD: The algebraic sum of the input signals applied to CH1 and CH2 is displayed.
In the STORAGE mode, the added waveform is stored in the CH1 memory, and the stored waveform is displayed.
When 10 μs/DIV is selected, ADD does not function. At this time, use the ranges other than 10 μs/DIV.

At the 10 µs/div range, the CH1 mode is established.
In the HOLD mode, the signal waveform stored in the CH1 memory is displayed.

Note:

In the STORAGE mode, the sampling mode is selected by combination of the V-MODE switch and the TIME/DIV switch as shown below.

Sampling mode	V-MODE / Time/div	CH1	CH2	ALT CHOP	ADD / DIFF
Normal/ Single mode	50 ns - 5 µs	CH1	CH2	Simultaneous	ADD/DIFF
	10 µs	CH1	CH2	Alternate	CH1
	20 µs - 0.5 s	CH1	CH2	Simultaneous	ADD/DIFF
ROLL mode	500 ms - 50 s	CH1	CH2	Simultaneous	ADD/DIFF
AVG mode	50 ns - 0.5 s	CH1	CH2	Alternate	ADD/DIFF *

* Excluding the 10 µs/div range setting.

⑱ DC BAL adjustment controls

These are used for the ATT balance adjustment.
See section 11. ADJUSTMENTS ... for the details.

(3) Horizontal deflection system

⑲ TIME/DIV switch

Sets the sweep speed of main sweep (A) or delayed sweep (B). The sweep speed increases when rotating the TIME/DIV switch clockwise. The established value is displayed on the right side of the CRT.

In the NON STORE mode, the setting of B sweep time is available when the DISPLAY mode is set to ALT or B. In the ALT mode, the A sweep is available by pressing the TIME/DIV switch. The B sweep is available by pressing it again. The A and B sweeps are alternately selected at each pressing of the switch.

In the STORAGE mode, the setting of B sweep time is available only when the DISPLAY mode is B.

Sweep time set by the TIME/DIV switch in the DISPLAY mode is shown below.

		Sweep time	
Display mode	A	ALT	B
NON STORE mode	A sweep	A/B sweep	B sweep
STORAGE mode	A sweep	A sweep	B sweep

* NON STORE mode:

A sweep time: 50 ns/DIV to 0.5 s/DIV (22 steps)

B sweep time: 50 ns/DIV to 50 ms/DIV (19 steps)

A TIME/DIV $\geq$ B TIME/DIV

* STORAGE mode:

A sweep time: 50 ns/DIV to 0.5 s/DIV (22 steps)

Note: Repeat mode range of 50 ns/DIV to 5 µs/DIV (7 steps) is used for only measuring the repeat waveform.

B sweep time: 10 µs/DIV to 50 ms/DIV (12 steps)

A TIME/DIV $\geq$ B TIME/DIV

* ROLL mode:

A sweep time: 0.5 s/DIV to 50 s/DIV

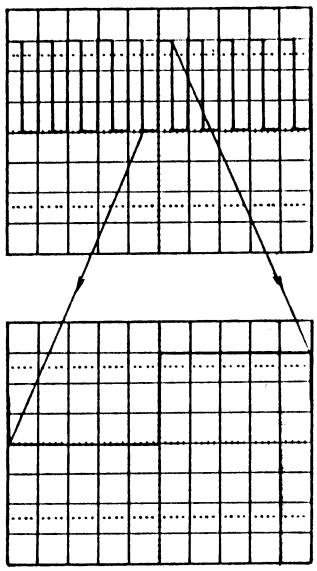
A sweep time only usable.

⑳ **SWP VAR control**

When this control is fully rotated in the direction of arrow, the CAL state is produced, and the sweep time is calibrated to the value indicated by the TIME/DIV control.
Counterclockwise rotation delays the sweep speed by 2.5 times or more. Normally hold the control to the CAL position.

㉑ **POSITION ⇆ control**
PULL x10 MAG

Moves the display in the horizontal direction in the NON STORE mode.
Display is moved toward right when the knob is rotated clockwise and toward left with counterclockwise rotation.
Sweep is magnified 10 times by pulling the POSITION knob.



Magnified waveform

Adjust this control to position the portion of the waveform to be magnified to the graticule center.
Then, pull the control to magnify the waveform. In this time, the sweep time is automatically converted to 1/10 and displayed on the CRT.
In the STORAGE mode, the POSITION control is null.
When the control is pulled, the storage waveform of 1 division from a starting point marker is magnified by 10 times in the horizontal direction.

(22) **DISPLAY select switch**

Selects the operating mode of the horizontal axis system.

A: The A sweep is displayed. This mode is usually used.

ALT: Both main A sweep whose bright portion corresponding to B sweep and delayed sweep B are alternately displayed.
In the STORAGE mode, the operation is as same as that in the A mode.

B: The B sweep is displayed.
In all the STORAGE modes other than the ROLL mode, the B sweep is displayed at the speed corresponding to the B sweep time range when the A sweep time is from 10 µs/DIV to 0.5 s/DIV.

X-Y: Used when the instrument is used as an X-Y oscilloscope.
Apply the X signal to CH1 and the Y signal to CH2.
Set the vertical axis deflection sensitivity by the CH2 VOLTS/DIV switch. Set the horizontal axis deflection sensitivity by the CH1 VOLTS/DIV switch.
Use the CH2 POSITION control for positioning the waveform in the vertical direction.
For the horizontal movement of the waveform, use the horizontal POSITION control in the NON STORE mode and use the CH1 POSITION control in the STORAGE mode.

(23) **TRACE SEP ↑ control**

Adjusts the vertical position of the delayed sweep (B) in the ALT sweep mode. Use this control only in the NON STORE mode.

(24) **HOLD OFF control**

Rotate this control to obtain stable triggering in the case that complex displays such as high-frequency signal and irregular signal are hard to be triggered by the A LEVEL or B LEVEL control. Normally set this to MIN.

(25) **DLY/CURSOR control**

Used to vary the delay time continuously, displaying it on the upper left side of the CRT.

For the high speed control, rotate the control left or right, pressing it.

In the case of the cursor measurement (refer to (5).), the cursor can be shifted.

In the STORAGE mode, the DLY/CURSOR control is used to set SWP X10 MAG POINT, PRE TRIG, NO. OF SWEEP, etc.

This control has the functions of the scale factor (X1 or X10) selection and the initial setting of the system. When setting the scale factor of probe, rotate the control clockwise (X10) or counterclockwise (X1), pressing the PROBE button (31) .

Should the storage operation or the readout function operate abnormally, pull this control to restore the normal operation. When the function operates normally, pulling this control resets the instrument in the initial setting mode.

(See page 11.)

(4) Synchronization system

㉖ MODE select switch

AUTO: The instrument is brought into automatically triggering sweep in which sweep is always conducted. In the presence of triggered signal, normal triggered sweep is obtained and the waveform stands still. In the case of no signal or out of triggering, sweep line will appear automatically. This setting is convenient in usual cases. The displayed waveform continues to be renewed in the STORAGE mode regardless of the presence of triggered signal.

NORM: Triggered sweep is obtained and sweep is conducted only when triggering is effected. No sweep line will appear in the case of no signal or out of synchronization. Use this MODE when effecting synchronization to a very low frequency signal (30 Hz or less). The displayed waveform is not renewed but held in case the sweep is out of synchronization in the STORAGE mode.

TV(-): Used when observing the TV signal with negative polarity sync.
Pull the A LEVEL control ㉘ to set it to the TV-V mode, which enables the vertical synchronization.
Press the A LEVEL control to set it to the TV-H mode, which enables the horizontal synchronization.

㉗ TRIG SOURCE select switch

CH1: The signal supplied to CH1 is selected as the triggering source.

CH2: The signal supplied to CH2 is selected.

VERT MODE:
The signal selected by the MODE select switch ⑰ becomes the triggering source. (See below table.) However, when the CHOP or ADD mode is selected by the switch, CH1 is selected as the triggering source.

Mode(Vertical)	Source signal
CH1	CH1
CH2	CH2
ALT	CH1/CH2
CHOP	CH1
ADD	CH1

In the ALT mode, the CH1 and CH2 can be triggered even when they are not synchronized since the source signal is switched to CH1 and CH2 according to the alternate sweep.

In the STORAGE mode, VERT MODE triggering is not used. Since both the input signals applied to CH1 and CH2 are sampled at the same timing.

EXT: Input signal selected by the COUPLING switch is selected as the triggering source.

㉘ **A LEVEL control**

Sets the trigger level of main sweep (A). By controlling the trigger level, the sweep start point of the waveform is set. Depressed position (normal state) is for ⊕ SLOPE and the PULL position (pulled-out state) is for ⊖ SLOPE.

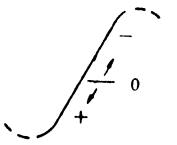
㉙ **B LEVEL control**

Sets the trigger level of delayed sweep (B).

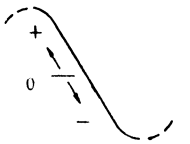
Refer to the A LEVEL control ㉘ description for the trigger level and trigger polarity.

When this control is rotated to the fully counterclockwise position, B trigger is set to the AUTO mode. In other positions, it is set to the NORM mode.

Explanation of trigger LEVEL



⊕ SLOPE



⊖ SLOPE

Explanation of trigger polarity SLOPE

Push
at time of
⊕ SLOPE

Synchronized at bold lines.

Pull
at time of
⊖ SLOPE

(30) **COUPLING select switch**

The signal selected by this switch can be the trigger signal when the TRIG SOURCE select switch is set to EXT.

When the INPUT(CH3) signal is displayed in the TRIPLE mode (16) and NON STORE mode, select the attenuation factor and the coupling method of the input signal.

AC: Blocks DC and cuts off the very low frequency component of the signal supplied to the INPUT (CH3) connector.
(Input readout sensitivity: 0.1 V/div)

DC: Directly connects the signal supplied to the INPUT (CH3) connector to the trigger circuit as the trigger signal.
(Input readout sensitivity: 0.1 V/div)

DC÷10: Connects the signal supplied to the INPUT (CH3) connector through 1/10 attenuator as the trigger signal.
(Input readout sensitivity: 1 V/div)

LINE: Selects the signal synchronized with the line frequency as the trigger signal.

(31) **PROBE key**

(Refer to the DLY/CURSOR control (25) .)

When the PROBE key is being pressed, the DLY/CURSOR switch (25) functions as the probe factor setting switch.

(5) Cursor measurement keys

㉜ [DLY-V / 1/T-T] **key (Cursor menu key)**

This key selects the DLY and the cursor menu.
In the A mode, the measurement mode is changed in the sequence of "no-cursor" → "ΔV" → "ΔT" → "1/ΔT."
In the B or ALT mode, the measurement mode is changed in the sequence of "DLY" → "ΔV" → "ΔT" → "1/ΔT."
In storage mode, this menu selection is available only when the ㊼ CURSOR key is on.

㉝ [REF / Δ] **key (Cursor selection key)**

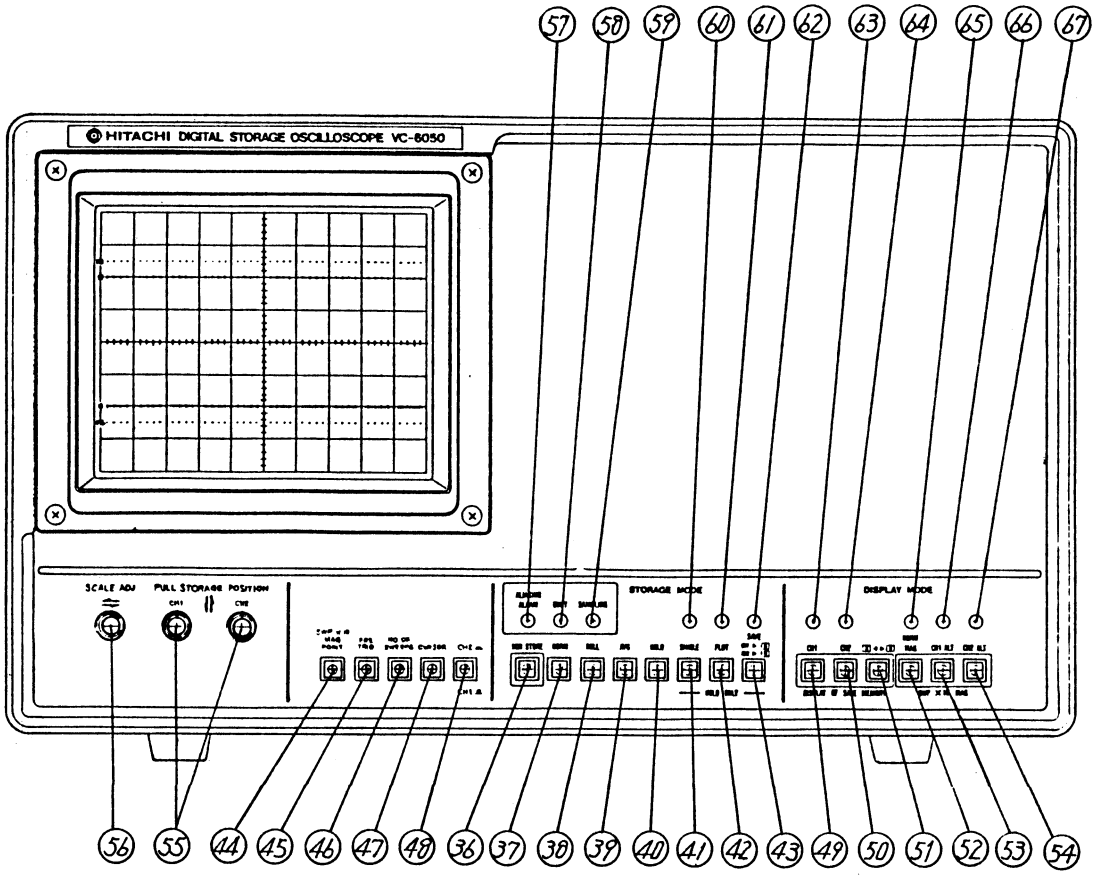
This key selects a cursor desired to be shifted in the cursor measurement.
The selected cursor can be shifted by the control ㉕ .

(6) Miscellaneous

㉞ **PROBE ADJ connector**
Output connector for square wave signal for probe calibration.

㉟ **GND terminal**
Ground terminal of the oscilloscope.

5.2 Front Panel Section B



(1) STORAGE mode

(36) **NON STORE key**

When the NON STORE key is pressed, the VC-6050 functions as a conventional oscilloscope.

(37) **NORM key**

When the NORM key is pressed, the STORAGE mode is established, and the VC-6050 functions as a storage oscilloscope.

(38) **ROLL key**

When the ROLL key is pressed, the stored waveform is shifted to the left hand side, and a new data is added to the right end of the waveform in real time.

(39) **AVG switch**

When the AVG key is pressed, the average waveform is displayed after the input signals for the number of preset sweeps are averaged. The averaging sweep times are set from 2 to 256 by pressing the NO. OF SWEEPS key.
Also a continuous averaging mode or a single averaging mode is selected.

(40) **HOLD key**

Holds the input signal on the screen.

(41) **SINGLE key**

When the SINGLE key is pressed with the HOLD key pressed, the single sweep of the input signal is displayed.
When the SINGLE key is pressed with the single mode of AVG selected, a waveform on the CRT is renewed once after computing the average of the designated number of sweeps (NO. OF SWEEPS).

(42) **PLOT key**

When the PLOT key is pressed in the HOLD mode, the displayed waveform is fed out as an analog signal, which can be used for recording on a recorder or the like.

(43) **SAVE key**

When the SAVE key is pressed, data is transferred from the buffer memory to the save memory.

The keys (44) to (54) are effective only when the keys (37) to (40) are pressed, that is, in the STORAGE mode.

(44) **SWP x10 MAG POINT key**

When the SWP x10 MAG POINT key is pressed, the start point marker for the magnified range and the data are displayed.
The spot is shifted in the horizontal direction by the DLY/CURSOR switch (25) .

(45) **PRE TRIG key**

When the PRE TRIG key is pressed, the trigger point marker is displayed and the pretriggered value is also displayed in DIV unit.

The trigger point is shifted by using the DLY/CURSOR key (25). The shift of the triggered point is not effective in the repeat mode and the roll mode and the pretriggered value is set to 0 div.

(46) **NO. OF SWEEPS key**

Displays the number of sweeps to be averaged and the operation mode, continuous or single operation.

(47) **CURSOR key**

When the CURSOR key is pressed, cursor measurement and delay time setting are performed by using the DLY/CURSOR switch (25), the DLY → V → 1/T → T key (33), the REF/Δ key (34).

(48) **CH1/CH2 key**

Selects the waveform for cursor measurement.

(2) DISPLAY MODE (DISPLAY OF SAVE MEMORY)

(49) **CH1 key**

When the CH1 key is pressed with the CH1 waveform being displayed, the waveform saved in memory A is displayed instead and the lamp lights in green.

When the CH1 key is pressed again, the CH1 waveform is displayed again and the CH1 LED will be extinguished. This operation repeats at each pressing of the key.

(50) **CH2 key**

When the CH2 key is pressed with the CH2 waveform being displayed, the waveform saved in memory B is displayed instead and the LED lights in red.

The operation is same as CH1 key operation.

⑤① **A◁▷B key**

When the CH1 and/or CH2 key is set to on, the data saved in memory A and in memory B are replaced with each other. For further details, see Item 7.2 (4), save memory display.

(3) DISPLAY MODE (SWP X10 MAG)

⑤② **NORM MAG key**

When the NORM MAG key is pressed, the displayed waveform is magnified by 10 times in terms of digital value.

⑤③ **CH1 ALT key**

When the CH1 ALT key is pressed, the original waveform of CH1 is displayed while the magnified waveform of CH1 is also displayed in place of the CH2 waveform. (The original waveform of CH2 disappears.)

⑤④ **CH2 ALT key**

When the CH2 ALT key is pressed, the original waveform of CH2 is displayed while the magnified waveform of CH2 is displayed in place of the CH1 waveform. (The original waveform of CH1 disappears.)

(4) POSITION

⑤⑤ **STORAGE POSITION controls**

Set the vertical position of the stored waveform.
The trace moves up when the control is pulled and rotated clockwise.
The trace moves down by counterclockwise rotation.
The CH1 memory waveform moves by rotating the CH1 control; the CH2 memory waveform moves by rotating the CH2 control.
It is useful for comparing the stored waveforms.
Set the control in the pressed state usually.

⑯ **SCALE ADJ control**

Sets the horizontal position of the stored waveform to the CRT graticule for easy measurements.
When the control is rotated, characters as well as the stored waveform are horizontally shifted. Normally set the control at the mid-position.

(5) LEDs

⑰ **ALIASING ALARM LED (red)**

Lights to alarm for possible aliasing when the sync signal frequency is higher than 1/4 the sample clock frequency.

⑱ **BUSY LED (red)**

Lights to alarm when the microcomputer is busy with GPIB and can not accept the switch and key data.

⑲ **SAMPLING LED (red)**

Lights to indicate that the VC-6050 is sampling the data.

⑳ **SINGLE LED (green)**

Lights until the waveform is updated in the SINGLE mode.

㉑ **PLOT LED (green)**

Lights to indicate that the VC-6050 feeds out the data to a recorder or a printer.

㉒ **SAVE LED (green)**

Lights momentary to indicate that the displayed waveform data is being stored in a save memory.

(63) **CH1 LED (green)**

Lights when the waveform stored in the save memory A is being displayed in place of the CH1 waveform.

CH1 LED (red)

Lights when the waveform stored in the save memory B is being displayed in place of the CH1 waveform.

(64) **CH2 LED (red)**

Lights when the waveform stored in the save memory B is displayed in place of the CH2 waveform.

CH2 LED (green)

Lights when the waveform stored in the save memory A is displayed in place of the CH2 waveform.

(65) **NORM MAG LED (red)**

Lights when the waveform is magnified by the NORM MAG key.

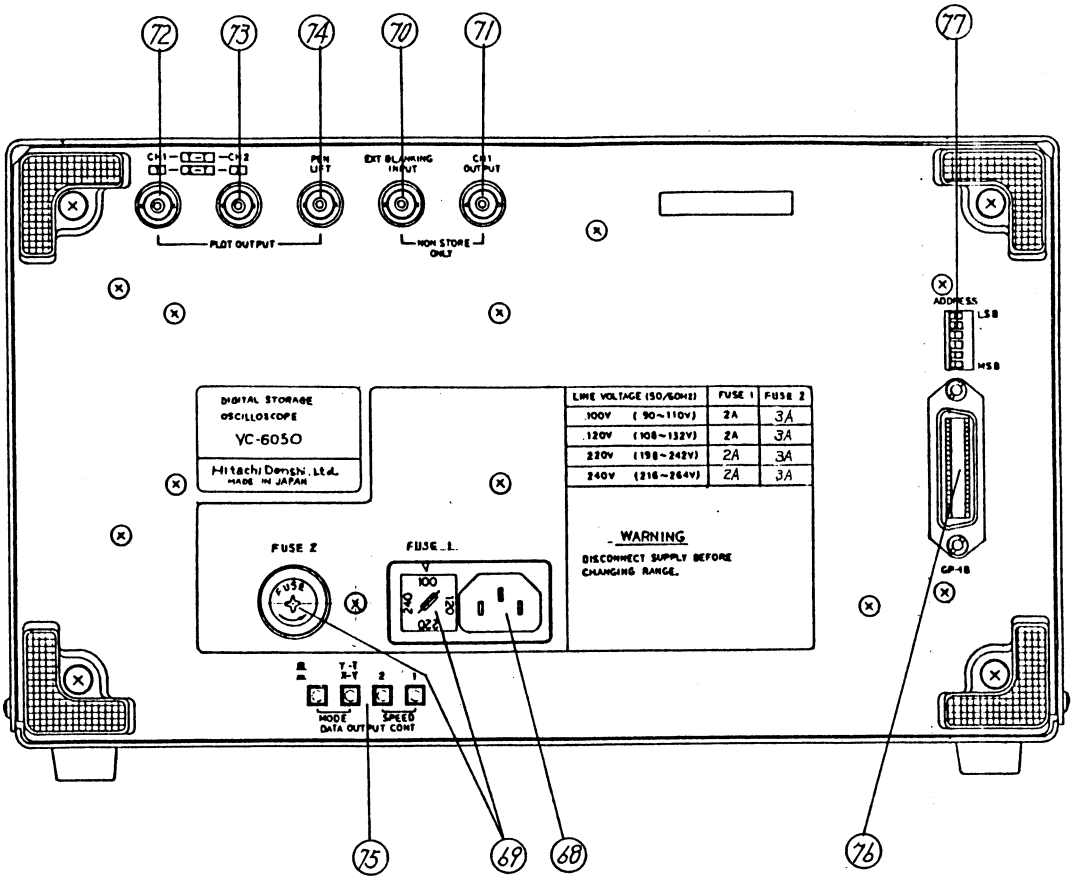
(66) **CH1 ALT LED (red)**

Lights when the waveform is magnified by the CH1 ALT key.

