MODEL VC-6015

DIGITAL STORAGE OSCILLOSCOPE

OPERATION MANUAL

Hitachi Denshi, Ltd.

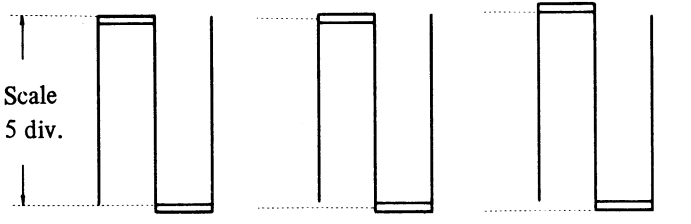
CONTENTS

It is suggested that you read this operation manual carefully so that you may be able to make best use of all the features in this digital storage oscilloscope.

1. NOTES

(1) To clean the enclosure or front panel, use neutral detergent. Refrain from using thinner, benzine, alcohol or other chemical agents.

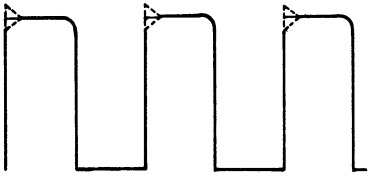
(2) Choose one of the three methods for your calibration for vertical sensitivity calibration.



Adjust the top sweep. | Adjust in the middle of both sweeps. | Adjust the bottom sweep.

(3) Depending on the positions the trace may tilt slightly from the scale line. To correct tilting, align the trace to the horizontal scale line by rotating the TRACE ROTATION on the front panel.

(4) When the probe is calibrated with the waveform from the PROBE CAL 0.5V terminal, the waveform displayed on the CRT will be round at the top right corner as shown below. To obtain the correct waveform, adjust the waveform at the top left corner.



(5) Avoid using the oscilloscope in a strong magnetic field, especially near a large power comsuming equipment. Waveforms may be distorted or trace may be oblique having influenced by the magnetic force.

(6) Avoid strong vibrations to the oscilloscope while in use. Excessive vibration may cause a damage to the scale illumination lamp. When it is required to use the oscilloscope in such a environment, be sure to turn SCALE ILLUM control fully counterclockwise.

The functions for the OSC (oscilloscope) mode:

1. ADD/DIFF
2. SWEEP VAR
3. X-Y display
4. TIME/DIV (1μs/div to 50μs/div)
   (The range is shifted to 0.1ms/div when the DISPLAY selector is set to the STORE mode).

The functions for the STORE (storage) mode:

1. PULL STORE POSI
2. PRE TRIG
3. FREE RUN DISPLAY TIME
4. RECORDER OUTPUT TIME/DIV
5. RECORDER OUTPUT CH1/CH2/X
6. START/RESET
7. READY
8. TIME/DIV (0.5 s/div and 1 s/div)
   (TIME/DIV becomes uncalibrated when the DISPLAY is set to the OSC mode.)

2. FEATURES

(1) The equipment can be also used as a conventional 10MHz oscilloscope.

(2) The two-channel system permits the observation of two different waveforms and their relations simultaneously and also the observation of the waveforms at different timing.

(3) Writing in a new trace is possible while holding the other data as it is.

(4) The pre trigger waveform is available for observation.

(5) The digital storage oscilloscope provides the CH1, CH2 and X signals to a pen-recorder at the same time.

3. COMPOSITION

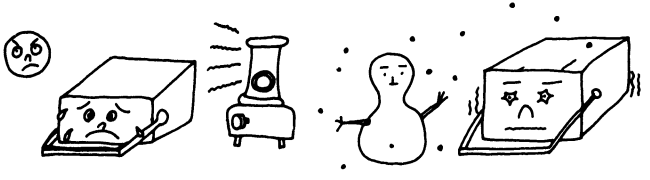
(1) The VC-6015 digital storage oscilloscope 1
(2) Probe AT-10AK1.5 2
(3) Dust proof cover 1
(4) Power cord 1
(5) Operation Manual 1

4. PRECAUTIONS

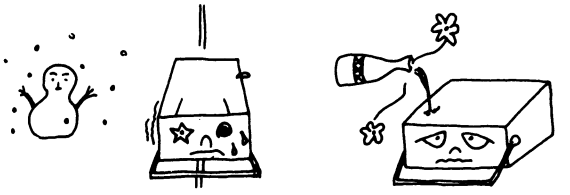
In order to maintain the proper function of the instrument for a long time, read following precautions carefully.

Installation site

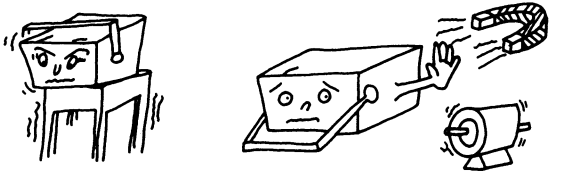
* Avoid installing instrument in an extremely hot or cold place.
  - Avoid placing this instrument in a place exposed to sunlight for a long period of time, in a closed car in midsummer, or near a room heating device such as a heater.
  - The operating maximum ambient temperature is 40°C (104°F).
* Do not leave instrument outdoors on a cold winter day. The operating ambient temperature is 0°C (32°F) or more.



* Avoid moving the instrument rapidly from a hot place to a cold place and vice versa, or condensation may form inside the instrument.
* Keep the instrument away from damp air, water, and dust, unexpected trouble may be caused.
* The operating ambient humidity is 35–85%. Since an accidential instrusion of water may also cause troubles, do not place a water-filled containers such as a vase on the digital storage oscilloscope.

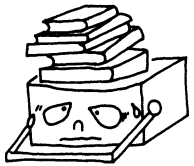


* Do not place or use the instrument in a place where vibration is strong. Since the digital storage oscilloscope is a precision instrument, excessively strong vibrations may cause damage.
* Do not place the instrument near a magnet or magnetic body. An digital storage oscilloscope is an equipment using electron beam. Therefore, do not bring a magnet close to the instrument or do not use the instrument near an equipment generating strong magnetic force.

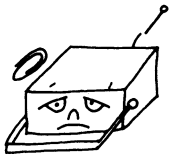


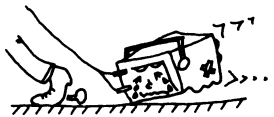
Handling

* Do not put a heavy objects on the digital storage oscilloscope. Do not block the ventillation holes.
* Do not apply a heavy shock to the digital storage oscilloscope.

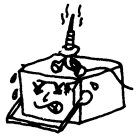


* Do not insert a wire, pin, etc. through the ventillation hole.
* Do not drag the set leaving the probe attached to it.





* 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 coaxial cable connected to EXT BLANKING or RECORDER OUTPUT terminal on the rear panel. Otherwise, the cable may be damaged.

When operation is faulty.

Recheck the operating procedure and if problem persists, contact your local Hitachi Denshi service station.

Care and repair

* Removal of stain from the case.
  - When the outside of the case is stained, remove the

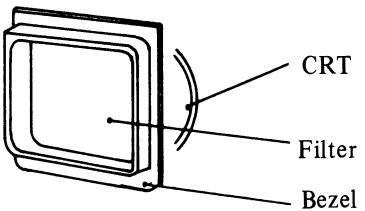
stain by first wiping it lightly with a cloth moistened with neutral washing agent and then wipe the surface with dry cloth.

- When the panel surface is stained, remove the stain in similar way with a clean, soft cloth. When heavy stains are present, first remove the stains by wiping the surface lightly with a cloth moistened with diluted neutral washing agent and then wipe thoroughly with a dry cloth.
- When dust has accumulated inside, remove it by using a dry brush, or by using a compressor or a vacuum cleaner.

NOTE: When opening the case, be sure to disconnect the power supply plug beforehand.
Before cleaning inside, discharge the voltage charged inside.

*** Cleaning of CRT**

Keep surface of CRT screen clean for accurate measurement. Remove the stains on CRT and filter by using a clean and soft cloth, paying attention not to impair them. When the stain is extremely heavy, wash them with neutral detergent and then leave them until the moisture is gone. If the screen is installed while there is moisture, condensation may form and make the screen blurred.
Do not leave finger prints on the screen.



* **Preparation for measurement**

* **Line voltage**

The operating voltage range of this digital storage oscilloscope is as shown in the chart. Check the line voltage before turning on the power switch.

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

If the VC-6015 is intended to be used on the AC line voltage other than set at factory before shipment, set the line voltage selector properly and change the fuse, if necessary.

* **Use only specified fuses**

In order to protect the circuit against overcurrent, a 2A (AC100V or 120V) source or 1A (AC220V or AC240V) source is used on the primary side of the power supply. When this fuse is blown out locate the cause and repair and replace with a specified fuse after shooting the trouble. Do not use the fuse other than specified.

* **Specified fuses**

	Shape (Diameter x length) mm	JIS type name
2A	6.35 x 31.8	MF61NM250V 2A AC
1A	6.35 x 31.8	MF61NM250V 1A AC

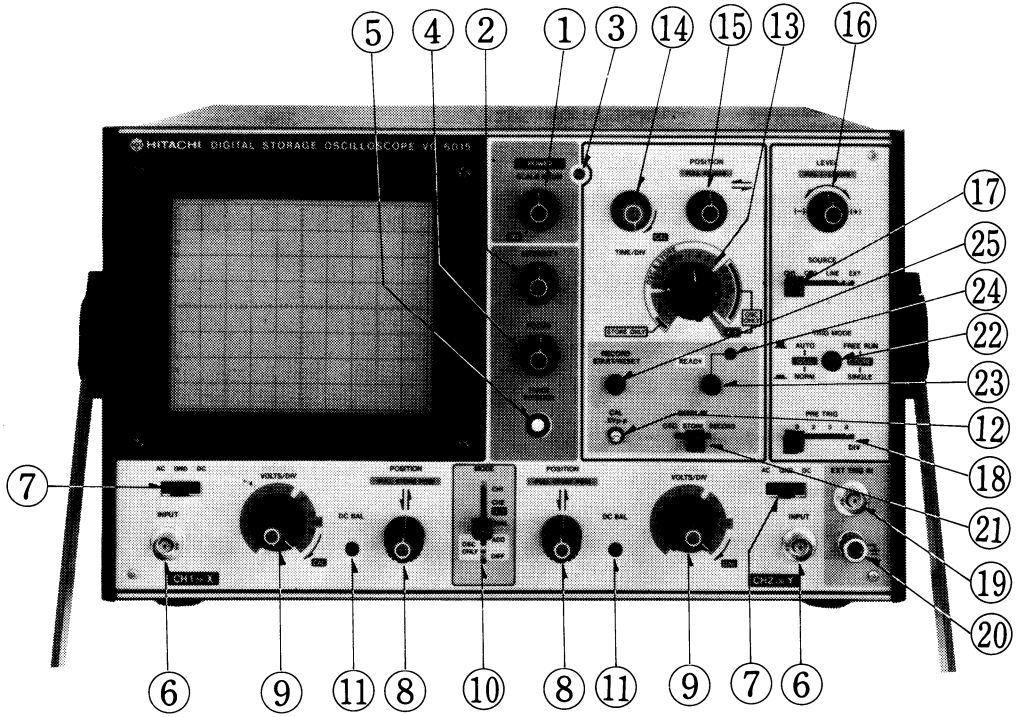
* Excess brightness of the display may strain your eyes and it may damage the CRT.

