

Lab 9 The Oscilloscope

Name _____

Section _____

PURPOSE

- * To measure time and frequency using an analog oscilloscope.
- * To generate various waveforms using a function generator and measure the amplitude and frequency of each.

EQUIPMENT

LAB SUPPLIED PARTS

KENWOOD 20MHZ SCOPE
Function Generator

PARTS KIT PARTS

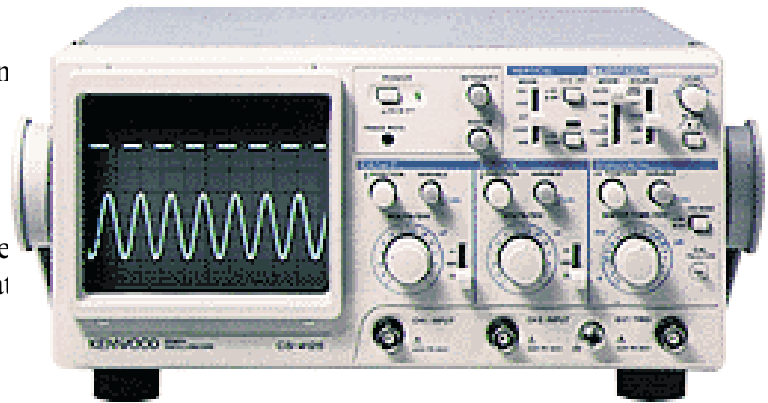
BNC - BNC lead

PreLab - Read this lab and do all the problems indicated.

The Oscilloscope

An oscilloscope is an excellent instrument for viewing the shape of repetitive voltage waveforms, like sine waves.

Traditional scopes work by repeatedly moving an electron beam horizontally across the face of cathode ray tube (CRT). The beam moves across the screen at constant speed determined by the time base setting (SWEEP TIME/CM control).



Because there are 10 divisions (cm) across the screen, a control setting of 0.2 ms means the beam will take 1 ms to cross the screen. A setting of 5 ms means it will take 50 ms to cross the screen.

The points on the CRT face that are struck by the crossing electron beam glow and then dim. If the beam traces the same path each time across the face of the CRT the points do not have time to dim so a stationary picture of the waveform appears.

The applied signal voltage is used to deflect the electron beam vertically as it crosses the screen. If no signal is input or a constant DC voltage is applied a single horizontal line will appear on the CRT screen. If the channel input switch is in the GND position, the line crossing the screen indicates where zero volts is located.

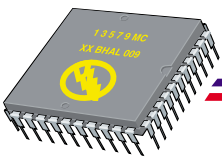
Zero volts can be moved vertically anywhere on the screen using the channel POSITION control. If a sine wave is applied to the signal input the beam moves up and down as it crosses the screen tracing out the waveform.

The amount the beam deflects up or down is determined by the amplitude setting (VOLTS/CM control). A setting of 2 volts means a 5 volt input signal will move the beam up 2.5 divisions from zero volts.

Oscilloscope Triggering

For an oscilloscope to display a stationary waveform the electron beam must trace the same path with each sweep across the screen. An alternating waveform must be triggered properly in order for this to happen. This is accomplished by starting each sweep at the same slope and voltage level.

A positive or negative slope is selected using the *slope* control. The starting voltage level is adjusted by turning the *triggering level* control.

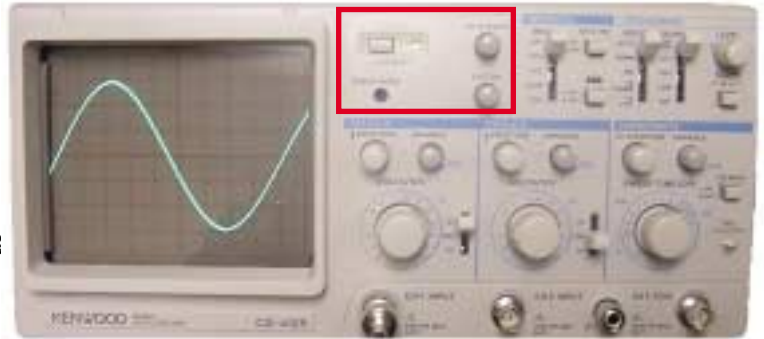


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After a trace has been completed the oscilloscope will not start the next trace until the correct slope and voltage level occur. This insures that the trace starts at the same point in the cycle each time. If the scope trigger is in **normal mode**, no trace will appear on the CRT unless the triggering criteria are met. If the scope trigger is in **auto mode** and the criteria are not met, the traces will start at random points in the cycle displaying a scrambled mess on the CRT. Note the **trigger source** control determines what input is examined for triggering purposes.