(67) **CH2 ALT LED (red)**

Lights when the waveform is magnified by the CH2 ALT key.

5.3 Rear panel



(68) **AC input connector**

connect the specified AC power source.

(69) **FUSE holder (FUSE 1 or FUSE 2)**

Install a fuse specified on the LINE VOLTAGE selector. Prior to fuse replacement, disconnect the power cable.

(70) **EXT BLANKING INPUT connector**

Input connector for brightness modulation. This is DC coupled. The brightness is reduced with a positive signal and increased with a negative signal.

⑦① **CH1 OUTPUT connector**

Output connector of the signal supplied to CH1.

NOTE:

Do not use this connector when the CH1 PULL X5 GAIN control is pulled, because much noise appears in this mode.

⑦② **PLOT OUTPUT (CH1) BNC connector**

CH1 data is fed out from the Y-T output (pen recorder output). From the X-Y output (X-Y recorder output), the selected data of CH1 or CH2 is fed out.

⑦③ **PLOT OUTPUT (CH2) BNC connector**

From the X-T output (pen recorder output), CH2 data is fed out. From the X-Y output (X-Y recorder output), the X-axis sweep signal is fed out according to the MODE select switch status.

⑦④ **PLOT OUTPUT (PEN LIFT) BNC connector**

Used to feed out the PEN LIFT signal for the recorder with the remote pen lift function.

PEN UP: High level (2.0 V or more)

PEN DOWN: Low level (0.8 V or less)

⑦⑤ **DATA OUTPUT CONT switches**

Sets the plot speed, and X-t output or X-Y output.

⑦⑥ **GPIB connector**

Used to connect with other terminals through GPIB.

The interface specifications conform to IEEE488-1978.

⑦⑦ **GPIB switch**

Sets the address of oscilloscope with the binary data by selecting the five switches.

Most significant bit (MSB) switch is not used.

6. OPERATING PROCEDURE

6.1 Operating Preparations

(1) Graticule

Vertical deflection factors and horizontal timing, as well as VOLTS and TIME cursors are calibrated to the graticule so that measurements of amplitude and time duration may be made directly on the displayed waveform.

(2) Grounding

The most reliable measurements are ensured when a unit under test is connected to the instrument by a common grounding lead after the instrument has been properly grounded to the earth ground. The ground lead on the probe provides the best grounding method for signal interconnection and ensures the maximum amount of shielding of the signal cable in the probe cable. A separate ground lead from the unit under test may be connected to the oscilloscope chassis ground connector located on the lower right of the front panel of the oscilloscope.

6.2 How to Obtain The Displays

Before turning ON the POWER switch, ensure the power supply voltage is within the rated AC voltage range.

Insert the plug on the power cord into the AC outlet and set the controls as follows.

POWER	OFF (non pushed state)
FOCUS	Midrange
INTEN	Fully counterclockwise
READOUT	Fully clockwise
AC-GND-DC	GND
↕ POSITION	Midrange (pushed state)
MODE	CH1
TRIG SOURCE	CH1
⇄ POSITION	Midrange (pushed state)
DISPLAY	A
Trigger MODE	AUTO
A LEVEL	Midrange
NON STORE	Pushed state

After completion of the above settings, turn ON the POWER switch. Then, the LEDs (58) - (67) on the Section B of the front panel light for a while. After they extinguish, characters will be displayed. (If characters are not displayed, pull the INITIAL SET switch.) Allow 15 seconds, and rotate the INTEN control clockwise, and the trace is displayed.

When the oscilloscope is not used for a long period with the power supplied, rotate the INTEN control counterclockwise to reduce the brightness and press the READ OUT PUSH ON/OFF control to allow the character display to disappear.

Align the trace with the horizontal CRT graticule at the center by CH1 POSITION.

In case the trace be slightly slanted due to magnetism, align the trace with the horizontal graticule by the TRACE ROTATION on the front panel.

Note: In the NON STORE mode, the INTEN control varies the brightness of the waveform, while in the STORAGE mode, the STORAGE & READOUT control varies it.

When the INTEN control is at the fully CCW position, the waveform in the STORAGE mode is displayed, but that in the NON STORE mode is not displayed.

Adjust the two controls properly.

6.3 How to Connect Signals

The first step of measurements is to introduce the signal to be measured to the oscilloscope properly.

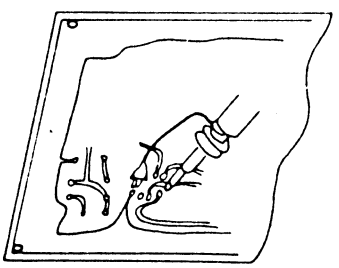
(1) When using a probe

To measure a high frequency signal with high accuracy, set the 10:1, 1:1 select switch of the attached probe AT-10 AP 1.5 to 10:1.
With this probe, the signal connected to the instrument is reduced to 10:1. Therefore, this probe is recommended for measuring a large signal.

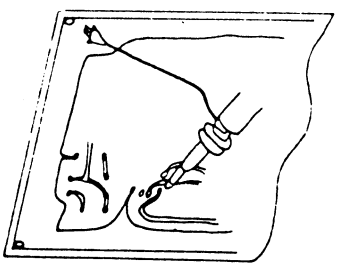
<CAUTIONS>

- o Do not apply a signal in excess of 500 V (DC + peak AC at 1 kHz).
- o Bring the grounding point of the earth lead wire of the probe close to the point to be measured when measuring a rapid rising signal or a high frequency signal. Long earth lead wire may cause waveform distortions such as ringing and overshoot.

Connection of earth lead wire



(a) A good example



(b) A bad example

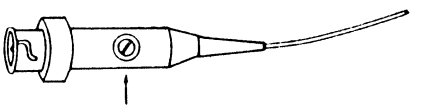
o Multiply the reading of the VOLTS/DIV select switch by 10 when using the 10:1 probe.
For example, if the VOLTS/DIV select switch is set to 50 mV/div, then read the waveform as

50 mV/div x 10 = 500 mV/div

(As for readout display, the reading is used as it is since the readout display can be automatically converted according to the probe setting.)

o To avoid measurement errors, check if the probe is properly compensated.

1) Connect the tip of the probe to the PROBE ADJ connector of calibration square wave (0.5 V, 1 kHz approximately).
2) Connect the earth lead to the GND terminal.
Fig. (a) illustrates the waveform when the probe has been properly compensated.
Fig. (b) illustrates the waveform when the probe has been under-compensated.
Fig. (c) illustrates the waveform when the probe has been over-compensated.



Probe compensation control

(a) Properly compensated (b) Under-compensated (c) Over-compensated

(2) Direct connection

When connecting a signal directly to the oscilloscope without using the attached probe AT - 10 AP 1.5, pay attention to the following points in order to minimize measurement errors.

- o Avoid measurement using a bare lead wire, because measurement errors may be caused by static stray coupling with other circuit and power line. The measurement errors cannot be ignored even in low frequency region.
  When using a shield wire connect one end of the shield to the earth terminal of the oscilloscope and the other to the grounding of the circuit to be measured. It is desirable to use a coaxial cable with BNC type connector.
- o The following cautions must be observed when performing a wide band measurement. It is necessary to terminate with the characteristic impedance of the cable when measuring a rapid rising waveform or a high frequency wave.
  Especially when using a long cable, the absence of a terminating resistor will necessarily lead to a measurement error derived from ringing phenomenon. Some measuring circuits require a terminating resistor equal to the characteristic impedance of the cable also on the measurement terminal side.
  A BNC type terminating resistor (50 ohms) is conveniently used for this purpose.
- o In order to perform measurement with the measuring circuit put in proper operating state it is sometimes necessary to terminate the cable with an impedance which corresponds to the circuit to be measured.

- The stray capacity of the shield wire must be taken into account when performing measurement with a long shield wire. Since the shield wire normally in use has a capacity of about 100 pF per meter, its effect on the circuit to be measured cannot be ignored. Use a probe (10:1) to minimize the effect on the circuit.
- When the length of the shield wire used or the non-terminated cable reaches 1/4 wave length or its multiples within the band of VC-6050 type (1/4 wavelength is about 1 meter when using a coaxial cable at 60 MHz), oscillation may cause near the 5 mV/DIV range.

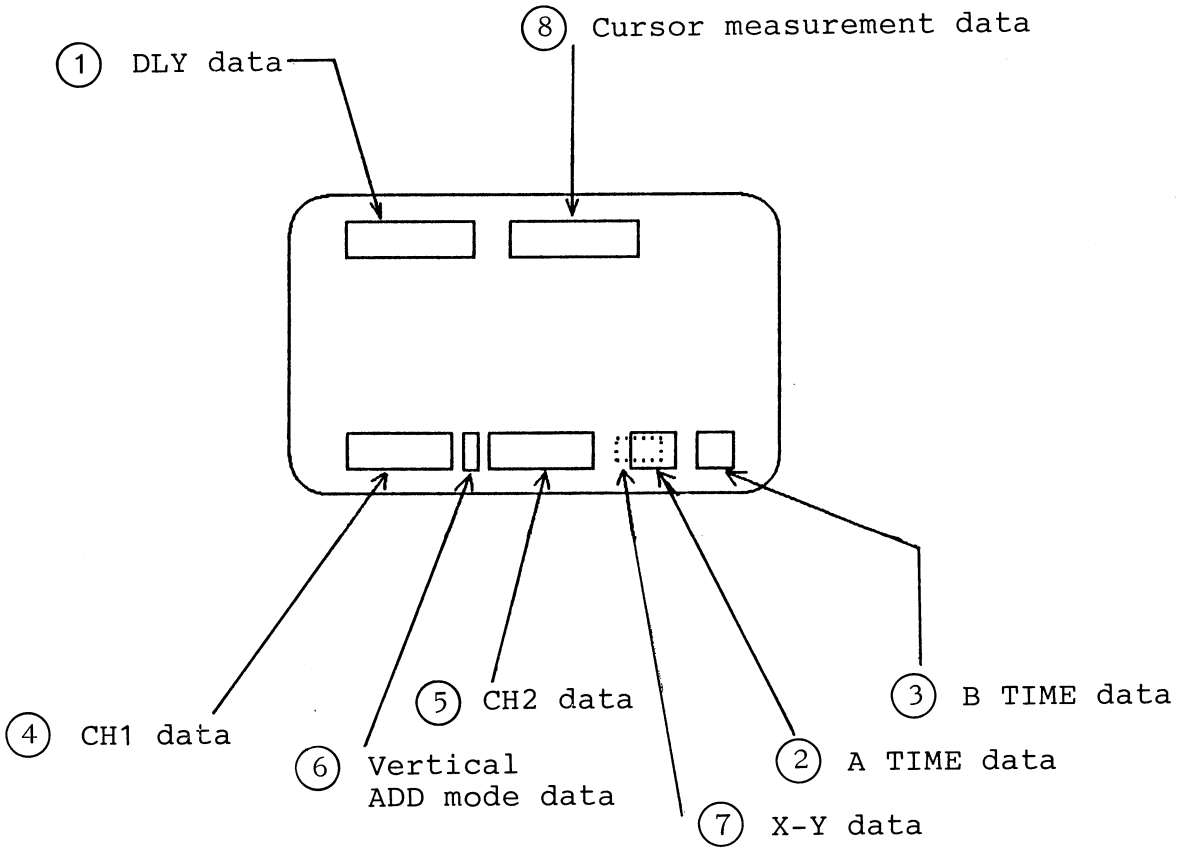
  This is due to the resonance between the externally connected high-Q inductance and the input capacity and can be avoided by reducing the Q.

  Connect the cable or the shield wire to the input connector by way of a serially connected 100-ohm to 1000-ohm resistor, or perform measurement at other VOLTS/DIV range.

6.4 Data Display

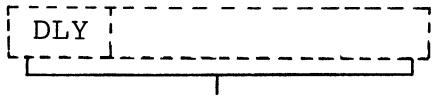
(1) Data display in the NON STORE mode

(a) Data display positions on the CRT



① DLY data

The delay time is displayed when the DISPLAY select switch is set to ALT or B.



- o Normal state : Delay time display (Example; 19.99ms)
- o When the SWP VAR control is set to the position other than CAL. : Division display (Example; 4.99div)
- o When the B LEVEL control is set to the position other than AUTO. : TRIG DLY

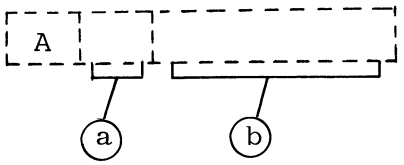
When the underline cursor comes under DLY, the setting by the DLY/CURSOR control is possible.

In the following cases, the DLY display blinks.

- o When the DLY/CURSOR control is further rotated clockwise though the delay time or the division display has reached the maximum.
- o When the DLY/CURSOR control is further rotated counter-clockwise though the delay time or the division display has reached the minimum.

② A TIME data

The sweep time of main sweep (A) is displayed when the DISPLAY select switch is set to A, ALT, or B.



ⓐ When the SWP VAR switch is set to the position other than CAL: ›

X10 MAG mode : * (B TIME data is simultaneously set in the X10 MAG mode.)

Normal state : =

ⓑ A sweep data : ┌ Normal state : 50 ns to 0.5 s
└ X10 MAG mode : 5 ns to 50 ms

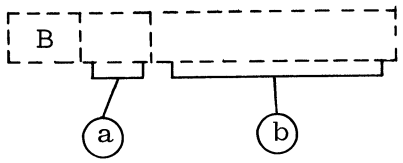
The setting is possible when the underline cursor is under A. In the ALT mode, the position of the underline is changed by each pressing of the TIME/DIV switch.

In the following cases, the A TIME display blinks.

- o When the TIME/DIV control is further rotated clockwise though the set value of A TIME display has reached the maximum.
- o When the TIME/DIV control is further rotated counter-clockwise though the set value of A TIME display has reached the minimum.

③ B TIME data

The sweep time of delay sweep (B) is displayed when the DISPLAY select switch is set to ALT or B.



ⓐ X10 MAG mode: *
Normal state: =

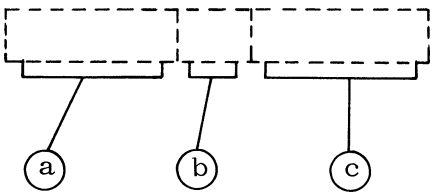
ⓑ B sweep data
Normal state: 50 ns to 50 ms
X10 MAG mode: 5 ns to 5 ms

The setting in the ALT mode is possible when the underline cursor is under B. The underline is moved to A or B at each time of pressing the TIME/DIV switch.
In the following cases, the B TIME display blinks.

- When the TIME/DIV control is further rotated clockwise though the set value of B TIME has reached the maximum.
- When the TIME/DIV control is further rotated counterclockwise though the set value of B TIME has reached the minimum.

④ CH1 data

The CH1 data is displayed when the MODE select switch is set to CH1, ALT, CHOP, or ADD.



ⓐ Probe compensation display

- X10 mode: P_{10X}
- X1 mode: Blank

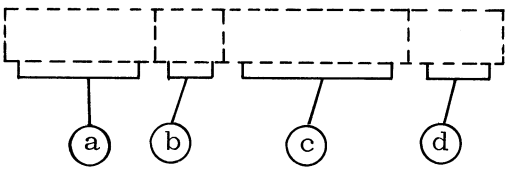
ⓑ

- X5 GAIN mode: *
- VOLTS/DIV UNCAL: >
- Normal state: Blank

ⓒ Volt/division: 1 mV to 50 V

⑤ CH2 data

The CH2 data is displayed when the MODE select switch is set to CH2, ALT, CHOP, or ADD.



ⓐ Probe compensation display

- X10 mode: P_{10X}
- X1 mode: Blank

ⓑ

- X5 GAIN mode: *
- VOLTS/DIV UNCAL: >
- Normal state: Blank

ⓒ Volts/division: 1 mV to 50 V

ⓓ INVERT mode: ↓
Normal state: Blank

⑥ **ADD mode data (on vertical axis)**

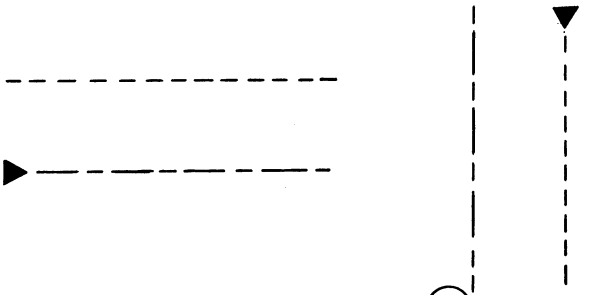
ADD mode: +
Normal state: Blank

⑦ **X-Y data**

The X-Y is displayed in the X-Y mode.

⑧ **Cursor data**

The two cursors of a REF line (dotted) and a Δ line (dash) are displayed in the cursor measurement.
The movable cursor is marked with ▶ or ▼ .



At the cursor data position ⑧, the voltage, time difference, or frequency from the REF line to Δ line is displayed.

(a) ΔV measurement

- ΔV1, ΔV2, ΔV$^{1}_{2}$
- +, -
- mV, V

(b) ΔT measurement

- ΔTA, ΔTB
- +, -
- ns, μs, ms, s

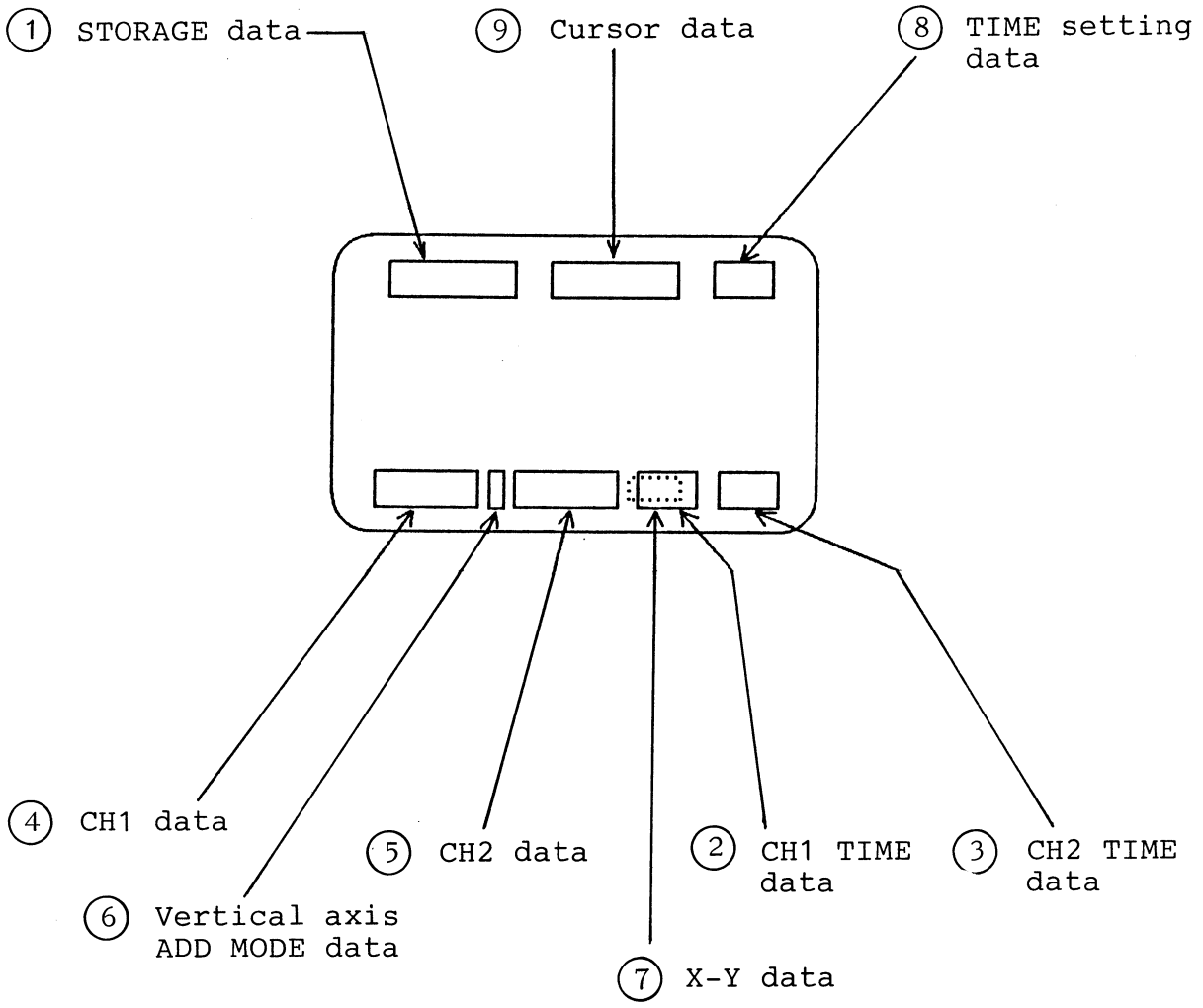
(c) 1/Δ T measurement

- 1/Δ TA, 1/Δ TB
- MHz, kHz, Hz

Notes: In (a), 1, 2, and $^{1}_{2}$ represent the measuring channels.
In (b) and (c), A or B represent the A sweep or B sweep respectively.

(2) Data display in the STORAGE mode

(a) Data display positions on the CRT



① STORAGE data

In the STORAGE mode, the setting data corresponding to the operations shown below are displayed.

* When the SWP X10 MAG POINT key is ON:

  Displays the start point of horizontal magnification.

  (Example: MAG 9.0 div)

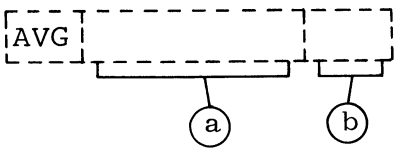
* When the PRE TRIG key is ON:

  Displays the triggering point of the waveform.

  (Example: TRG 9.9 div)

* When the NO. OF SWEEPS key is ON:

  Displays the number of sweeps processed in the average mode and the sweep mode.



