OPERATION MANUAL
OSCILLOSCOPE
TOS-7000 SERIES

TOPWARD

Khayo Vannucci Rodrigues - 2023

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1 GENERAL

This manual describes all 7000's scope, some functions mentioned may not be found to certain models.

1-1 Safety Information

To insure safe operation, the user must carefully read the fallowing information.

1-1-1 Electrical

Apply not more than 250 VRMS AC power to the instrument. To avoid electrical shock, the instrument must be grounded through the ground conductor of the power cord to an approved safety outlet. Do not attempt to remove covers and to perform any internal repair or voltage conversion. Refer all servicing to qualified personnel.

Not to increase the light intensity of traces more than necessary. It is because excessive light intensity left for a long time, can damage the CRT phosphor surface.

1-1-2 Environmental

The instrument must not be operated in extremely dusty or moist, explosive and chemically corrosive environment. When in continuous operation, proper air circulation must be practiced.

The Oscilloscope can be operated in any position, but preferably by used in horizontal position or on its tilt stand.

1-2 Feature

Topward model 7000 series is a portable, advanced design oscilloscope. Its logical arrangement of controls can help the user to master the operation quickly.

Many convenient features are listed below:

Wide Bandwidth

The instrument can accept signals from DC to frequency of at least 20MHz for model 702x and 40MHz for model 704x at -3dB.

Sensitive Vertical Amplifier

The 1 mV/DIV sensitivity allows extremely low-level signal to be observed.

Advanced CRT

The 6-inch rectangular CRT, with percentage markers and internal graticule, eliminates parallax error and ensures high accuracy, of waveform display.

X-Y Operation

X-Y mode uses CH1 for X input and CH2 for Y input. Lissajous pattern can be viewed and phase shift measured.

TV Coupling

TV sync separator circuit enables table measurements of video signals.

Fast Sweep Rate

High speed or fast risetime signal observable with 20ns/DIV maximum sweep rate.

Algebraic Operation

The ADD mode can display the sum or simultaneous observation of CH1 and CH2 input signals of differing frequencies.

CH1 Output (7020/40 not allowance)

The CH1 input can be used as a preamplifier to provide approximately 50mV/DIV signal level at the CH1 output to drive external instrument such as frequency counter.

Delayed Sweep Time Base (7022/42/23 only)

Delayed time base B provides magnified waveform observation and accurate time interval measurement.

Holdoff Function (7020/40 not allowance)

The variable Holdoff circuit permits triggering of complex signal and aperiodic pulse waveform.

Auto Time Base (7023 only)

The AUTO mode sets horizontal deflection factor automatically. However, the manual control is also possible.

1-3 Accessories

The fallowing accessories are provided:

Standard:	AC power cord, instruction manual.
Option:	ACS-010 (10:1)
	ACS-011(10:1, 1:1)

1-4 Specification

Model	7020/7040	7021/7041	7022/7042	7023
	Vertical Deflection System			
CH1, CH2 Sensitivity	5mV/DIV - 5V/DIV ± 3%, 10 Calibrated Steps, Selectable 1-2-5 Sequence x5 MAG: 1mv/DIV - 1V/DIV			
CH1, CH2 Bandwidth (-3dB)	DC(AD:10Hz) – 20/40 MHz x5 MAG: 15/20 MHz			
CH3 Sensitivity	Not Allowance	0.1V/DIV, 0.5V/DIV ± 3%		
Display Mode	CH1, CH2, ADD, CH2 INV, BOTH	CH1, CH2, CH2 INV, CH3, ADD ALT, CHOP		
Rise Time	17.5nS, 23nS (x5 MAG) for 702x/8.8nS, 17.5nS(x5MAG) for 704x			
Input Impedance	1Mohm // 25 PF			
Input Coupling	AC, DC, GND	AC, DC, GND (CH1, CH2). DC, DC/5 (CH3)		
Max. Input Volt	400V DC + Peak AC (CH1, CH2) 100V DV + Peak AC (CH3)			
Output Signal	Not Allowance	50mV/DIV at 50ohm (CH1 only) Approx.		
	Horizontal Deflection System			
Main Time Base	0.2uS/DIV – 0.5S/DIV ± 3 %, Selectable 1-2-5 Sequence 20 Calibrated Steps X10 MAG: 20nS/DIV – 50mS/DIV			0.5uS/DIV-0.2S/DIV ± 3% Selectable 1-2-5 Sequence Auto 18 Calibrated Steps x10 MAG: 50nS/DIV – 20mS/DIV
Delayed Time Base	Not Allowance	0.2uS/DIV – 0.5mS/DIV, 11 Calibrated Steps		
Display Mode	A		A, A INT B, B	
	Trigger System			
Mode	AUTO, NORM, TV	AUTO, NORM, SINGLE		AUTO, FIX, NORM
Source	CH1, CH2, EXT	CH1, CH2, VERT MODE, LINE, EXT, EXT/S		
Coupling	AC, TV, DC	AC, HF (50KHz), REJ, TV, DC,		
Polarity	+, -			
Sensitivity Int (Ext)	DC-10MHZ: 0.5DIV (0.1V) DC-20/40MHz: 1.5DIV (0.2V)			
Hold Off	Not Allowance	Variable to > 4 Times (Time Base < 5mS/DIV)		
	X-Y Operation			
Mode	CH1: X Axis, CH2: Y Axis			
Sensitivity	5mV/DIV-5V/DIV			
Bandwidth (-3dB)	DV-1MHz for 702X 2MHz for 704X			
Phase Difference	< 3 deg (DC-50KHz for 702X 100KHz for 704X)			

Z Axis Input (Intensity Modulation)				
Model	7020/7040	7021/7041	7022/7042	7023
Sensitivity	Not Allowance	3Vp-p, TTL Compatible Positive-going Input Decreases Intensity		
Bandwidth (-3dB)	Not Allowance	DC-5MHz		
Impedance	Not Allowance	5Kohm		
CRT				
Screen	6-inch Rectangular, internal Graticule, with percentage Markers and Photographic			
Effective Area	8 x 10 DIV (1DIV = 1cm)			
Intensity	A		A, B	
Acceleration	2KV Approx for 702 X / 12KV Approx for 704 X			
Illumination	Not Allowance	Yes		
Phosphor	P31			
Calibrator				
Waveform	Square Wave			
Repetition Frequency	1KHz Approx			
Output Voltage	0.5V +- 2%			
Duty Ratio	40% to 60%			
Power Supply				
Voltage Range	100V (90-110V) or 115V (104-126V) or 215V (194-236V) or 230V (207-253V)			
Power Consumption	40VA Approx			
Frequency Range	50 or 60 Hz			
Environmental Characteristics				
Limit Operation Temperature	0-40 deg C			
Limit of Operation Humidity	35-85%			
Rated Range of Use Humidity	45-85%			
Storage and Transport Temperature	-20~70 deg C			
Physical Characteristics				
Dimension	314(W) X 165(H) X 425(D) mm			
Weight	9 Kg Approx			