Front Panel Controls Kenwood CS 4125

- POWER** - Turns ac mains on and off
- INTENSITY** - This adjusts the brightness of the trace line.
- FOCUS** - For adjusting the focus and attaining the clearest display possible.



The CRT Screen

The scope has two axis, X-axis (time) and Y-axis (amplitude).

Each axis is divided into 1 cm divisions. Each division or (cm) is further subdivided for accuracy.

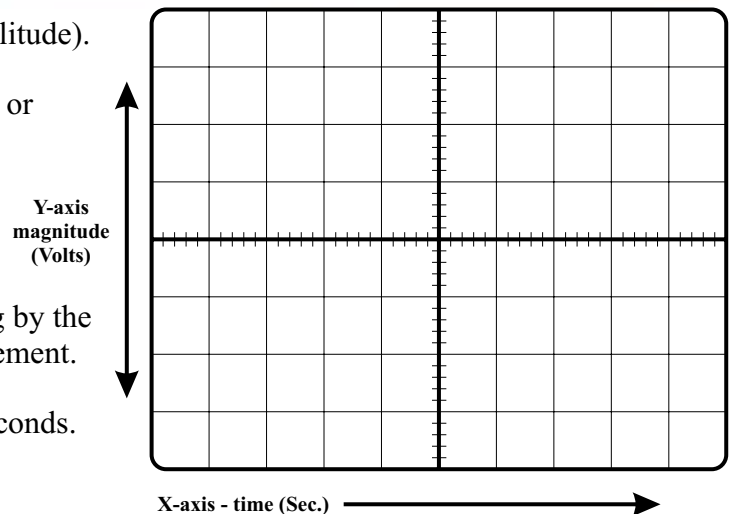
The X-axis represents time in seconds.
The Y-axis represents amplitude (magnitude) in volts.

Counting the total number of divisions and multiplying by the time base or vertical attenuation will equal the measurement.

Each 1 cm division can represent a different time in seconds.

e.g.) **TIME BASE** = 1ms/cm along the x-axis

e.g.) **VERTICAL ATTENUATION** = 1V/cm along the y-axis. These settings are similar to selecting ranges on a meter.

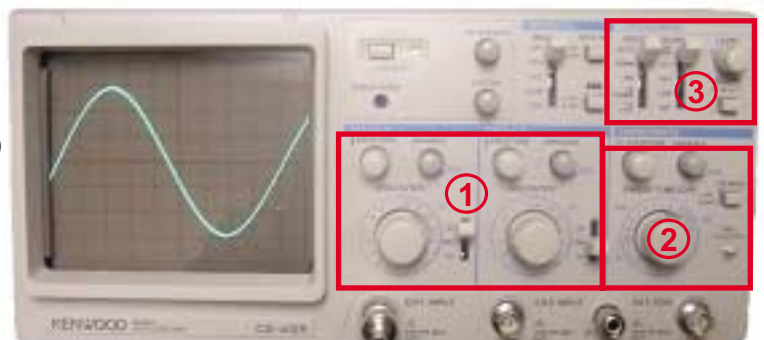


Basic Scope Controls

The controls on an oscilloscope can be grouped into three basic categories.

- ① VOLTAGE CONTROLS (vertical attenuation)
- ② TIME BASE CONTROLS (sweep time)
- ③ TRIGGERING CONTROLS (level)

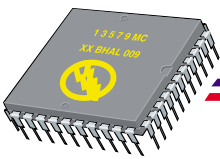
See the last page of this lab for a location of the controls listed below.



Voltage Controls

[10 - 15] VOLTS/CM - This sets the scale or vertical attenuation along the Y- axis for two separate input channels CH1 or CH2.

NOTE: MAKE SURE THE VARIABLE CALIBRATION IS FULLY CLOCKWISE FOR BOTH



Time Base Controls

- [28] SWEEP TIME / DIV - This sets the scale or horizontal time base along the X - axis for both input channels CH1 and CH2.
- [29] Note the POSITION < > controls.

AGAIN MAKE SURE THE CALIBRATION DIAL IS FULLY CLOCKWISE AND X10 MAG IS OFF.