ⓐ Number of sweeps: 2, 4, 8, 16, 32, 64, 128, 256

ⓑ Sweep modes:

  Continuous sweep: CNT

  Single sweep : SNG

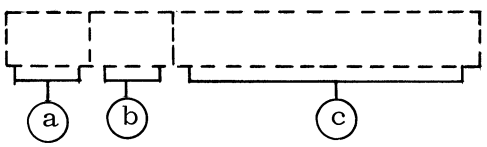
* When the CURSOR key is ON:

  Delay amount is displayed when ALT or B is selected by the DISPLAY switch.

  The display format and the delay amount are established in the same manner as in the NON STORE mode.

② CH1 TIME data

When the waveform is displayed in the CH 1 sweep, the time setting data when the waveform is sampled are displayed.



ⓐ Kinds of the displayed memory

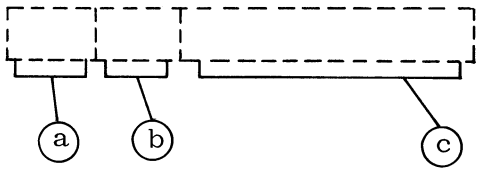
- CH1 memory: 1
- SAVE memory A: S_A
- SAVE memory B: S_B

ⓑ
- Horizontal magnification SWP X10 MAG: *
- SWP UNCAL : >
- Normal display : =

ⓒ TIME/DIV: TIME setting data when the waveform is acquired into the memory.

③ CH2 TIME data

When the waveform is displayed in the CH2 sweep, the TIME setting data at sampling the waveform are displayed.



ⓐ Kinds of the displaying memory

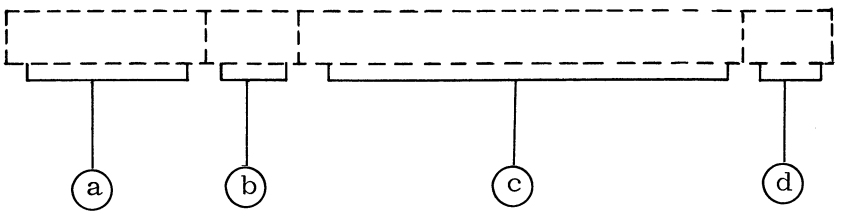
- CH2 memory: 2
- SAVE memory A: S_A
- SAVE memory B: S_B

ⓑ
- Digital horizontal magnification SWP X10 MAG: *
- Normal display : =

ⓒ TIME/DIV: TIME setting data when the waveform is acquired into the memory.

④ CH1 data

When the waveform is displayed in the CH1 sweep, the attenuating setting data when the waveform is sampled are displayed.



ⓐ PROBE compensating factor display

- X10: P_{10X}
- X1 : Blank

ⓑ
- X5 GAIN: *
- VOLTS/DIV UNCAL: ›
- Normal state: Blank

(X1)

ⓒ VOLTS/DIV display

- Normal display: VOLTS/DIV setting data when the CH1 waveform is acquired into the memory.

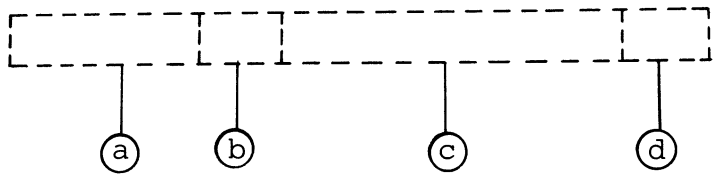
When the two waveforms of different VOLTS/DIV settings are added.: ADD

When the two waveforms of different VOLTS/DIV settings are subtracted.: SUB

ⓓ
- INVERT: ↓
- Normal state: Blank

⑤ CH2 data

When the waveform is displayed in the CH2 sweep, the attenuation factor when the waveform is sampled is displayed.



ⓐ PROBE compensation display

X10: P_{10X}
X1: Blank

ⓑ
X5 GAIN: *
VOLTS/DIV UNCAL: >
Normal: Blank

ⓒ VOLTS/DIV display

Normal display: VOLTS/DIV setting data when the CH2 waveform is acquired into the display memory.

When the two waveforms of different VOLTS/DIV settings are added: ADD
When the two waveforms of different VOLTS/DIV settings are subtracted: SUB

ⓓ
INVERT: ↓
Normal state: Blank

NOTE

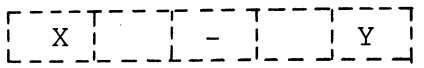
The VOLTS/DIV display in the ADD or the SUB mode

When the VOLTS/DIV values of the two channels are different in the ADD or the SUB, ADD or SUB is displayed. When both the values are equal, the setting value is displayed.

⑥ Vertical axis ADD MODE

ADD: Blank
Normal display: Blank

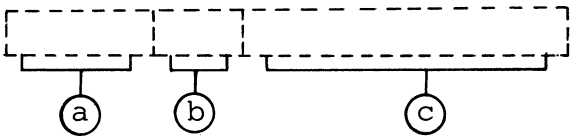
⑦ X-Y data:



X-Y operation display

⑧ TIME setting value:

TIME/DIV data set by the TIME/DIV switch is displayed.



ⓐ DISPLAY mode:
A, ALT, or X-Y: A
B: B

ⓑ SWP UNCAL: >
SWP X10 MAG: *
Normal display: =

ⓒ TIME/DIV setting value

⑨ Cursor measurement value

The voltage or time difference between the two cursor lines are simultaneously displayed in the same manner as in the NON STORE mode.

The data are displayed when ΔV, ΔT, or 1/ΔT is selected by the cursor menu key (DLY → V → 1/T → T) with the CURSOR key set to ON.

(a) ΔV measurement

- ΔV_1, ΔV_2
- +, -
- mV, V, ADD, SUB

(b) ΔT measurement

- ΔT_1, ΔT_2, ΔT_{SA}, ΔT_{SB}
- ns, μs, ms, s

(c) 1/ΔT measurement

- $1/\Delta T_1$, $1/\Delta T_2$, $1/\Delta T_{SA}$, $1/\Delta T_{SB}$
- MHz, kHz, Hz

The data of the waveform selected by the CH1/CH2 key is displayed.

Notes:

The display data of CH1 TIME display (2), CH2 TIME display (3), CH1 display (4), CH2 display (5), and cursor measurement value (9) are displayed according to the conditions when the waveforms being displayed on the CRT are acquired into the display memory in the STORAGE mode.

When setting values are changed by the TIME/DIV switch or VOLTS/DIV switch in the HOLD mode or during displaying the SAVE memory waveform, the display values remain unchanged and the data at the time when the waveform is held or when the save waveform is acquired into the display memory are displayed.

For the STORAGE setting value (1), and TIME setting value (8), the current setting data is displayed.

(3) How to use a probe of a different scale factor

The displayed data of the vertical axis sensitivities of CH1 and CH2 can be changed when the DLY/CURSOR control is rotated CW (+) or CCW (-) while pressing the PROBE button. For instance, when changing the scale factor from X1 to X10 at 10 mV/div range, rotate the DLY/CURSOR control to CW (+) while pressing the PROBE button.

Then, the displayed data of the vertical axis sensitivity is changed from 10 mV to 0.1 V and the probe compensation data P_{10X} is also displayed on the CRT.

6.5 Preparation for Measurement

(a) Prior to normal measurements, set the VAR PULL X5 GAIN and SWP VAR switches as follows.

VAR PULL X5 GAIN : Turn this switch fully CW.
In this case, the VOLTS/DIV is calibrated to the displayed data and the UNCAL symbol › disappears.

SWP VAR : Turn this switch fully CW.
In this case, the TIME/DIV is calibrated to the displayed data and the UNCAL symbol › disappears.

(b) Perform the probe compensation in accordance with the probe to be used.

1:1 probe : The displayed VOLTS/DIV data can be read directly.

10:1 probe : "P_{10X}" is displayed before the VOLTS/DIV data.
In this case, the data multiplied by 10 is displayed so that the data can be read directly.

7. BASIC OPERATIONS

The VC-6050 is provided with the NON STORE mode and the STORAGE mode and the selection of the modes are made by the switches of the STORAGE MODE area.

The basic operations are described below.

Cautions:

Prior to measurements, allow 20 minutes of warmup time.

7.1 NON STORE mode

The VC-6050 works as a conventional oscilloscope.

(1) Normal sweep display

① Set the switches, keys, and controls as shown in Table 7-1. Check that the NON STORE key of the STORAGE MODE is set to ON.

Table 7-1 Initial setting of basic display

Vertical axis	VOLTS/DIV	Set according to the amplitude of the applied signal.
	VAR PULL X5 GAIN	CAL position (Rotated fully clockwise, not pulled)
	AC-GND-DC	AC
	Vertical POSITION	Mid-position
	MODE	CH1
CRT	INTENSITY	Proper position
	FOCUS	Mid-position
	ILLUM	Mid-position
	STORAGE & READOUT	Fully clockwise
Horizontal axis	DISPLAY	A
	TIME/DIV	1 ms/div
	X10 MAG	Off (Not pulled)
	Horizontal POSITION	Mid-position
	SWP VAR	CAL (Fully clockwise)
Trigger	A LEVEL	Mid-position
	TRIG SOURCE	CH1
	COUPLING	AC
	MODE	AUTO

(2) Connect the signal to CH1 INPUT connector using the probe which meets the input impedance. Refer to Section 6 for connection.

(3) Adjust the INTEN control for proper illumination.

④ Adjust the VOLTS/DIV of Channel 1 and vertical and horizontal POSITION controls so that the trace is displayed within the screen.

⑤ Adjust the A 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 observing a single waveform

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

MODE select switch	:	CH1
TRIG SOURCE select switch	:	CH1
Trigger MODE switch	:	AUTO
DISPLAY select switch	:	A

Under these settings almost all the repetitive signals of approximately 30 Hz or more supplied to CH1 can be triggered and observed by adjusting the A LEVEL control. Since the MODE of horizontal axis is at AUTO, the trace appears even when no signal is present or when the input coupling switch is at GND. This means that the DC voltage can be measured. The following switching is needed when observing low frequency signals of approximately 30 Hz or less.

Trigger MODE switch	:	NORM

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

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

MODE select switch	:	CH2
TRIG SOURCE select switch	:	CH2

(3) When observing two waveforms

Observation of two waveforms can be made easily by setting the MODE select switch to ALT or CHOP.
When observing two waveforms of high repetition frequencies, set the MODE select switch to ALT and, in the case of low frequencies, set it to CHOP.
When measuring the phase difference, trigger a signal whose phase advances.

(4) When observing three waveforms

Three waveforms CH1, CH2, and CH3 can be observed by pulling the PULL TRIPLE & CH3 POS control when the MODE select switch is set to ALT or CHOP.

(5) When observing waveform in the X-Y mode

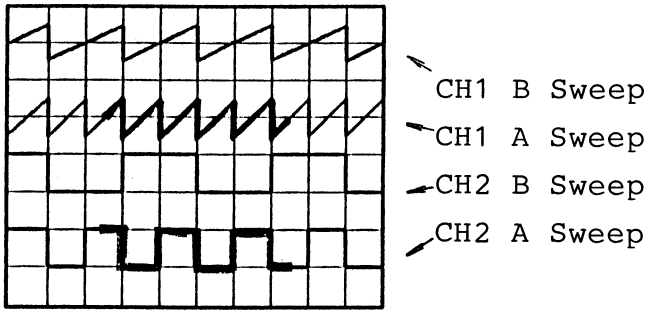
Set the DISPLAY select switch to X-Y to make the instrument to operate as an X-Y oscilloscope.
Each input signal is supplied to the instrument as follows:

X-axis signal (horizontal axis signal): CH1 INPUT
Y-axis signal (vertical axis signal) : CH2 INPUT

In this case, leave the horizontal axis magnification switch (PULL X10 MAG) at the pushed position.

(6) Alternate sweep

By setting the DISPLAY select switch to ALT, main sweep (A) and delayed sweep (B) are alternately displayed on the CRT.
The following figure shows the display in the ALT sweep mode.



A sawtooth waveform is supplied to CH1 and a square wave to CH2 in this case. The B trace can be moved up to approximately four divisions above the A sweep trace by rotating the TRACE SEP control for the convenience of observation. By pulling the PULL TRIPLE & CH3 POS control in the ALT sweep mode, two more traces, six traces in total, appear on the CRT. These two traces are A and B sweeps of CH3.

(7) Operation procedure of delayed sweep

The delayed sweep is used to magnify any position of a complexed waveform in the horizontal direction.

(a) AUTO (continuous delay sweep)

Effect triggering by A sweep, and set the controls as follows:

B LEVEL control	:	AUTO
DISPLAY select switch	:	ALT
A TIME/DIV	:	As desired
B TIME/DIV	:	As desired

Under these settings, a brighter portion will appear on the trace of A sweep. Rotate the DLY/CURSOR control and the brighter portion will move continuously. (For faster operation, rotate the DLY/CURSOR control while pressing it.) Bring this brighter portion to the position to be magnified. Then, the brighter portion is magnified to occupy the full area of the screen.

(b) NORM (triggering delay sweep)

Effect triggering by A sweep, and set the controls as follows:

B LEVEL control	:	Normal (non pulled state)
DISPLAY select switch	:	ALT
A TIME/DIV	:	As desired
B TIME/DIV	:	As desired
SLOPE	:	(+) or (-)

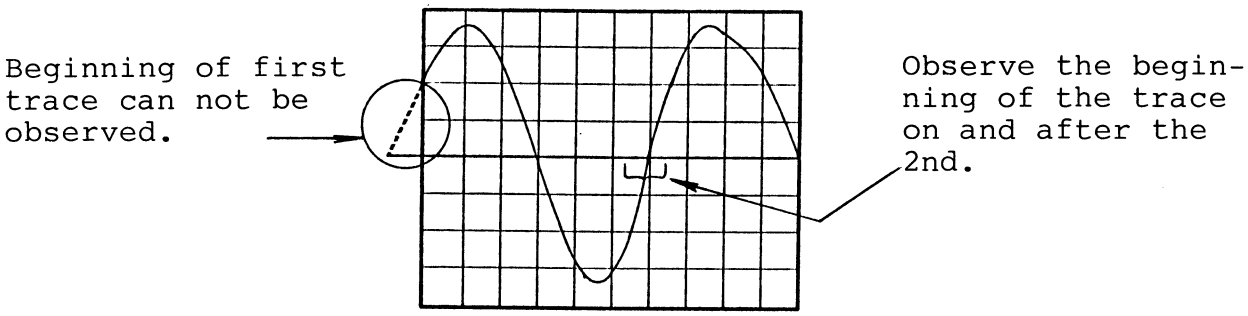
Rotate the B LEVEL control, then a brighter portion will appear on the trace of A sweep. Rotate the DLY/CURSOR control and the brighter portion discontinuously moves to the next peak. Bring this brighter portion to the position to be magnified by using the B LEVEL and the DLY/CURSOR controls. Then, the brighter portion is magnified to occupy the full area of the screen.

7.2 Digital Storage Display

The operating procedures of the digital storage functions are described below. When the vertical MODE switch is selected in the NORM mode and any of the DISPLAY OF SAVE MEMORY switches is selected, the waveform to be stored is displayed on the CRT screen. (Table 7-2)

(1) Normal storage mode (NORM)

① Display the waveform to be stored in the NON STORE mode.
② Press the NORM switch.
③ The slower the sweep rate, the longer the time is required for the acquisition and display of the waveform. It takes 10 seconds approximately until a waveform is acquired at the sweep rate of 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 set in 10 μs/div to 0.5 s/div (15 steps), a single shot waveform and a repetitive waveform can be stored.
When the TIME/DIV control is set in 50 ns/div to 5 μs/div (7 steps), the repetitive waveform only can be stored in the REPEAT mode. Precautions for the REPEAT mode are shown below.
a. The beginning of the first trace is not displayed in the REPEAT mode. So, observe the beginning of the trace on and after the second.



REPEAT mode display

b. It takes 13 seconds or more to store the input signal of 1 kHz or lower.

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 of 0.3 μs or higher.

Table 7-2

DISPLAY SAVE MEMORY switches / Vertical MODE switch position	CH1 (Lamp)	—— ——	Pressed (Green)	Pressed (Red)	—— ——
	CH2 (Lamp)	—— ——	—— ——	—— ——	Pressed (Red)
CH1		CH1	SAVE A	SAVE B	CH1 and SAVE B
CH2		CH2	SAVE A and CH2	SAVE B and CH2	SAVE B
ALT		CH1 and CH2	SAVE A and CH2	SAVE B and CH2	CH1 and SAVE B
CHOP		CH1 and CH2	SAVE A and CH2	SAVE B and CH2	CH1 and SAVE B
ADD		ADD	SAVE A	SAVE B	ADD and SAVE B

* Each square box in the bold lines represents a CRT screen. For example, SAVE A represents that the SAVE A waveform is displayed on CRT and SAVE A and CH2 represents that the SAVE A waveform is displayed on upper half of the CRT screen and the CH2 waveform on lower half of the screen.

* The data saved in memories A and B are replaced with each other at each pressing of the A ◁ ▷ B key.

(2) Average mode (AVG)

The AVG mode is used to extract a repetition signal which does not appear on the CRT due to noise.
In this mode, the measurements of continuous mode and single mode are available.
Take the following procedures.

① Setting of the number of sweeps to be averaged

Ⓐ Press the NO. OF SWEEPS button in the STORAGE mode. Then the number of sweeps is displayed on the upper left side of the CRT.
"2" is displayed when the power switch is turned on.

Ⓑ Set to an appropriate number by the DLY/CURSOR switch.
Clockwise rotation increases the number and counterclockwise rotation decreases it.

Ⓒ Press the DLY/CURSOR switch to select the continuous mode or the single mode.
The mode is alternately switched by a press of the DLY/CURSOR switch.

② Press the NORM button and allow a trace to be displayed on the CRT. Set the MODE lever to NORM, and rotate the A LEVEL control to stabilize the trace.

③ Press the AVG switch.

④-1 In case of continuous mode
As far as the AVG key is being pressed, the waveform data acquired by the preset number of the sweeps are averaged and the display is renewed repeatedly.
When the HOLD key is pressed while the waveform is being displayed, the waveform at that time is held.

④-2 In case of SINGLE mode
When the AVG key is pressed, the display is being held.
When the SINGLE key is pressed in this mode, the waveform acquired by the preset number of the sweeps, the display is renewed only once and the hold mode is gained again.

Notes:

1. The number of the sweeps of the stored waveform is selectable from 2 to 256 in binary sequence.
2. The digital storage circuit displays the averaged waveform after acquiring the preset number of sweeps.
   The previous average waveform is displayed in the continuous mode at this time.
   In the continuous operation mode, a new storage cycle starts while a preceding averaged waveform is being displayed. This cycle repeats until a new mode is selected. When the data being acquired are affected by changing the setting position of the front panel controls, a new waveform selected by this setting is acquired and a new storage cycle thus starts.
3. After 256 sweeps are averaged, it takes a minute approximately to display the resultant waveform. The SAMPLING LED blinks for the duration to indicate the averaging is being performed.

(3) Save mode

① Press the HOLD key.
② Press the SAVE key of the STORAGE MODE.
③ The CH1 waveform data is stored in memory A; the CH2 waveform data is stored in memory B.
   The SAVE LED lights in green during the SAVE operation.
④ To display the waveform data stored in the SAVE memory, take the operations shown in (4) described below.
   Caution - The waveform data stored in the SAVE memories will be destroyed when:
   1 Power is turned off.
   2 Initial settings are performed.
   3 The AVG mode is activated.

(4) Save memory display

① Display of SAVE memory A

Press the CH1 key of the DISPLAY MODE.

Then, the waveform stored in SAVE memory is displayed in place of the CH1 waveform and the CH1 LED lights in green.

When the key is pressed again, the input waveform is displayed again, and the green-lamp turns off. These operations repeat at each pressing of the key.

② Display of SAVE memory B

Press the CH2 key of the DISPLAY MODE.

Then, the waveform stored in SAVE memory B is displayed in place of the CH2 waveform, and the CH2 LED lights in red.

When the key is pressed again, the input waveform is displayed again, and the red-lamp turns off. These operations repeat at each pressing of the key.

③ Exchange of SAVE memories A and B

When either or both of the SAVE memories A and B are being displayed, the waveforms can be replaced with each other.

How to use CH1 key

i) Press the CH1 key of the DISPLAY MODE. Then, the SAVE memory A waveform is displayed in place of the CH1 waveform (same as (4)-①mode).

ii) Press the A ◁▷ B key of the DISPLAY MODE.
The SAVE memory B waveform changes to the SAVE memory A waveform displayed in place of the CH1 waveform. Accordingly, the CH1 LED illumination changes from green to red.

iii) Press the A◁▷B key again.
The SAVE memory A waveform is displayed in place of the CH1 waveform.

iv) Press the CH1 key to allow the input waveform to be displayed again.

How to use CH2 key

i) Press the CH2 key of the DISPLAY MODE. Then, the SAVE memory B waveform is displayed in place of the CH2 waveform (same as (4)-② mode).

ii) Press the A◁▷B key of the DISPLAY MODE.
The SAVE memory A waveform changes to the SAVE memory B waveform displayed in place of the CH2 waveform. Accordingly, the CH2 LED illumination changes from red to green.

iii) Press the A◁▷B key again.
The SAVE memory B waveform is displayed in place of the CH2 waveform.

iv) Press the CH2 key to allow the input waveform to be displayed again.

Note: The above operations are available only in the NORM and HOLD modes.
In the ROLL mode or the AVG mode, the save memory display is not available.

(5) ROLL mode

The displayed waveform is rolled from right to left. The right end of each trace is the trigger point of a new data. The ROLL mode facilitates measurement of a signal of 100 Hz or lower.

