EXPERIMENT NO: 02

Aim: Measurement of voltage and frequency using a ~~CRO~~. digital oscilloscope.

Objective:

i. Detailed study of CRO and its functions.
ii. Measurement of amplitude and frequency of a given function.

Apparatus Required: Function generator (Signal source), CRO, BNC connecting probes.

Theory:

a. Function Generator:

A function generator is electronic test equipment used to generate different types of waveforms over a wide range of frequencies. function generators are capable of producing a variety of repetitive waveforms, some of which are listed below.

Sine Wave: A function generator will normally have the capability to produce a standard sine wave output. this is the standard waveform that oscillates between two levels with a standard sinusoidal shape as shown in Fig. 2.1.

Figure 2.1: Sine Wave

Square Wave: A square wave is normally relatively easy for a function generator to produce. it consists of a signal moving directly between high and low levels as shown in Fig. 2.2.

Figure 2.2: Square Wave

Pulse: A pulse waveform is another type that can be produced by a function generator. it is effectively the same as a square wave, but with the mark space ratio very different to 1:1 as shown in Fig. 2.3.

Figure 2.3: Pulse

Triangular Wave: This form of signal produced by the function generator linearly moves between a high and low point as shown in Fig. 2.4.

Figure 2.4: Triangular Wave

Saw Tooth Wave: Again, this is a triangular waveform, but with the rise edge of the waveform faster or slower than the fall, making a form of shape similar to a saw tooth as shown in Fig. 2.5.

Figure 2.5: Sawtooth Wave

These waveforms can be either repetitive or single-shot. function generators are used in the development, test and repair of electronic equipment. Fig. 2.6 shows front view of a function generator.

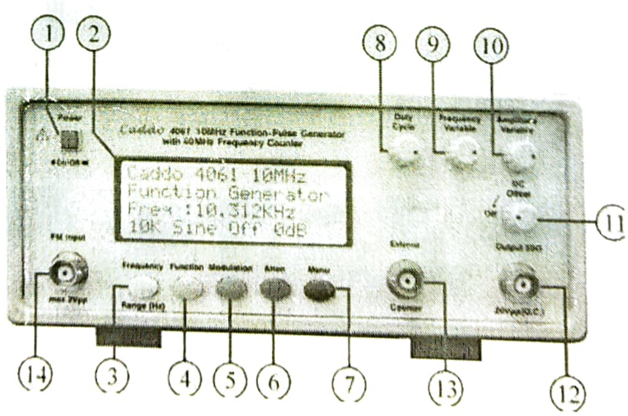


Figure 2.6: Front View of Function Generator

Table 2.1: Function Generator Control Knobs

Knob No.	Control Name	Functions
1	Power	Push button switch to power ON the instrument.
2	LCD Display	20 x 4 Character bright back lit Liquid Crystal Display.
3	Frequency	Used for selection of frequency range step by step.
4	Function	Used for selection of Particular waveform. A total number of 6 different waveforms: ➢ Sine ➢ Square ➢ Triangular ➢ Ramp ➢ Pulse
5	Modulation	Used for selection of Frequency Modulation.
6	Attenuation	Used for Selection of 20dB or 40dB attenuation
7	Menu	Used for selection of Function Generator/Frequency counter mode.
8	Duty Cycle	When pulse output function is selected, this controls the pulse duty cycle from 15% to 85%.
9	Frequency Variable	In conjunction with frequency range, selected by frequency key on front Panel.
10	Amplitude Variable	In conjunction with attenuators (6), this varies the level of output.
11	DC Offset	This control provides DC offset. Approximately ±5VDC is superimposed on the output. Keep the control off if DC offset is not required.
12	Output (BNC Connector)	Output of 10 MHz function generator i.e. 20Vpp (Open Circuit)
13	External Counter (BNC Connector)	Input BNC connector for measuring the frequency of external signal when External Counter mode is selected

		by Menu key on the LCD display.
14	Modulation Input	Maximum modulation Input i.e. 2Vpp.

b. Cathode Ray Oscilloscope (CRO): X

It is primarily used for visual indication of signal waveform. it is basically a very fast X – Y plotter. the heart of CRO is a vacuum tube called Cathode Ray Tube (CRT).

CRT consists of 3 basic components as shown in Fig. 2.7:

1. **Electron gun,** which produces sharply focused beam of electron accelerated to a very high velocity. It consists of cathode, anode and grid.
2. **Deflection system,** which deflects electrons, both in horizontal & vertical planes. It consists of X &Y-plates
3. **Fluorescent screen,** upon which beam of electrons impinges to produce a spot of visible light.