* Do not apply an excessive voltage.

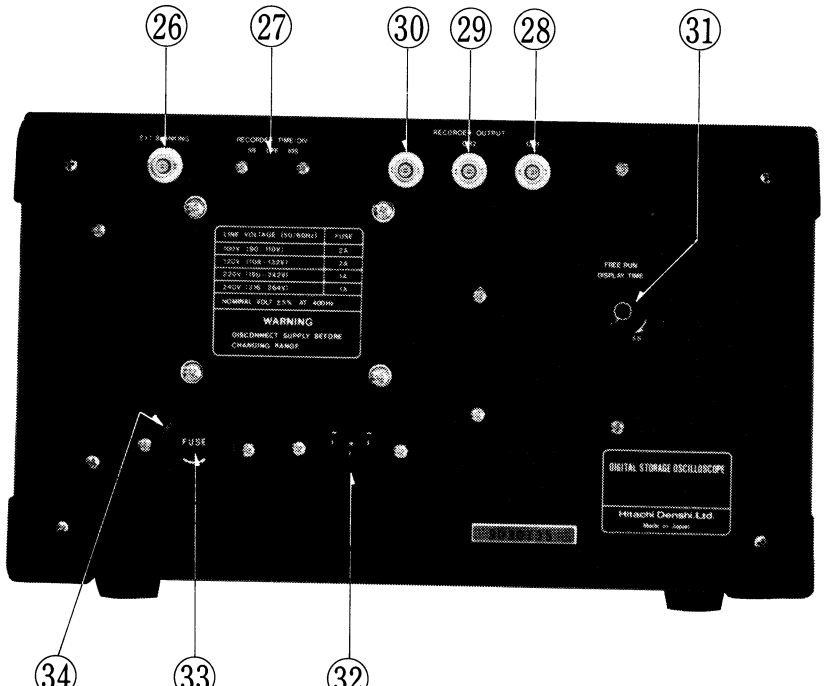
The input withstand voltage of each input connector and probe input is as follows. Never apply a voltage higher than specified.

INPUT direct	250V (DC + AC peak at 1 kHz)
When probe is used	600V (DC + AC peak at 1 kHz)
EXT TRIG INPUT	250V (DC + AC peak)
EXT BLANKING	30V (DC + AC peak)

5. PANEL DESCRIPTIONS



Front View


26
27
30
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28
31
34
33
32
FUSE
WARNING
DISCONNECT SUPPLY BEFORE
CHANGING RANGE
FREE RUN
DISPLAY TIME
DIGITAL STORAGE OSCILLOSCOPE
Hitachi Denshi Ltd.

Rear View

(1) Power supply and CRT

Operating voltage and fuse

This model can be operated from either a 100-volt, a 120-volt, a 220-volt or a 240-volt nominal line voltage source. The Line Voltage Selector assembly on the rear panel selects suitable voltage. The assembly also includes the line fuse. Use the following procedure to change line voltage.

1. Disconnect the instrument from the power source. And uncap the fuse holder.
2. To convert from 100-volts nominal to 220-volts nominal line voltage and vice versa, pull out the voltage selector switch turn it, and plug it back into the proper holes. Change the line-cord power plug to match the power-source receptacle.
3. Before applying power to the instrument, check the indicating tabs on the rear panel.

① POWER
SCALE ILLUM

1) Check the line voltage, and rotate the POWER switch fully counterclockwise to set the power off.
2) Connect the power cord to an AC outlet.
3) This knob also controls the scale illumination lamp for the waveform photography.

② INTENSITY

Rotate clockwise to increase intensity of the display.

③ Pilot lamp

Lights when the power is on.

④ FOCUS

Provides adjustment for optimum display definition.

⑤ TRACE ROTATION

Corrects slight tilting of trace caused by external magnetic fields.

(2) Vertical deflection

⑥ CH1 OR X INPUT

This is an input receptacle with the CH1 vertical amplifier and X-axis (horizontal axis) amplifier for X-Y operation.

⑦ AG–GND–DC

(Alternating Current-Ground Direct Current)
Switches the coupling of the signal fed to the vertical axis input. DC coupling is obtained on the DC position. On AC position, the direct current component is blocked by a capacitor. The GND position grounds the input of the amplifiers and opens the input terminal.

⑧ POSITION (Black knob)

PULL STORE POSI (Red knob)

1) POSITION control knob in the OSC (oscilloscope) mode: the vertical position is adjusted. The trace moves upward when this is rotated clockwise. The trace moves downward when this is rotated counter-clockwise.
2) PULL STORE POSI control knob in the storage mode: Rotation of the knob in the pulled out position will vary the vertical position of the trace on the screen by ±3 div. from its original position. When the knob is pushed in, the position of the trace returns to the original position.

⑨ VOLTS/DIV

(CH1 or X sensitivity switch)

This knob is used for switching the sensitivity of the input signal fed to CH1. Switching action is accomplished in ten steps from 5mV/div to 5V/div. On X-Y operation, the knob controls the sensitivity of the X-axis.

VOLTS/DIV (CH2 or Y sensitivity switch)

This knob is used for switching the sensitivity of the input signal fed to CH2. Switching action is accomplished in ten steps from 5mV/div to 5V/div. On X-Y operation, the knob controls the sensitivity of the Y-axis.

To measure by the indicated voltage sensitivity, be sure to set each of the VARIABLE to CAL position by turning fully clockwise. If a signal is applied to the input terminal with a 1/10 low capacitance probe, the values are ten times the indicated voltage.

VARIABLE

This is a vartical axis sensitivity fine adjustment which is capable of attenuating to less than 1/2.5 by indication of each range of VOLTS/DIV.

To measure a voltage by the use of voltage sensitivity indicated by VOLTS/DIV, turn the VARIABLE clockwise fully to CAL.

⑩ MODE

- CH1
  Only the input signal applied to CH1 is displayed.
- CH2, X-Y
  Only the input signal applied to CH2 is displayed.
- DUAL
  Dual trace display can be obtained by CHOP or ALT TIME/DIV switch ⑬ does automatic-change over to CHOP at 1ms/div-0.2s/div, and to ALT at 1μs – 0.5 ms/DIV. (Only in the OSC mode)
- ADD (addition)
  The input signals of CH1 and CH2 are algebraically

added and displayed. (Only in the OSC mode)

○ DIFF

The input signals of CH1 and inverted signals of CH2 are algebraically added and displayed.

⑪ DC BAL

The vertical DC balance adjustment is made easily.

1) Set the AC-GND-DC switches for the CH1 and CH2 at the GND position. Push out the AUTO NORM switch at the AUTO position, and select OSC mode on the DISPLAY switch to allow the trace to appear at the center.
2) Adjust the DC BAL control with a screw driver so that the trace does not move when the VOLTS/DIV switch is rotated from 5mV to 10mV.

⑫ PROBE CAL .5V

Signal output terminal for probe calibration. The frequency is approx. 1kHz.

⑬ TIME/DIV

This is a sweep time switch. Seventeen steps are provided for the OSC mode, and thirteen steps for the STORE mode.

When the oscilloscope is set to the OSC mode, set the SWP VAR control to the CAL position (fully clockwise) for an observation with the displayed time division.

Further set the TIME DIVISION switch to the X-Y position, then the X-Y mode is established by making CH1 as X-axis and CH2 as Y-axis. For the X-Y mode, also set the MODE switch ⑩ to the {CH2 / X-Y} position.

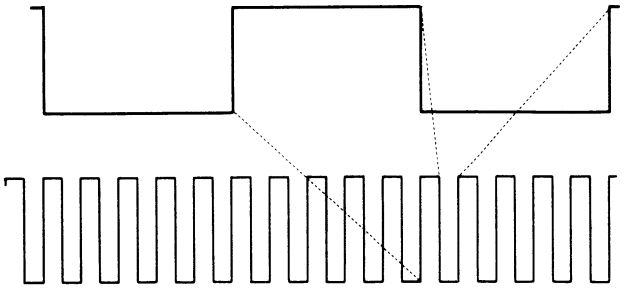
Set the POSITION control ⑧ to the mechanical midpoint. (X-Y is only possible with the OSC mode.)

⑭ SWEEP VAR (Adjustment of sweep time)

This is fine adjustment covering time not covered by the time change-steps.

⑮ POSITION, PULL X10 MAG

MAG x 10 Magnified waveform



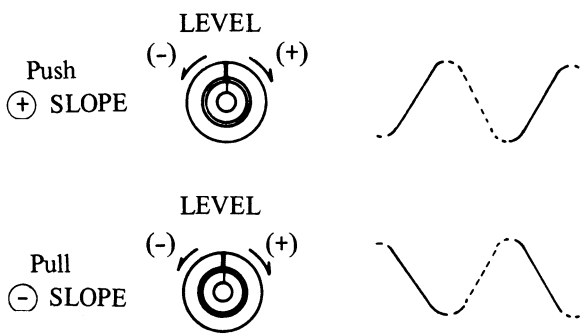
This knob is used to position the trace int he horizontal direction. When this knob is pulled out, the horizontal sweep is magnified by 10.

(4) Triggering

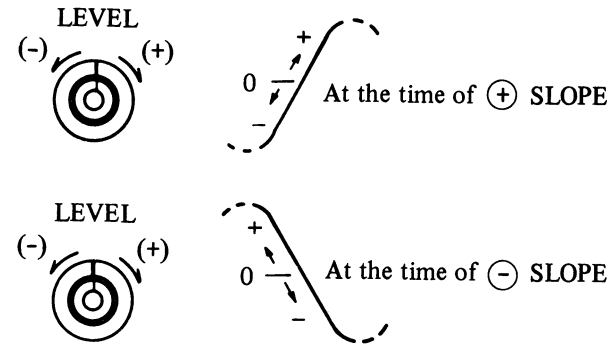
⑯ LEVEL, PULL (-) SLOPE

This knob is used to decide at which portion of the waveform should the sweep be started by setting trigger level. This knob enables to switch SLOPE. Depressed position (normal state) is for ⊕ SLOPE and PULL position (state in which the knob is protruding) is for ⊖ SLOPE.

* Explanation of synchronization polarity SLOPE.



* Explanation of synchronization level.



⑰ **SOURCE:** Select sync signal source.

- ○ CH1, CH2 — Used when triggering is made by observing signal at CH1 or CH2.
- ○ LINE — Used when observing a signal triggered with the frequency of AC power source.
- ○ EXT — Used when triggering is made by a signal applied to EXT TRIG IN connector ⑲, independently from observation signal.

⑱ PRE TRIG lever switch

This lever provides the trigger points at 0, 2, 5 and 8 divisions, to be used for the waveform observation of

pre trigger and post trigger.
The trigger point appears as an intensified illumination dot to discriminated the pre trigger and post trigger waveform.

⑲ EXT TRIG INPUT

This is an input BNC connector for external trigger signal.

⑳ GND

This is the ground terminal.

㉑ DISPLAY

OSC: The selection of OSC position sets the oscilloscope as a 10MHz dual trace oscilloscope.

STORE: The selection of the STORE position will set the oscilloscope to the digital storage oscilloscope.

RECORD: This enables a pen-recorder (X-Y recorder) to record the waveform stored with the STORE mode.

㉒ AUTO

NORM

When the DISPLAY switch is set to OSC, the button performs as a trigger mode selector.