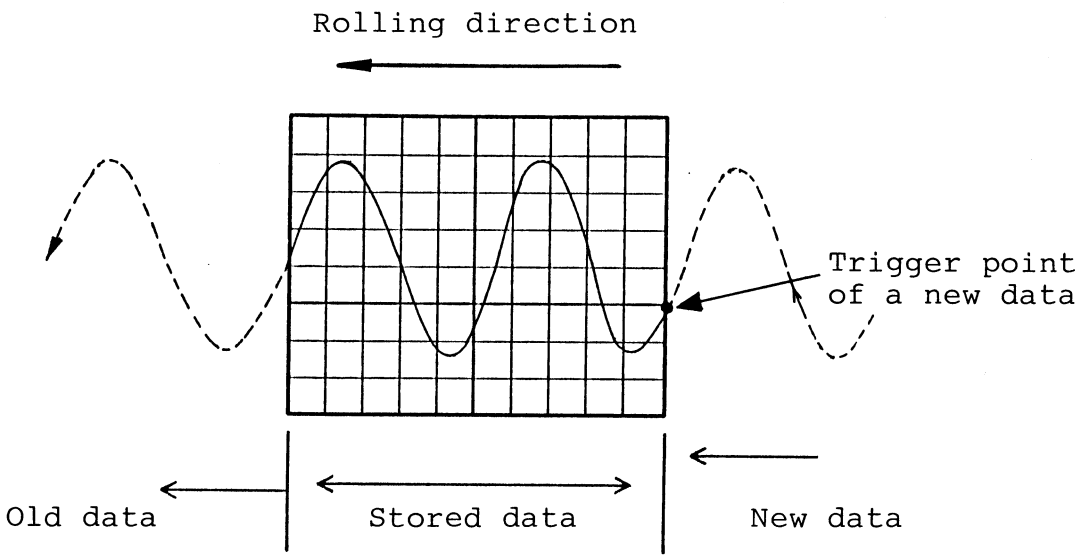


Fig. 7.1

① Press the ROLL key of STORAGE MODE.
Data is acquired into the memory by pressing the ROLL key, and ROLL mode display starts.

② Select the time range for measuring the input signal with the TIME/DIV switch.
* Selectable time range in the ROLL mode: 0.5 s/div to 50 s/div
* Time range has been pre-set to 0.5 s/div.

③ When the HOLD key is pressed, the ROLL mode stops and the final waveform of the ROLL mode is held on the CRT.

Note: In the ROLL mode, the following keys are all null:
CURSOR, SWP X10 MAG POINT, PRE TRIG, and NO. OF SWEEPS

(6) Magnification of time axis

NORM MAG, CH1 ALT, and CH2 ALT MAG switches are available for the magnification of sweeps in the NORM mode.

① NORM MAG switch

The original digital waveform on the CRT is magnified by 10 times.

ⓐ Press the SWP X10 MAG POINT key.
Then, a cursor line which indicates the starting point of the magnified range is displayed.
Adjust the DLY/CURSOR switch to move the cursor to the starting point of the waveform to be magnified.
Clockwise rotation moves the cursor to the right; counterclockwise rotation moves it to the left.

(b) Press the NORM MAG key of DISPLAY MODE.

◎ LED lights in red

NORM
MAG key

The NORM MAG LED lights in red, and the waveform of one division from the cursor position is magnified by 10 times.

Note:

When the CH1 and CH2 waveforms are both displayed, both the waveforms are magnified by 10 times.

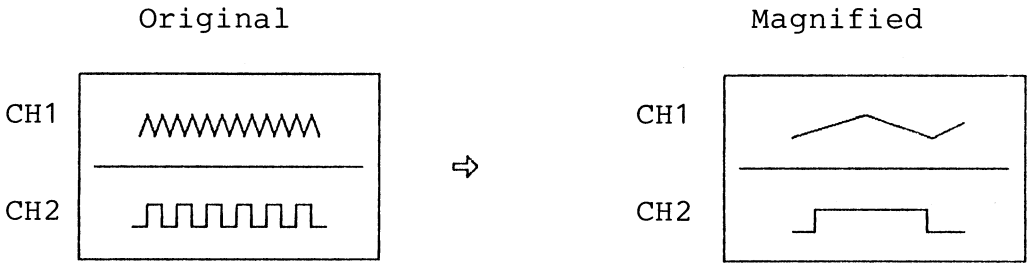


Fig. 7.2

(c) Press the NORM MAG key again. Then, LED will extinguish and the original waveform(s) will be displayed.

(2) CH1 ALT switch

(a) Press the SWP X10 MAG POINT key.
Adjust the DLY/CURSOR switch to move the cursor line to the starting point of the waveform to be magnified.

ⓑ Press the CH1 ALT key of DISPLAY MODE.
Then, the original waveform of CH1 remains displayed, but the CH2 waveform disappears and the magnified CH1 waveform is displayed instead of the CH2 waveform. The CH1 ALT LED lights in red.

ⓒ When the original waveform and the magnified waveform are superimposed, adjust the CH1 or CH2 controls of PULL STORAGE POSITION.

CH1 control: Original waveform
CH2 control: Magnified waveform

Example

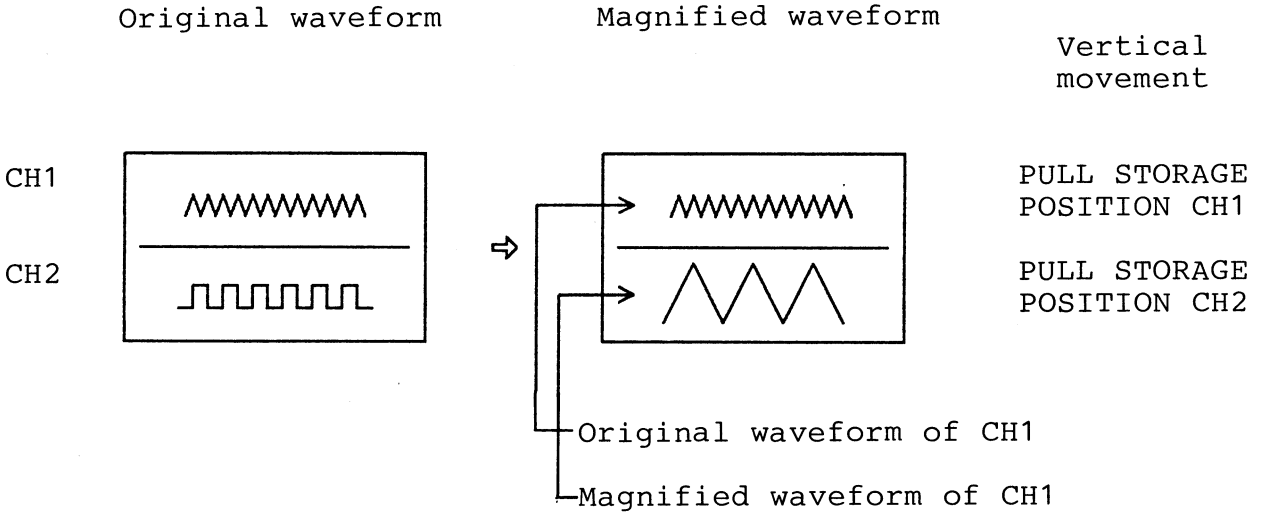


Fig. 7.3

ⓓ Press the CH1 ALT key for the original display.

③ CH2 ALT switch

The original CH2 waveform and its magnified waveform are simultaneously displayed.

ⓐ Press the SWP X10 MAG POINT key.
Set the cursor to the starting point of the waveform to be magnified by the DLY/CURSOR switch.

ⓑ Press the CH2 ALT key of DISPLAY MODE.
Then, the CH2 ALT LED lights in red, and the CH2 original waveform and the magnified waveform are displayed while the CH1 waveform disappear.

ⓒ Adjust the CH1 or CH2 controls of PULL STORAGE POSITION to position the two waveforms properly.
CH1 control: Magnified waveform
CH2 control: Original waveform

ⓓ Press the CH2 ALT key for the original display.

Example

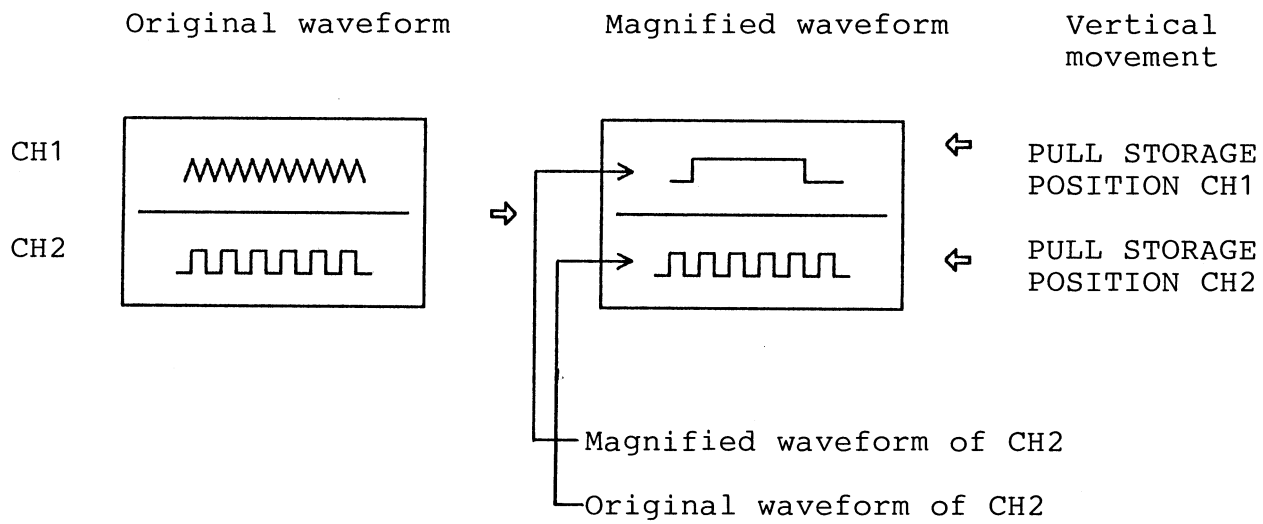


Fig. 7.4

④ PULL X10 MAG switch

When the PULL X10 MAG switch is used with the NORM MAG, CH1 ALT, or CH2 ALT mode, the magnified waveform is further magnified by 10 times.

ⓐ Press the NORM MAG, CH1 ALT, or CH2 ALT key for magnification.

ⓑ Pull the PULL X10 MAG switch.

Thus, the magnified waveform is further magnified by 10 times.

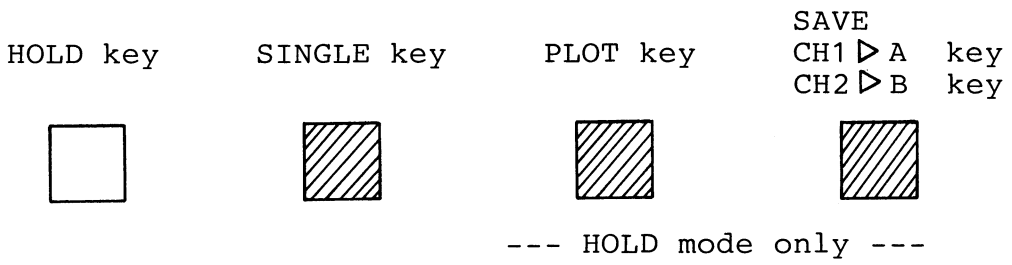
(7) HOLD mode

When the HOLD key is pressed, the sampling operation of the NON STORE, NORM, ROLL, or AVG mode is interrupted and the data right before the HOLD key is pressed remains displayed.

Notes:

1. When the mode is changed from NON STORE (oscilloscope mode) to HOLD, the waveform displayed in the storage mode (NORM, ROLL or AVG mode) just before the mode was changed to the NON STORE mode is displayed again.
2. When the power is set to on with the HOLD key pressed, the initial setting trace is displayed at the center of the CRT.

(1) The following three modes are effective in the HOLD mode.



The PLOT and the SAVE keys are effective only when the HOLD key is pressed.
The SINGLE key is effective not only in the HOLD mode but in the SINGLE mode of the average operation.

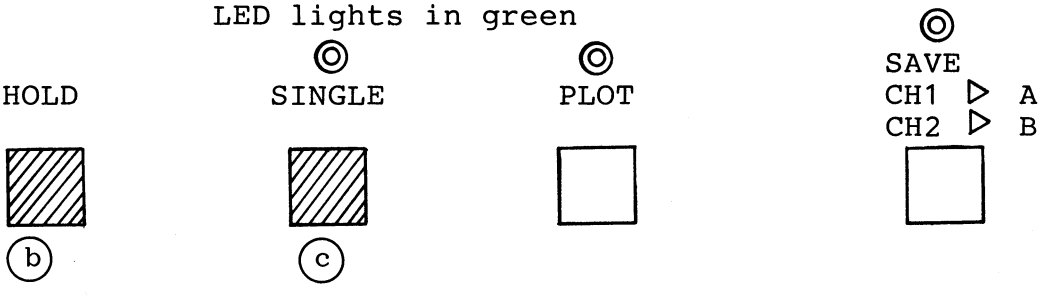
② In the HOLD mode, the information established on the front panel is not changed by the controls, since the waveform display is held on the CRT.
When changing the mode to NORM, AVG, ROLL, SINGLE, etc., set the VOLTS/DIV according to the setting of the switches on the panel and the time range according to the TIME/DIV data displayed on the upper right of the CRT.

(8) SINGLE operation in the HOLD mode

Sampling is made only once and the waveform on the CRT is renewed.

① SINGLE operation procedure

ⓐ Set the trigger MODE switch to NORM.
Set the trigger A LEVEL control to proper position for measuring the input signal.
ⓑ Press the HOLD key.
ⓒ Press the SINGLE key.
When the SINGLE key is pressed, the SINGLE LED lights in green until the displayed waveform is renewed.



ⓓ The SINGLE LED distinguishes to indicate the SINGLE operation is completed.
The new waveform is displayed, and the data remains displayed.

② The SINGLE sweep operation does not activate until the input signal is triggered after the SINGLE key is pressed.
Consequently, this operation is useful for the digital storage of transient waveform (single shot).
While the input signal is not triggered, the SINGLE LED lights.
To release the standby mode, that is, to extinguish the SINGLE LED, apply the signal for triggering the input signal, or set the trigger MODE switch to AUTO.

③ When the trigger MODE switch is set to AUTO, the SINGLE operation is activated by internal triggering.

(9) PLOT output in the HOLD mode

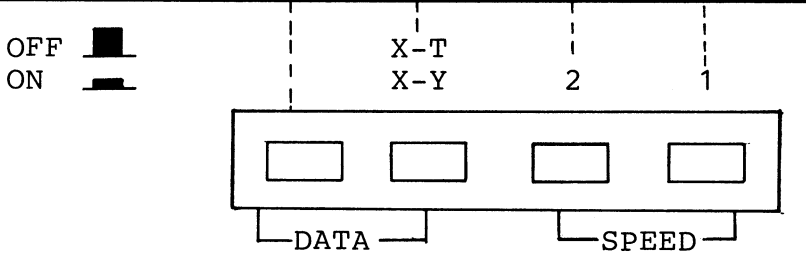
The displayed waveform is fed out to a recorder, etc.

① PLOT mode

PLOT speed, Y-T output and X-Y output are selected by the DATA OUTPUT CONT switches on the rear panel.

Rear panel

	Plot speed	MODE switches		SPEED switches		Remarks
		——	Y-T X-Y	2	1	
Y-T output (To pen recorder)	1 s/div	X	OFF	OFF	OFF	CH1 and CH2 outputs are fed out simul-taneously.
	2 s/div	X	OFF	OFF	ON	CH1 data: CH1 terminal
	5 s/div	X	OFF	ON	OFF	CH2 data: CH2 terminal
	10 s/div	X	OFF	ON	ON	See Fig.7.5, ③ for con-nections.
X-Y output	1 s/div	X	ON	OFF	OFF	CH1 or CH2 data: Y terminal
	2 s/div	X	ON	OFF	ON	
	5 s/div	X	ON	ON	OFF	X-axis sweep signal: X terminal
	10 s/div	X	ON	ON	ON	See Fig.7.7.



DATA OUTPUT CONT

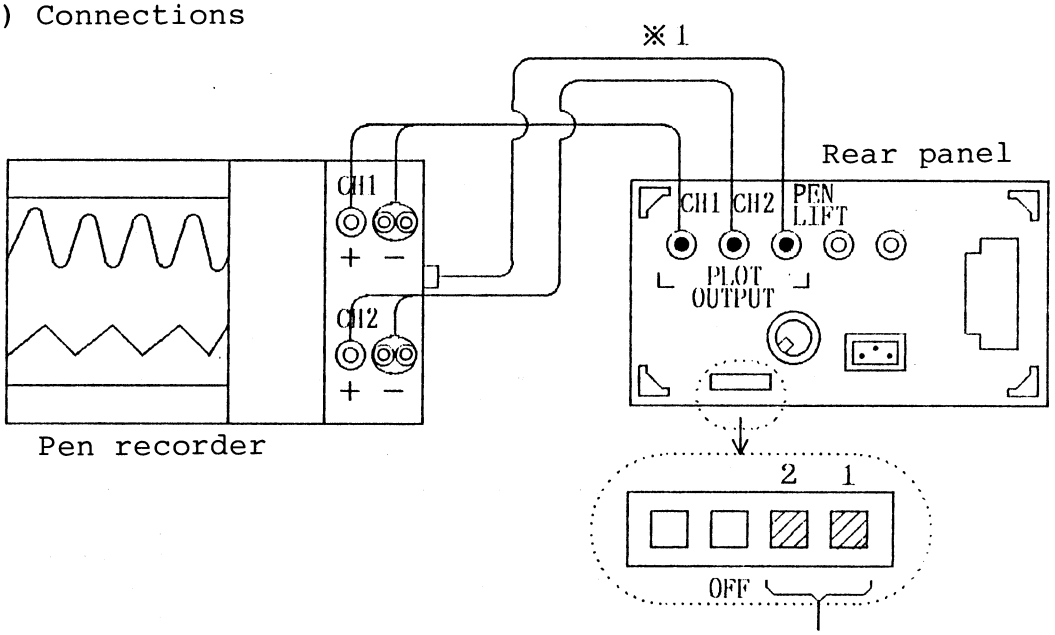
② Operation

i) Press the HOLD key to hold the displayed waveform.

ii) Press the PLOT key, and the PLOT LED lights.
The PLOT LED lights in green and the VC-6050 starts to feed out the data output.
After the data output is fed out, the PLOT LED extinguishes and the PLOT mode is released.
To make the data output stop, press the PLOT key again. Then, the PLOT mode is released and the PLOT LED extinguishes.

③ Output to pen recorder (Y-T output)

i) Connections



Pen speed is selectable.

*1 Use the PEN LIFT connector when the pen recorder is provided with pen lift functions.

[1TTL (Negative logic, fan-out 1)]

Fig. 7.5

ii) Output condition

Connection to CH1 and CH2

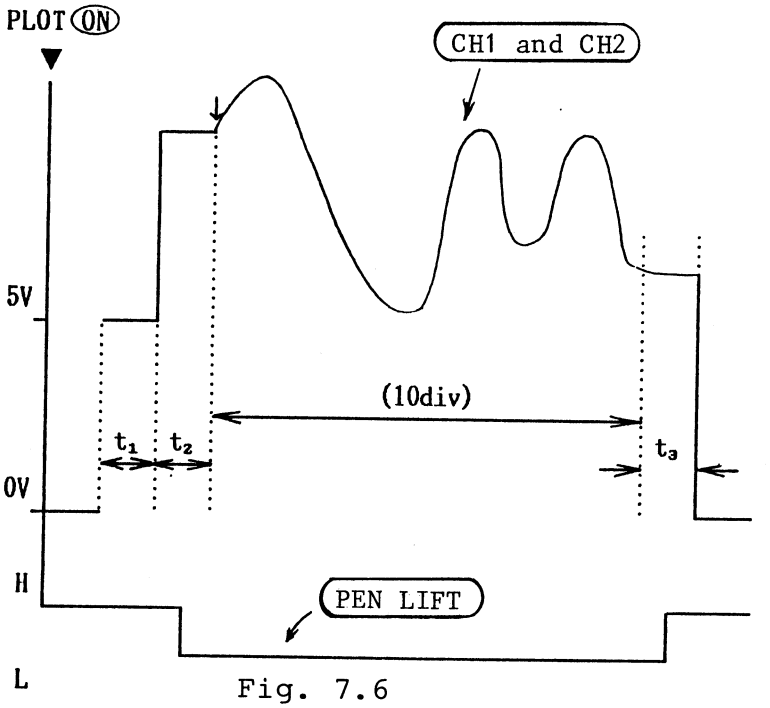


Fig. 7.6

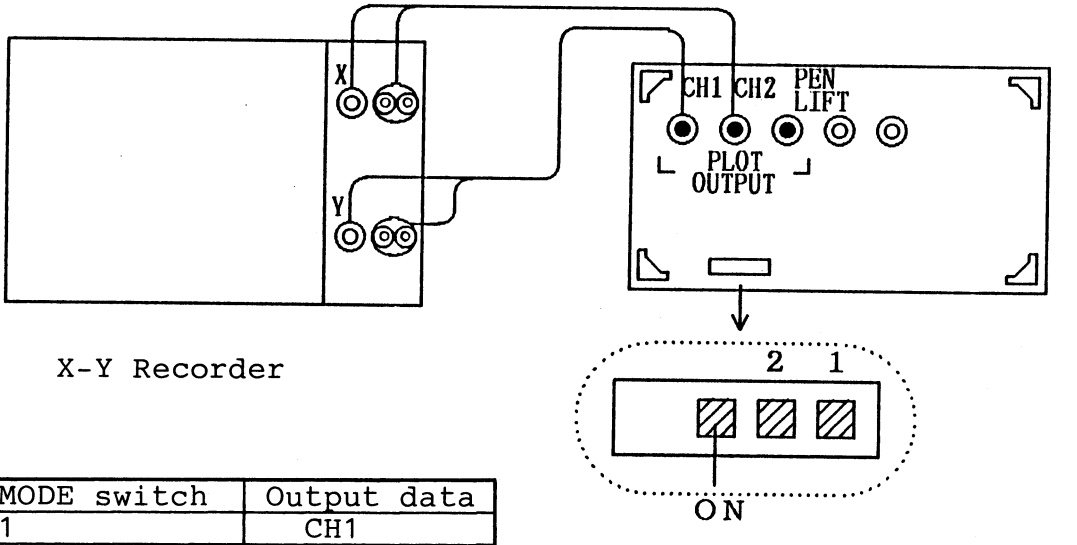
t1, t2, t3 = 2 seconds

When the PLOT switch is pressed while data are being fed out, CH1 and CH2 are 0 V and PEN LIFT is H.

The PLOT switch is null in the period between t1 and t2.