When the cathode is heated (by applying a small potential difference across its terminals), it emits electrons. Potential difference between the cathode and the anode (electrodes) accelerate the emitted electrons towards the anode, forming an electron beam which passes to fall on the screen. when the fast electron beam strikes the fluorescent screen, a bright visible spot is produced.

The grid, which is situated between the electrodes, controls the amount of electrons passing through it thereby controlling the intensity of the electron beam. the X&Y- plates are responsible for deflecting the electron beam horizontally and vertically. a sweep generator is connected to the X-plates, which moves the bright spot horizontally across the screen and repeats that at a certain frequency as the source of the signal. the voltage to be studied is applied on Y-plates. the combined sweep and Y voltages produce a graph showing the variation of voltage with time.

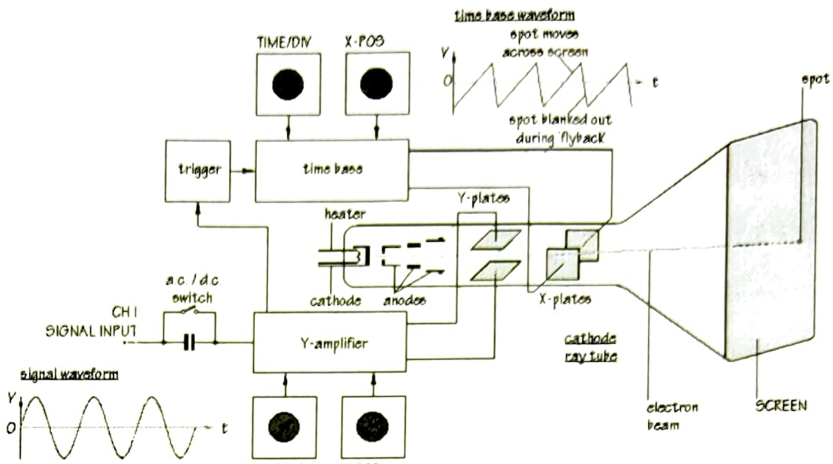


Figure 2.7: Cathode Ray Oscilloscope

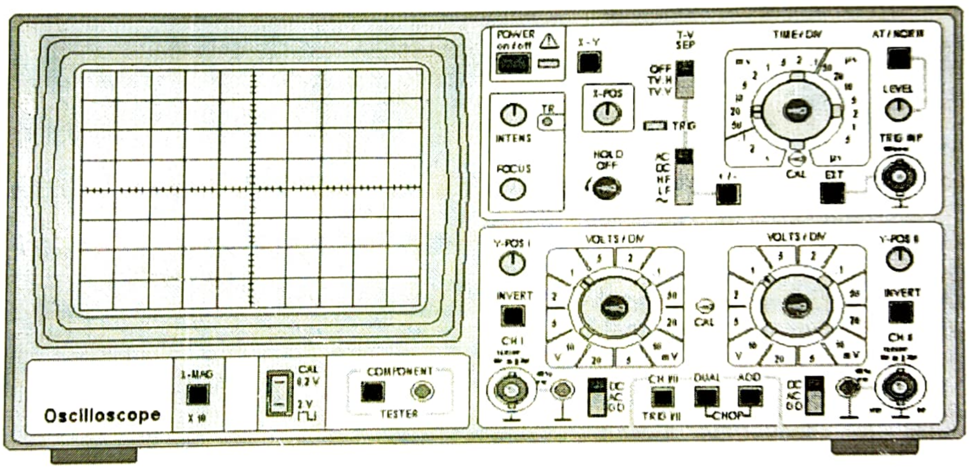


Figure 2.8: View of Oscilloscope

Fig. 2.8 shows 2-D view of CRO. it consists of:

Screen: Usually displays a V/t graph, with voltage V on the vertical axis and time T on the horizontal axis. the scales of both axes can be changed to display a huge variety of signals.

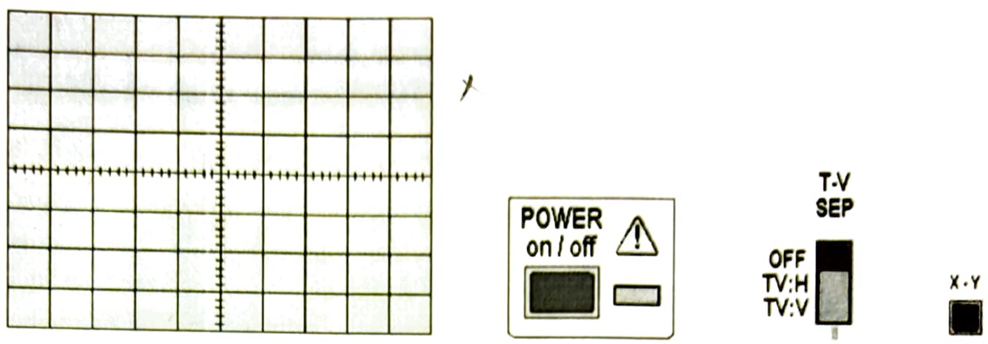


Figure 2.9: Front View of Oscilloscope

Power On/Off switch Pushed in to switch the oscilloscope on. the LED illuminates.