- ○ AUTO When there is no signal or a signal stepping out of synchronization, the trace will appear automatically.
- ○ NORM This mode provides synchronizing sweep only when signal is synchronized. If there is no signal or a signal stepping out of synchronization, the trace will not appear. This mode is used for synchronizing a low frequency signal of less than 100Hz.

When the DISPLAY switch is set to the STORE position.

FREE RUN: This provides automatic repetion of the waveform record and erase operations.

SINGLE: When this button is pushed in and the READY switch is pushed, the displayed waveform disappears and a new trace appears on the screen to be stored on the screen.

The FREE RUN and SINGLE button does not operate in the RECORD mode of the DISPLAY switch.

㉓ READY

When this is pushed, the waveform on the screen disappears and writes in a waveform again.

㉔ READY lamp

This lamp indicates that the writing into the memory is under operation.

㉕ START/RESET

Allow 5 seconds after setting the switch until the output for the pen-recorder starts feeding.
Set the pen on the pen-recorder ready for writing. When the output to the pen-recorder finishes, it keeps holding the last data. When the switch is reset, the waveform will appear on the CRT for observation again.

㉖ EXT BLANKING (BNC connector)

This is the input connector for brightness modulation, and DC coupled.

㉗ RECORDER TIME/DIV

While the X-Y recorder is operating, 5 s/div (50 s/10 div) or 10 s/div (100 s/10 div) is selected as the speed for the X-axis output.

㉘ ㉙ ㉚ RECORDER OUTPUT (BNC connectors)

These are the output connectors for the pen-recorder and X-Y recorder. In case of the X-Y recorder, use ㉘ or ㉙ for the Y axis, and ㉚ for the X-axis.
As for the X-axis output, 0V corresponds to 0 division, and +10V to 10 divisions.

㉛ FREE RUN DISPLAY TIME

The display and storage times are set in the FREE RUN MODE.
Display time: 1 s to 5 s approx.

㉜ POWER SOURCE RECEPTACLE

㉝ FUSE

The fuse is released when the cap is rotated counter-clockwise.

㉞ LINE VOLTAGE SELECTOR

This model can be operated from either a 100V, a 120V, a 220V or a 240V nominal line voltage source.
The Line Voltage Selector assembly on the rear panel selects suitable voltage. The assembly also includes the line fuse.

6. HOW TO PRODUCE THE TRACE

Unless handled erroneously, this instrument will never become faulty by ordinary operation.

Before turning ON the POWER switch, insure the power supply voltage is within the range of 108 to 132V for AC 120V set, 198 to 242V for AC 220V set, and 216 to 264V for AC 240V set. Refer to the indication on the rear panel of the instrument for other voltages.

Connect the plug of the power cord on the rear panel into the power supply wall socket and set the knobs as follows.

POWER	OFF
FOCUS	Center
AC – GND – DC	GND
↓↑ POSITION	Center (the knob is in the depressed state.)
VOLTS/DIV	Arbitrary
MODE	AUTO
SOURCE	CH1
TIME/DIV	0.5 ms/div.
LEVEL	Center
⇆ POSITION	Center (the knob is in the depressed state.)
MODE	CH1
DISPLAY	OSC
INTENSITY	Fully counterclockwise

Set all the sliding switches to the left or to the upper position. When the above procedures are completed, set the POWER switch to ON, and wait for 15 seconds. Then, turn the INTENSITY control clockwise sweep line appears on the screen. (Hereafter sweep line are defined as trace.)

CAUTION

For a usual measurement, set the following controls to "CAL" positions. VARIABLES' Rotate in the direction of arrow. The VOLTS/DIV will be calibrated to the indicated value.

SWP VAR: Rotate in the direction of arrow, TIME/DIV will be calibrated to the indicated value.

Align the trace to the horizontal scale line at the center by operating the CH1 POSITION control. The trace may slightly oblique to the scale line effected by the earth magnetism. In this case, align the trace line by controlling the TRACE ROTATION control on the front panel.

(1) General measurement

For single waveform measurement

Select channel CH1 or CH2 for the observations other than two waveforms and X-Y operations.

When CH1 is selected, set the lever switches as follows.

MODE lever	:	CH1
AUTO⊓ NORMAL⊔ lever	:	AUTO⊓

SOURCE lever : CH1
DISPLAY : OSC

Under the above setting, almost all the repetitive signals over 100 Hz applied to CH1 can be observed by adjusting the LEVEL control.
When the MODE lever is set to the AUTO position, trace appears even when the AC-GND-DC switch is set at GND. Therefore DC voltage measurement is also made.
The following setting is necessary for the measurement of low frequency signals below 100 Hz.

AUTO⊓NORMAL⊓lever : NORM⊓

Triggering can be effected to the frequencies of 20 Hz to 100 Hz by controlling the LEVEL control.

(2) When observing two waveforms

Observation of two waveforms can be made easily by setting the MODE switch of vertical axis to DUAL.
When observing two waveforms of high repetition frequencies set the TIME/DIV switch to 1μs-0.2s/div. TIME/DIV switch does automatically change over to CHOP at 1ms-0.2s/div and to ALT at 1μs-0.5ms/div.
When measuring the phase difference, measure after effecting triggering with leading phase signal.

(3) When observing waveform with X-Y

Set the MODE switch of vertical axis to CH2 (X-Y) and TIME/DIV switch to X-Y. Then the instrument works as an X-Y oscilloscope.

Each input is applied 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 × 10MAG at depressed position, and the AC-GND-DC of X-axis (CH1) to AC.

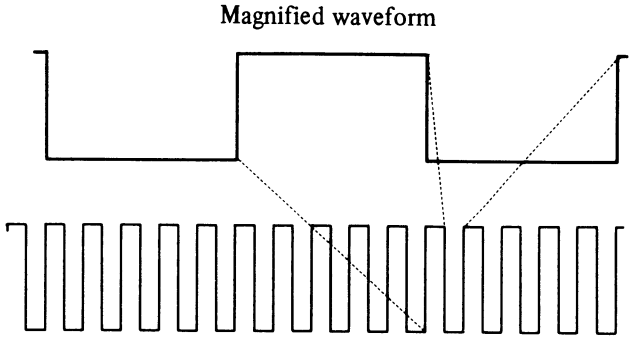
(4) How to use ADD

Select ADD position at the vertical MODE, and the added product of two waveforms can be observed.

(5) Sweep magnification

To attain easy magnified waveform observations, this oscilloscope is equipped with 10 times magnifying circuit. First bring the magnifying portion of the wave to the center of the screen by adjusting the horizontal POSITION control.
Then set the PULL × 10 MAG selector to the pulled out

position, and the waveform is magnified in its width 10 times sweep time of what is attained by TIME/DIV, and the indicated sweep time should be read by its 1/10.



PULL x 10MAG operation

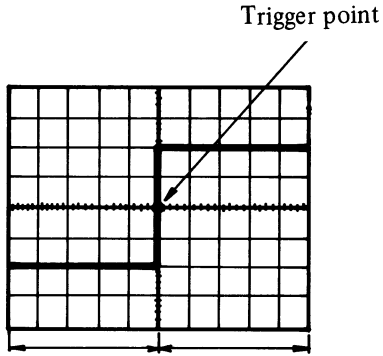
(6) How to use as a digital storage oscilloscope

Memory function:

1. Observation of repeated waveform
   Set the DISPLAY control to STORE, and the FREE RUN/SINGLE control to FREE RUN.
   Since the waveforms are displayed repeatedly, set the FREE RUN DISPLAY TIME control for the optimum observation position. (1 to 5 s)

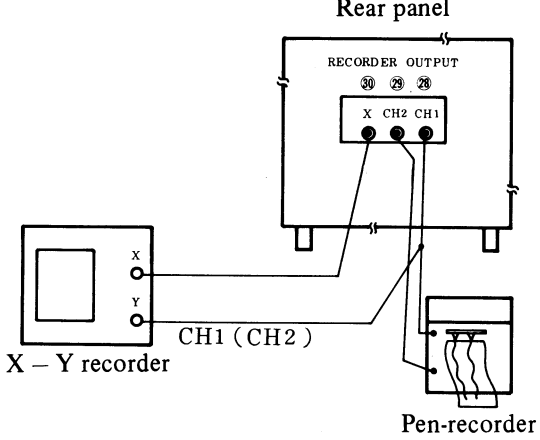
   When the FREE RUN/SINGLE switch is set to SINGLE, the waveform becomes stationary. If the READY switch is pushed in the SINGLE mode, the waveform display is renewed on the screen.

2. Observation of pre trigger waveforms.
   The waveform prior to or after the trigger is displayed by setting the PRE TRIG lever switch to 0, 2, 5 or 8 div.



(7) How to use the reccorder output.

1. Connections
   The CH1, CH2 and X connectors are provided as the recorder output. The connectors are usually connected to an X-Y recorder or a pen-recorder. In case of the pen-recorder, the X connector is not used.

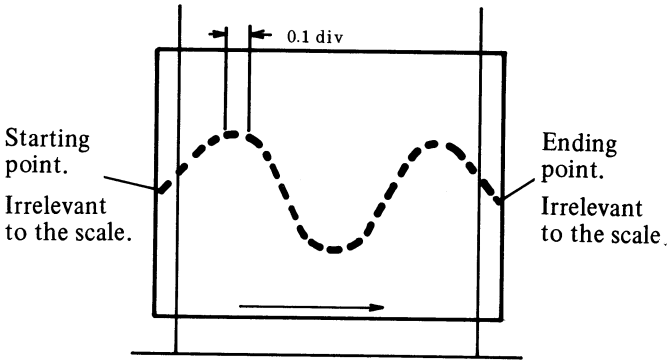


2. Operation

As the X-axis output speed for the X-Y recorder, 5 s or 10 s/div is selected. The setting times are changed by the RECORDER OUT TIME/DIV switch.

The X-axis output is not obtainable when the RECORDER OUT TIME DIV (27) is set to off. When the connection and setting of the recorder are finished, set the DISPLAY switch (21) to RECORD and push the START/RESET switch (25). Since the data is held when the full data is stored, push the START/RESET button to reset the recorder. The X-Y recorder is recommended for more detailed waveform recording.

In the RECORD mode, a dotted waveform corresponding to the output waveform by a dot per 0.1 div. appears on the screen. This is not very correct. However, if both the start and end points are displayed, the waveform is normal.



ALIASING PHENOMENON

When a cycle of a sampling waveform is longer than that of a repetitive waveform by more than half times, a waveform having a longer cycle than an actual cycle is displayed on a CRT. This is called Aliasing phenomenon. Sampling cycle changes when the TIME/DIV switch is rotated.

Table 1 illustrates the Relation of input waveform cycle and oscilloscope time range not causing aliasing phenomenon.

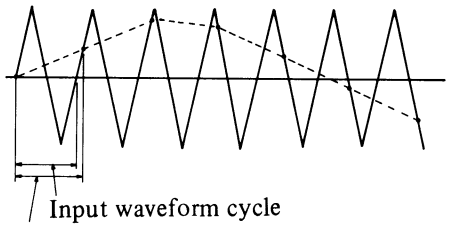


Fig. 1 Aliasing phenomenon

Table 1 Relation of input waveform cycle and time range

Input waveform cycle	10 μs	20μs	40μs	0.1ms	0.2ms	0.4ms	1ms	2ms	4ms	10ms
Time range TIME/DIV	0.5ms or higher	1ms or higher	2ms or higher	5ms or higher	10ms or higher	20ms or higher	50ms or higher	0.1s or higher	0.2s or higher	0.5s or higher

To monitor an input waveform in the STORE mode, take the following procedures.