④ Output to X-Y recorder

i) Connection

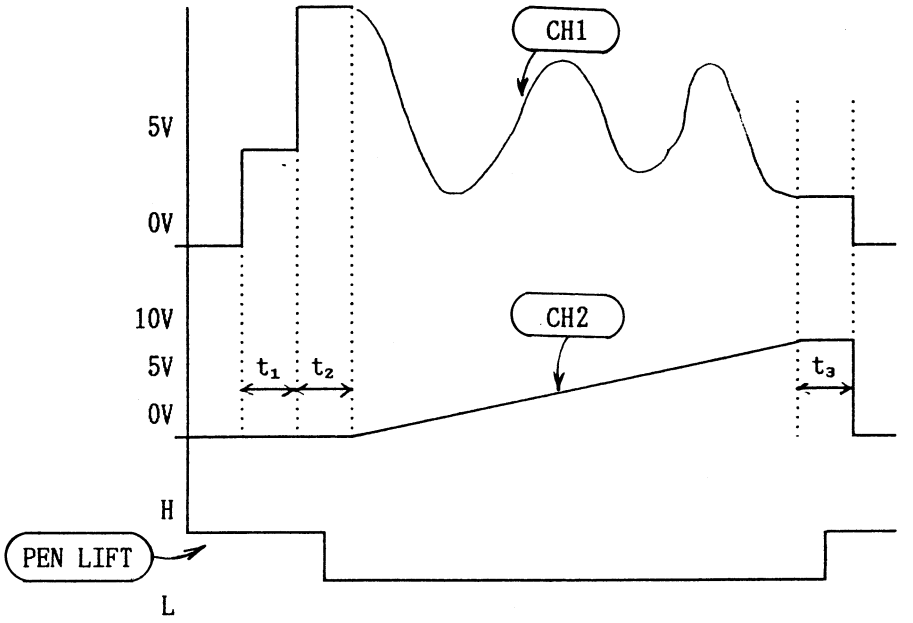


X-Y Recorder

V-MODE switch	Output data
CH1	CH1
CH2	CH2
ALT,CHOP,ADD	CH1

Fig. 7.7

ii) Output condition



t1, t2, t3 = 2 seconds

When the PLOT switch is pressed while data are being fed out, CH1 and CH2 are 0 V and PEN LIFT is H.

The PLOT switch is null in the period between t1 and t2.

Fig. 7.8

(10) SAVE in the HOLD mode

The displayed waveform 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 reference operation.

① SAVE operation
When the digitized waveform is displayed in the storage mode.

i) Press the HOLD key to hold the displayed waveform.

ii) Press the SAVE/CH1 ▷ A /CH2 ▷ B key to store the waveform data of CH1 and CH2 in the memories A and B respectively.
During the SAVE operation, the SAVE/CH1 ▷ A/CH2 ▷ B LED lights in green.

iii) Now, the CH1 and CH2 data have been stored in the respective save memories. These data continue to be stored until the POWER switch is set to OFF. When the above operations are performed again, the stored data are replaced by new data.

Note: The saved data are destroyed when the AVG operation is executed.

(11) X-Y display

The X-Y display of the stored waveform is available by setting the DISPLAY switch to X-Y.
The X-Y presentation is displayed by making the CH1 storage waveform as the X axis and the CH2 storage waveform as the Y axis.

① The X-Y display is available in any mode of NORM, ROLL, AVG, and HOLD. The waveforms stored at the sampling speed set by the TIME/DIV switch are displayed in succession in the mode other than HOLD.

② The most appropriate TIME range is set in the range where approximately two cycles of the measured waveform are in the 10 divisions in horizontal direction in time axis measurement other than X-Y.
When the waveform cycles are more than two, phase error can be caused.

7.3 Measurement By Cursors

The voltage (Δ V), the time difference (ΔT), and the reciprocal of time difference (1/ΔT) can be measured with two cursor lines regardless of the NON STORE and the STORAGE modes.

Cursor measurement is available in the STORAGE mode when the CURSOR key is pressed.

(1) Measurement by ΔV cursor

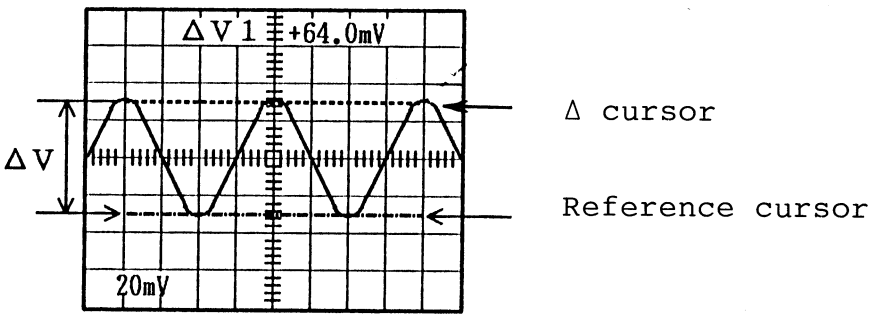
Press the cursor menu key (DLY → V → T → 1/T) repeatedly until the two horizontal cursor lines are displayed on the CRT.

Press the cursor selection key (REF → Δ) and select a cursor line to be moved. Rotate the DLY/CURSOR control so that the cursor line is moved to the position to be measured.

Then the voltage ΔV between the REF line and the Δ line is displayed with the cursor menu ΔV at the upper part of the CRT.

The voltage value is positive (+) when the Δ line is above the REF line and negative (-) when the REF line is above the Δ line. When the DLY/CURSOR control is turned clockwise, the cursor moves up and when it is turned counterclockwise, the cursor moves down.

ΔV cursor measurement for AC voltage



Note:

The ΔV cursor measurement is available for CH1 and CH2. As to the displayed waveform in the NON STORE mode and in the NORM mode, see the Tables 7-2 and 7-3.

(a) NON STORE mode

Table 7-2 ΔV cursor measurement in the NON STORE mode

Vertical MODE setting position	Waveform measured by cursor
CH1	CH1 waveform
CH2	CH2 waveform
CHOP	CH1 waveform
ALT	CH1 waveform
ADD CH1 range = CH2 range CH1 range ≠ CH2 range	 Measured value is displayed. CH1 > CH2 or CH1 < CH2 is displayed.
X-Y	CH2 (Y)

(b) NORM mode

When the CH1/CH2 key on the lower right side of the CRT is set to the CH1, the cursor data of the waveform which can be moved up and down by the PULL STORAGE POSITION CH1 control is displayed.

When the CH1/CH2 key is set to the CH2, the cursor data of the waveform which can be moved by the PULL STORAGE POSITION CH2 control is displayed.

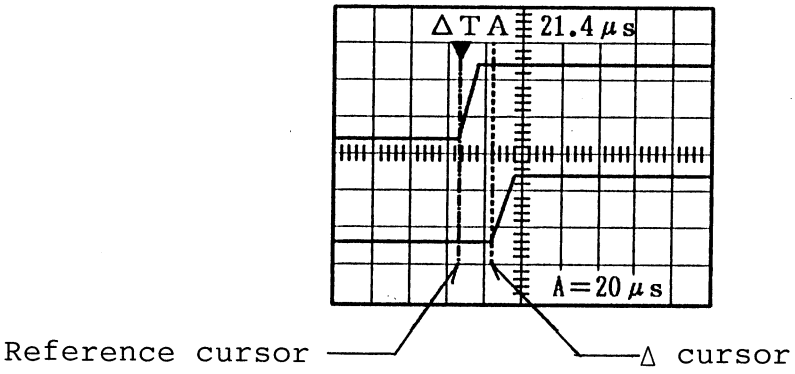
Table 7-3 ΔV cursor measurement in the NORM mode

MODE setting	Waveforms measured by cursor	
	CH1/CH2 key: CH1(released)	CH1/CH2 key: CH2(pushed)
CH1	CH1 waveform	No display
CH2	No display	CH2 waveform
CHOP or ALT	CH1 waveform	CH2 waveform
ADD CH1 range = CH2 range CH1 range ≠ CH2 range	 Displayed No display	 No display No display
X-Y	No display	CH2 (Y)
DISPLAY OF SAVE MEMORY : ON	SAVE waveform displayed instead of CH1 signal	SAVE waveform displayed instead of CH2 signal
SWP X10 MAG : ON	Magnified waveform instead of CH1 waveform or CH1 original waveform	Magnified waveform instead of CH2 waveform or CH2 original waveform

(2) Measurement by ΔT cursor

When the cursor menu key (DLY → V → T → 1/T) is pressed again in the ΔV cursor measurement mode, two vertical cursor lines are displayed on the CRT.

ΔT cursor measurement for time difference



Press the cursor selection key (REF → Δ) and select a cursor line to be moved. Rotate the DLY/CURSOR control so that the cursor line is moved to the position to be measured.

Then the time difference between the REF line and the Δ line is displayed with the cursor menu ΔT at the upper part of the CRT.

The displayed time difference value is positive (+) when the Δ line locates at the right side of the REF line and negative (-) when the Δ line locates at the left side of the REF line.

Notes:

The displayed waveform changes in the NON STORE mode or the NORM mode.

(a) NON STORE mode

The ΔT cursor measurement is also available when the sweep mode is ALT or B.

In the case of ALT, the measurement value is displayed in the time range which is marked with an underline, A TIME range or B TIME range. In the case of B, measurement value is displayed in the B TIME range.

In the case of X-Y mode, ? is displayed.

(b) STORAGE mode

When the two waveforms of different time ranges are displayed in the storage mode, each setting value is displayed on the CRT.

Like the ΔV cursor measurement, the cursor data of the waveform which can be moved by the PULL STORAGE POSITION CH1 control is displayed when the CH1/CH2 key is set to CH1.

When the CH1/CH2 key is set to CH2, the cursor data of the waveform which can be moved by the PULL STORAGE POSITION CH2 is displayed.

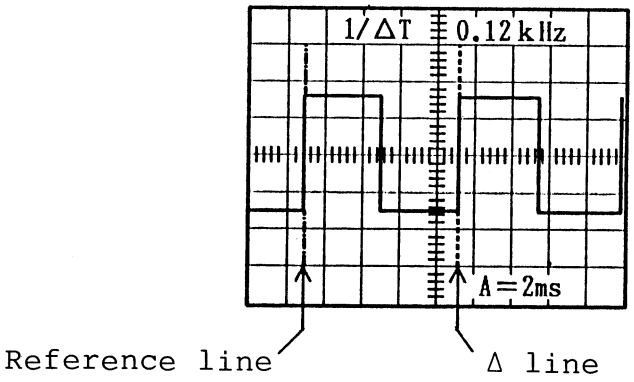
Table 7-4 ΔT cursor measurement in the NORM mode

MODE setting	Waveforms measured by cursor	
	CH1/CH2 key: CH1(released)	CH1/CH2 key: CH2(pushed)
CH1	CH1 waveform	No display
CH2	No display	CH2 waveform
CHOP or ALT	CH1 waveform	CH2 waveform
ADD	CH1 (ADD)	No display
X-Y	?	?
DISPLAY OF SAVE MEMORY: ON	SAVE waveform instead of CH1 waveform	SAVE waveform instead of CH2 waveform
SWP X10 MAG : ON	Magnified waveform instead of CH1 waveform or CH1 original waveform	Magnified waveform instead of CH2 waveform or CH2 original waveform

(3) Measurement by 1/ΔT cursor

When the menu key (DLY→ V→ T→ 1/T) is pressed in the ΔT cursor measurement mode, 1/ΔT mode is established.

1/ΔT cursor measurement for frequency



Press the cursor selection key (REF → Δ) and select a cursor line to be moved. Rotate the DLY/CURSOR control so that the cursor line is moved to one period position from the reference line.
Then the frequency (1/ΔT) between the REF line and the Δ line is displayed with the cursor menu 1/ΔT at the upper part of the CRT.
When the DLY/CURSOR control is turned clockwise, the cursor moves right and when it is turned counterclockwise, the cursor moves left.

Note:
The displayed waveform at 1/ΔT cursor measurement changes in the NON STORE mode or the STORAGE mode.

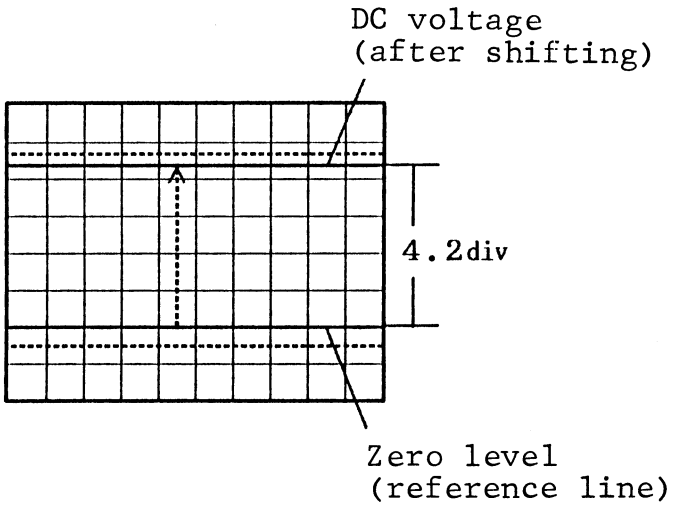
8. MEASUREMENT PROCEDURES

Precautions:

* Set the INTEN and FOCUS controls to their optimum positions to facilitate measurement.
* Display the waveform as large as possible to avoid possible reading errors.
* Check the probe compensation according to Item 6.3 (1), in the case of using a probe.

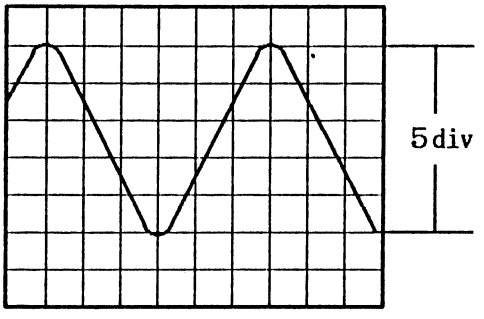
(1) DC voltage measurement

Set AC-GND-DC to GND and set the zero level properly. Set VOLTS/DIV appropriately to facilitate measurement and set AC-GND-DC to DC. Since the base line shifts by the amount of DC voltage, the DC voltage of the signal can be obtained by multiplying the shifted amplitude by the indicated value of VOLTS/DIV. Provided that VOLTS/DIV is set to 50 mV/DIV in the figure below, 50 mV/div x 4.2 = 210 mV. However, if the probe AT - 10 AP 1.5 (10:1) is in use, the true value of the signal becomes 10 times the value, or 50 mV/div x 4.2 x 10 = 2.1 V.



(2) AC voltage measurement

Provided that VOLTS/DIV switch is set to 1 V/DIV in the figure below, 1 V/DIV x 5 = 5 Vp-p (50 Vp-p for the probe AT-10 AL 1.5). When magnifying and observing a signal of a small-amplitude, which is superimposed on a high DC voltage, set AC-GND-DC to AC. The DC voltage is then cut off and AC voltage can be observed by increasing sensitivity.



Using the ΔV cursor measurement function described in Item 7.3 facilitates the reading of voltage.

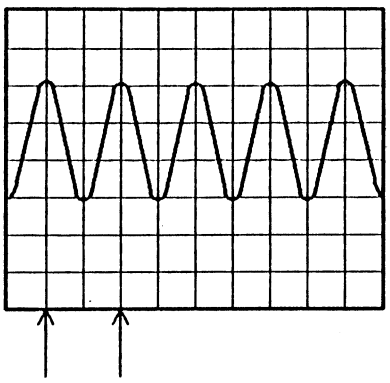
(3) Measurement of frequency and period

This will be explained taking the following figure as an example. One period covers the time A and time B, which are separated from each other by 2.0 DIV on the screen. When the sweep time is 1 ms/DIV, the period is given by

1 ms/DIV x 2.0 = 2.0 ms.

Accordingly, the frequency is

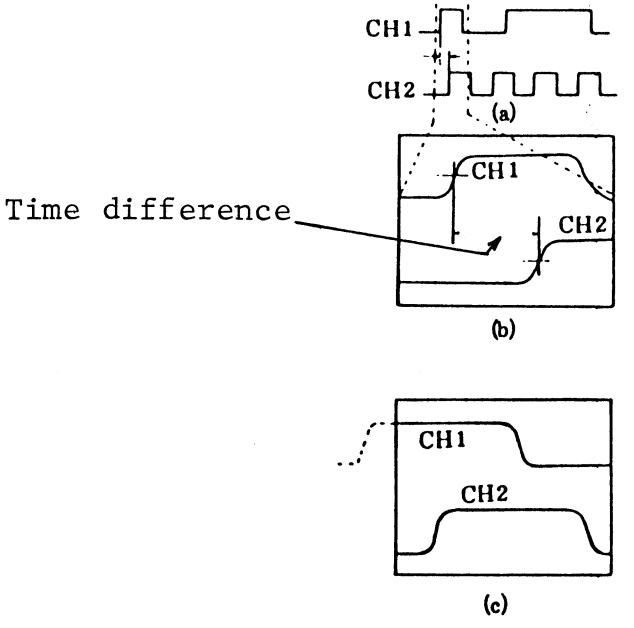
1/2.0 = 500 Hz.



Using the 1/ΔT cursor measurement function described in Item 7.3 facilitates the reading of frequency.

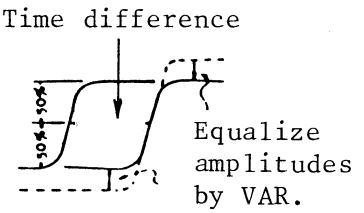
(4) Measurement of time difference

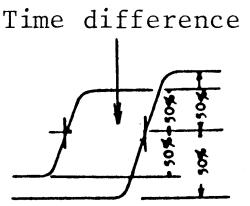
A triggering signal source is selected as the reference signal when measuring the time difference between two signals. Assuming pulse trains as shown in (a), then (b) shows the case when CH1 is selected as the triggering signal source and (c) the case when CH2 is selected.



This means that CH1 is used as the triggering signal source when investigating the time difference between CH1 and CH2 using CH1 as the reference. CH2 is used when the reverse is the case. In other words, the signal advancing in phase is selected as the triggering signal source. If this process is reversed, the portion to be measured may sometimes not appear on the screen. Equalize the amplitudes of the two signals appearing on the screen or superimpose one on the other and read the time difference by the interval between 50% amplitude points of the two signals.

Sometimes the superimposing method is more convenient than the equalized amplitude method from the point of view of procedures.





Equal amplitude method Superimposing method

Using the ΔV cursor measurement function described in Item 7.3 facilitates the reading of time difference.

[CAUTIONS]
Since the pulse waveform contains many high-frequency wave components (higher harmonics) depending on its width or period, pay the same attention as given to high frequency signals when handling it. Accordingly, use a probe or coaxial cable and shorten the earth lead wire as much as possible.

(5) Measurement of rise (fall) time

To measure the rise time, pay attention not only to the above mentioned items but also to a measurement error. The following relationship exists between the rise time Trx of the waveform to be measured, the rise time Trs of oscilloscope, and the rise time Tro displayed on the screen.

$$Tro = \sqrt{Trx^2 + Trs^2}\ .$$

When the rise time of the pulse to be measured is sufficiently longer than that of the oscilloscope (5.8 ns in our case), the effect of the rise time of the oscilloscope can be neglected. However, if both are close each other, a measurement error may be caused.

The true rise time is given by

$$Trx = \sqrt{Tro^2 - Trs^2}\ .$$

Moreover, in general, in a circuit free from waveform distortion such as overshoot and sag, the following relationship is established between frequency band and rise time.

$$f_c \times t_r = 0.35$$

Where, f_c : Frequency band (Hz)

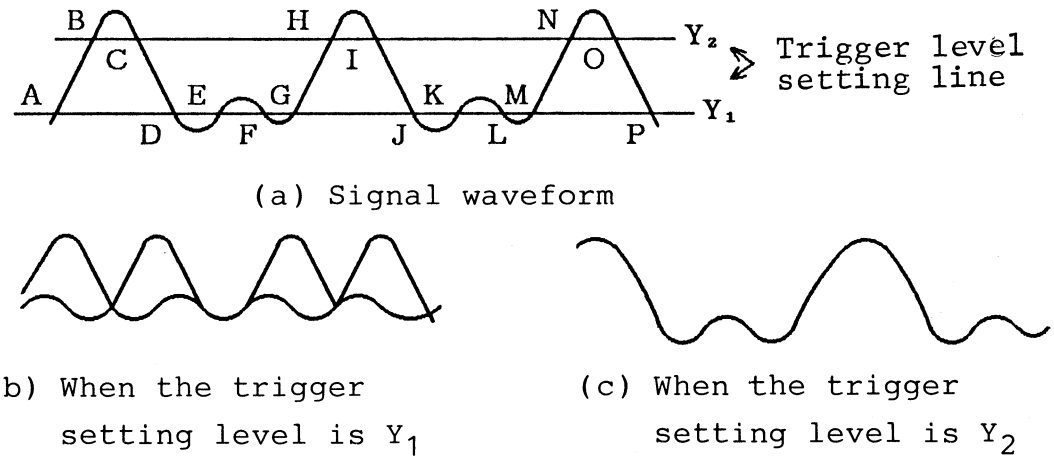
t_r : Rise time (s).

(6) Triggering method

(a) Complexed waveform

In the case shown in Fig. (a) where large and small amplitudes appear alternately, the waveform can be doubled if the trigger level is not set properly. In the case where the trigger level is selected as Y_1 line, two waveforms, one starting with A and advancing to B, C, D, E, F, ... and the other starting with E and advancing to F, G, H, I ..., will appear alternately on the screen. They will be doubled as shown in Fig. (b), for which no synchronization can be taken.

In such a case, rotate the LEVEL control clockwise until the trigger level comes to Y_2 line. Then the waveform on the screen becomes the one as shown in Fig. (c) which starts with B and advances to C, E, F, ..., allowing synchronization.



(a) Signal waveform

(b) When the trigger setting level is Y_1

(c) When the trigger setting level is Y_2

Synchronization of complexed waveform

(b) Alternate triggering

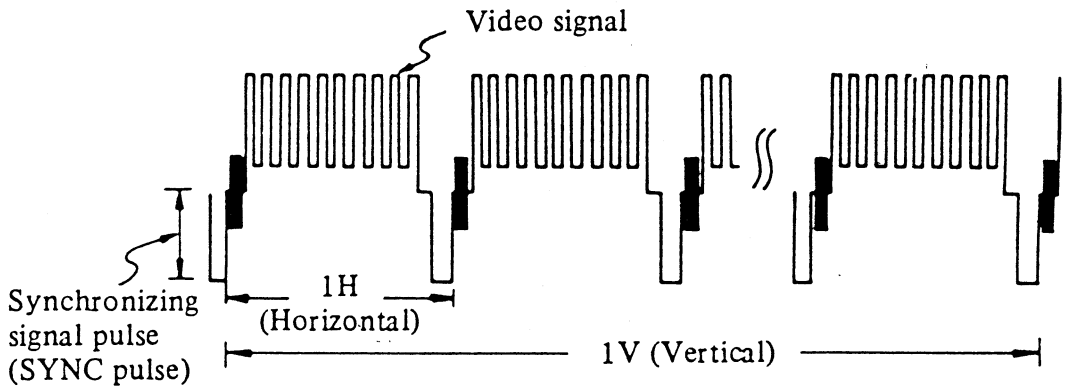
When the MODE select switch is set to ALT, the alternate triggering mode can be obtained by setting the TRIG SOURCE select switch to VERT MODE.