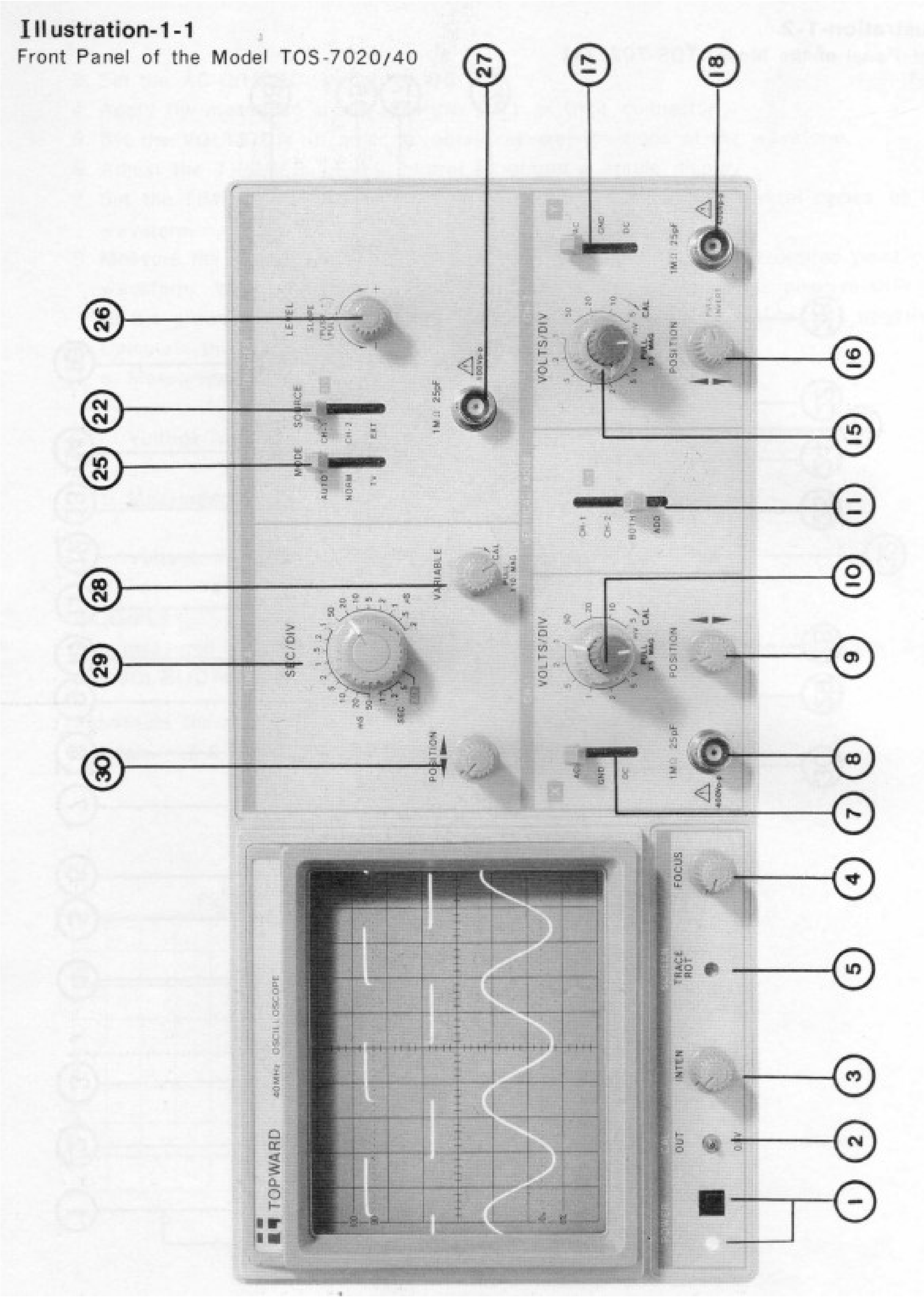


Figure 1-1 - Front Panel of the Model TOS-7020/40

Illustration-1-2
Front Panel of the Model TOS-7021/41

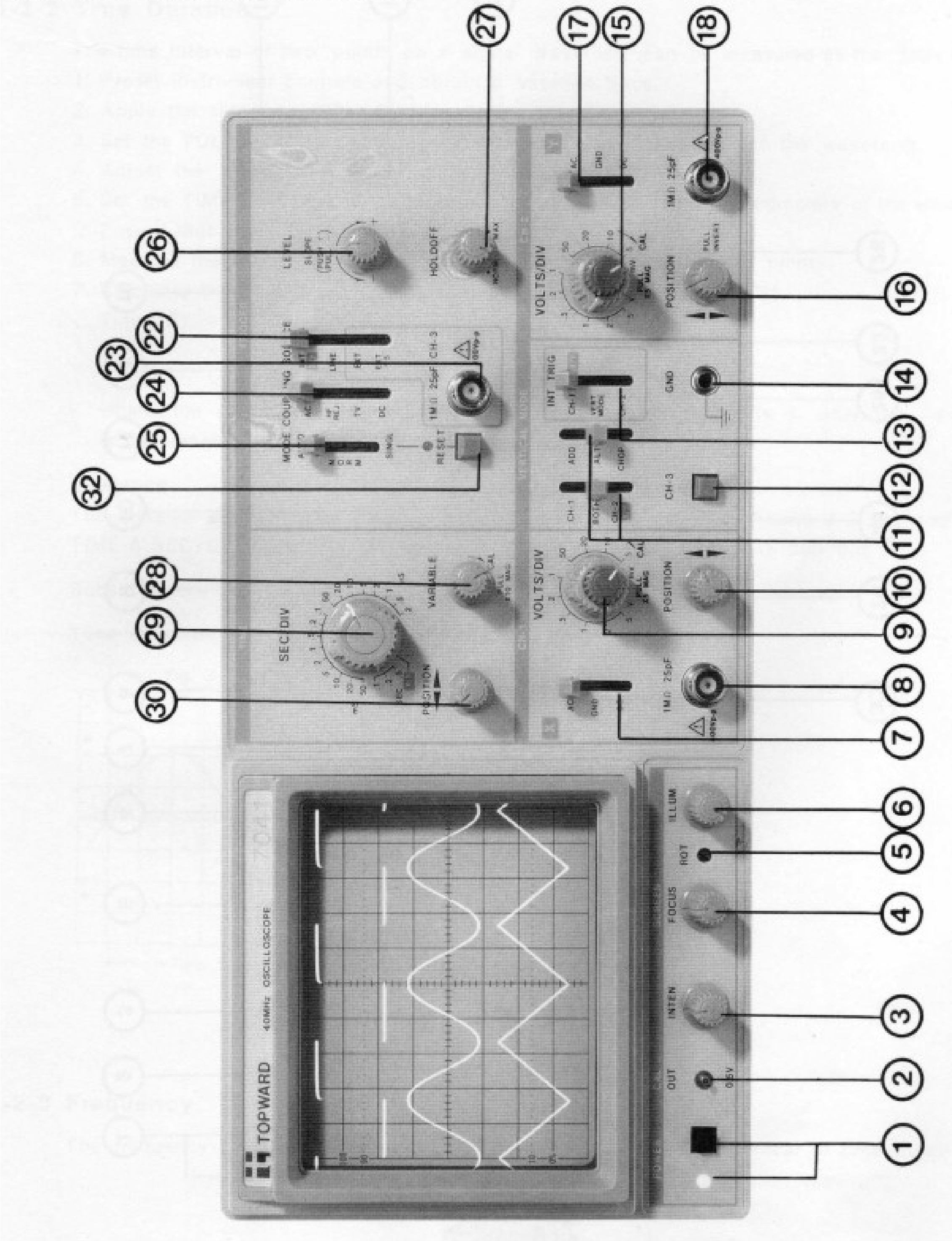


Figure 1-2 - Front Panel of the Model TOS-7021/41

Illustration-1-3
Front Panel of the Model TOS-7022/42

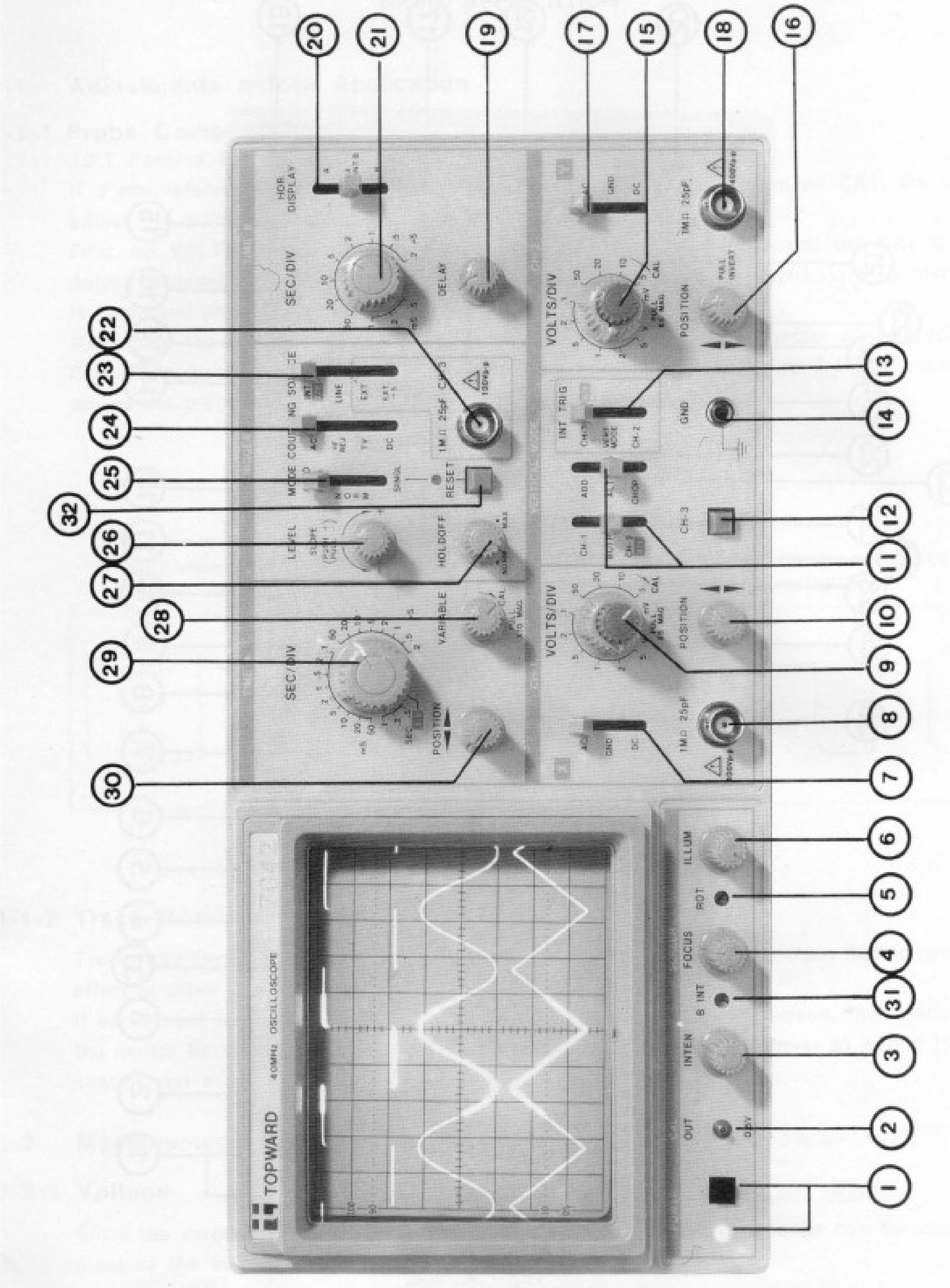


Figure 1-3 - Front Pane of the Model TOS-7022/42

Illustration-1-4

Front Panel of the Model TOS-7023

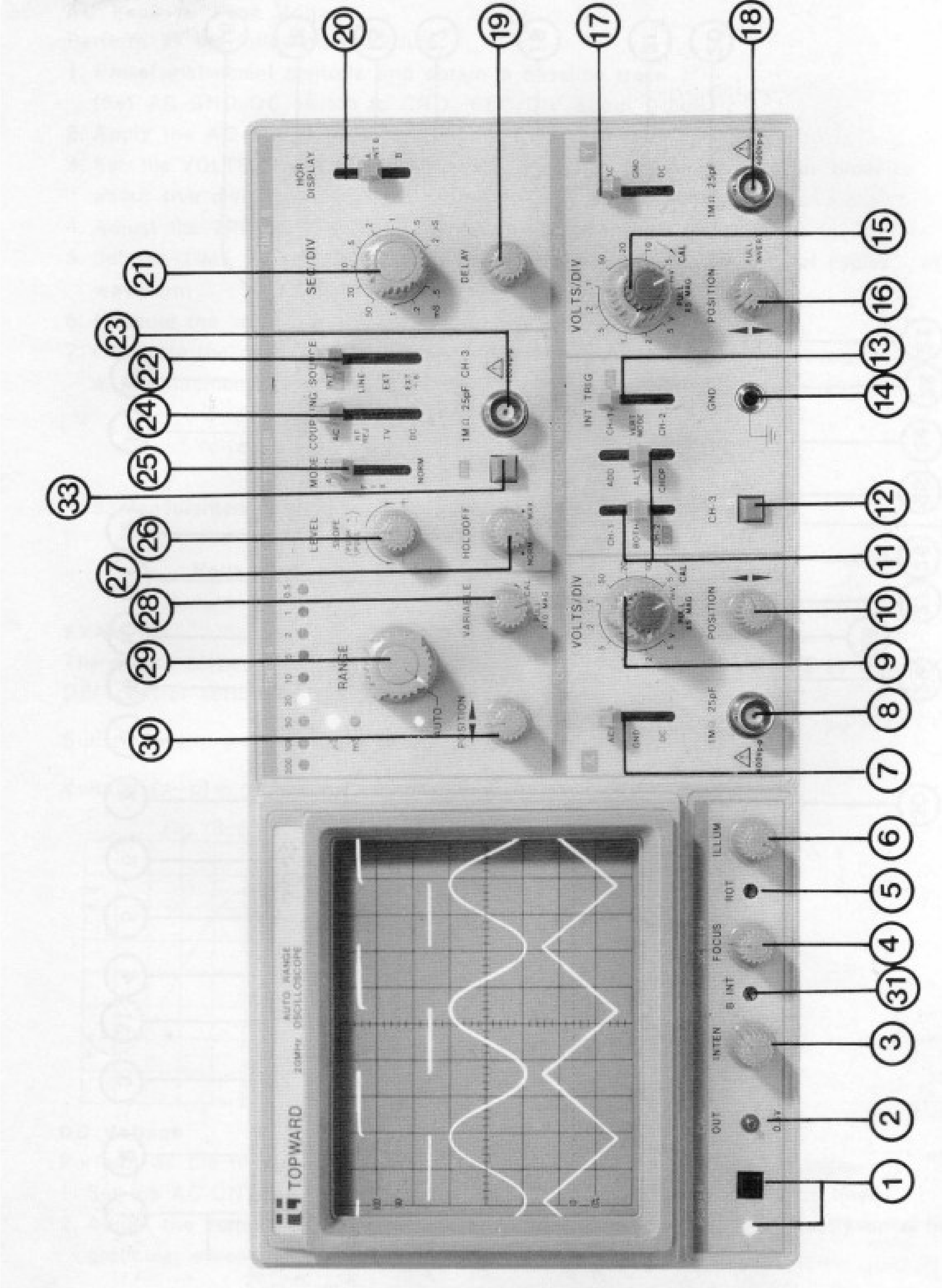


Figure 1-4 - Front Panel of the Model TOS-7023

2 OPERATING INFORMATION

2-1 Explanation of Front Panel

Please refer to illustration – 1

2-1-1 Screen

1. **POWER** Switch – Main line voltage switch. Press in for ON, press again for OFF. When the power is ON the LED is lighted.
2. **OUT** terminal – Output 0.5Vpp, 1KHz square wave for fast voltage calibration.
3. **INTEN** control – Adjust brightness of display waveform.
4. **FOCUS** control – Adjust the focus of display trace.
5. ROT control – Compensate tilting of display trace.
6. **ILLUM** control (7020/40 not allowance) – Adjust graticule illumination.
31. **B INT** control (7022/23/42 only) – Adjust the brightness of the B sweep trace.