X-Y Control: Normally in the OUT position.

When the X-Y button is pressed IN, the oscilloscope does not display a *V/t* graph. Instead, the vertical axis is controlled by the input signal to CH II. this allows the oscilloscope to be used to display a *V/V* voltage/voltage graph.

The X-Y control is used when you want to display component characteristic curves.

TV-Separation: Oscilloscopes are often used to investigate waveforms inside television systems. this control allows the display to be synchronized with the television system so that the signals from different points can be compared.

Time / Div: Allows the horizontal scale of the *V/t* graph to be changed.

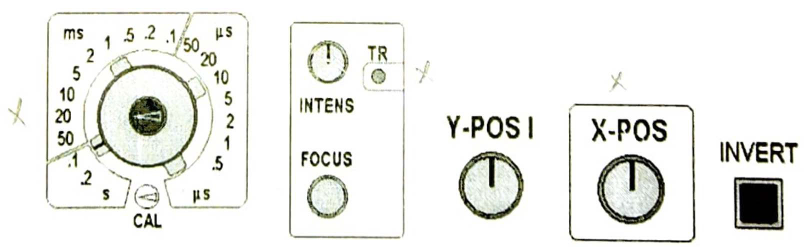


Figure 2.10: Time division, Intensity, focus, X-Y mode knobs

Intensity and Focus: Adjusting the INTENSITY control changes the brightness of the oscilloscope display. the FOCUS should be set to produce a bright clear trace.

If required, TR can be adjusted using a small screwdriver so that the oscilloscope trace is exactly horizontal when no signal is connected.

X-POS: Allows the whole *V/t* graph to be moved from side to side on the oscilloscope screen.

This is useful when you want to use the grid in front of the screen to make measurements, for example, to measure the period of a waveform.

Y-POS I and Y-POS II: These controls allow the corresponding trace to be moved up or down, changing the position representing 0 V on the oscilloscope screen.

To investigate an alternating signal, adjust Y-POS so that the 0 V level is close to the centre of the screen. For a pulse waveform, it is more useful to have 0 V close to the bottom of the screen. Y-POS I and Y-POS II allow the 0 V levels of the two traces to be adjusted independently.

Invert: When the INVERT button is pressed IN, the corresponding signal is turned upside down, or inverted, on the oscilloscope screen. this feature is sometimes useful when comparing signals.

CH I And CH II Inputs: Signals are connected to the BNC input sockets using BNC plugs.

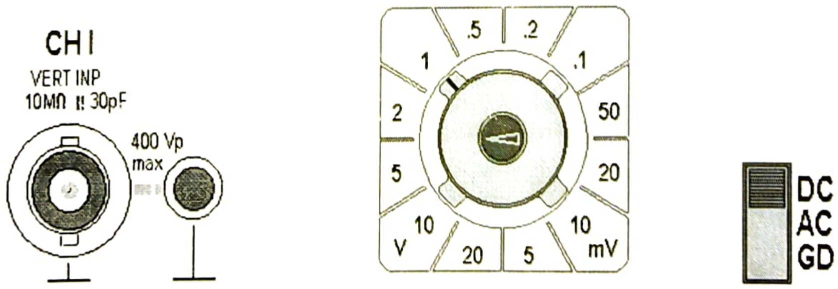


Figure 2.11: Voltage division, Channels, AC, DC and GND knobs

The smaller socket next to the BNC input socket provides an additional 0 V, GROUND or EARTH connection.

Volts / Div: Adjust the vertical scale of the *V/t* graph. the vertical scales for CH I and CH II can be adjusted independently.

DC/AC/GND Slide Switches: In the DC position, the signal input is connected directly to the Y-amplifier of the corresponding channel, CH I or CH II. In the AC position, a capacitor is connected into the signal pathway so that DC voltages are blocked and only changing AC signals are displayed.

In the GND position, the input of the Y-amplifier is connected to 0 V. this allows you to check the position of 0 V on the oscilloscope screen. the DC position of these switches is correct for most signals.