(1) Set the DISPLAY switch to OSC side, then confirm the input waveform cycle.

(2) Set an appropriate time range referring to Table 1.
Confirm that the aliasing phenomenon does not appear.

(3) For more precise display of waveform, select a higher speed range.

7. METHOD FOR CONNECTING SIGNALS

The first step of measurement is to apply the signal desired to be measurered to the oscilloscope properly. Do it with utmost care.

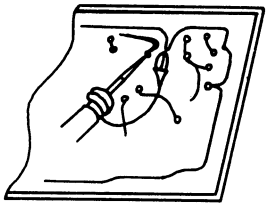
(1) When using a probe

Use the attached probe, AT-10AK 1.5, when measuring a high frequency wave with high accuracy.
The input signal is attenuated by this probe to 1/10 and 1/1 before it is input to the oscilloscope the use of the probe is advantageous for high level signals.

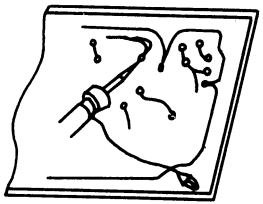
<CAUTIONS>

- Do not apply a signal which exceed 600 V (DC+AC peak at 1 kHz).
- 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



Good connection

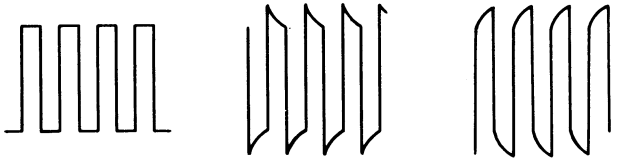


Improper connection

- Multiply the reading of VOLTS/DIV by 10. (at using x 10) For example, if the VOLTS/DIV is 50 mV/div, then read the waveform as

  50mV/div x 10 = 500mV/div

- To avoid measurement error, put the probe in the following correction state and check it before measurement without fail. Connect the tip of the probe to the terminal PROBE CAL 0.5 V of 1 kHz calibration square wave voltage. The displayed wave should have flat tops. Waveform distortion is caused by incorrect probe compensation. If overshoot or undershoot is present, turn the semi-fixed control in the probe by a screwdriver to obtain a flat-top presentation.



(a) Correct (b) Overshoot (c) Undershoot

(2) At time of direct connection

When connecting a signal directly to the oscilloscope without using the attached probe AT-10AK 1.5 (10:1), pay attention to the following points in order to minimize the measurement error.

- When performing observation using a bare lead wire, no trouble occurs when the circuit of low impedance and high level is measured. However, note that, in most cases, measurement error may be caused by static stray coupling with other circuit and power line.

  This measurement error cannot be ignored even in low frequency region.

  In general, it is safe to avoid measuring with non-shielded connecting wire. When using a shielding wire connect one end of the shield to the earth terminal of the oscilloscope and the other end to the grounding of the circuit to be measured. It is desirable to use a coaxial cable with BNC type connector.

- 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 of 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 terminating resistors equal to the characteristic impedance of the cable also on the measurement terminal side.

  BNC type terminating resistor (50 Ω) is convent for this purpose.

- In order to measure the circuit 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 shielded wire must be taken into account when performing measurement with a long shielded wire.

  Since the shielded wire normally has a capacity of about 100 pF per meter, its effect on the circuit to be measured cannot be ignored. Use a probe to minimize the effects on the circuit.

- When the length of the shielded wire or then the length of the nonterminated cable reaches 1/4 wave length or

its multiples within the band of VC-6015 type (1/4 wave length is about 5 meter when using a coaxial cable at 10 MHz), oscillation may be caused 5 mV/div range. This is caused by the reasonance between the externally connected high-Q inductance and the input capacity and can be avoided by reducing the Q.

Connect the cable or shield wire to the input connector with a serially connected 100 Ω to 1 kΩ resistor, or perform measurement at other VOLTS/DIV range.

(3) Caution for using the measured signal as an external trigger signal.

When using the measured signal connected to the INPUT and EXT TRIG connectors as an external trigger signal, use a divider so that the both connectors are not connected directly. Otherwise, the measuring waveform may be distorted or oscillated.

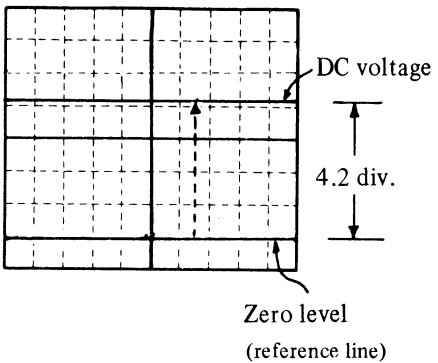
8. MEASURING PROCEDURES

- Adjust the brightness and FOCUS for easy read out.
- Display the waveform as large as possible to minimize reading errors.
- Check the probe calibration. (Refer to Paragraph (1) "When using a probe" of Section 7. "Method for connecting signal" for the method for correcting capacity.)

(1) DC voltage measurement

Set AC-GND-DC switch to GND and determine the zero level properly.

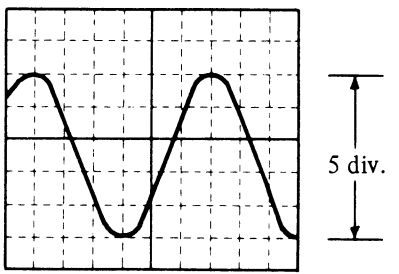
Set VOLTS/DIV appropriately and set AC-GND-DC to DC. Since the trace shifts by the amount of DC voltage, the DC voltage of the signal can be obtained by multiplying the shift width by the indicated value of VOLTS/DIV. When VOLTS/DIV is 50 mV/div, then 50 mV/div x 4.2 = 210 mV (However, if the probe AT-10 AK 1.5 (10:1) is in use, the true value of the signal becomes 10 times the value, it will be 50 mV/div x 4.2 x 10 = 2.1 V.)



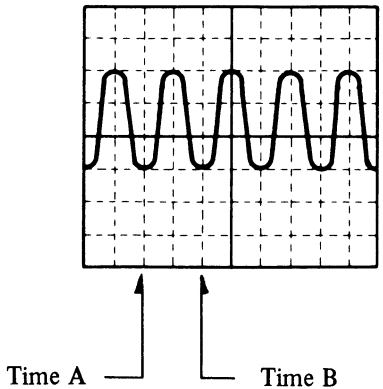
(2) AC voltage measurement

AC voltage measurement is the same as paragraph 6 (1), "DC voltage measurement", but there is no need for matching the zero level with the scale line. Adjust the zero level at any position for an easy observation.

In the followig drawings VOLTS/DIV is 1 V/div x 5 = 5 Vp-p [50 Vp-p using the probe AT-10AK 1.5 (10:1)]. For an magnified observation, a small-amplitude signal superinposing as it increases, set AC-GND-DC switch to AC. The DC voltage is cut off and AC voltage can be observed by increased sensitivity.



(3) Period measurement



One period covers the time between A and B, which are separated from each other by 2.0 div on the CRT.
When the sweep time is 1 ms/div, the period is given by

$$1 \text{ ms/div} \times 2.0 = 2.0 \text{ ms}$$
$$= 2.0 \times 10^{-3} \text{ s}$$

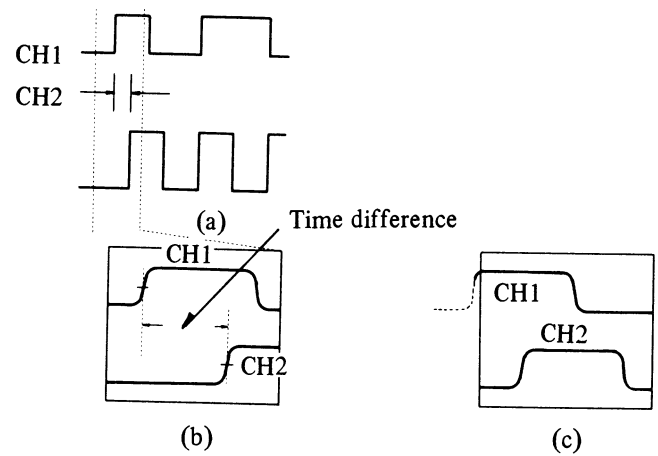
Accordingly, the frequency is

$$1/(2.0 \times 10^{-3}) = 500 \text{ Hz}$$

(However, when the knob MAG x 10 is at pulled out position, TIME/DIV must be converted to 1/10 since the sweep is magnified.)

(4) Measurement of time difference

Triggering signal source "SOURCE" is selected as offering reference signal when measuring the time difference between two signals. Assuming that pulse trains as shown in (a), (b) will be displayed when CH1 is selected as the triggering signal source and (c) shows when CH2 is selected.

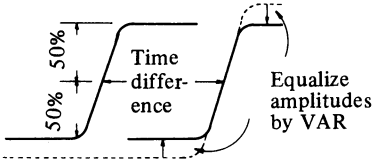


CH1 is used as the triggering signal when the delay of CH2 signal from that of CH1 is measured. CH2 is used in a reversed case. In other words, the signal leading in phase is selected as the triggering signal source.
When the wrong signal is used as a trigger, the portion to be

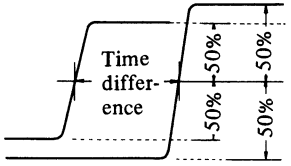
measured may sometimes not appear on the screen. Equalize the amplitudes of the two signals appearing on the screen or superimpose one another for proper measurement.

Read the time difference by the interval between 50% amplitude points of the two signals.

Sometimes the superimposing method is more convenient as a procedure.



Equal amplitude measuring method.



Superposition measuring method

<CAUTION>

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

(5) Measurement of rise or fall time

To measure the rise or fall time, pay attention not only to the above mentioned item but also to not to make measurement errors.

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.

$$Trx^2 + Trs^2 = Tro^2$$

When the rise time of the pulse going to be measured is sufficiently longer than the rise time of the oscilloscope (35ns in our case), the effect of the rise time of the oscilloscope on the measurement can be neglected. However, if both are close to each other, 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 as overshoot and sag, the following relationship is established between frequency band and rise time.

$$f_c \times t_r = 0.35$$

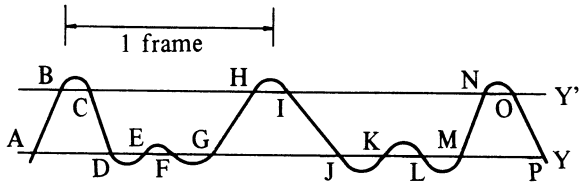
where, f_c : Frequency band (Hz)

t_r : Rise time(s)

The rise time and fall time are determined by the time elapsed, between the 10% and 90% of pulse amplitude.

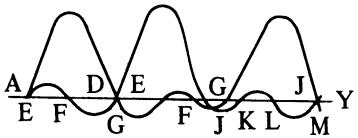
(6) Triggering of complexed waveform

As it is shown in Fig. (a) where two waveforms of greatly different amplitude alternately appear, the waveform becomes double traces if the trigger level is not set properly. In the case where the trigger level is selected as Y line, shown below, 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 become double traces as shown in Fig. (b), for which no triggering can be obtained.