Triggering Controls

- [25] LEVEL + - this adjusts the trigger threshold level. Determines at what point on the signal the slope sweep will commence.
(12 O' CLOCK is a good starting point.)
- [24] SLOPE CONTROL - Selects the slope on which the trigger will be performed.
Source rising + / or source falling \ - .
(Slope + is a good starting point.)
- [22] TRIGGERING MODE SWITCH

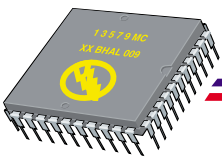
AUTO - Sweep trigger is performed automatically.

NORM - Sweep is performed by a trigger signal (adjust - level +).
In absence of a suitable trigger signal a trace will not appear.

(Trigger AUTO is a good starting point.)

Input Sources And Controls

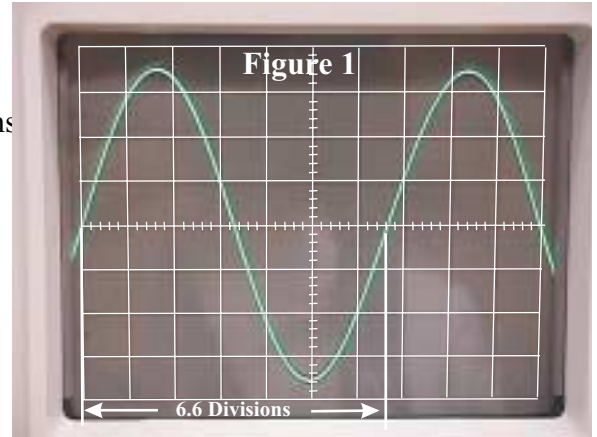
- [13 - 18] CH1 - CH2 INPUTS - BNC connections for input signals.
- [19] VERTICAL MODE SWITCH
- CH1 displays CH1 on the CRT.
 - CH2 displays CH2 on the CRT.
 - ALT displays CH1 and CH2. *(The sweep switches between them)*
 - CHOP displays CH1 and CH2. *(Usually at low frequencies where flicker is noticeable.)*
 - ADD displays combined waveform of [CH1 + CH2]. *(CH2 set INV the difference of CH1 and CH2 [CH1 - CH2].)*



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Taking Measurements of Sine Waves

Figure 1 shows a waveform displayed on an oscilloscope CRT. The amplitude and time base setting are shown at the bottom of the CRT. Find the peak to peak voltage, the peak voltage, the rms voltage, the period, and the frequency of the waveform.



Horizontal Sweep Time 0.1 mS / DIV. Vertical Attenuation 1 V / DIV.

Frequency

Find the period T

From the CRT we can see 6.6 Divisions at 0.1 mS /Div
This gives a period of 0.66 mS

$$\text{From the formula } f = \frac{1}{t} = \frac{1}{0.66 \text{ mS}} = 1.52 \text{ kHz}$$

To Measure the P-P Voltage

- 1) Move the waveform down using the vertical position until the bottom of the waveform touches a horizontal line.
- 2) Next move the waveform to the left or right using the horizontal position until the waveform's highest point is located over the centre graticule. (See the waveform to the right)
- 3) Using the small graduations on the centre graticule, carefully measure the peak to peak height of the waveform.
- 4) Multiply the height of the waveform by the setting on the vertical attenuator to get the peak to peak voltage of the waveform.

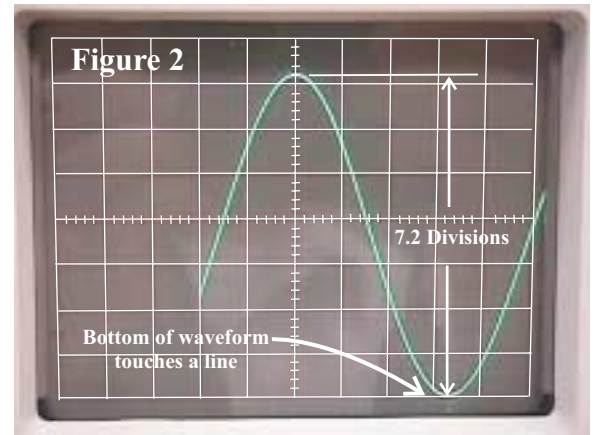
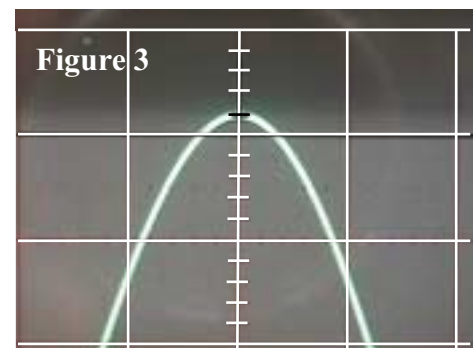


Figure 3 shows the waveform under the small graduations on the centre graticule. This makes it easier to read.