2-1-2 Vertical Section

7. **(17) AC-GND-DC switch** – Select coupling mode between input signal and vertical amplifier.
8. **CH1 (X) INPUT** – CH1 input connector.
18. **CH2 (Y) INPUT** – CH2 input connector.
9. **(15) VOLTS/DIV** control – Select vertical trace position.
10. **POSITION** control – Adjust CH1 vertical trace position.
16. **POSITION (PULL INVERT)** control – Adjust CH2 vertical trace position. The polarity of the input signal reverses when the knob is pulled.
11. **VERTICAL MODE** switch – Select the operating mode of the vertical deflection system.
12. **CH3** switch – Switch for CH3 trace display
13. **INT TRIG** switch – Select the internal triggering signal source.
14. **GND** – Connect to signal source ground.

2-1-3 Horizontal Time Base

20. **HOR DISPLAY** switch (7022/23/42 only) – Select A or B sweep mode.
21. **Time B SEC/DIV** control – Select the sweep time for delayed sweep.
19. **DELAY time** control (7022/23/42 only) – When in A INT B mode, this knob selects the portion of A sweep waveform to be magnified.
26. **VARIABLE** control – Change A sweep time.
29. **Time A SEC/DIV** control – Select the sweep time for the main sweep.
30. **POSITION** control – Adjust horizontal trace position.

2-1-4 Triggering Section

22. **SOURCE** switch – Select CH1, CH2, line as internal trigger source. Also select ch3 or external trigger source
23. **CH3 (EXT) INPUT** connector (7020/40 not allowance) – Accept external triggering source or CH3 signal.
24. **COUPLING** switch – Select the coupling mode for internal trigger signal.
25. **MODE** switch – Select trigger mode.
32. **RESET** switch (7021/22/41/42 only) – initiate a single sweep mode. Ready state is indicated by LED.
26. **LEVEL** control – Set synchronous level for trigger source.

27. **HOLDOFF** control (7020/40 not allowance) – Adjust sweep cycle for stable viewing of complex waveform.
33. **X/Y** switch (7023 only) – Press in for X/Y operation.

2-2 Explanation of Rear Panel

Please refer to illustration – 2.
For model 7020/40, the following is not allowance.

34. **Z AXIS INPUT** connector – Apply input signal to modulate the brightness of the CRT display.
35. **CH3 POSITION** control – Adjust the trace position.
36. **CH1 SIGNAL OUTPUT** connector – CH1 output can drive external instrument.