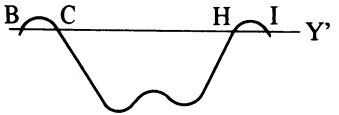


(a) Signal waveform

Trigger level setting line



(b) When the trigger setting level is Y



(c) When the trigger setting level is Y'

Triggering of complexed waveform

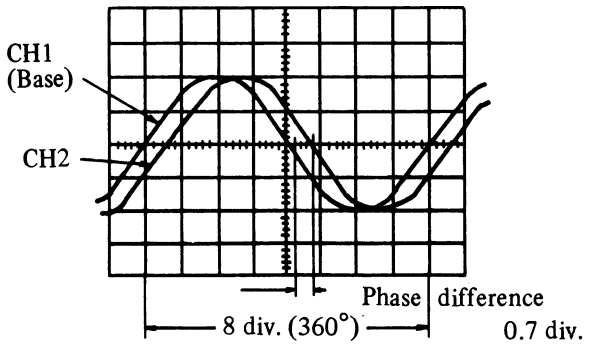
In such a case, rotate LEVEL clockwise until the trigger level comes to Y' line. Then the waveform on the screen becomes the one as it is shown in Fig.(c) above which start with B and advance to C, H, I, ... and which allows synchronization.

(7) Phase shift between two signals

To measure a phase shift between two signals of the same frequency, the dual trace display system can be utilized up to the upper limit frequency of the amplifier.

First, position both signals on the cneter line of the scale, e.g. just 4 div, as shown in the following figure by the VARIABLE and horizontal positioning knobs.

Next, set the distance, where the center of the waveform of the base channel intersects with, to 8 divisions horizontally on the scale line.



As shown above, set 1 cycle, 360° to 8 div. Then.

$$\frac{360^\circ}{8 \text{ div}} = 45^\circ/\text{div.}$$

Accordingly, the phase difference in the above example can be calculated as follows:
Horizontal distance on the screen: 0.7 div. Phase difference = 45°/div x 0.7 div = 31.5°
If the portion of the phase difference is much smaller, use the MAGNIFIER at the x10 position in the above setting. At this time, 360° is displayed in 8 div x10.

Then, $\frac{360^\circ}{8 \text{ div} \times 10} = 4.5^\circ/\text{div}$ (0.2 div = 0.9°)

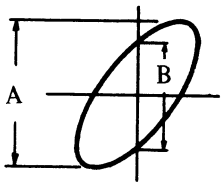
(8) Measurement by X-Y operation

The phase shift between two signals of the same frequency can also be measured using a Lisaajous's figure by X-Y operation.
A sine wave input is applied to the circuit being tested. The same sine wave input is applied to the vartical input of the oscilloscope, and the output of the testing circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be calculated from the resulting wave form.

1. Using an audio signal generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the audio network being tested.
2. Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may be observed on the oscilloscope. If the test circuit is over-driven, the since wave display on the oscilloscope is clipped. In this case, the signal level must be reduced.
3. Connect the Channel 2 probe to the output of the test circuit.
4. Set the sweep TIME/DIV to X-Y position.
5. Connect the CH1 INPUT probe to the input of the test circuit. (The input and output test connections to the vertical and horizontal oscilloscope inputs may be reversed.)

6. Adjust the CH1 and 2 gain controls for a suitable veiwing size.
7. Some typical results are shown in Fig. (b) If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal gains are properly adjusted, this line is at a 45° angle.
   A 90° phase shift produces a circular oscilloscope pattern.

Phase shift of less (or more) then 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope trace as shown in Fig. (a).



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

$$\text{WHERE } \phi = \frac{\text{PHASE}}{\text{ANGLE}}$$

Fig.(a) Phase shift calculation

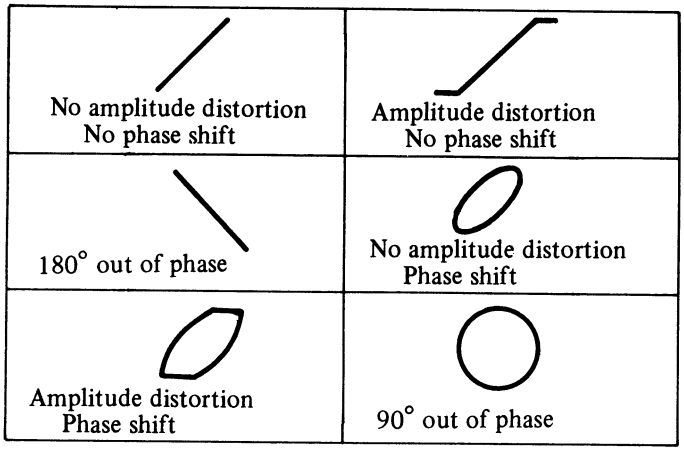


Fig.(b) Typical phase measurement oscilloscope displays.

9. USER ADJUSTMENTS

The following adjustments should be made with a screw driver.

(1) TRACE ROTATION

Adjust the TRACE ROTATION on the front panel when slight tilting of the trace is caused by the effect of external magnetic fields. Keep away from strong magnetic force.

(2) ASTIG ADJUSTMENT

Set the knob TIME/DIV switch to X-Y, and MODE switch to CH2 X-Y observing the spot on the center of the screen. RV1035 astigmatism adjustment provides optimum spot POWER/INTENSITY roundness when used in conjunction with FOCUS and POWER/INTENSITY control.
Readjustment is required after initial adjustment.

(3) Adjust VOLTS/DIV balance (STEP ATT BAL)

a. Position the trace to the center horizontal line with the vertical POSITION control.
b. Change the VOLTS/DIV switch from 5 mV/div to 10 mV/div. Trace should not move more than 0.1 division.
c. Adjust DC BAL, for minimum trace shift when rotating the VOLTS/DIV switch from 5 mV/div to 10 mV/div. If necessary, rotate the vertical position control to keep the trace in the center of the screen.

10. MAINTENANCE

1) This oscilloscope is equipped with various transistors and dioes of highly sensitive parts. And it is desired to pay careful attention for the storing or operating the instrument.
2) Periodic cleaning of the scale line screen and CRT screen surface is recommended. Wipe them with soft cloth or with deer skin.
3) The side panels are removable when setscrews are removed.
4) The ambient temperature of -10 to +60°C (14 to 140°F) is desirable for good storing condition.

11. SPECIFICATIONS

○ **Vertical deflection**

Input sensitivity

5 mV/div to 5 V/div (1, 2, 5-step 10 stages)

Sensitivity accuracy rate

±3%

Attenuates continuously to 2.5 times or more of the indicated value in each range

Frequency bandwidth (8 div Reference)

OSCILLOSCOPE:

DC to 10 MHz ($^{+1}_{-3}$ dB)

AC 20 Hz to 10 MHz ($^{+1}_{-3}$ dB)

DIGITAL STORAGE:

DC to 100 kHz ($^{+1}_{-3}$ dB)

AC 20 Hz to 100 kHz ($^{+1}_{-3}$ dB)

Rise time

OSCILLOSCOPE:

Less than 35ns

Resolution

DIGITAL STORAGE:

8 bits

Over shoot

±3% (at 100 kHz, Rise time more than 100 ns.)

Input impedance

Direct 1 MΩ, approx. 30pF

Maximum input voltage

Direct 250V (DC + AC peak at 1 kHz)
When using prove 600 V (DC + AC peak at 1 kHz)

Input coupling

AC-GND-DC

Magnifying function

x10

Operation mode

CH1, CH2, DUAL, ADD, DIFF

Dynamic range

More than 8 div.

Phase shift

Within 3° (DC to 50 kHz)

○ **Calibrator**

Waveform

1 kHz square wave, within ±30%

Voltage

0.5 V ±3%

○ **CRT**

CRT

6"-diameter storage tube

Acceleration voltage

Approx. 2 kV

Screen area

8 div x10 div, 1 div 10 mm

Trace rotation

Provided

Scale illumination

Variable edge lighting

○ **Memory**

Memory capacity 1000 words/channel (1 word = 8 bit)
Writing speed 1 μs/word to 10 ms/word

○ **Power supply**

VOLTAGE	FUSE
100 V (90 to 110 V)	2A
120 V (108 to 132 V)	2A
220 V (198 to 242 V)	1A
240 V (216 to 264 V)	1A

Power supply frequency

50/60 Hz

Power consumption

Approx. 60 W

○ **Temperature**

Recommended range: +10 to +35°C (50 to 95°F)
Operational limit: 0 to 40°C (32 to 104°F)
Durable limit for storing and transportation
-20 to +70°C (-4 to +158°F)

○ **Humidity**

35 to 85%.

○ **Dimensions**

Approx. 310 (W) x 180 (H) x 410 (D) mm
(12.2 x 7.1 x 16.1 inch)
(Dimension of cabinet)

○ **Weight**

Approx. 10 kg (22 lb.)

○ **Horizontal deflection**

Sweep mode

AUTO, NORM, FREE RUN

Sweep time

OSCILLOSCOPE
1 μs/div – 0.2 s/div
DIGITAL STORAGE
0.1 ms – 1 s/div

Maximum sweep time

OSCILLOSCOPE
100 ns (at MAG x10)

Sweep variable

2.5 times or more

Sweep time accuracy

±3% (at x1)
±5% (at x10 MAG)

Sweep magnification

x10

Time linearity

±3% (at x1)
±5% (at x10MAG)

Position adjustment

Possible

○ **Triggering**

Coupling

CH1, CH2 AC
EXT DC

Triggering polarity

+, -

Pre trigger

DIGITAL STORAGE
0, 2, 5, 8 div

Triggering sensitivity and frequency

Frequency	Internal	External
DC to 2 MHz	0.5 div.	200 mV
2 MHz to 10 MHz	1.5 div.	800 mV

External trigger input impedance

Approx. 1 MΩ, approx. 30 pF

Maximum input voltage

Direct 250 V (DC + AC peak at 1 kHz)
At using x10 probe 600 V
(DC + AC peak at 1 kHz)