Peak Voltage

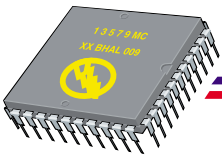
$$V_{p-p} = 7.2 \text{ Divisions times } \times 1 \text{ V/Div} = 7.2 V_{p-p}$$

$$\text{For sine waves } V_{pp} = 2V_p$$

$$\text{Therefore } V_p = \frac{V_{pp}}{2} = \frac{7.2V_{pp}}{2} = 3.6V_p$$

Effective Voltage or rms Voltage

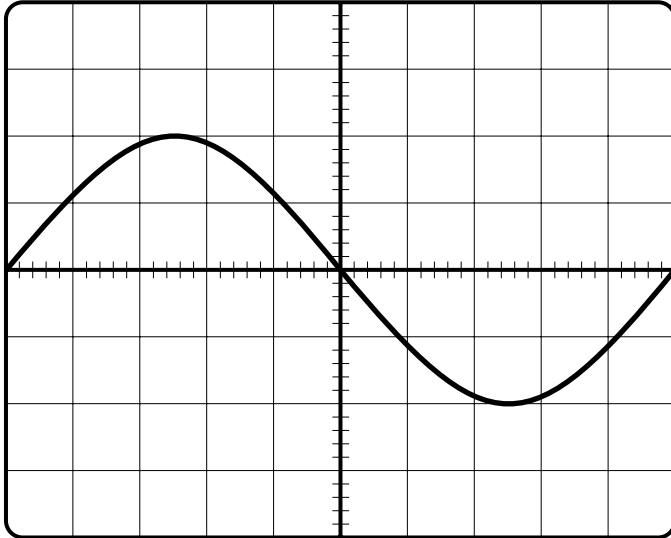
$$\begin{aligned} \text{From the formula } V_{rms} &= .707 V_p \\ &= .707 (3.6V_p) \\ &= 2.55V \end{aligned}$$



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Prelab

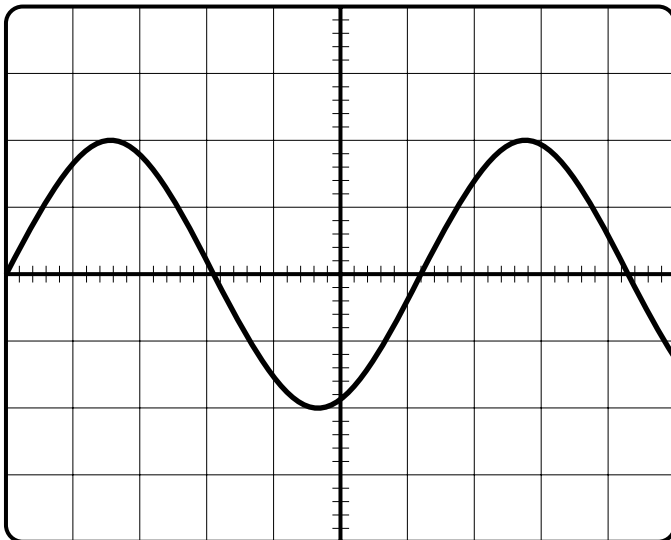
The diagrams below shows a waveform displayed on an oscilloscope CRT. The amplitude and time base setting are shown for each.. Find the peak to peak voltage, the peak voltage, the rms voltage, the period, and the frequency of the waveform.



Horizontal Sweep Time
0.1 mS / DIV.

Vertical Attenuation
1 V / DIV.