Illustration - 2
Rear Panel of the Model TOS-7000 Series

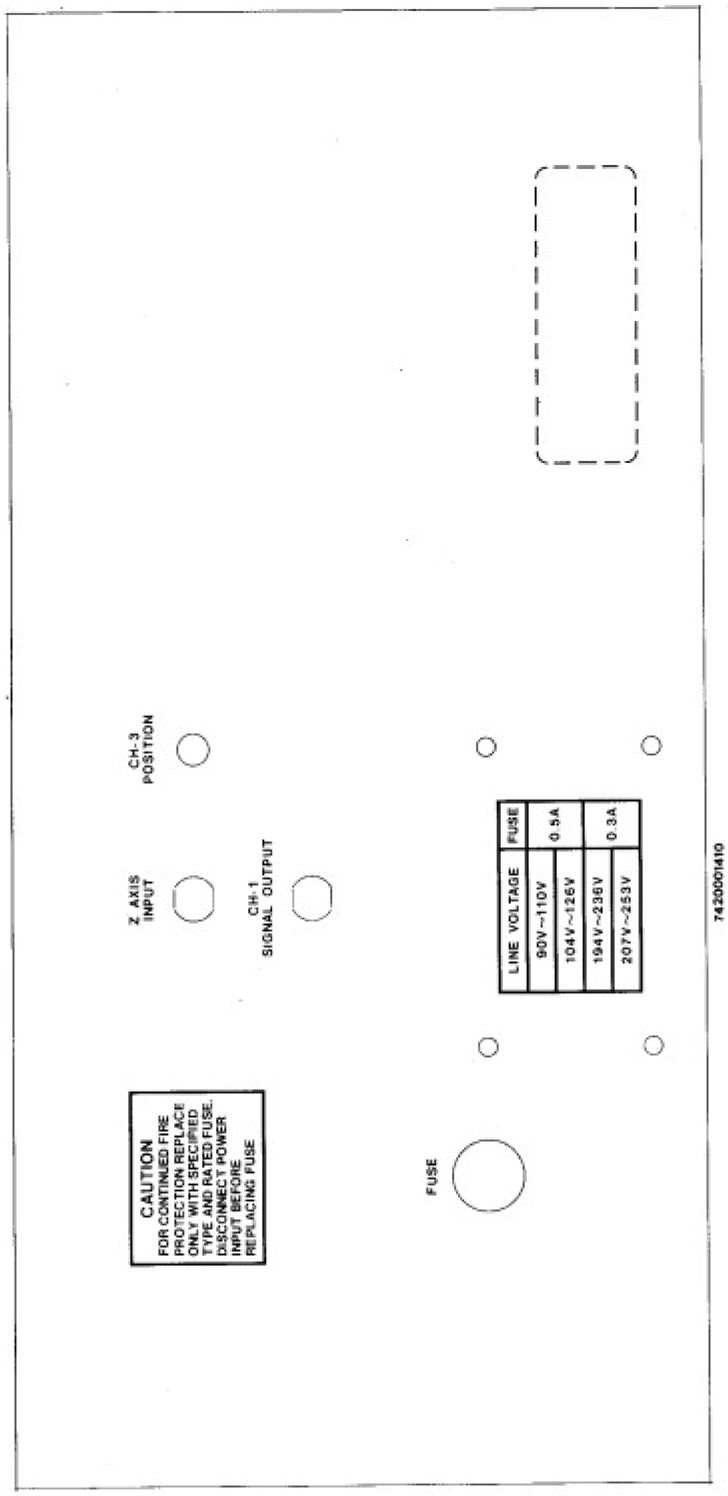


Figure 2-1 - Rear Panel of the Model TOS-7000 Series

2-3 Basic Functional Operations

2-3-1 Line Voltage Selection

Before operating the instrument, user must make sure the voltage of applied AC power meet the followings:

Voltage Range	90 – 110V / 104-126V
	194 – 236V / 207 – 253V
Frequency:	50/60Hz

2-3-2 Using an Attenuated Probe

A shielded probe must be used in order to reduce the adverse effect of external field on the signal measurement. The most popular probe used has an attenuation ratio 10:1 or 1:1.
A 10:1 probe feature compensation in high frequency. It can be used as less loss from DC to 100MHz, it also has high input impedance (10Mohm). High impedance probe reduces the load effect on the signal source. The use of probe at 1:1 ratio is recommended only for measuring low frequency signals. If a 10:1 probe is used, the input signal is attenuated to one-tenth, so we must correct the indicated amplitude value by multiplying 10.

2-3-3 Vertical Deflection Setting

CH1 VOLTS/DIV and CH2 VOLTS/DIV controls

Corrects waveform measurement implies an appropriately sized amplitude display on the CRT. The deflection factor is controlled by the Volts/DIV controls and the variable(orange) knob. When the orange knob is turned fully clockwise to the CAL position, the deflection factor is directly indicated by VOLTS/DIV dial. When the orange knob is pulled, the vertical amplifier sensitivity is multiplied 5 times, or actual value is indicated value divided by 5.

Input Coupling (AC-GND-DC) switches

Correct signal measurement requires proper selection of input coupling to the vertical amplifier.

AC coupling

When the switch is set to the AC position, only the AC component is passed, while the DC component is blocked by the capacitor so that the AC signal waveform will not be pushed out of the CRT screen by the DC offset voltage.
When observing low frequency waveform in the AC coupling mode, a sag will occur on square wave other signal will show attenuated amplitude. The attenuation is about -3dB at 10Hz.

DC coupling

When the switch is set to DC position, all frequency components of the input signals are allowed to pass. This mode should be used with a known DC level which is within the vertical range.

GND coupling

When the switch is set to ground, input of the vertical amplifier is grounded so that a ground potential is displayed on the CRT. This Potential is normally used as the reference potential in measuring signals.

CH1 CH2 INPUT connectors

Provide for application of external signals to the inputs of vertical deflection system or for an X-Y display. X-Y mode uses CH1 for X input and CH2 for Y input. The maximum peak-to-peak voltage is 400V.

POSITION controls

Provide for moving the signal up and down across the screen. When the SEC/DIV switch is set to X-Y, the CH1 POSITION control moves the display vertically. Also, when the CH2 POSITION control is pulled out, an inverter display will be gained.

Vertical Mode switch

CH1 – Select only the Channel 1 input signal for display.
CH2 – Select only the Channel 2 input signal for display.
BOTH – Select both Channel 1 and Channel 2 input signals for display. Always accompany by selecting either ADD, ALT or CHOP.
For model 7020/40, viewing input signal at sweeps from 0.2uS per division to 0.5S per division, it uses CHOP mode.
ALT – Alternatively display Channel 1 and Channel 2 input signals. The alternation occurs during retrace at the end of each sweep. This mode is suitable for observing two signals of high frequency. Alternate sweeps are possible in the full range of SEC/DIV, but lowering the sweep rate cause a flickering, which makes dual trace observation difficult.
CHOP – The display switches between the Channel 1 and Channel 2 input signals. input signals are switched from one to the other at about 250KHz, so that it is difficult to observe high frequency signals because their traces appear like dotted lines.
ADD – Displays the algebraic sum of the Channel 1 and Channel 2 input signals. In using this mode, the deflection factors for the individual channels must be set to equal.

2-3-4 Horizontal Sweep Rate Setting

SEC/DIV control – Used to select the sweep speed, from 0.5 µS/DIV to 0.5 µS/DIV in 20 ranges. If X-Y mode is operated, this control must be rotated lower counter-clockwise at X-Y position.
POSITION control – Provide for moving the signal horizontally.
VARIABLE control – To have a calibrated reading, the VARIABLE control must the rotated clockwise at CAL position. When the VARIABLE control is pulled, the sensitivity is magnified 10 times, so the actual value is indicated value divided by 10.

2-3-5 Trigger System

The trigger operation involves many selection steps in order to obtain stable waveform display.

Mode Switches

AUTO – When this mode is selected, the horizontal circuit sweeps automatically. It only allows triggering of input signal over 50Hz. If the set trigger level is outside the trigger range, or no trigger level is present, a free running sweep will happen. For input signal of 50Hz or less, use NORM mode.
NORM – If an adequate trigger signal is applied, the input signal synchronizes as in the AUTO mode. In the absence of a trigger signal, the trace will be blanked out.
TV – Permit trigger on television field signal.
SINGL – As this mode is selected, when the RESET button is pressed, one sweep is displayed for each trigger level. At the same time, LED is lighted for ready state.
FIX – For model 7023 only. The trigger level is automatically maintained at the optimum value irrespective of the trigger amplitude.

COUPLING switches

AC – Only the AC component of the trigger is used for triggering. Because the DC component is blocked, synchronization can be achieved regardless of the DC level in the trigger signal.
DC – DC level may be used for triggering. This position is useful for displaying low frequency.
HF REJ – In this mode, the trigger circuit is coupled via a low pass filter. Trigger frequency above 50KHz or trigger signal mixed with high frequency noise is attenuated by the filter which passes only the low frequency component of the low frequency component of the trigger signal.
TV – Synchronize with composite video signal. Time base A SEC/DIV control selects TV-V (0.1mS-0.5S) and TV-H (0.2-50 µS).