○ **Z-AXIS brightness modulation**

Voltage

Brightness is reduced with a positive signal of +5 V or more

Frequency bandwidth

DC to 2 MHz

Input impedance

Approx. 47 kΩ

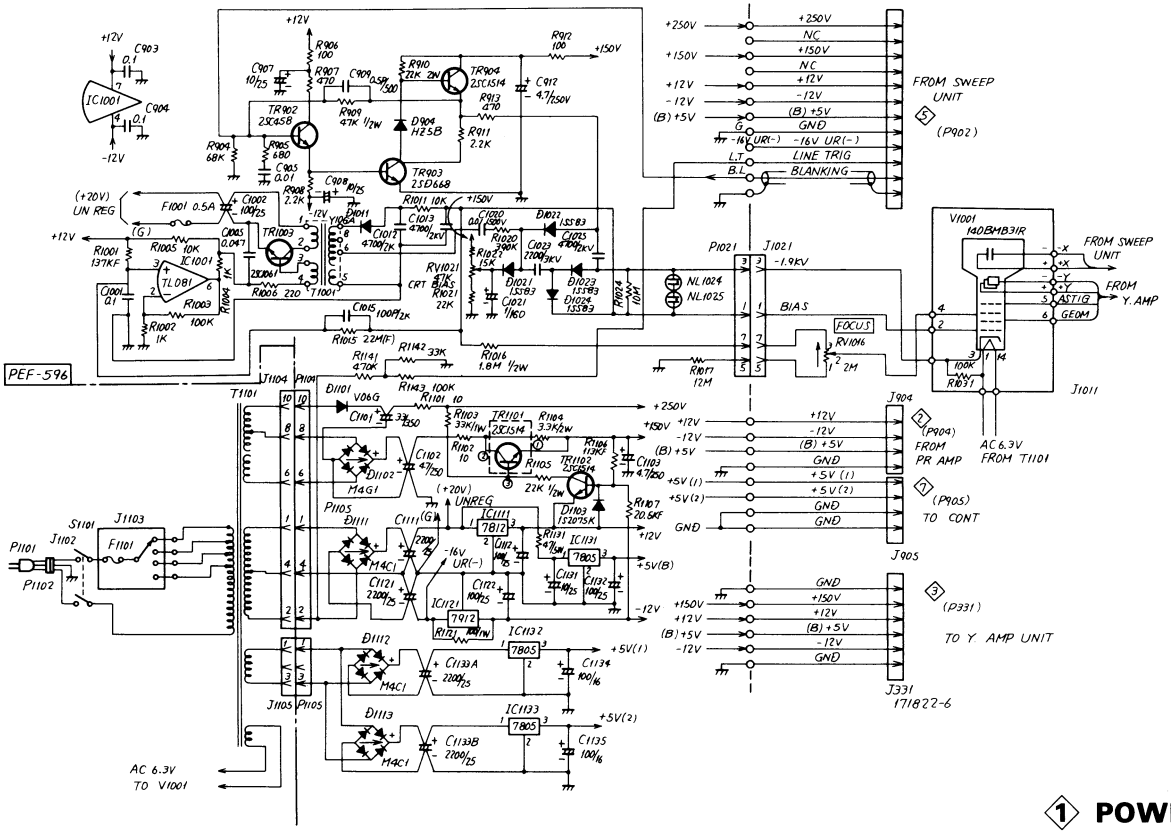
Maximum input withstand voltage

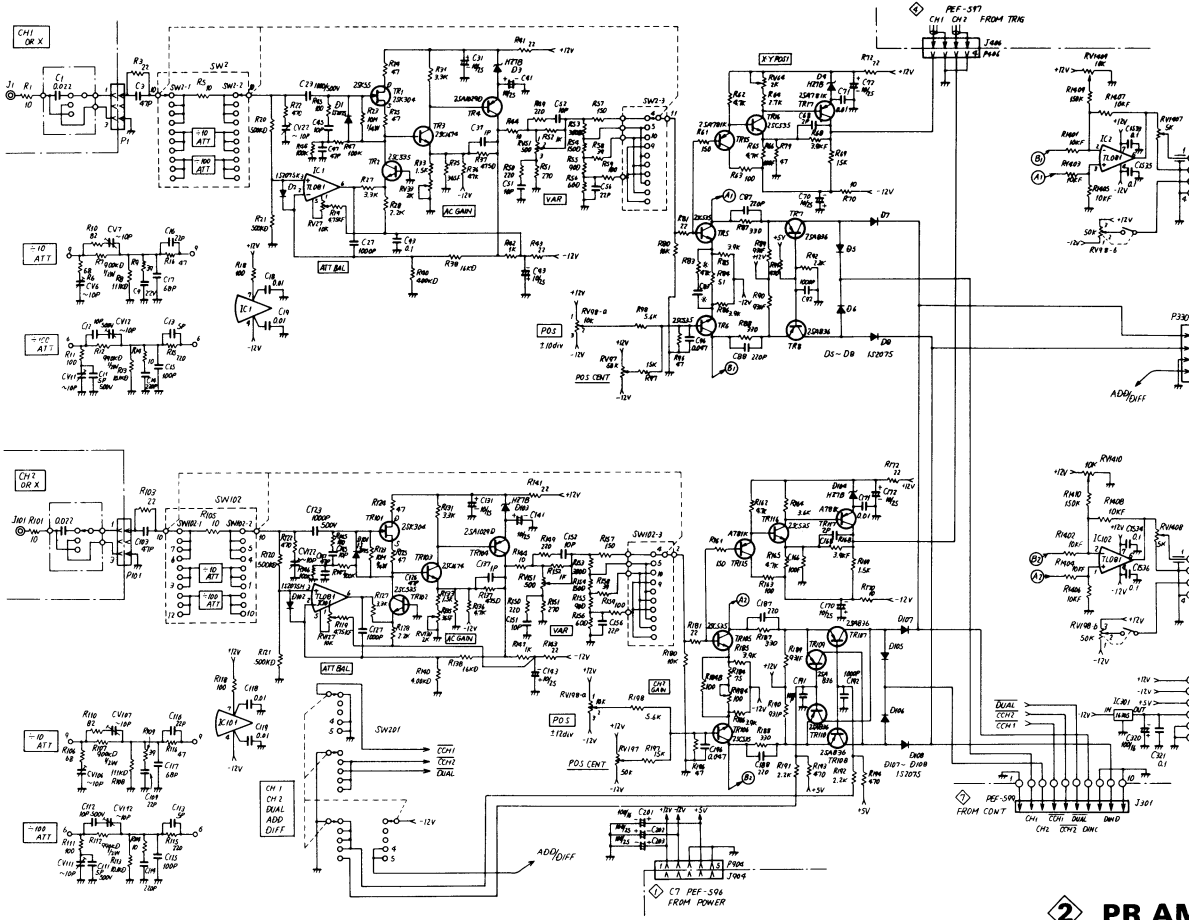
30 V (DC + AC peak)

○ **X-Y operation**

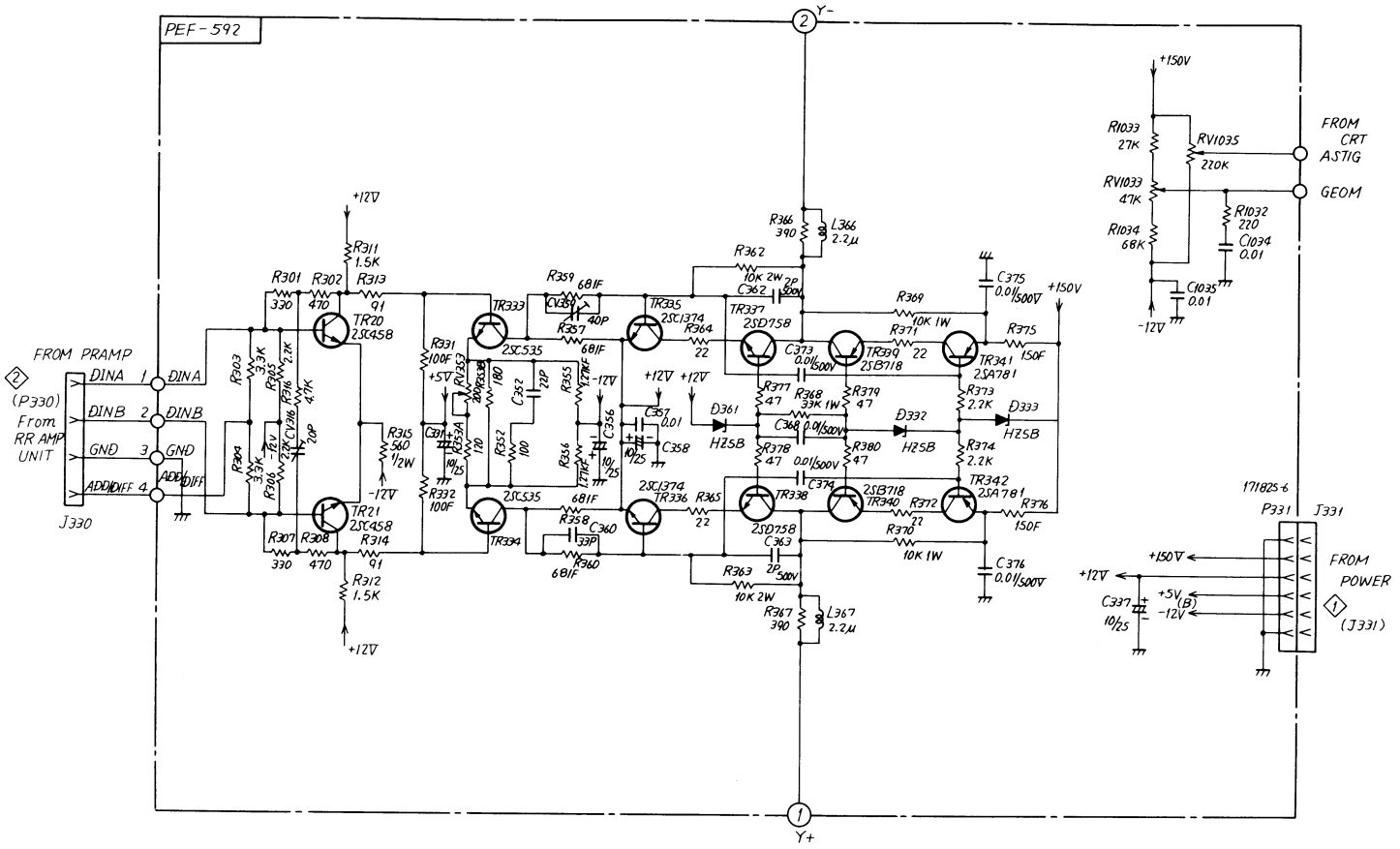
X input	CH1
Y input	CH2
Sensitivity	Same as vertical axis
X frequency bandwidth	DC to 500 kHz (-3dB)
Phase error	3° or less from DC to 50 kHz