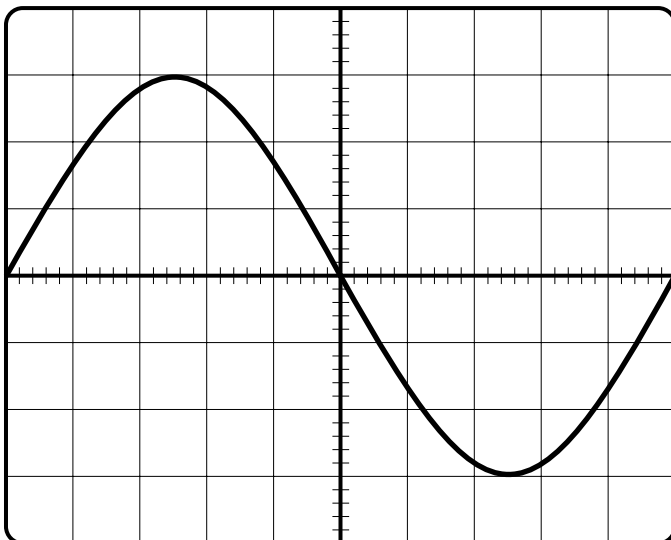
Frequency _____
P-P Voltage _____
Peak Voltage _____
Effective Voltage _____



Horizontal Sweep Time
20 μS / DIV.

Vertical Attenuation
50 mV / DIV.

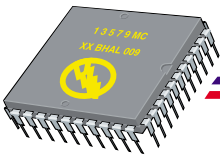
Frequency _____
P-P Voltage _____
Peak Voltage _____
Effective Voltage _____



Horizontal Sweep Time
50 μS / DIV.

Vertical Attenuation
20 mV / DIV.

Frequency _____
P-P Voltage _____
Peak Voltage _____
Effective Voltage _____



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Procedure

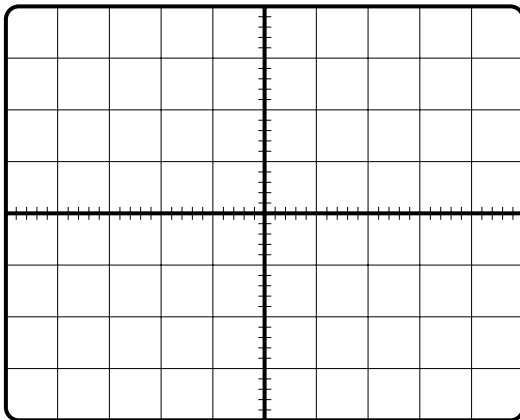
Measuring Time , Frequency and Amplitude

Connect the HIGH (20V p-p) output of a 182 WAVETEK Function Generator to the CH1 input on the scope. Set the sine waveforms listed in Table 1 using the oscilloscope and complete the rest of the table.

Sketch the waveforms on the graticules provided.. Record the HORZ. and VERT. settings. Use the space below for your calculations and rough work.

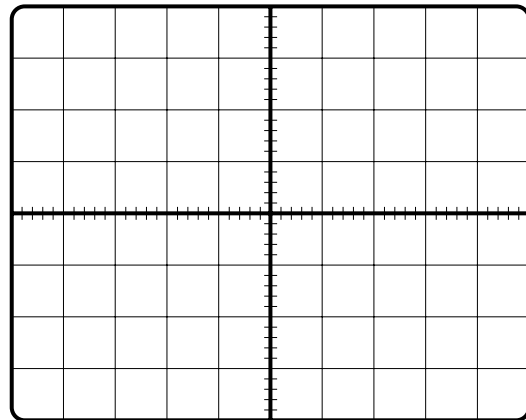
Freq. and Amplitude	Time (sec.)	Peak Amplitude (V_p)	Effective Voltage V_{rms}
f = 500 Hz @ 800 mV _{p-p}			
f = 10 kHz @ 10 V _{p-p}			
f = 25 kHz @ 14 V _{p-p}			
f = 125 kHz @ 5 V _{rms}			