SOURCE switches

For model 7020/40
CH1 – Selects trigger internally as the source of Channel 1 input signal.
CH2 – Selects trigger internally as the source of Channel 2 input signal.
EXT – Selects trigger externally, there exists a BNC connector for using external trigger. For model 7021/22/23/41/42
INT – Selects trigger internally. Input signal is internally routed to the trigger circuit.
LINE – Line trigger allows stable triggering in measuring line frequency or line frequency harmonics independent of the vertical deflection system and input signal frequency.
EXT – Selects trigger externally. A signal that has time relationship with the signals applied at CH1 and CH2 is applied to CH3 terminal.
EXT/5 – Selects trigger externally but the voltage is attenuated by a factor of 5.

LEVEL and SLOPE control

This control selects from where the sweep takes place. When the control is rotated clockwise (+), set the signal to be sync at more positive level.
When the control is rotated counterclockwise (-), set the sync level reversely. When the control is pulled out, sweep is triggered from the negative-going slope of the trigger signal. When the control is pushed in, sweep is triggered from the positive-going slope of the trigger signal.

HOLDOFF control

For complex signals and aperiodic phase waveforms, the display cannot be stable, so this control provides continuous control holdoff time between sweeps. When it is rotated fully clockwise, the holdoff time is increased by a factor greater than 4.

2-3-6 Horizontal Display Selection

For the delay sweep oscilloscope (model 7022/23/42), part of the display waveform can be magnified with the HOR DISPLAY selection.
A – Use the A sweep circuit only. Sweep rate is set by TIME A.
A INT B – A is intensified by B. Part of the desired display waveform is intensity-enhanced. Indicate the start position and length of B sweep.
B – Use the B sweep circuit only. Sweep rate set by TIME B. The intensity-enhanced position in A INT B mode is displayed fully magnified on the CRT.
DELAY control – Selects which part of the display waveform to be magnified.

The delayed sweep function is used to magnify and display a portion of the original signal at a specific time after a sweep start point. The A SEC/DIV and DELAY TIME are used for delay time settings. A and B SEC/DIV selections determine magnification ratio. For example: A sweep is

10mS/DIV, B sweep is 0.5ms/DIV, delayed sweep starts 6.3 divisions after the start point of A sweep, the delay time is 10mS/DIV ÷ 0.5mS/DIV = 20.
This mode offers the advantage that B sweep can be started at any position on the A sweep. However, if magnification is greater than 50 delay jitters may appear on the CRT.

3 BASIC APPLICATION

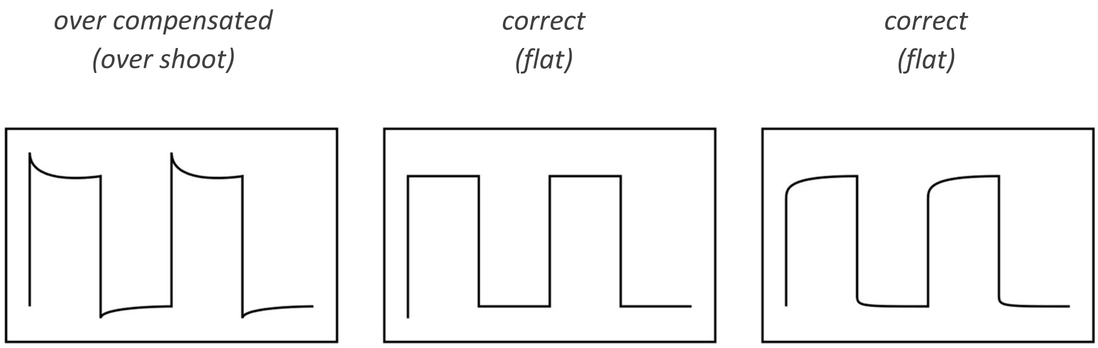
3-1 Adjust Before Application

3-1-1 Probe Compensation

10:1 Passive Probe Phase Adjustment

If a mismatched probe is used, there will display a wrong waveform on CRT. Be sure to adjust the probe correctly before making measurement.
First, set VOLTS/DIV to 10mV, connect the 10:1 probe to INPUT and the CAL 0.5V output terminal so that a calibration voltage waveform with an amplitude of 5 divisions is displayed on the CRT screen:
Next, turn the variable capacitor which located near the BNC connector of the probe.
Check the waveform presentation for overshoot and roll-off (see figure 3.1.1) if necessary, adjust the probe compensation for flat tops on the waveform.

Figure 3-1-1



3-1-2 Trace Rotation Compensations

Trace may become not parallel to the graticule lines on the CRT screen due to geomagnetic effect or other cause.
If adjust is needed, first display a baseline trace on the CRT screen, then move it to the center horizontal graticule line, and use a small flat-bit screwdriver to adjust the ROT control and align the trace with the center horizontal graticule line.

3-2 Measurement

3-2-1 Voltage

Since the vertical deflection is proportional to input voltage, oscilloscope can be used measure the voltage of input signal.

AC Peak-to-Peak Voltage

Perform as the following procedure:

1. Preset instrument controls and obtain a baseline trace.
   (Set AC-GND-DC switch to GND, SEC/DIV about 0.2uS)
2. Apply the AC signal to either CH1 or CH2 connector.

3. Set the VOLT/DIV VARIABLE control (be sure in CAL position) in order to obtain about five divisions of the waveform.
4. Adjust the TRIGGER LEVEL control to obtain a stable display.
5. Set the TIME A SEC/DIV control to a position that displays several cycles of the waveform.
6. Measure the vertical deflection from peak-to-peak.
7. Calculate the peak-to-peak voltage by using the following equations(eq.1)
    a. Measurement with the 1:1 probe

$$Voltage\ (p-p) = VOLTS/DIV\ setting\ value \times\ Vertical\ Deflection$$

    b. Measurement with the 10:1 probe

$$Voltage\ (p-p) = VOLTS/DIV\ setting\ value \times Vertical\ Deflection \times 10$$

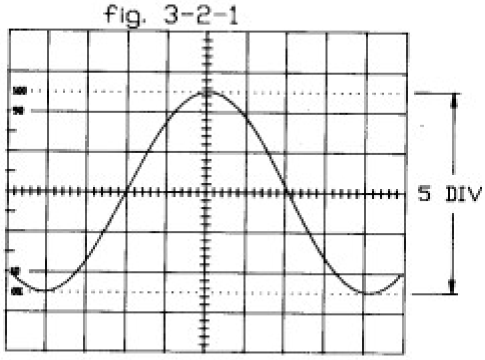
EXAMPLE

The measured peak-to-peak vertical deflection is 5.0 div (see fig 3-1-2) with a VOLTS/DIV control setting of 10mV using a 1:1 probe.