Trace Selection Switches: The settings of these switches control which traces appear on the oscilloscope screen.

Experimental Procedure:

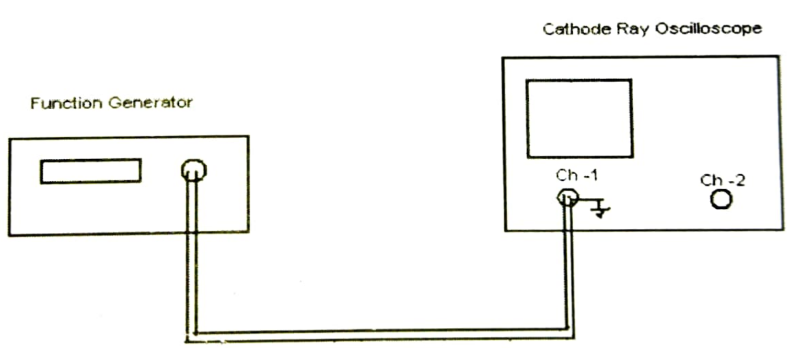
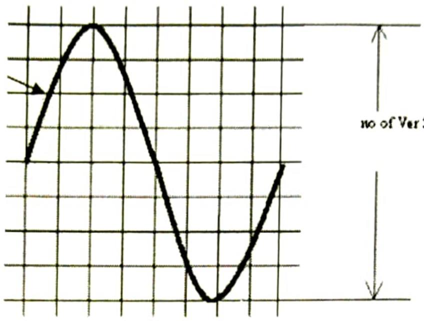


Figure 2.12: Set up for measurement of Voltage& Frequency

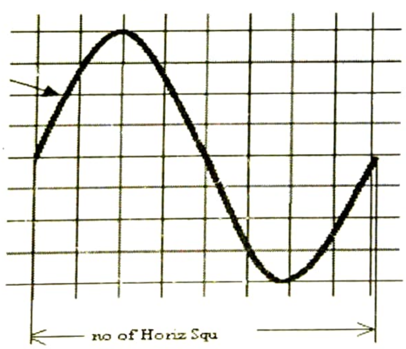
1. Turn on the Oscilloscope
2. Adjust the intensity and the focus of the trace.
3. Use the X & Y knobs to center the trace horizontally and vertically.
4. Connect the cable from Ch1 of the CRO to Function generator.
5. A signal will appear on the screen.

6. Make sure that the inner red knobs of the Volt/Div and the Time/Div are locked clockwise.
7. Set the frequency of the generator to 100 Hz.
8. Adjust the Volt/Div and the Time/Div knobs so that you get a suitable size signal
9. **For voltage measurement:** Count the number of vertical squares lying within the signal, then calculate the peak to peak value as:



$V_{p\text{-}p}$= (no. of vertical divisions or units noted) × $(\frac{Volts}{Divisions})$

10. **For frequency measurement:** Count the number of horizontal squares lying within the one Duty Cycle, then calculate time value as:



Waveform is displayed on screen & one complete cycle is visible on screen. thus accuracy increases if a single cycle occupies as much as horizontal distance on screen.

T = No. of horizontal divisions occupied by one cycle × $(\frac{Time}{Division})$

Frequency can be calculated as Frequency (f) = $\frac{1}{T}$

Observations:

(1) Measurement of Voltage:

S.No.	Waveform	No. of vertical divisions (A) (div)	Amplitude multiplier position (B) (volt/div)	Peak-to-Peak Voltage (V_{p-p}) A*B	Maximum amplitude ($V_m = V_{p-p}/2$)
1.	Sine				
2.	Square				
3.	Triangular				
4.					
5.					
6.					

(2) Measurement of Frequency:

S.No.	Waveform	Applied Frequency	Horizontal division X (div)	Time multiplier Y (ms/div)	Time period T (X*Y) (ms)	Observed Frequency ($F=1/T$) (Hz)	Error %
1.	Sine						
2.	Square						
3.	Triangular						
4.							
5.							
6.							

Result: Detailed study of CRO has been completed and the voltage and frequency values of the given function have been observed on CRO and calculated.

Result Analysis & Discussion: This section should be written individually by each student.

Inferences & Conclusion: This section should be written individually by each student.

Learning Outcomes:

1. Knowledge of different functions of CRO.
2. Knowledge of different waveform patterns
3. Knowledge of measurement of amplitude and frequency for any unknown waveform.

Applications:

1. To examine waveforms.
2. In measurement of voltage and current.
3. In measurement of phase and frequency.

Precautions:

1. Check the power supply before turning on CRO.
2. Take the readings carefully.
3. Make calculations for voltage and current carefully.