500 Hz @ 800 mV_{p-p}



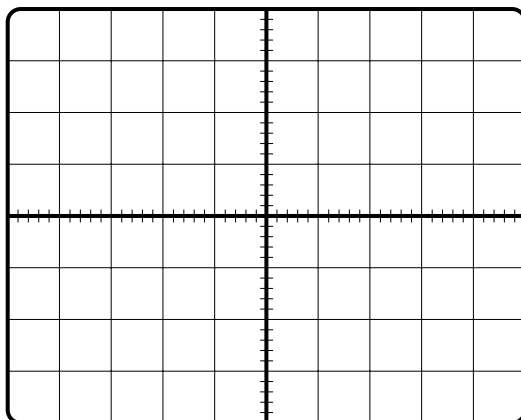
Volts/Div: _____ Time/Div: _____

10 kHz @ 10V_{p-p}



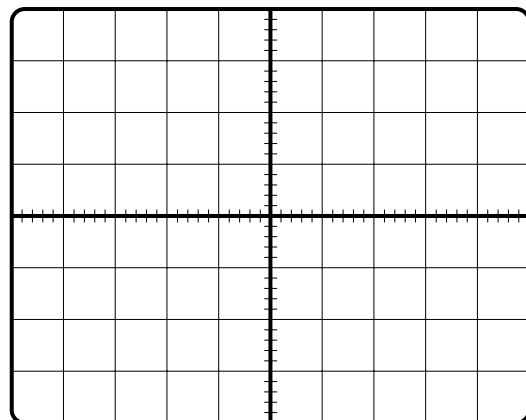
Volts/Div: _____ Time/Div: _____

25 kHz @ 14 V_{p-p}

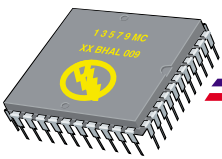


Volts/Div: _____ Time/Div: _____

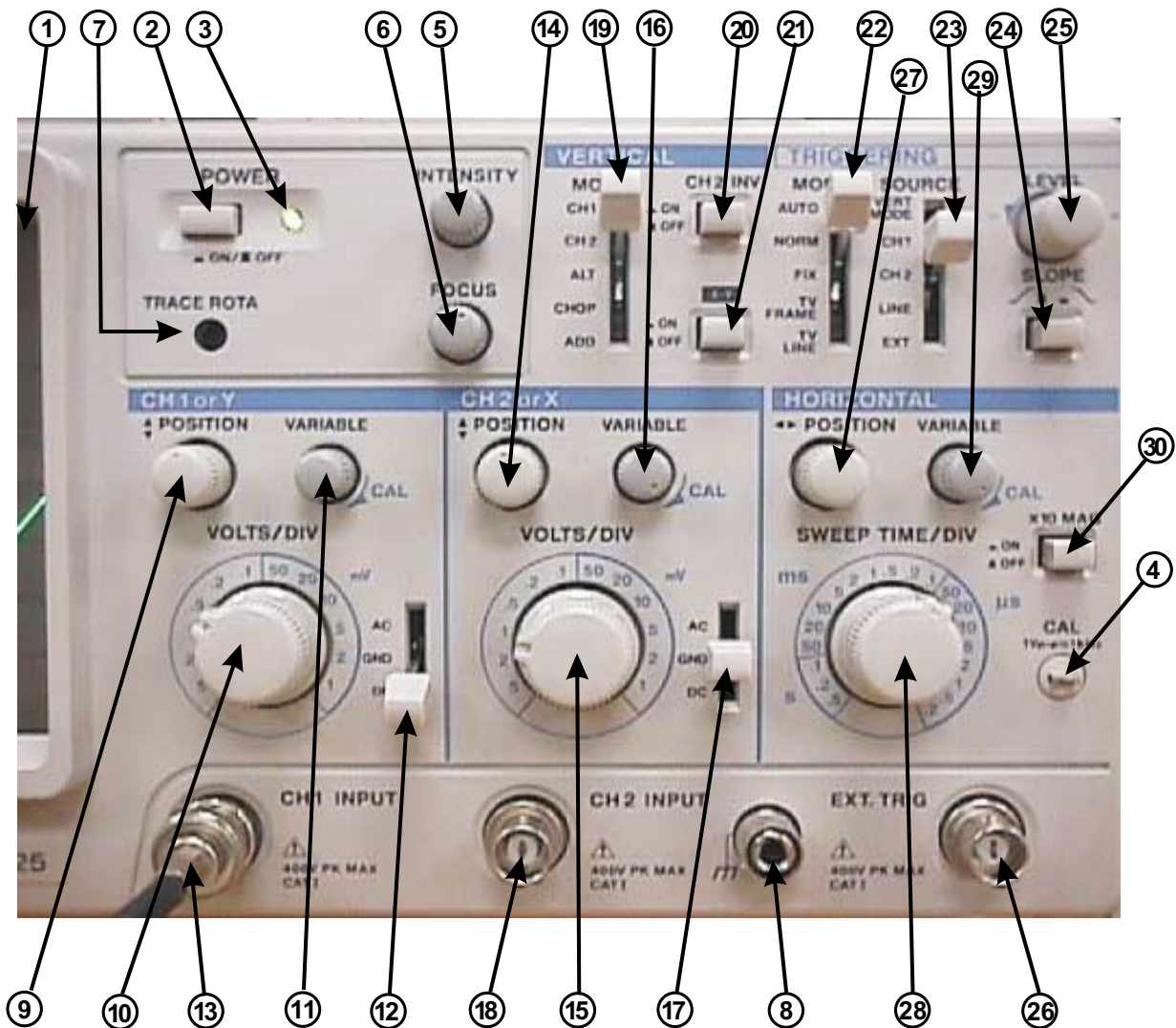
125 kHz @ 5 V_{rms}



Volts/Div: _____ Time/Div: _____



Front Panel Explanation



FRONT PANEL

(1) Cathode Ray Tube (CRT)