12. SCHEMATIC DIAGRAMS

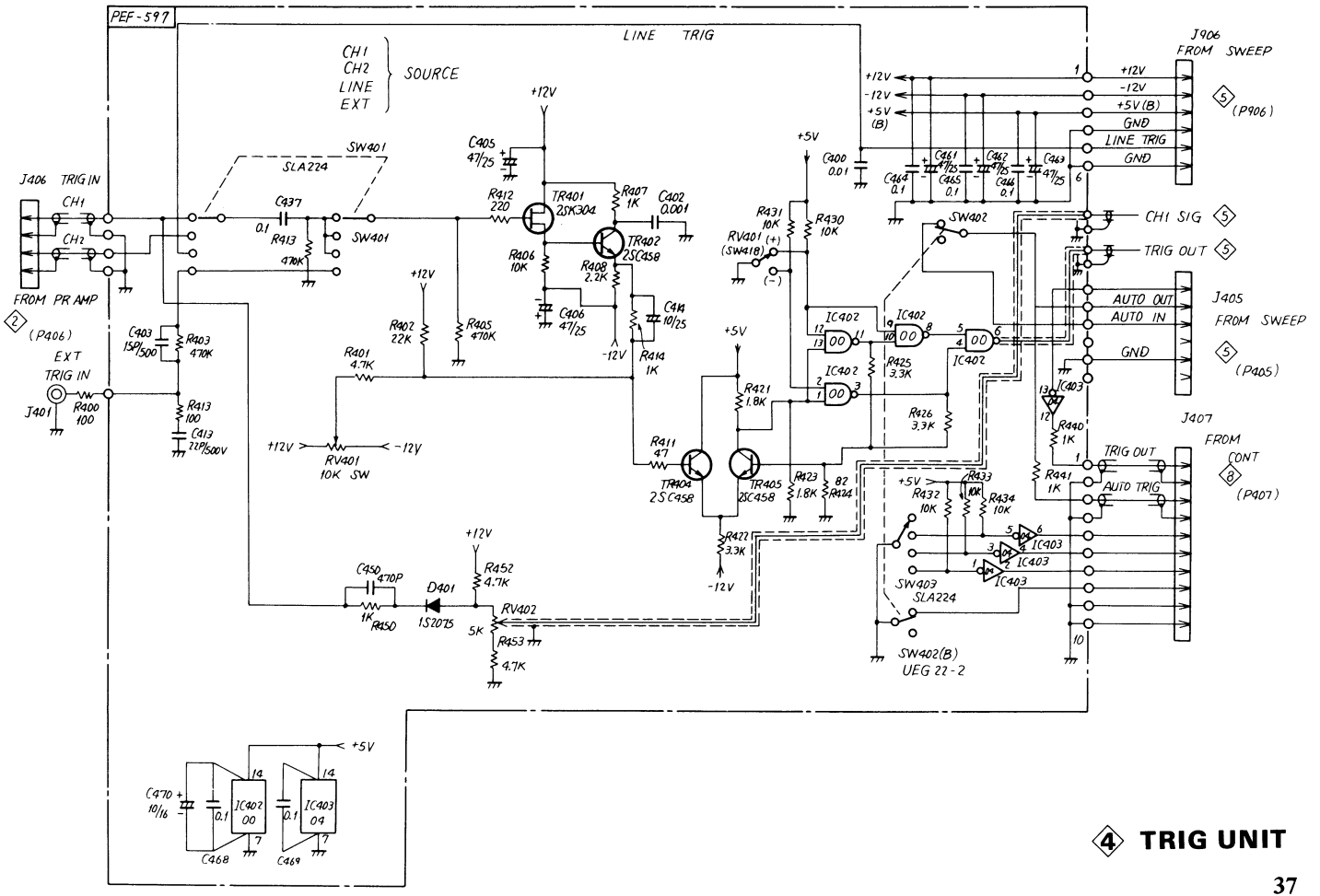




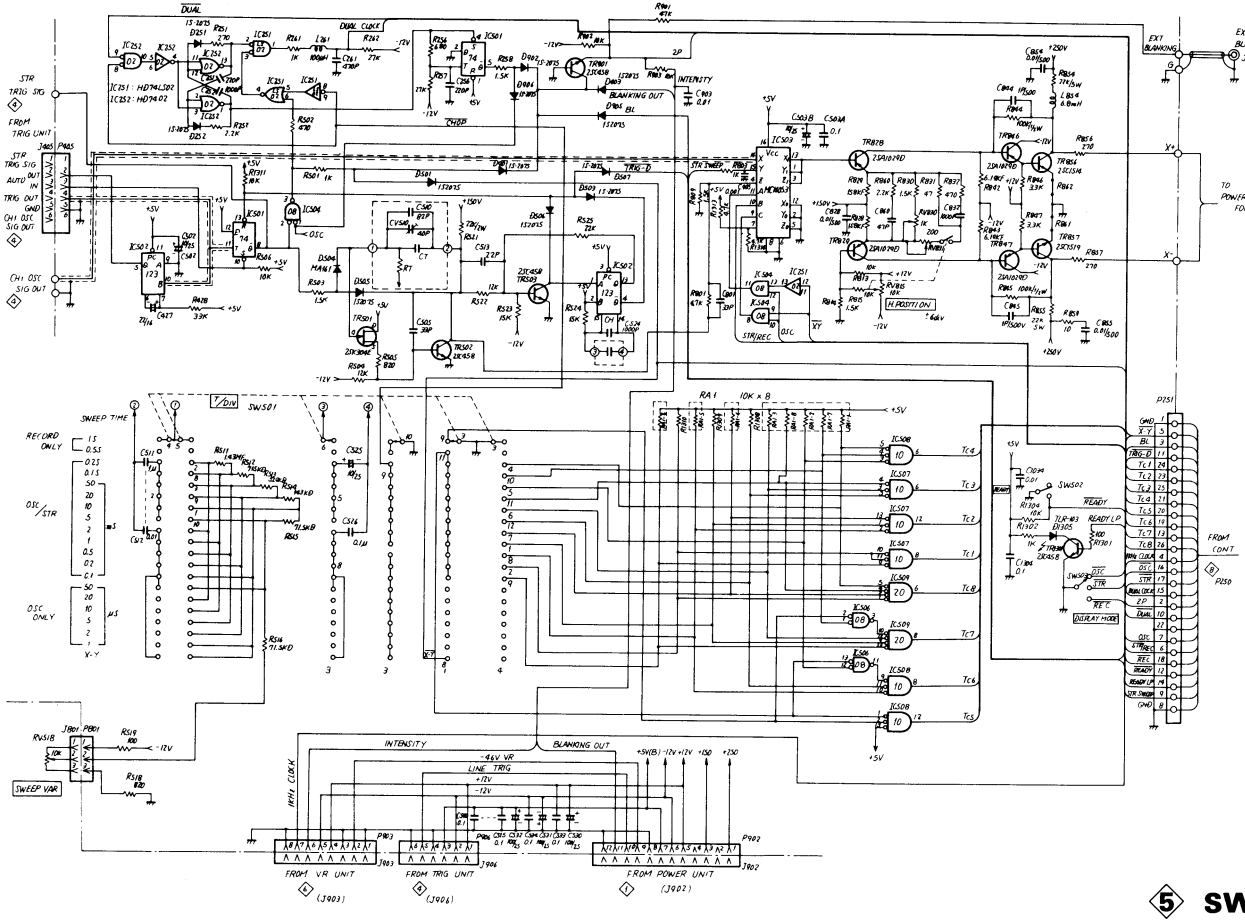
2 PR AMP UNIT


PEF-592
FROM PRAMP
(P330)
From RR AMP UNIT
DINA
DINB
GND
ADD DIFF
J330
TR20 2SC458
TR21 2SC458
TR333
TR334
TR335 2SC1374
TR336 2SC1374
TR337 2SD758
TR338 2SD758
TR339 2SB718
TR340 2SB718
TR341 2SA781
TR342 2SA781
D361 HZ5B
D332 HZ5B
D333 HZ5B
2SC535
+12V
-12V
+5V
+150V
Y-
Y+
FROM CRT ASTIG
GEOM
P331
J331
171825-6
FROM POWER
(J331)

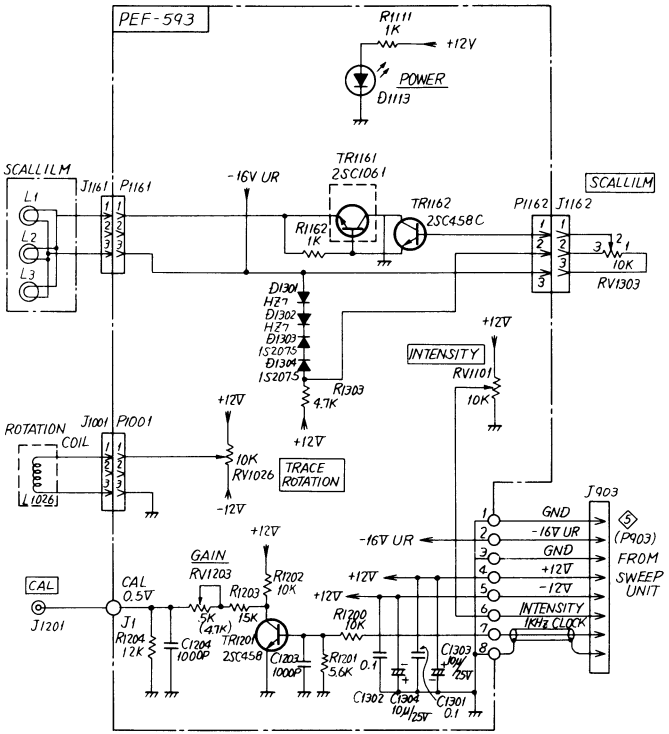
③ V AMP UNIT

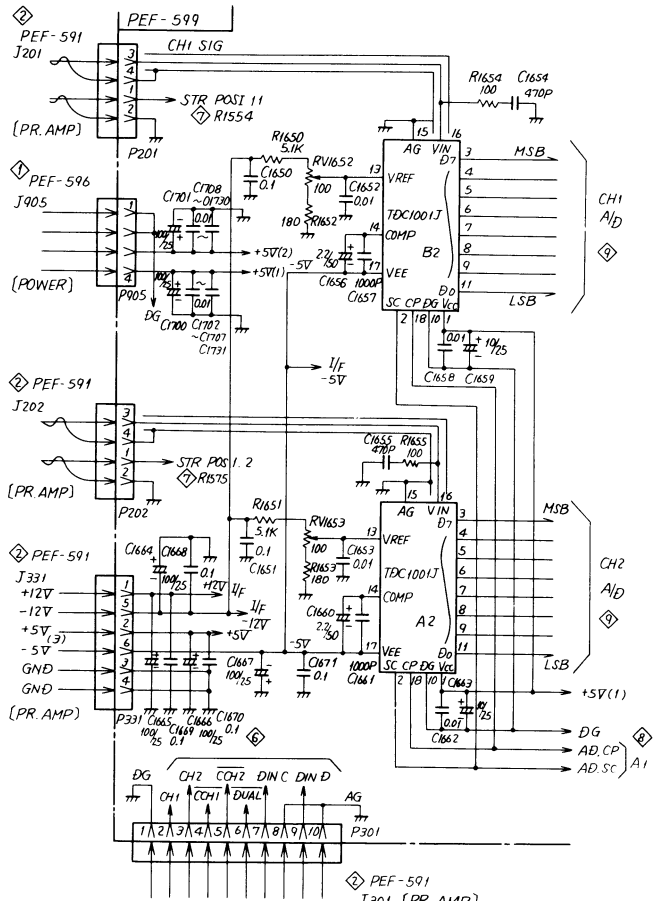

PEF-597
LINE TRIG
CH1
CH2
LINE
EXT
SOURCE
SW401
SLA224
J406 TRIG IN
CH1
CH2
FROM PR AMP
(P406)
EXT
TRIG IN
J401
C403 15P/500
R403 470K
R400 100
R413 100
C413 22P/500V
C437 0.1
R413 470K
SW401
+12V
C405 47/25
R412 220
TR401 2SK304
R407 1K
C402 0.001
TR402 2SC458
R406 10K
R408 2.2K
C406 47/25
C411 10/25
R414 1K
-12V
R402 22K
R405 470K
R401 4.7K
+12V
RV401 10K SW
-12V
+5V
C400 0.01
R431 10K
RV401 (+) (SW418)
(-)
R430 10K
IC402
R425 3.3K
R426 3.9K
R421 1.8K
TR404 2SC458
TR405 2SC458
R423 1.8K
82
R424
R422 3.3K
-12V
R411 47
C450 470P
1K R450
D401 1S2075
RV402 5K
R452 4.7K
R453 4.7K
+12V
+5V
C470 10/16
C468
C469
IC402 00
IC403 04
J906 FROM SWEEP
+12V
-12V
+5V (B)
GND
LINE TRIG
GND
C460 0.1
C461 47/25
C465 0.1
C462 47/25
C464 0.1
C463 47/25
(P906)
SW402
CH1 SIG
TRIG OUT
J405 FROM SWEEP
AUTO OUT
AUTO IN
GND
(P405)
IC403
R440 1K
R441 1K
J407 FROM CONT
TRIG OUT
AUTO TRIG
(P407)
R433 10K
R432 10K
R434 10K
IC403
SW403 SLA224
SW402(B) UEG 22-2