In the alternate triggering mode, stabilized alternate waveforms can be obtained even when both signals of CH1 and CH2 are not synchronized.

(c) TV synchronization

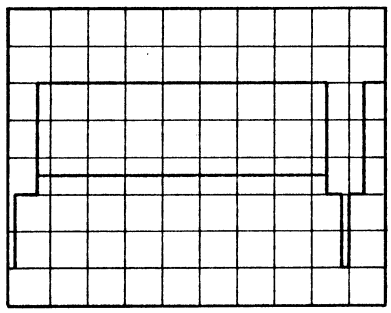
① **On the video waveform of TV**

In the work concerned with TV, complexed signals containing a video signal, a blanking pedestal signal, and a synchronizing signal are measured.



② **Operation**

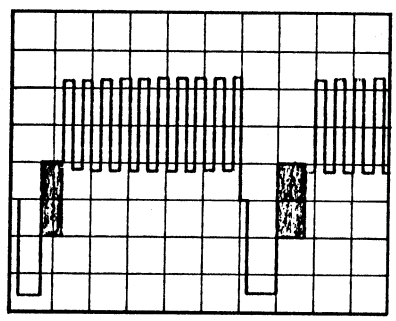
To observe vertical signal



* TV-V
Trigger MODE switch : TV(-)
A LEVEL control : Pulled state
A TIME : 0.1 ms to 0.2 s

TRIG MODE : TV-V

To observe horizontal signal



* TV-H
Trigger MODE switch : TV(-)
A LEVEL control : Pushed state
A TIME : 20 ns to 50 µs

TRIG MODE : TV-H

Since TV(-) mode is available only when the sync signal is a negative, triggering cannot be obtained with a positive sync signal.

(d) TV signal delay sweep

i) TV auto delay

	A	B
Trigger MODE	TV(-)	TV(-)
A LEVEL	Pulled state (TV-V)	Pushed state (TV-H)
B LEVEL	AUTO	AUTO
DISPLAY	ALT or B	ALT or B
A TIME/DIV	As desired	As desired
B TIME/DIV	As desired	As desired

When above setting A is selected, A sweep is triggered by the vertical sync signal. In this case, the desired portion of the waveform in the vertical sync period can be magnified by rotating the DLY/CURSOR control.

When setting B is selected, A sweep is triggered by the horizontal sync signal, and the desired portion of the waveform in the horizontal sync period can be magnified by rotating the DLY/CURSOR control.

ii) TV triggered delay (B triggerable after delay time)

	C	D
Trigger MODE	TV(-)	TV(-)
A LEVEL	Pulled state (TV-V)	Pushed state (TV-H)
B LEVEL	Normal state (non AUTO)	Normal state (non AUTO)
DISPLAY	ALT or B	ALT or B
A TIME/DIV	As desired	As desired
B TIME/DIV	As desired	As desired

When setting C is selected, A sweep is triggered by the vertical sync signal, and B sweep is automatically triggered by the horizontal sync signal regardless of the setting by the B LEVEL control. When setting D is selected, A sweep is triggered by the horizontal sync signal, and B sweep delay can start from the desired point in the horizontal period by rotating the B LEVEL control.

(7) Measurement of the signal before the trigger point

Although a conventional oscilloscope can not display the triggered point at the left end of the screen since the sweep starts at the triggered point of the signal, the VC-6050 can display a signal before the triggered point in 0.1 div steps at anywhere on the screen in the STORAGE mode, using the PRE TRIGGER function so that it is possible to measure the portion before trigger point precisely.

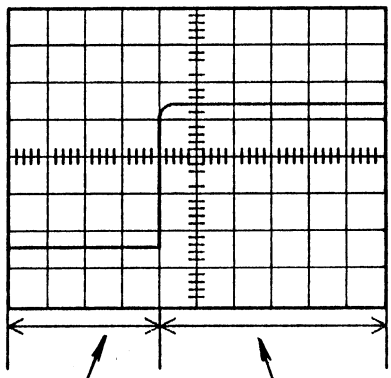
(a) Press the PRE TRIG key, and select the trigger point.

(b) Position the trigger point on the screen with the DLY/CURSOR control.

The trigger point can be set to any point ranging from 0 div (left end) to 9.9 div (right end) in 0.1 division intervals.

Example:

In the case of 4.0 div setting, the signal of the rise (from the triggered point) can be observed as shown below.



(4 div display)

Note:

The PRE TRIGGER function is not activated in the faster range than 10 µs/DIV.

9. GPIB

9.1 Introduction

The Hitachi GPIB unit is general purpose interface bus system which conforms to Institute of Electrical and Electronics Engineers (IEEE) standard, which provides an interface between digital equipment by using exclusive connectors and cables.

The GPIB unit is used for transmitting and receiving data of different transfer rate between self-contained instrument or devices and the GPIB can support up to 15 independent devices connected in parallel with each other.

Data transmission instructions between the VC-6050 digital storage oscilloscope and other independent devices such as a personal computer via the GPIB are described in this manual.

9.2 GPIB System

9.2.1 General

Fig. 9.1 shows an example of the GPIB system.

While only four instruments are shown, the GPIB can support up to 15 independent devices connected directly to the bus. GPIB system equipment functions are sorted into the three following classes, talker, listener and controller.

During interface system operation, the connected equipment operates in one of the corresponding GPIB system functions. A talker is an instrument that can send data to one or more listeners, while a listener is an instrument that can accept data from the talker. A controller is an instrument that determines which of the instruments on a bus will talk and which instruments will listen during any given time interval. The controller also has the ability to assign itself as either a talker or a listener, whenever the program routine requires.

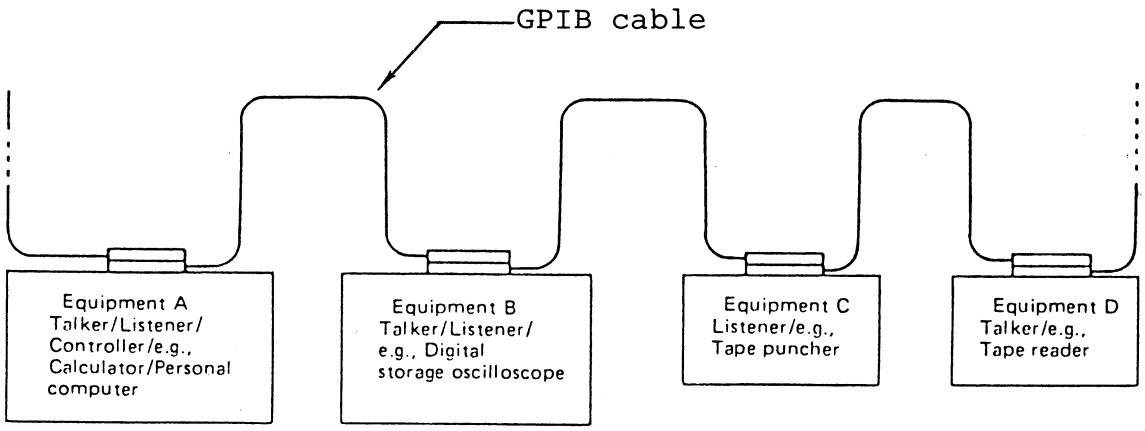


Fig. 9.1 Configuration example of GPIB system

9.2.2 Specifications

(1) Message paths and bus structure

Fig. 9.2 shows the 16 signal lines of the GPIB system functionally divided into three component busses: an eight-line data transfer bus, a three-line handshake control bus and a five-wire management bus.

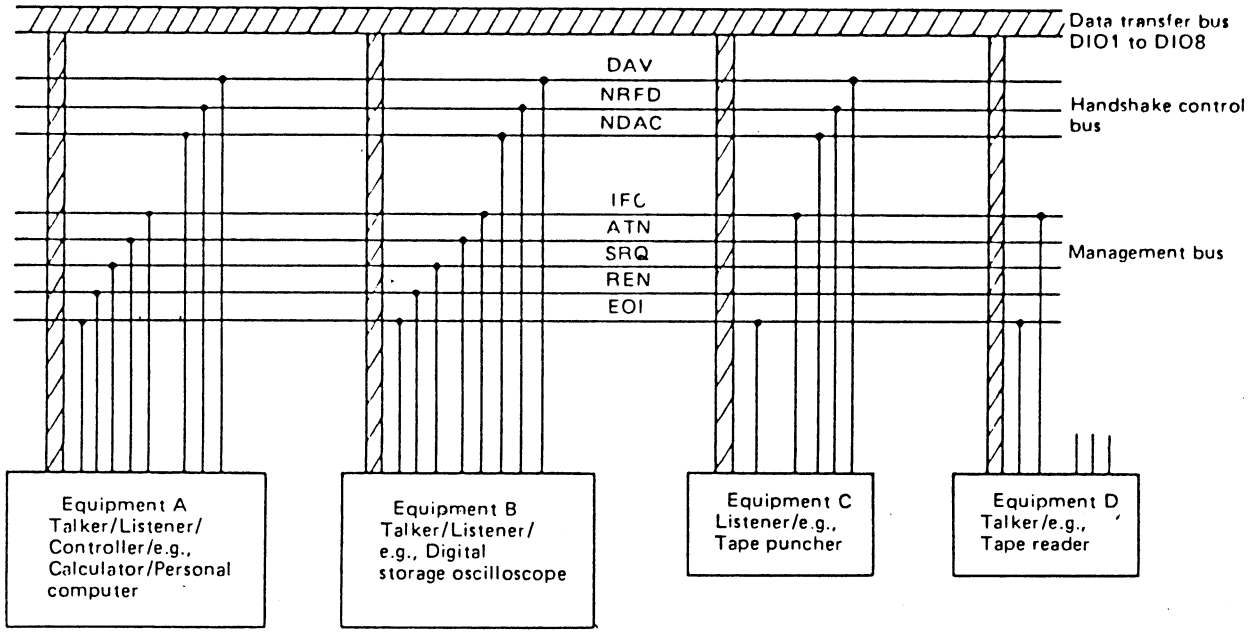


Fig. 9.2 GPIB structure

(i) Handshake control bus

a. DAV : Data Valid

Asserts that data on the data bus is valid.

When DAV is LOW: Data is valid for the listener.

When DAV is HIGH: Data is invalid for the listener.

b. NRFD : Not Ready For Data

A HIGH NRFD indicates that all the assigned listeners are ready to receive the next data byte from the talker.

LOW NRFD: Not ready to receive data.

c. NDAC : Not Data Accepted

A HIGH NDAC indicates that all assigned listeners have accepted the current data.

LOW NDAC: Not have accepted the current data

(The talker will control data bus and DAV lines, while the listener controls NRFD and NDAC lines.)

(ii) Management bus

a. IFC : Interface Clear

Only the system controller can generate this IFC signal.

When IFC is LOW for at least 100 μs, all interfaces for the talker and the listener are in a quiescent state. Then, the control priority is sent by the controller.

b. ATN : Attention

Only a controller can generate the ATN signal.

LOW ATN: Establishes command mode.

HIGH ATN: Establishes data mode.

c. SRQ : Service Request

Any instrument connected to the bus can request the controller's attention by sending the SRQ message. SRQ message can be set only when IFC is HIGH.

d. REN : Remote Enable

The system controller sends the REN message to an instrument whenever the interface system is operating under remote program control.

e. EOI : End Or Identify

A talker can use the EOI message to indicate the end of a data-transfer sequence, or to execute a polling sequence by a controller. When ATN is HIGH, the talker sends the EOI LOW message to indicate the last byte of data is transmitted.

(iii) Data bus

D101 to D108: Data Input Output

The data bus has eight bidirectional signal lines, D101 through D108. Information, in the form of data bytes are transferred over this bus.

A handshake sequence between an enabled talker and the enabled listeners transfers one data byte at a time. Data bytes in either an interface or device-dependent message are sent in a byte-serial sequence over the data bus.

(2) GPIB connector and cable

Physical arrangement of the 24-conductor GPIB connector (located on the rear panel) meets IEEE-488-1978 GPIB standards.

A contact assignments of the cable connector and the device connector shall be as shown in Fig. 9-3. Sixteen of 24 conductors shall be used for signal lines and the balance used for logic returns and overall shield.

The voltage and current should conform to TTL standard; voltage shall be less than +5.5 V against GND.
When the voltage is low level of +0.8 V or lower, the signal is set to logic "1" in the TRUE mode.
When the voltage is high level of +2 V or higher, the signal is set to logic "0" in the FALSE mode.

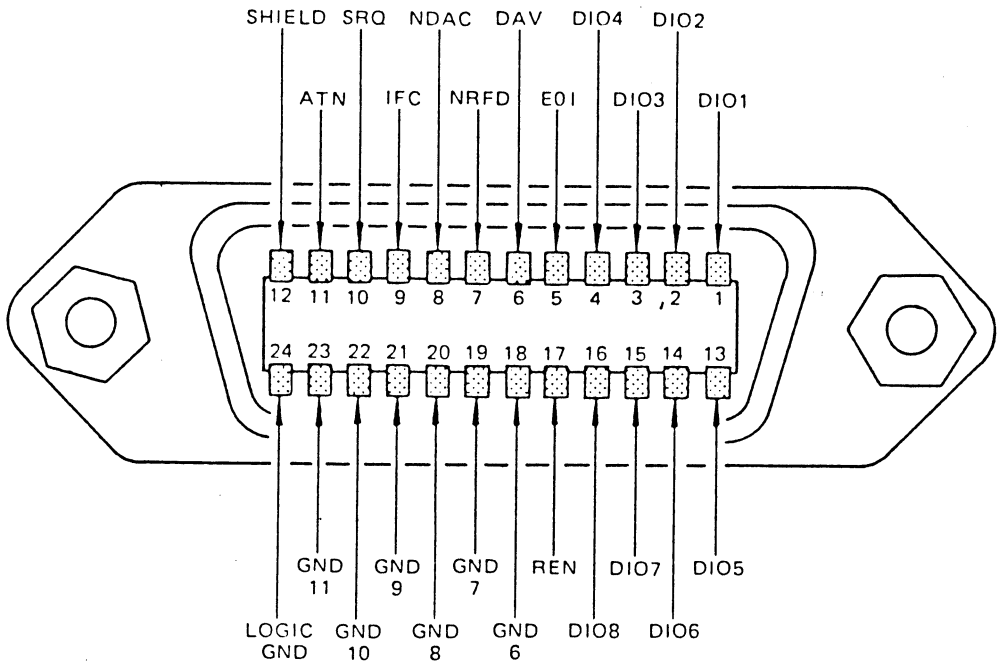


Fig. 9.3 GPIB interface connector

Use a double shielded GPIB cable which especially meets the following conditions in IEEE-488-1978 GPIB standard.

1. Total cable length: 20 m max. (Total of each cable length)
2. Single cable length: 4 m max. (One span connection)
3. Connectable equipment number: 15 sets max. (Including a controller)

9.2.3 Multiline interface message command

The message command is transmitted from the controller to each device connected with the GPIB when an ATN signal is LOW. Then, the received device starts operations specified in GPIB standard.

Table 9-1 shows Multiline Interface Messages including Output codes for message command and ASCII codes.

Table 9-1 Multiline Interface Messages

(SENT AND RECEIVED WITH ATN = 1)

b_7 b_6 b_5 Bits					0 0 0	MSG①	0 0 1	MSG	0 1 0	MSG	0 1 1	MSG	1 0 0	MGS	1 0 1	MSG	1 1 0	MSG	1 1 1	MSG
b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	Column / Row ↓	0		1		2		3		4		5		6		7	
0	0	0	0	0	NUL		DLE		SP		0		•		P				p	
0	0	0	1	1	SOH	GTL	DC1	LLO	!		1		A		Q		a		q	
0	0	1	0	2	STX		DC2		"		2		B		R		b		r	
0	0	1	1	3	ETX		DC3		#		3		C		S		c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$		4		D		T		d		t	
0	1	0	1	5	ENQ	PPC①	NAK	PPU	%		5		E		U		e		u	
0	1	1	0	6	ACK		SYN		&		6		F		V		f		v	
0	1	1	1	7	BEL		ETB		'		7		G		W		g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(		8		H		X		h		x	
1	0	0	1	9	HT	TCT	EM	SPD	)		9		I		Y		i		y	
1	0	1	0	10	LF		SUB		*		:		J		Z		j		z	
1	0	1	1	11	VT		ESC		+		;		K		[		k		{	
1	1	0	0	12	FF		FS		,		<		L		\		l		|	
1	1	0	1	13	CR		GS		-		=		M		]		m		}	
1	1	1	0	14	SO		RS		.		>		N		^		n		~	
1	1	1	1	15	SI		US		/		?	UNL	O		_	UNT	o		DEL	

MLA ASSIGNED TO DEVICE

MLA ASSIGNED TO DEVICE

MTA ASSIGNED TO DEVICE

MTA ASSIGNED TO DEVICE

MEANING DEFINED BY PCG CODE

MEANING DEFINED BY PCG CODE

ADDRESSED COMMAND GROUP (ACG)

UNIVERSAL COMMAND GROUP (UCG)

LISTEN ADDRESS GROUP (LAG)

TALK ADDRESS GROUP (TAG)

PRIMARY COMMAND GROUP (PCG)

SECONDARY COMMAND GROUP (SCG)

NOTES:
① MSG = INTERFACE MESSAGE
② b_1 = DIO1 ... b_7 = DIO7
③ REQUIRES SECONDARY COMMAND
④ DENSE SUBSET (COLUMNS 2 THROUGH 5)

9.3 GPIB for The Digital Oscilloscope VC-6050

9.3.1 GPIB function for the VC-6050

Ten interface functions including sub-sets of up to 28 are specified in the IEEE-488 standard. The GPIB may not include all of the functions specified by the standard. Necessary functions, which are selectable according to product application, are available by selecting combinations of the interface message command described in Item 9.2.3.

Each sub-set offers a precise interface function.

Table 9-2 shows the multiline interface message commands for interface functions.

Table 9-2 Interface function of the VC-6050

No.	Identification	Function	Relevant interface message	VC-6050's function
1	SH (Source Handshake) SH0, SH1	Transfers message onto data bus.	——	SH1: Complete capability.
2	AH (Acceptor Handshake) AH0, AH1	Receives message from data bus.	——	AH1: Complete capability.
3	T (Talker) T0 to T8 [TE0 to TE8: extended talkers]	Sends data to another device over data bus. (Incld. Serial Poll)	MTA (My Talk Address) MSA (My Secondary Address)	T6: Basic talker * Serial poll * Unaddress if MLA
4	L (Listener) L0 to L4 [LE0 to LE4: extended listeners]	Receives data from another device over data bus.	MLA (My Listen Address) MSA (My Secondary Address)	L4: Basic listener * Unadress if MTA

No.	Identification	Function	Relevant interface message	VC-6050's function
5	SR (Service Request) SR0, SR1	Requests service asynchronously from controller.	SPE (Serial Poll Enable) SPD (Serial Poll Disable)	SR1: Complete capability.
6	RL (Remote Local) RL0 to RL2	Selects remote/ local source. (Program control/ Front panel control)	GTL (Go To Local) LLO (Local Lock Out)	RL0: No capability.
7	PP (Parallel Poll) PP0 to PP2	Present status information (PPR message) of one bit to controller without being previously addressed to talk.	PPC (Parallel Poll Configure) PPU (Parallel Poll Unconfigure) PPE (Parallel Poll Enable) PPD (Parallel Poll Disable)	PR0: No Capability.
8	DC (Device Clear) DC0 to DC2	Device(s) in groups or individual are initialized.	DCL (Device Clear) SDC (Selected Device Clear)	DC1: Complete capability.
9	DT (Device Trigger) DT0, DT1	Starts each or each group of device(s).	GET (Group Execute Trigger)	DT0: No capability.
10	C (Controller) C0 to C28	Sends device address, universal command and addressed command to another devices over data bus.	UNT (Untalk) UNL (Unlisten) TCT (Talk Control)	C0: No capability.

For further details of subsets of SH1, AH1, etc., refer to the IEEE 488-1978 standard.

9.3.2 Multiline interface message command and the VC-6050's operation

Table 9-3 through 9-6 show the multiline interface message command and the VC-6050's operation.

(1) Primary Command Group (PCG)

Table 9-3 Address Command Group (ACG)

No.	Command	Function	VC-6050's operation
1	GTL (Go To Local)	Establishes local mode.	None
2	SDC (Selected Device Clear)	Initializes selected device.	Initializes GPIB.
3	GET (Group Executive Trigger)	Provides Trigger signal.	None
4	PPC (Parallel Poll Configure)	Establishes parallel poll mode.	None
5	TCT (Take Control)	Takes over control of interface.	None

Table 9-4 Universal Command Group (UCG)

No.	Command	Function	VC-6050's operation
1	LLO (Local Lock Out)	Disables switch operations.	None
2	DCL (Device Clear)	Initializes all the bus function.	Initializes GPIB.
3	PPU (Parallel Poll Unconfigure)	Releases parallel poll mode.	None
4	SPE (Serial Poll Enable)	Establishes serial poll mode.	Establishes serial poll mode.
5	SPD (Serial Poll Disable)	Releases serial poll mode.	Releases serial poll mode.

Table 9-5 Listener Address Group (LAG) and UNL

No.	Command	Function	VC-6050's operation
1	MLA 0 to 30 (SP to >)	Indicates the address of device to be a listener.	VC-6050 itself becomes the listener in accordance with the VC-6050's address.
2	UNL (?)	Clears the listener's address.	Clears the listener's address.

Table 9-6 Talker Address Group (TAG) and UNT

No.	Command	Function	VC-6050's operation
1	MTA0 to 30 (@ to ^)	Indicates the address of device to be a talker.	VC-6050 itself becomes the talker in accordance with the VC-6050's address.
2	UNT (-)	Clears the talker's address.	Clears the talker's address.