The effective display screen surface runs over an area of eight lcm divisions along the vertical axis and ten lcm divisions along the horizontal axis. With an inner graticule etched right onto the tube face, the chance of measurement errors due to parallax occurring between the trace and the graticule have been significantly reduced. There is also a % display for measuring rise time on the left edge of the graticule.

(2) POWER Switch (... ON/ ... OFF)

A push-button type switch that turns the power source on and off. Pressing the switch turns the power on. Pressing it again turns power off.

(3) Pilot Lamp

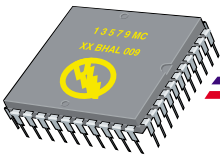
Light ups when the power is turned on.

(4) CAL Terminal

A voltage terminal for calibration. To be used for adjusting the probe. Capable of 1 volt peak to peak, positive polarity, square wave signals with approx. 1kHz is enabled.

(5) INTENSITY Control

For adjusting the brightness of the trace line.



(6) Focus Control

For adjusting the focus and attaining the clearest displays possible. The automatic focussing corrects out-of-focus automatically even when the INTENSITY control is turned.

(7) TRACE ROTATION Control

For adjusting the slope of the horizontal trace line. The slope of the line will change due to such influences as the earth's magnetic force. Use a screwdriver to keep the trace line parallel with the horizontal axis graticule.

(8) GND Terminal

This is the ground terminal to be used when setting up a common ground with other equipment.

(9) POSITION Control

For adjusting the vertical position of the CHANNEL 1 waveform displayed on the CRT screen. During X - Y operation, it is used to adjust the position of Y axis.

(10) VOLTS/DIV Control

For setting the vertical axis sensitivity with the CHI vertical axis attenuator. It can be set in steps of 1,2 and 5. Setting the VARIABLE control all the way to the right at CAL enables calibrated vertical sensitivity. During X - Y operation, it becomes the attenuator control for the Y-axis.

(11) VARIABLE Control

For fine adjustment of CHI vertical axis sensitivity. Allows continuous variable adjustment within the VOL TS/DIV range. When set to the right at CAL, the attenuator can be calibrated. During X - Y operation, it becomes the fine adjustment control for the Yaxis.

(12) AC-GND-DC Switch

For selecting the CHANNEL 1 vertical axis input signal coupling mode.

AC : The input signal will be capacitively coupled, and all DC components will be eliminated. The low range -3dB attenuation point will be 10 Hz or less when using either a 1:1 probe or a coaxial cable, and 1Hz or less when using a corrected 10:1 probe.

GND: Vertical amplifier input is grounded, and the ground potential can be checked. At an input resistance of 1M Ω relative to the ground, the input signal is not grounded. In this mode, the anti-trace line jump circuit prevents the trace position from changing suddenly when switching from GND to AC.

DC: : Provides direct coupling of the input signal, and measurement can be carried out with the direct current component intact.

(13) Input Jack

The CHANNEL 1 vertical axis input jack.
During the X-Y operation, it becomes the Y - axis input jack.

(14) POSITION Control

For adjusting the vertical position of the CHANNEL 2 waveform displayed on the CRT screen. During X - Y operation, it is used to adjust the position of Y axis.

(15) VOLTS/DIV Control

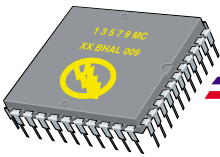
The vertical attenuator CH2. It is operated in the same way as the CHANNEL 1 VOL TS/DIV control. During X - Y operation, it becomes the X -axis attenuator.

(16) VARIABLE Control

For fine adjustment of CH2 vertical axis sensitivity. It is operated in the same way as the CHANNEL 1 VARIABLE control. During X- Y operation it is used for fine adjustment of X-axis sensitivity.

(17) AC-GND-DC Switch

For selecting the CHANNEL 2 vertical axis input signal coupling mode. It is operated in the same way as the CHANNEL 1 AC-GND-DC switch. During X- Y operation, it becomes the X-axis input switch.