Substitute the given values:

$$Voltage\ (p-p) = 5.0\ div \times 10\ mV/div = 50mV$$

fig. 3-2-1



DC Voltage

Perform as the fallowing procedure:

1. Set AC-GND-DC switch to GND. It is used as 0 volts reference line.
2. Adjust the vertical POSITION control in order to place the trace exactly on a horizontal graticule, which helps to read the signal.
3. Set AC-GND-DC switch to DC.
4. Apply the measured signal to either CH1 or CH2 connector.
5. Set the VOLTS/DIV in order to obtain several divisions of the waveform.
6. Adjust the TRIGGER LEVEL control to obtain a stable display.
7. Set the TIME A SEC/DIV control to a position that displays several cycles of the waveform.
8. Measure the vertical deflection between the reference line and the desired point on the waveform. When the trace shifts upward, the voltage is negative.
9. Calculate the voltage by using the following equations (eq2).
    a. Measurement with the 1:1 probe

$$Voltage = VOLTS/DIV\ setting\ value \times Vertical\ Deflaction \times Polarity\ (+or-)$$

    b. Measurement with the 10:1 probe

$$Voltage = VOLTS/DIV\ setting\ value \times Vertical\ Deflaction \times Polarity\ (+or-) \times 10$$

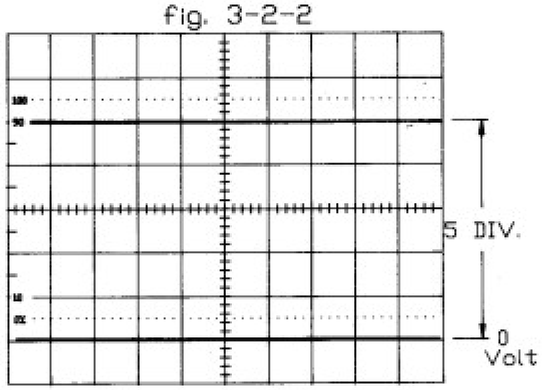
EXAMPLE

The measured vertical deflection is 5.0 div above the refence line (see figure 3-2-2) the VOLTS/DIV control is set to 10mV, using a 10:1 probe.

Substitute the given values:

$$Voltage = 5.0\ div \times 10mV \times (+1) \times 10 = 0.5V$$

fig. 3-2-2



3-2-2 Time Duration

The time interval of two point on a signal waveform can be measured as the following:

1. Preset instrument controls and obtain a baseline trace.
2. Apply the signal to either CH1 or CH2 connector.
3. Set the VOLTS/DIV in order to obtain several division of the waveform.
4. Adjust the TRIGGER LEVEL control to obtain a stable display.
5. Set the TIME A SEC/DIV control to a position that display a complete of the waveform. Ensure that the VARIABLE control is in the CAL position.
6. Measure the horizontal distance between the time – measurement point.
7. Calculate the time duration by using the following equation (eq.3)

$$Time(S) = SEC/DIV\ setting\ value \qquad S/DIV$$
$$\times\ horizontal\ distance \qquad (divisions)$$
$$\times\ reciprocal\ number\ of \times 10\ MAG\ setting\ value$$

where, the reciprocal number of the ×10 MAG settings value is 1 when the sweep is not magnified, and 1/10 when the sweep is magnified.

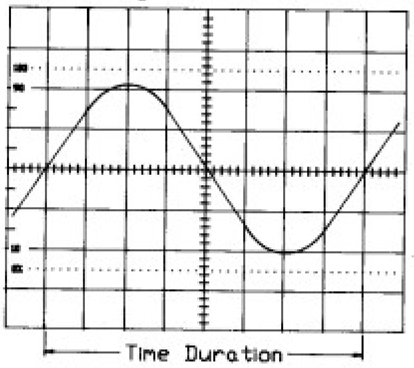
EXEMPLE

The distance between the time-measurement points is 8 div (see picture 3-2-3), and the TIME A SEC/DIV control is set to 5µS. The ×10 MAG switch is pulled out.

Substitute the given values:

Time Duration = 8 div × 5mS/DIV × 1/10 = 4mS

fig. 3-2-3



3-2-3 Frequency

The frequency of an input signal can be determined by reciprocal of time duration.

$$Frequency = \frac{1}{Time\ Duration}$$

3-2-4 Pulse Width

The basic pulse width measurement procedure is as following:

1. Preset instrument controls and obtain a baseline trace.
2. Apply the signal to either CH1 or CH2 connector.
3. Set the VOLTS/DIV control in order to have a pulse waveform cover 80% of the vertical area.
4. Display the pulse waveform near the center of CRT. If A is the amplitude of the pulse waveform, then set the vertical position in order to have the distance between the top part of the pulse and the horizontal center line of the graticule is A/2.
5. Set SEC/DIV control in order to have an easy observation.
6. Read the distance between the center of rising and falling edges.
7. Calculate the pulse width by the eq.3.

Example

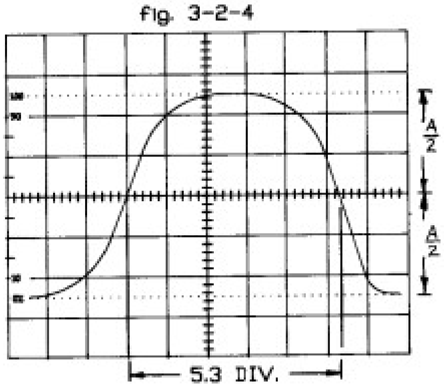
The distance between center of rising and falling edges is 5.3 div, and the TIME A SEC/DIV control is set to 20µS/DIV.

The ×10 MAG switch is pulled out. (See figure 3-2-4)

Substitute the given values:

$$Time = 5.3\ \ div \times 20\mu S/DIV \times 1/10 = 10.6\ \mu S$$

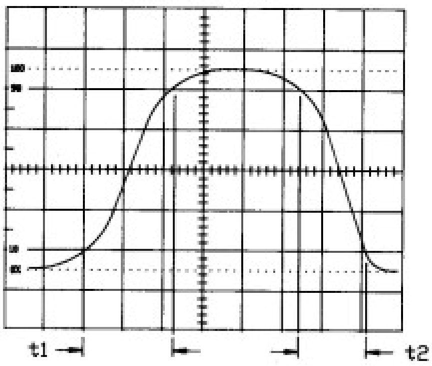
fig. 3-2-4



3-2-5 Pulse Rise Time and Fall Time

Rise time (T1) is the time duration between the 10% and 90% points on the leading edge of the waveform. Fall time (T2) is the time duration between the 90% and 10% points on the trailing edge of the waveform (see figure 3.2.5).

fig. 3-2-5



Measurement procedure of rise-time (fall-time) is the following:

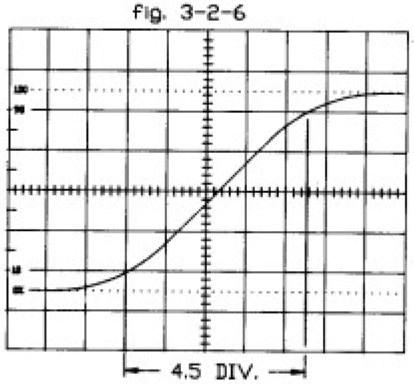
1. Display the pulse waveform by setting the VOLTS/DIV to obtain 6 divisions vertically.
2. Adjust the vertical POSITION control so that the zero reference of the waveform touches the 0% graticule line and top of the waveform touch the 100% graticule line.
3. Set the Time A SEC/DIV control for a single waveform display with the rise time (fall-time) spread horizontally as much as possible.
4. Set the horizontal POSITION so that the 10% (90%) point on the waveform intersects the vertical graticule line.
5. Measure the horizontal distance between the 10% and 90% points on the waveform.
6. Calculate the rise time (fall time) by eq.3.