(2) Secondary Command Group

In the case of the VC-6050, the Secondary Command Group is not employed.

9.3.3 Uniline command and VC-6050's operation

Uniline command is used for the controller to make directly access to all the devices through the bus line (IFC and REN). Uniline command and the VC-6050 functions are shown in Table 9-7.

Table 9-7 Uniline Commands and VC-6050's operation

No.	Command	Function	VC-6050's operation
1	IFC (Interface Clear)	Initializes interface.	Clears data bus.
2	REN (Remote Enable)	Enables remote mode.	None (GPIB is always in the remote mode.)

The transmit/receive data which is used by the VC-6050 is shown below:

* Multiline interface message command ..... The data transmitted from the controller to the VC-6050
* Function command ..... The data transmitted from the controller to the VC-6050
* Waveform data ..... The VC-6050 can transmit the waveform data as a talker.

9.3.4 Address switch setting of the VC-6050

Each device will have a proper GPIB address. The controller specifies the device function by indicating the corresponding address. The address data is defined by ASCII character (i.e. Listener/Talker's addresses of the Multiline Interface Message Command). Table 9-8 shows the address coding for the VC-6050. Address is set by the Address setting switch of the GPIB unit on the rear side of the VC-6050. Addresses of 0 to 30 are selectable.

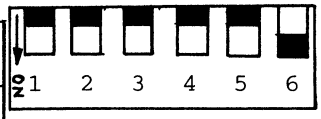
Address settings must be done with power off.

If the setting is done with power on, the switch setting is invalid.

This switch setting has been set to "1" (Position 6 is ON) at the factory.

Table 9-8 GPIB Address Coding of the VC-6050

GPIB Address	Listener's address			Talker's address			DIP switch						
	Character	Code ( ) 16	Code ( ) 10	Character	Code ( ) 16	Code ( ) 10	-	2^4	2^3	2^2	2^1	2^0	* Note
0	SP	20	32	@	40	64	NC	0	0	0	0	0	
1	!	21	33	A	41	65	NC	0	0	0	0	1	
2	"	22	34	B	42	66	NC	0	0	0	1	0	
3	#	23	35	C	43	67	NC	0	0	0	1	1	
4	$	24	36	D	44	68	NC	0	0	1	0	0	
5	%	25	37	E	45	69	NC	0	0	1	0	1	
6	&	26	38	F	46	70	NC	0	0	1	1	0	
7	'	27	39	G	47	71	NC	0	0	1	1	1	
8	(	28	40	H	48	72	NC	0	1	0	0	0	
9	)	29	41	I	49	73	NC	0	1	0	0	1	
10	*	2A	42	J	4A	74	NC	0	1	0	1	0	
11	+	2B	43	K	4B	75	NC	0	1	0	1	1	
12	,	2C	44	L	4C	76	NC	0	1	1	0	0	
13	-	2D	45	M	4D	77	NC	0	1	1	0	1	
14	.	2E	46	N	4E	78	NC	0	1	1	1	0	
15	/	2F	47	O	4F	79	NC	0	1	1	1	1	
16	0	30	48	P	50	80	NC	1	0	0	0	0	
17	1	31	49	Q	51	81	NC	1	0	0	0	1	
18	2	32	50	R	52	82	NC	1	0	0	1	0	
19	3	33	51	S	53	83	NC	1	0	0	1	1	
20	4	34	52	T	54	84	NC	1	0	1	0	0	
21	5	35	53	U	55	85	NC	1	0	1	0	1	
22	6	36	54	V	56	86	NC	1	0	1	1	0	
23	7	37	55	W	57	87	NC	1	0	1	1	1	
24	8	38	56	X	58	88	NC	1	1	0	0	0	
25	9	39	57	Y	59	89	NC	1	1	0	0	1	
26	:	3A	58	Z	5A	90	NC	1	1	0	1	0	
27	;	3B	59	[	5B	91	NC	1	1	0	1	1	
28	<	3C	60	\	5C	92	NC	1	1	1	0	0	
29	=	3D	61	]	5D	93	NC	1	1	1	0	1	
30	>	3E	62	^	5E	94	NC	1	1	1	1	0	



* Note:

Preset: "1": ON

"0": OFF

9.3.5 Function command of the VC-6050

The Function Command is data sent from the controller to the VC-6050 when the ATN line is set to High.
The command requires the VC-6050 to send data or specifies the operation. Table 9-9 shows the function of the Function Command messages.

Table 9-9 Function Commands

<table>
<tr><th>No.</th><th>Commands</th><th>Function</th><th>Remarks</th></tr>
<tr><td>1</td><td>S1 Command</td><td>* Receives signal and commands the data acquistion in display memory according to the control panel status.
(The same as SINGLE SWEEP operation)
* When S1 command is received, a SINGLE SWEEP is displayed.
When the sweep finishes, then, "the data acquisition finish" status is sent.</td><td>Controller checks whether SRO is present on bus, or detects SRQ by interruption. Then, it acquires status byte on serial poll.</td></tr>
<tr><td>2</td><td>Ri Command</td><td>* Commands the data transfer of the measurement status or data of memory "i"s.
After receiving the command, the VC-6050 converts the data format, and transmits status byte request for data transfer.

The Ri commands are as follows:

Note
RO(i); Send the measurement status in memories "i".
(i=1 to 4)

Note
Ri(m,n) Send "n" words from address "m" of the memory "i".

Note: "i" indicates the memory number.

<table><tr><th>No.</th><th>i</th><th>Memory</th></tr><tr><td>1</td><td>1</td><td>CH1 display memory</td></tr><tr><td>2</td><td>2</td><td>CH2 display memory</td></tr><tr><td>3</td><td>3</td><td>SAVE memory A</td></tr><tr><td>4</td><td>4</td><td>SAVE memory B</td></tr></table>
"m": Address in memories.
Four-digit integer: 0000 to 3999
"n": Number of words.
Four-digit integer: 0001 to 4000</td><td>Controller sets the equipment (VC-6050) to a talker after transmitting the Ri command, so that the required data communication is enabled.</td></tr>
</table>

The format of function commands

(1) S1 command

S	1	DEL

Notes: 1) All data in ASCII coding.
2) Refer to Section 9.3.7.

(2) Ri command

R	0	(	i	)	DEL

R	i	(	m	m	m	m	,	n	n	n	n	)	DEL

i : 1 to 4, Memory number
mmmm: 0000 to 3999, Address in memory
nnnn: 0001 to 4000, Number of data

9.3.6 Format of measurement status data and waveform data

(1) Measurement status data

The VC-6050 transmits the measuring condition data according to the next format when the VC-6050 becomes a talker by receiving the R0 command.

ID	,	V.M	,	S.M	,	H.C	,	T.D	,	P.F	,	V.M	,	V.C	,	V.D	,	INV	,	P.T	,	D.T	,	S.C	,	DEL
																		Add								

(,: Data delimiter)

(2) Waveform data

ID	,	ADDR	,	N	,	D1	D2	,	.....	DN	,	S.C	DEL
						Data							

(,: Data delimiter)

See Table 9-11 for details.

9.3.7 Delimiter

For the transmission of the waveform data or function command message, the controller sends delimiter to indicate the data's end to the VC-6050. The VC-6050 has three delimiters to be met with any device's delimiter. The VC-6050 sends back the same delimiter as the end of the function command messages to the controller.

However, if the controller is not provided with the following delimiters, it is necessary to send some delimiter (usually HEX data).

1) "EOI"
2) "C/R", "L/R"
3) "C/R", "EOI"

Table 9-10 Format for Measurement Status

	No.	Abbrev.	Item	Format	Byte number	Remarks
	1	ID	Memory number	# x @	3	
	2	V.M.	Vertical Mode	"CH1","CH2","ADD" or "CHOP" (right set)	4	
	3	S.M.	Sweep Mode	A, B (A Time or B Time)	1	
	4	H.C.	Time CAL	"CAL", "UNCAL" (right set)	5	
	5	T.D.	TIME/DIV	Time: XX.X (Note 1) Unit: "S", "MS", "MICS" (right set)	9	
	6	P.F.	Probe factor	"X1", "X10" (right set)	3	
	7	V.M.	Volt MAG	"X1", "X5"	2	
	8	V.C.	Volt CAL	"CAL", "UNCAL" (right set)	5	
	9	V.D.	VOLT/DIV	Volt: XX.X (Note 1) Unit: "V" or "MV" (right set)	7	
Add	10	INV	Invert	Blank, INV	3	
Change Nos.	11	P.T.	Pretrigger word	0000 to 3999	7	
	12	D.T.	Delay	0.3 to 9.9 DIV	9	
	13	S.C.	Sum Check	Hexadecimal ASCII data	2	
	14	DEL	DELimiter	1. C/R L/F 2. C/R "EOI" 3. "EOI" (One out of above three.)	Variable	Conform to delimiter of the HOST CPU.

Note: Four figures including the first decimal place

Table 9-11 The Format of the Waveform Data

No.	Abbrev.	Item	Format	Byte number	Remarks
1	ID	Memory number	The same as Table 9.10 No.1.	3	
2	ADDR	Heading address	Decimal, four-digit 0000 to 3999	4	
3	N	Number of data	Decimal, four-digit 0001 to 4000	4	
4	Di	Data	Decimal, three-digit/1 data 000 to 255	3	
5	S.C.	Sum Check	The same as Table 9-10 No.6	2	
6	DEL	DELimiter	The same as Table 9-10 No.7	Variable	

9.3.8 Status byte

The VC-6050 sends the byte in order to respond to a message command, or to inform the controller of the status.

The following is the format of these status bytes.

2^7							2^0
0	SRQ	ERR	BUSY				

1. SRQ = 1 : Indicates that the SRQ is being transmitted.
2. ERR = 1 : Indicates that the received data is in error status.
3. BUSY= 1 : Indicates that the VC-6050 is occupied.

No.	Status byte	Description
1	41	Data acquistion by S1 command is completed.
2	51	Indicates that the equipment is occupied.
3	61	Data format error.
4	62	SRQ is made at no transmitting data mode or occupied mode. Feeds back "*DEL".

Note: Status byte is a hexadecimal number.

9.4 Protocol

9.4.1 Switching of the command mode and data mode

Fig. 9.4 shows the ATN signal and commands.
Command mode is ahead of the data mode and commands are in a lump. Data mode ends by the appearance of the delimiter.
As a rule, interruption of the command mode shall no be done.

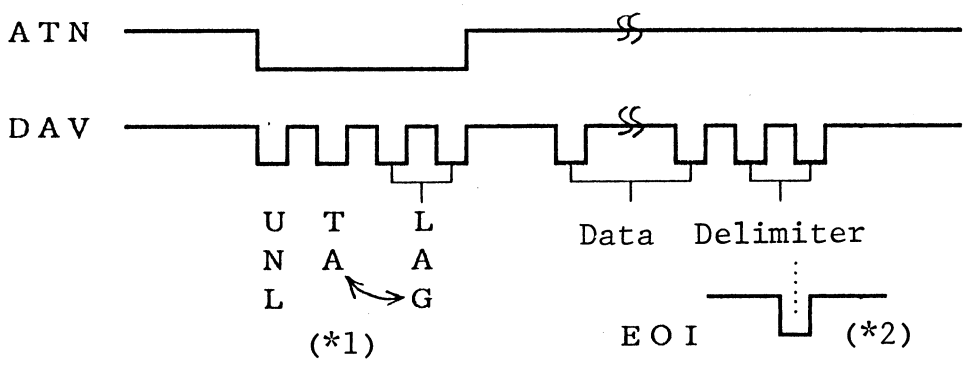


Fig. 9.4 Command Mode and Data Mode

Notes: 1. Order of the talker address group (TA) and the listener address (LAG) may be at random.
2. EIO is simultaneously fed out with the final data byte including delimiter.

9.4.2 Address command

Fig. 9.5 shows the portocol of SDC.

TA may be replaced with LAG as shown below.

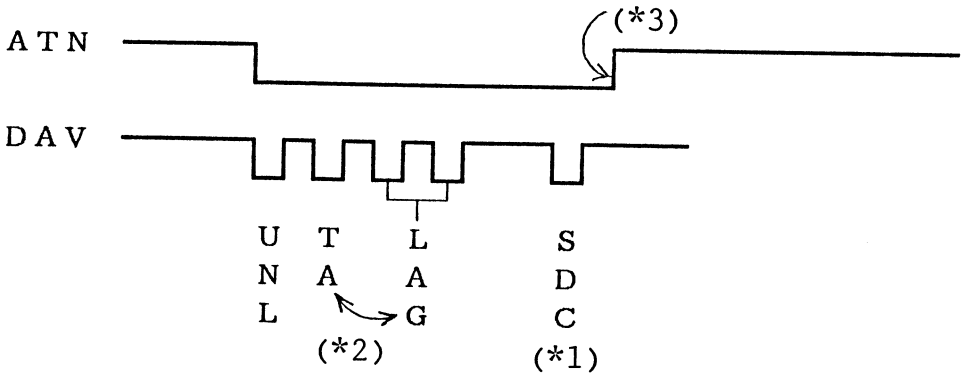


Fig. 9.5 Address Command

Notes: 1. The illustrated SDC only is used for the VC-6050, while others such as GTL, GET, and TCT are not used in this case.

2. The order of TA to LAG may be at random.

3. ATN level requires to be "High" by any means such as usage of other order.

9.4.3 Universal command

Fig. 9.6 shows protocol of the Universal Command.

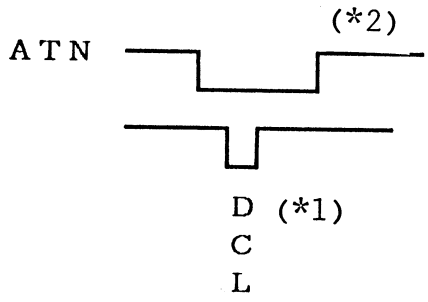


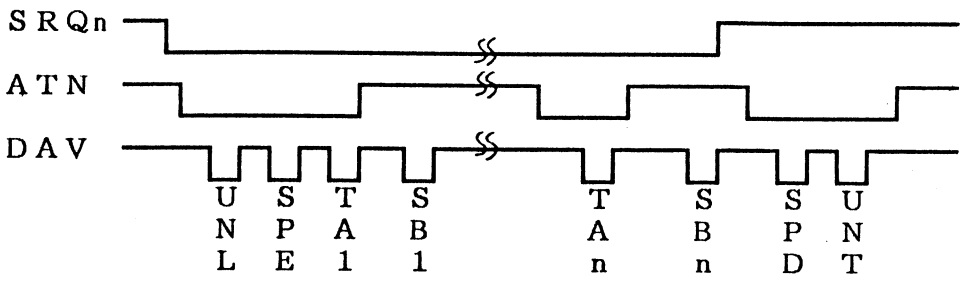
Fig. 9.6 Universal Command

Notes: 1. The illustrated DCL is only used for the VC-6050, while LLO is not used in this case.

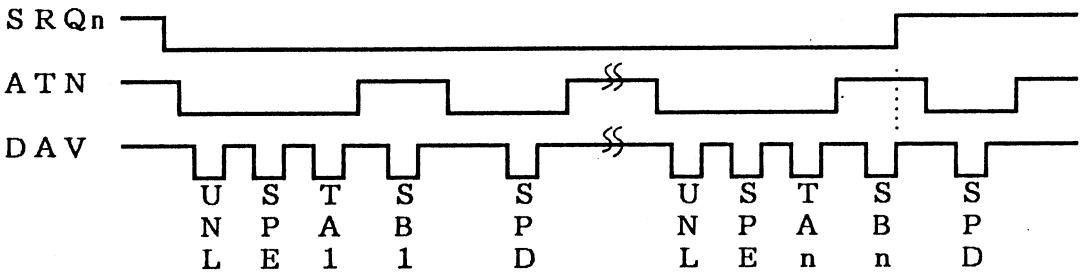
2. ATN level requires to be "High" by any means such as usage of other order.

9.4.4 Serial poll

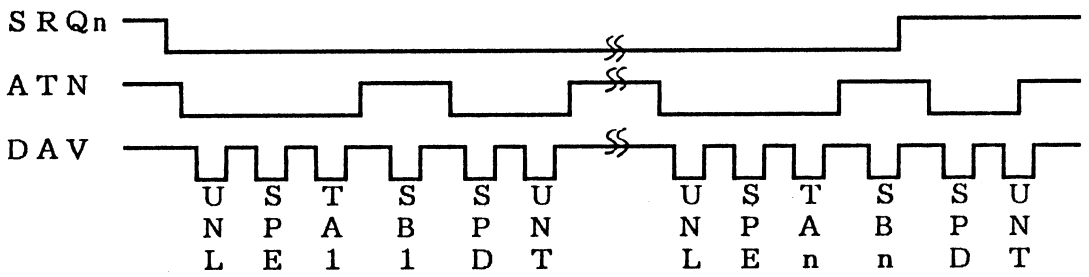
Fig. 9.7 shows three protocols of Serial Polling.



(a) Method for reading status byte serially.



(b) Method for reading status byte one by one
(UNT is not inserted after SPD.)



(c) Method for reading status byte one by one
(UNT is inserted after SPD.)

Fig. 9.7 Protocol of Serial Polling

9.4.5 Protocol

1) The equipment responds to ANT as first priority, and therefore, the processing is halted if the ATN becomes "L" during data transmission or in reception.
2) When TA or LAG command succeeds the same address, the last command (TA or LAG) will be accepted.
3) Address command may be repeated.
   The LAG and COMi address commands are repeated as follows, and the related LAG is processed. (Only portions of commands are processed.)
   ANTL, LAG1, COM1, COM2, LAG2, COM1, COM2, ATNH
   Note: Processes of LAG2, COM1, and COM2 are excepted.
4) Universal and address commands may exist at the same time. However, the command from the universal command to the address command will require the TA command (or LAG command).
5) Other protocols conform to Specifications of IEEE-488=1975/78 Standard.

9.5 Caution on The Transmitting Data Sequence

1) Status byte is transmitted to inform the sequence error when a talker request is received with no transmitting data.
2) Error status is attached to the status byte when there is a format error in the message command.

9.6 Connection and Operation of The VC-6050 and The GPIB

1) Turn power off on the VC-6050.
2) Connect the GPIB cable between the VC-6050 and the controller (GPIB system).
3) Set the VC-6050 address independent of the other devices. (See Item 9.3.4.)
4) Set the VC-6050 power to on, and set the front panel controls for proper signal observation. Repress the HOLD mode function switch. (In the case of the VC-6050, data transmission is available only when the VC-6050 is in the HOLD mode; the data transmission is invalid when the VC-6050 is in other modes.)
   Then, the VC-6050 will be operated by receiving a command from the controller.

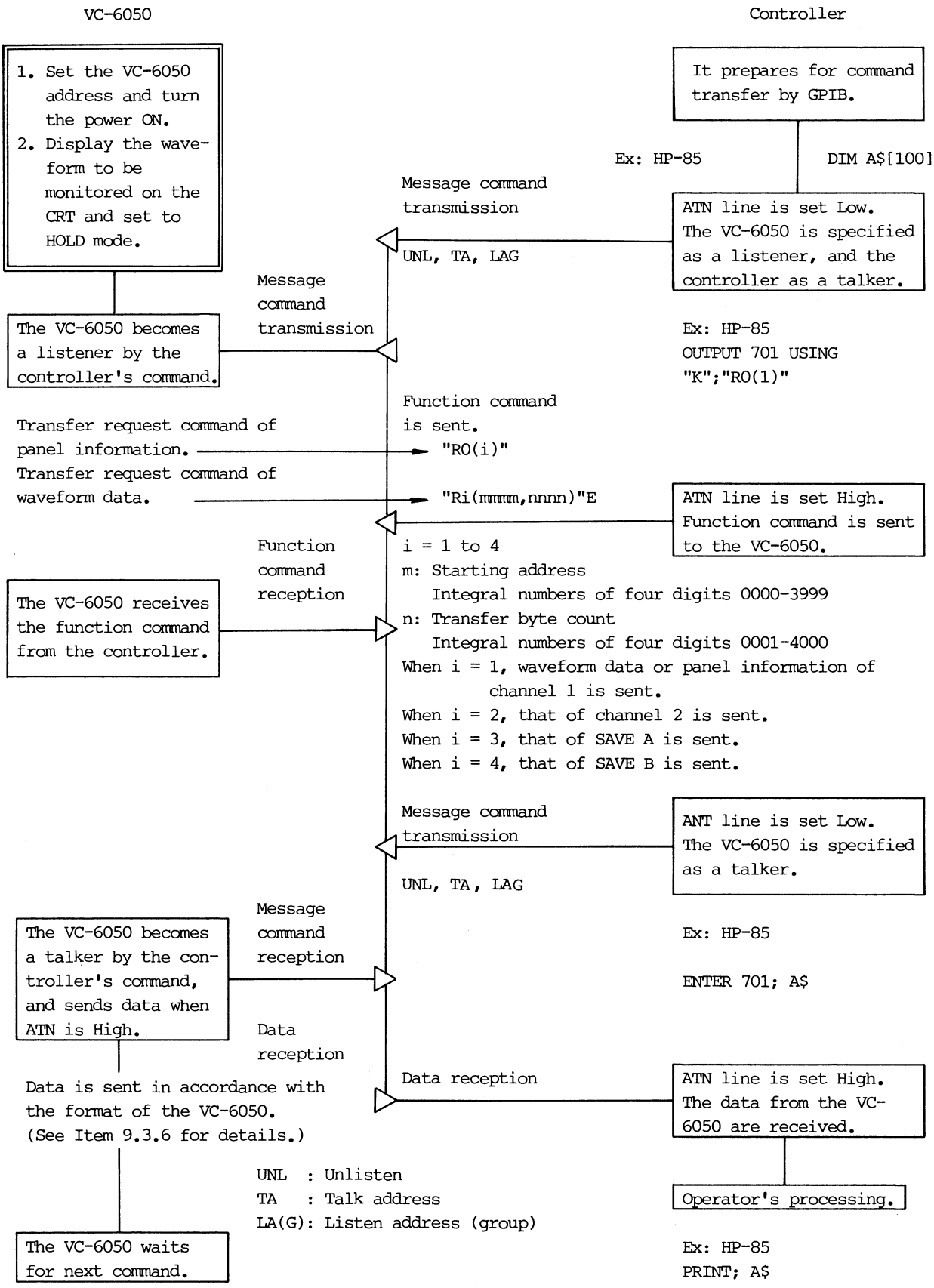
9.7 Programing for Data Transmission

Programing of data input/output for the GPIB is classified into two methods. One is the method employing the macro instruction from the controller itself such as "PRINT", "INPUT", etc.