(18) INPUT Jack

The CH2 vertical axis input jack. During X - Y operation, it becomes the X -axis input jack.

(19) **VERTICAL MODE Switch** For selecting the vertical axis operation mode.

CH1: For displaying the CH1 input signal on the CRT screen.

CH2 : For displaying the CH2 input signal on the CRT screen.

ALT : Switches between CH1 and CH2 input signals for each sweep and displays them on the CRT screen.

CHOP: For displaying CH1 and CH2 input signals one after the other on the CRT screen, irregardless of sweep and at an occurrence rate of about 150kHz.

ADD: For displaying combined waveform of CH1 and CH2 input signals on the CRT screen. However, when CH2 is set at INV, the difference between CH1 and CH2 will be displayed.

Alternate (ALT) and Chop (CHOP) Modes:

When using these modes during dual trace operation, the display will be divided up according to time. In the chop mode, each channel will be subdivided according to time within each sweep.

Normally, this kind of measurement is carried out with signals of either slower sweep rates from 1ms/ div or low repetition rates where flicker is quite noticeable.

In the alternate mode, each channel will be displayed one after the other as soon as one sweep has been made.

Therefore, each channel display appears much clearer. Normally, a faster sweep is employed.

(20) CHANNEL 2 INVERT Switch

When the button is pushed all the way in, the polarity of the CH2 input signal display will be inverted.

(21) X- Y Oscilloscope Setting Switch

When the button is pushed all the way in, ignores the **VERTICAL MODE** setting and commences operation as an X-Y oscilloscope with CHANNEL 1 as Y axis and CHANNEL 2 as X-axis.

(22) TRIGGERING MODE Selector Switch For selecting trigger operation modes.

AUTO: Sweep is performed by a trigger signal. However, in the absence of a trigger signal, free run will commence and a trace will appear.

NORM: Sweep is performed by a trigger signal. In the absence of a suitable trigger signal, a trace will not appear.

FIX: Sweep trigger level is fixed. In this case, triggering is made regardless of LEVEL control (25) setting.

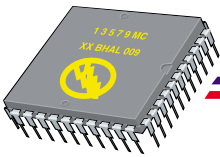
TV - FRAME: Composite video signal vertical sync pulses are selected out and coupled to the trigger circuit.

TV-LINE: Composite video signal horizontal sync pulses are selected out and coupled to the trigger circuit.

Note: The trigger signal is capacitively coupled to the trigger circuit in this oscilloscope.

(23) SOURCE Selector Switch For selecting the trigger signal source.

VERT MODE: The trigger signal source will be selected by the VERTICAL_Mode setting. (See table 1)



- CH1:** The CH1 input signal will become the trigger signal source.
- CH2:** The CH2 input signal will become the trigger signal source.
- LINE:** The commercial-use power source voltage waveform will become the trigger signal source.
- EXT:** The signal being input into the EXT. TRIG jack will become the trigger signal source.

Vertical Mode	Trigger Signal Source
CH1	CH1
CH2	CH2
ALT	Switches between CH1 and CH2 input signals for each sweep and selected for trigger signal source
CHOP	CH1
ADD	Combined signal of CH1 and CH2 input signal

Table 1 Settings for the Vertical Mode Switch

(24) SLOPE Control

.....For selecting the slope polarity of the triggered sweep signal. When the push- button is out , triggering will be performed with thetrigger source signal rising. When the push- button is pressed in, triggering will be performed with the trigger source signalfalling.

(25) LEVEL Control

.....For adjusting the trigger threshold level. This will determine at what point on the signal waveform slope sweep willcommence.

(26) EXT.TRIG Input Jack

.....The input terminal for externally generated trigger signals. When the SOURCE switch is set at EXT, signals input throughthis terminal will become the trigger signal source.

(27) POSITION Control

.....For adjusting the horizontal position of waveform displayed on the CRT screen.

(28) SWEEP TIME/DiV Control

.....For setting the sweep time. Setting can be carried out over 20 steps between 0.2 μ S s/div and 0.5s/div in a 1-2-5 step sequence.When the VARIABLE control is set all the way to the right at CAL, sweep rate values will become calibrated.

(29) VARIABLE Control

.....Continuous sweep time adjustment can be carried out within the SWEEP TIME/DIV range by this fine control. The sweeptime becomes compensated by turning the CAL all the way clockwise.

(30) x 10 MAG Switch

.....Press this switch to magnify the display 10 X left and right from the centre of the CRT screen.