EXAMPLE

The horizontal distance between the 10% and 90% points on the waveform is 4.5div (see figure 3-2-6), and the TIME A SEC/DIV control is set to 10µS.

$$Rise\ Time = 4.5\ \ div \times 10\mu S/div \times 1 = 45\ \mu S$$

fig. 3-2-6



3-2-6 Time Difference

TOPWARD model 7000 series have calibrated sweep and dual-trace features so that it can be used to measure the time difference between two continuous time-related pulses.

Procedure is the following:

1. Connect the input signals to CH1 and CH2. Select CH1 as the reference signal and CH2 as the comparison signal.
2. Set both AC-GND-DC switches to the same position, depending on the type of input coupling desired.
3. Set vertical mode either ALT or CHOP according to the frequency of input signals. If input signals are high frequency, use ALT mode, otherwise use CHOP mode.
4. Select CH1 as the trigger source.
5. Select both VOLTS/DIV controls for several divisions display.
6. If the two signals are of opposite polarity, pull out the CH2 PULL INVERT button to invert the CH2 display.
7. Adjust the TRIGGER LEVEL control for a stable display.
8. Adjust the vertical POSITION controls in order to center each of displays vertically.
9. Set the TIME A SEC/DIV control to a sweep speed which provides three or more divisions of horizontal separation between the two displays.
10. Measure the horizontal difference between the two displays and calculate the time difference by eq.3.

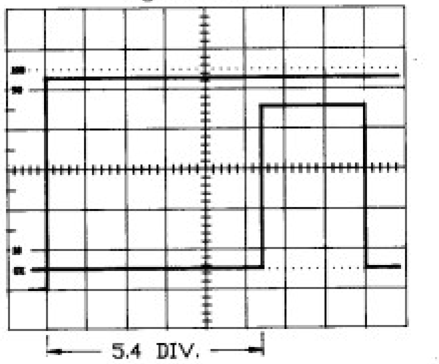
EXAMPLE

The horizontal difference between the two displays is 5.4 div (see figure 3-2-7), and the TIME A SEC/DIV control is set to 50µS. The x10 MAG switch is pulled out.

Substitute the given the values:

$$Time\ Difference = 5.4\ \ div \times 50\mu S/div \times 1/10 = 27\ \mu S$$

fig. 3-2-7



3-2-7 Phase Difference

TOPWAR model 7000 series can be used to compare the phase difference between two input signals of same frequency.

Measurement procedure is the following:

1. Display the waveform according to the procedure of time difference measurement from step 1 to 8.
2. Position the display and adjust the TIME A SEC/DIV control so that one reference signal cycle occupies exactly 8 horizontal graticules divisions. Now each division of the graticule represents 45 deg of the cycle (360 deg/8 div).
3. Measure the horizontal difference between the two displays at a common horizontal graticule line and calculate the phase difference by using the following equation (eq.4)

$$Phase\ Difference = horizontal\ difference\ X\ horizontal\ graticule\ calibration$$

NOTE: More accurate phase difference measurement can be made by using the x10 MAG to increase the sweep speed without changing the SEC/DIV control.

There is another method to measure the phase difference – see X – Y operation.

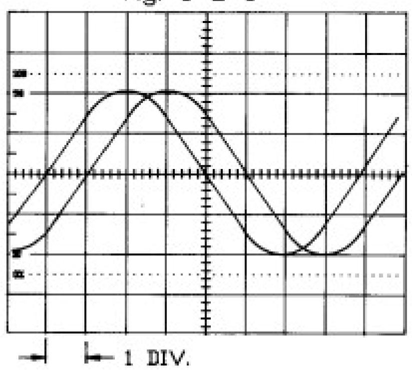
EXAMPLE

The horizontal difference between the display at a common horizontal graticule line is 1.0 div with a graticule calibration of 45 deg per division. (See figure 3-2-8)

Substitute the given values:

$$Phase\ Difference = 1.0\ div\ X\ 45\ deg/div\ = 45\ deg$$

fig. 3-2-8



3-3 X – Y Operation

If the HORIZONTAL TIME A control is rotated counter-clockwise to X – Y mode, then Lissajous pattern can be viewed, and phase difference measured. The following procedure is to measure phase difference between two input signals of same frequency.

1. Connect the input signals to CH1 and CH2. The signal on CH1 drives the horizontal axis and the signal on CH2 drives the vertical axis.
2. Set TRIGGER SOURCE to INT X/Y
3. Set VERTICAL MODE to X/Y
4. Rotate the HORIZONTAL TIME A control counterclockwise to X/Y mode. A Lissajous pattern can be viewed. (See figure 3-3-1).
5. Use the POSITION control to move the trace symmetric at the origin.
6. Measure the amplitudes A and B of the pattern shown.
7. Calculate the phase difference by the following equation (eq.5).

$$Phase\ Difference\ (deg) = \text{arc sin}\frac{B}{A}$$

EXAMPLE

Refer to figure 3-3-2, A = 4.8 divisions and B = 3.9 divisions.

Calculate the phase difference.

Substitute the given values:

$$Phase\ Difference = \text{arcsin}\frac{3.9}{4.8} = 54.37\,\text{deg}\ \ (approx)$$

fig. 3-3-1

Lissajous Pattern

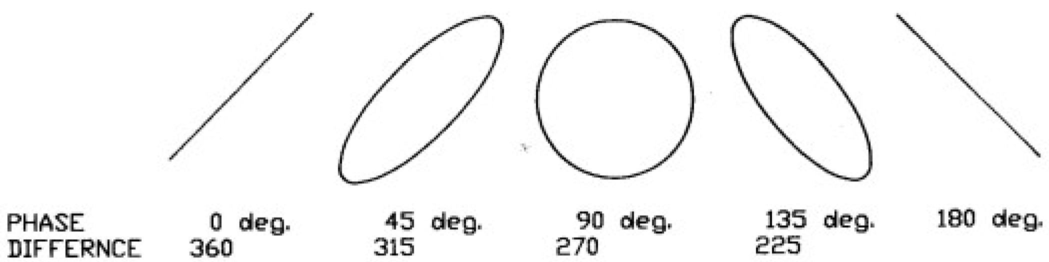


fig. 3-3-2