The other is the method employing the command directly controlling the GPIB bus line such as "PEEK", "POKE", etc.

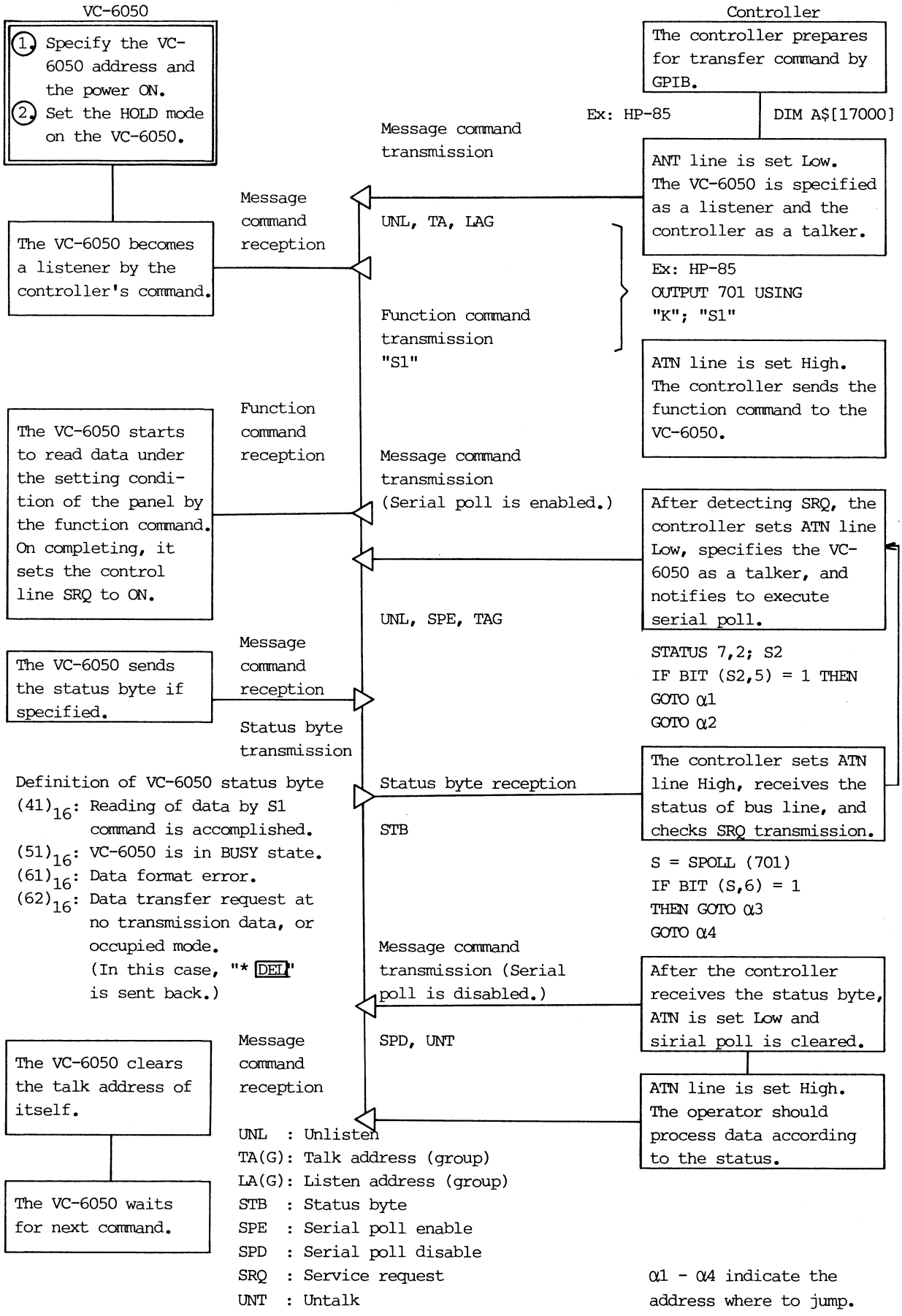
* **Macro ordering method:**
  Although the Macro controlling method simplifies the programing, the sequence by the macro control of the GPIB may not correspond to sequence of the GPIB.
* **Direct control method:**
  Although the programing is complicated by this method, data transmission between the VC-6050 and the GPIB is always available.
  When the computer is provided with assembly language only, only this method is applicable.
  To facilitate programing, first execute a simple test program, send the function command to the VC-6050 by the simple program, and check the resultant data received from the VC-6050. This simple test program will check system validation and then a complete program can be written.
  The following program statement depends on the employing controller; transmitting method of multiline interface message command, function command, receiving method of the data etc.
  Before transmission, read thoroughly the employing controller manual, because controllers may require preparation such as data bufer area reservation and delimiter setting.
  Items 9.7.1 through 9.7.3 describe the basic methods of producing program.

9.7.1 GPIB - VC-6050 CONTROL PROGRAMING 1
(Panel information and waveform data transfer)



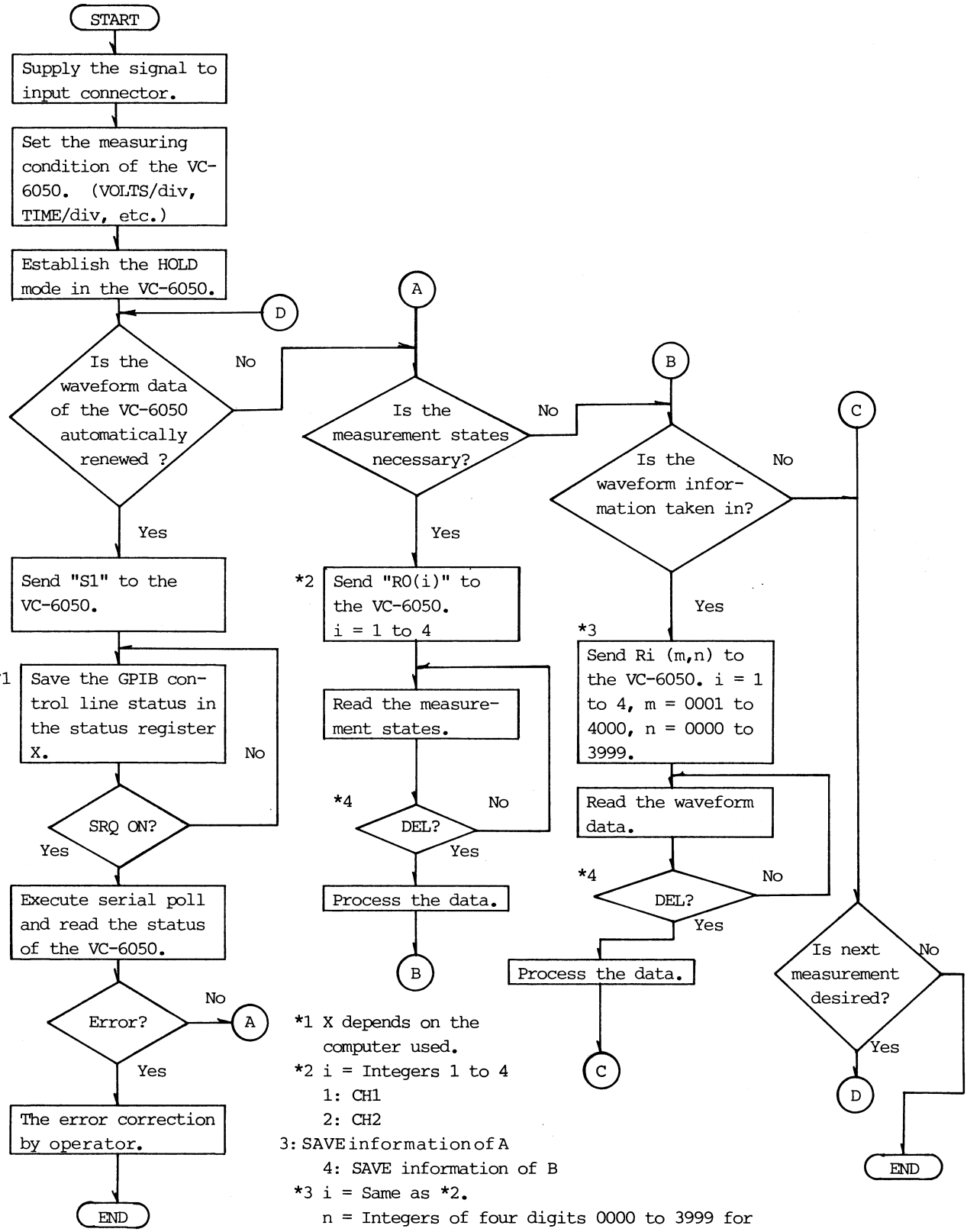
9.7.2 GPIB - VC-6050 CONTROL PROGRAMING 2

(Indication of data reading to the VC-6050 and serial poll)



9.7.3 GPIB - VC-6050 CONTROL PROGRAMING 3

Flowchart for data transfer to the VC-6050
(The controller program)



*1 X depends on the computer used.

*2 i = Integers 1 to 4
1: CH1
2: CH2
3: SAVE information of A
4: SAVE information of B

*3 i = Same as *2.
n = Integers of four digits 0000 to 3999 for starting address of the memory
m = Integers of four digits 0001 to 4000 for number of transferred data

*4 DEL is a delimiter. One of (CR)(LF), (CR)(EOI), or (EOI) is sent back in accordance with the DEL sent from the controller.
"," is sent between data and data.

9.8 In Case of Poor Data Transmission

If the data transmission is poor, check the following.

(1) Is a cable(s) connected?
Is the system powered?

(2) Is the VC-6050 in the HOLD mode?

(3) Is the trigger signal set to the NORM trigger mode?
(When the single sweep from the controller by S1 command)

(4) Does function command correspond to that of the VC-6050?

(5) Does the address setting of the VC-6050 correspond to the address speciffied by the controller?
Does the other device use the same address as the specified address by the controller?

(6) Is the same format of the VC-6050 delimiter used by the device?
Is the same delimiter used at transmitting of data and at receiving of data?
(If C/R and L/F delimiters are used at transmission but C/R only is used at receiving, each delimiter is different and optimum data can not be transmitted.)

(7) Does initialzation of the VC-6050 after the address change the VC-6050. When the VC-6050 is powered, the VC-6050 reads the address switch settings and memorizes them as its adders. Consequently, the VC-6050 address can not be changed while the power is on.

(8) In cases not-provided, executation of functions such as PPC, GET, TCT will fbe tried, but the transmission is invalied.

(9) Is the buffer area available for data?
Is proper data required with respect to the buffer area of the listener? (If the data exceeds the buffer area capacity of the listener for required transmitted, data can not be transmitted.)

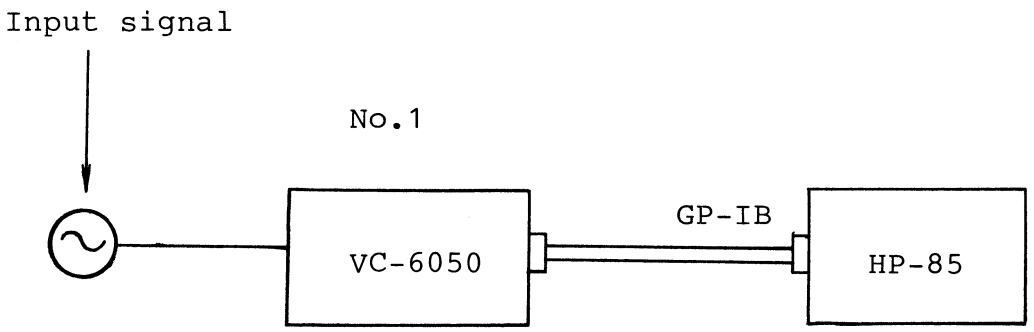
(10) At serial polling, is the address of the status register for detecting the SRQ of the control line properly assined?

(11) Is the statement for rhe program proper?
Is the control of decimal and hexadecimal proper?

Note: When the power of a device connected but not-used is set to off, the GPIB may not operate properly due to reduced noise margin of the bus line.
If a device among the system is unused, disconnecting the device or setting the device's power to on is recommended.

9.9 Programing Example

The following is an example of the programs in the configuration of the VC-6050 and HP85.



Outline of the program:

Receive the signal to print out waveform data and measurement status.

Input channel: CH1
Output : 1000 words from 0 address

```
100 DIM A$[17000]
110 OUTPUT 701 USING "K";"S1"..... Transmit "S1" command.
120 STATUS 7,2;S2..................... Status byte -- S2
130 IF BIT (S2,5)=1 THEN GOTO 150.... Is Status byte 2^4 ON?
                                      (SRQ)
140 GOTO 120
150 S=SPOLL (701)..................... Serial poll
160 IF BIT (S, 6)=1 THEN GOTO 180.... Is Status byte 2^6 ON?
                                      S1 command process end.
170 GOTO 270
180 OUTPUT 701 USING "K";
    "R0(1)"........................... Transmits "R0(1)"
                                      command.
190 ENTER 701;A$...................... Receives measuring
                                      status data.
200 PRINT ............................ Carriage return
210 PRINT A$.......................... Prints  measurement
                                      status data.
220 OUTPUT 701 USING "K";
    "R1 (0000, 1000)"................. Transmits R1 (0000,
                                      1000) command.
230 ENTER 701;A$...................... Receives waveform data.
240 PRINT............................. Carriage return.
250 PRINT A$.......................... Prints waveform data.
260 STOP
270 DISP "ERR.STATUS=";S.............. Error indication.
280 END
```

10. SPECIFICATIONS

o CRT

Configuration:	6-inch rectangular screen with internal graticule, scale illumination, and 0, 10, 90, and 100% markers
Useful screen:	8 x 10 div (1 div = 1 cm)
Acceleration potential:	12 kV approx.
External intensity modulation:	DC to 5 MHz, 5 Vp-p or more Input impedance: 22 kΩ (typical) Maximum input voltage: 50 V (DC + AC peak)

o VERTICAL DEFLECTION SYSTEM

Sensitivity:	<CH1 and CH2> 5 mV/div to 5 V/div ±3% (at 10 to 35°C), in 10 calibrated steps (CAL mode) X5: 1 mV/div, 2 mV/div ±5%, continuously variable control between steps at least 1 : 2.5 (with UNCAL displayed) <CH3> 0.1 V/div ±10% ÷10: 1 V/div ±10%
Bandwidth:	<CH1 and CH2> DC to 60 MHz (-3 dB), 6 divisions as a reference (CAL mode) X5: DC to 10 MHz (-3 dB), 6 divisions as a reference (CAL mode) <CH3> DC to 60 MHz (-3 dB), 6 divisions as a reference

Rise time:	5.8 ns X5: 35 ns
Signal delay:	Leading edge can be monitored.
Maximum input voltage:	400 V (DC + AC peak) at 1 kHz
Input coupling:	<CH1 and CH2> AC, GND, DC <CH3> AC, DC
Input impedance:	
Direct:	<CH1 and CH2> 1 MΩ ±1.5%, 23 pF approx. <CH3> 1 MΩ approx., 23 pF approx.
Vertical modes:	CH1, CH2 (normal or invert), CHOP (250 kHz approx.), ADD, difference mode (with CH2 inverted in ADD mode)
Triple mode:	Available at ALT and CHOP modes Permits positioning independently
Polarity switching:	+ or - (CH2 only)
Dynamic range:	8 div or more
Common-mode rejection ratio (CMMR):	At least 20 dB at 10 MHz
X-Y operation:	CH1: X axis CH2: Y axis
Sensitivity:	5 mV/div to 5 V/div (CAL mode) X5: 1 mV/div to 5 V/div (CAL mode)
Phase error:	3^{o} or less from DC to 50 kHz (CAL mode)
X bandwidth:	DC to 2 MHz (-3 dB) (CAL mode)

o HORIZONTAL DEFLECTION SYSTEM

Sweep method:	Trigger, automatic trigger, continuous delay, trigger delay, alternate sweep (in NON STORE mode only), TV-V, TV-H

Sweep time:

NON STORE mode:

A (main) sweep:	50 ns/div to 0.5 s/div ±3% (CAL mode) (at 10 to 35°C) in 22 calibrated steps Uncalibrated continuous control between steps 1 : 2.5
B (delay) sweep:	50 ns/div to 50 ms/div ±3% (CAL mode) (at 10 to 35°C) in 19 calibrated steps

STORAGE mode:

A (main) sweep:	50 ns/div to 0.5 s/div ±3% (at 10 to 35°C) in 22 calibrated steps (50 ns/div to 5 µs/div: valid only for the repetition waveform)
B (delay) sweep:	10 µs/div to 50 ms/div ±3% (at 10 to 35°C) in 15 calibrated steps
ROLL mode:	500 ms/div to 50 s/div in 7 calibrated steps
Holdoff time:	Variable
Delay time:	1 µs to 5 s
Jitter:	1/20,000 or less
Sweep magnification:	10X
Maximum sweep rate:	5 ns/div (CAL mode)

o TRIGGER

Trigger signal:

A:	CH1, CH2, ALT (NON STORE mode only), LINE, CH3, CH3 ÷ 10
B:	AUTO, NORM

Trigger coupling:

A:	DC
B:	DC

Trigger sensitivity:

Frequency	CH1, CH2	CH3
DC to 10 MHz	0.4 div	0.5 div
10 to 60 MHz	1.5 div	1.5 div

Notes:

o Except for the ALT and the CHOP modes and the readout operation

o CH1 and CH2: x1 mode
The amplitude of five times the x1 mode is required.

Variable trigger level: -8 to +8 div

Bandwidth in AUTO mode: 30 Hz or more

Trigger slope: ± (for both A and B)

o READOUT FUNCTION

Panel setting displays:

Vertical axis: V/div (CH1 and CH2 only), INVERT, ADD, UNCAL, MAG, probe factor

Horizontal axis: s/div, UNCAL, MAG

Others: Delay time, X-Y, SWP X10 MAG POINT, PRE TRIG, NO. OF SWEEPS

Cursor readout functions:

Voltage difference ΔV: Δ - REF

Time difference ΔT: Δ - REF

Frequency 1/ΔT: 1/|Δ - REF|

o CH1 OUTPUT:

Output voltage: 25 mV/div ±20%
(terminated into 50 Ω)

Frequency bandwidth: DC to 20 MHz (-3 dB)
(terminated into 50 Ω)

Output impedance: 50 Ω approx.

o CALIBRATOR

Waveform: 1 kHz ±20%, square wave

Voltage: 0.5 V ±1%

DIGITAL STORAGE FUNCTIONS

o WAVEFORM DATA STORAGE

Memory capacity:	4000 words/CH x 2
Vertical resolution:	8 bits/10 div
Horizontal resolution:	400 steps/div
Maximum sampling rate:	
1-channel sampling:	40 MHz
2-channel sampling:	20 MHz
	Sampling rate depends on the time range. (400 data/div)
Maximum storage frequency:	
Single-shot signal:	10 MHz (Maximum amplitude error: 30% or less)
Repetitive signal	60 MHz

o DATA ACQUISITION

Normal storage mode:	Renews the data by each triggering
Average mode:	Averages input signals by the selected number of sweeps and displays the result after the averaging has reached the selected number. (Number of average: 2^n, maximum 2^8 (256))
SINGLE operation:	Performs the average operation only once, and holds the data.
Repetitive operation:	Repeats the average operation continuously
HOLD mode:	Holds the waveform displayed on the CRT by the HOLD key.
SINGLE sweep:	Renews the data by the first trigger and accepts no more trigger.

ROLL mode: Shifts the data right to left continuously on the CRT. (The renewing point is the right end.)

o DATA SAVE: Up to two waveforms can be saved by the SAVE key. Stored waveforms can be displayed on the CRT. (In the AVG mode, the saved data are destroyed.)

o PRETRIGGER: 0 - 9.9 DIV variable (in 0.1 DIV steps) The pretriggered amount is set by the DLY/CURSOR control. The setting value is displayed on the CRT, and the pretriggering position is indicated by the vertical PRETRIG cursor.

o DATA OUTPUT

PLOT output:

Y axis output: 2 channels (Y-t output)
1 channel (X-Y output)
1 V/div ±100 mV

Output for X-Y recorder:

X axis output: 1 channel
1 V/div ±100 mV

Output time: 4-step switching (1, 2, 5, and
(X and Y) 10 s ±5%/div)

Load resistance: 2 kΩ or more
(X and Y)

Pen lift output: TTL negative, fan out 1

o DIGITAL OUTPUT: Provides data through GPIB interface.
Data: Measurement conditions and waveform

Measurement conditions: Vertical mode, sweep mode, TIME/DIV, probe factor, VOLTS/DIV, pretrigger, delay, etc.
Waveform: Decimal progression (By block transfer system)

o MAGNIFYING DISPLAY: Magnifies one division of the stored waveform starting from the cursor point by ten times. By combination use with the PULL X10 MAG control, the waveform can be magnified by hundreds times.

o POWER SUPPLY:

Voltage:

Voltage	Fuse 1	Fuse 2
100 V (90 to 110 V)	2 A	3 A
120 V (108 to 132 V)	2 A	3 A
220 V (198 to 242 V)	2 A	3 A
240 V (216 to 264 V)	2 A	3 A

Frequency: 50 to 60 Hz

Power consumption: 120 W approx.

o ENVIRONMENT

Operation temperature: 0 to 40°C (30 to 104°F)

Operation humidity: 35 to 85%

Temperature for guaranteed specifications: 10 to 35°C (50 to 95°F)

Humidity for guaranteed specifications: 45 to 85%

Storage temperature: -20 to +70°C (-4 to +158°F)

Storage humidity: 35 to 85% (70% or less in the temperature of 50°C (114°F))

o DIMENSIONS AND WEIGHT

Dimensions:	330 (W) x 190 (H) x 470 (D) mm approx. (12.9 (W) x 7.5 (H) x 18.5 (D) inch approx.)
Weight:	15 kg approx.

11. ADJUSTMENT

The ATT balance of the vertical axis can be made easily:

(1) Set each AC-GND-DC switch of CH1 and CH2 to GND and set the trigger MODE switch to AUTO. Position the base line to the center.

(2) Rotate the VOLTS/DIV switch from 5 to 10 mV, and adjust the DC BAL control so that the base line does not move.

12. EXTERNAL VIEW