④ TRIG UNIT

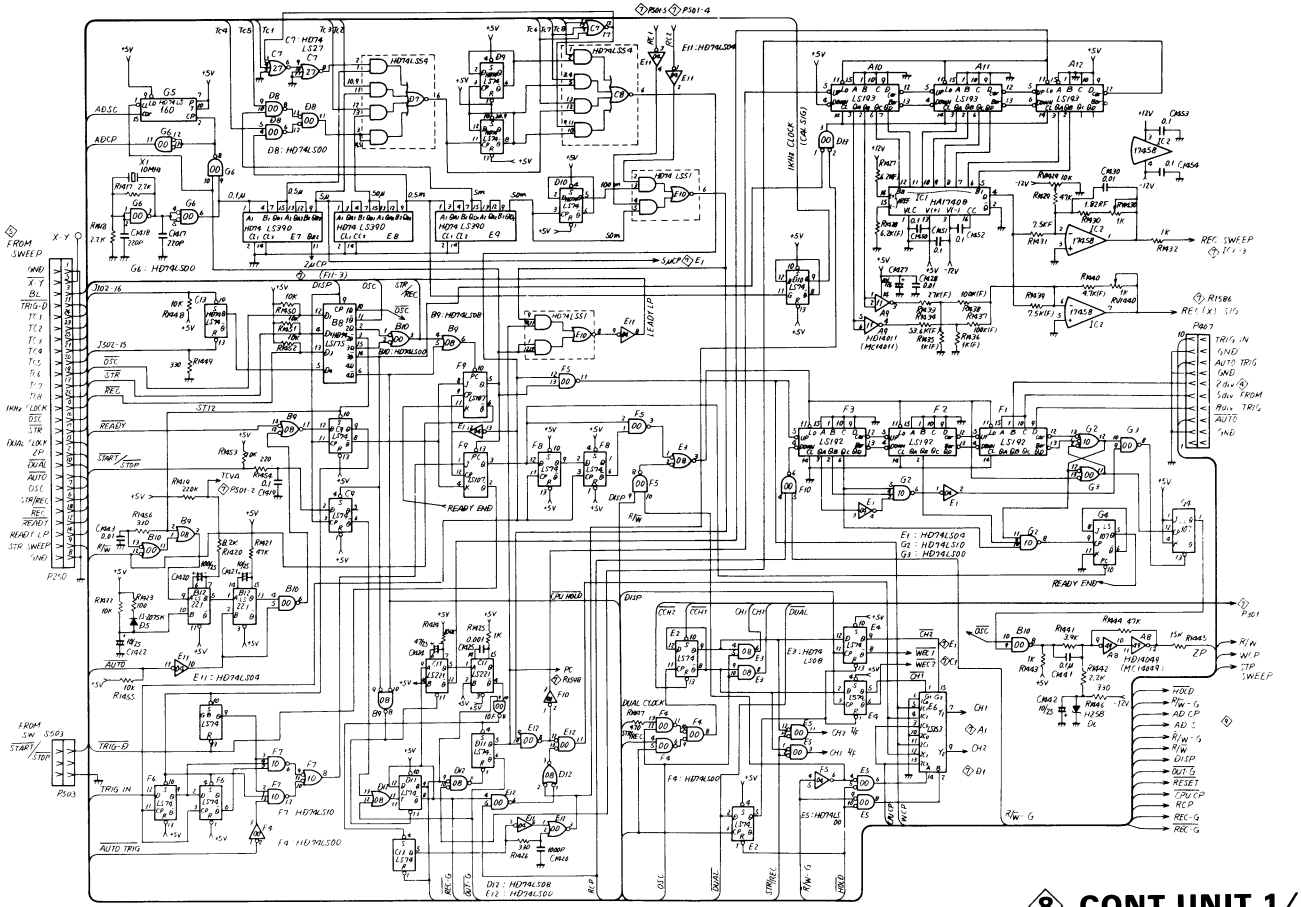

DUAL
DUAL CLOCK
STR TRIG SIG
FROM TRIG UNIT
STR TRIG SIG OUT
AUTO IN
TRIG OUT
GND
CH1 OSC SIG OUT
CH1 OSC SIG OUT
IC251 : HD74LS02
IC252 : HD74L02
SWEEP TIME
RECORD ONLY
OSC / STR
OSC ONLY
X-Y
SW501
SWEEP VAR
INTENSITY
BLANKING OUT
-46V VR
LINE TRIG
FROM VR UNIT
FROM TRIG UNIT
FROM POWER UNIT
(J903)
(J904)
(J902)
EXT BLANKING
TO POWER UNIT FOR CRT
FROM CONT
READY
READY LP
DELAY MODE
STR/REC
H POSITION
RA1 10K x 8

5 SWEEP UNIT

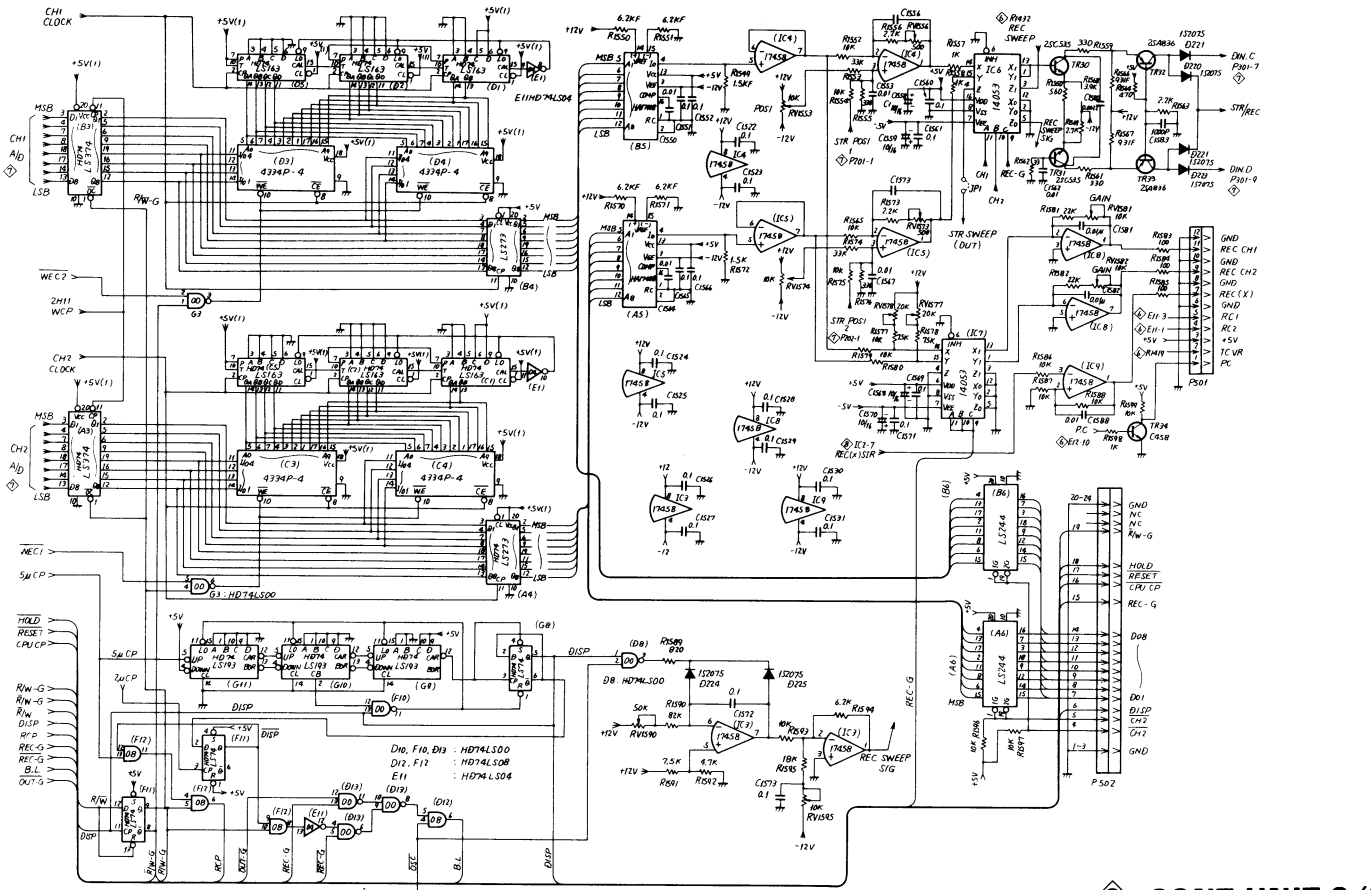

PEF-593
R1111
1K
+12V
POWER
D1113
SCALLILM
J1161
P1161
L1
L2
L3
-16V UR
TR1161
2SC1061
TR1162
2SC458C
R1162
1K
P1162
J1162
SCALLILM
3
2
1
10K
RV1303
D1301
HZ7
D1302
HZ7
D1303
1S2075
D1304
1S2075
R1303
4.7K
+12V
INTENSITY
RV1101
10K
ROTATION
COIL
J1001
P1001
L1026
+12V
10K
RV1026
TRACE
ROTATION
-12V
J903
GND
-16V UR
GND
+12V
-12V
INTENSITY
1KHz CLOCK
5
(P903)
FROM
SWEEP
UNIT
+12V
GAIN
RV1203
-16V UR
CAL
CAL
0.5V
J1201
J1
R1204
12K
C1204
1000P
5K
(4.7K)
R1203
15K
R1202
10K
+12V
+12V
R1200
10K
TR1201
2SC458
C1203
1000P
R1201
5.6K
0.1
C1303
104
25V
C1302
C1304
10μ/25V
C1301
0.1


PEF-599
CH1 SIG
PEF-591 J201
[PR. AMP]
P201
STR POSI 11
R1554
R1654 100
C1654 470P
R1650 5.1K
C1650 0.1
RV1652
C1652 0.01
R1652 180
C1658 ~C1707
C1731
C1700 ~C1707
C1731
PEF-596 J905
[POWER]
P905
+5V(2)
+5V(1)
-5V
22 50
C1656 1000P
C1657
TDC1001J
B2
AG VIN
VREF
COMP
VEE
SC CP DG Vcc
D7 D0
MSB
LSB
CH1 A/D
C1658 C1659
I/F -5V
PEF-591 J202
[PR. AMP]
P202
STR POSI. 2
R1575
C1655 470P
R1655 100
R1651 5.1K
C1651 0.1
RV1653
C1653 0.01
R1653 180
C1660 22 50
C1661 1000P
C1667 100 15
C1671 0.1
A2
CH2 A/D
PEF-591 J331
+12V
-12V
+5V (3)
-5V
GND
GND
[PR. AMP]
P331
C1664 100 25
C1668 0.1
C1665 100 25
C1669 0.1
C1666 100 15
C1670 0.1
C1643 10 25
C1662 0.01
+5V(1)
DG
AD.CP
AD.SC
A1
DG CH2 CCH2 DIN C DIN D
CH1 CCH1 DUAL AG
P301
PEF-591 J301 [PR. AMP]

7 AD UNIT



8 CONT UNIT 1/2



9 CONT UNIT 2/2