EXPERIMENT 9

USING AN OSCILLOSCOPE

Structure

9.1 INTRODUCTION

In Unit 6, you have learnt that a **cathode ray oscilloscope** (CRO), simply called oscilloscope, is used for measuring the peak value and frequency of alternating voltages and currents, and tracing their waveforms. The CRO is used in quite a few experiments in electronics in a UG physics lab. Therefore, you should learn how to operate and maintain it.

A school or college physics laboratory has simple oscilloscopes with fewer numbers of control knobs on their front panel. You have studied about such an oscilloscope in Unit 6. In this experiment, we will familiarise you with the control knobs of a simple oscilloscope. You will learn how to use the CRO to measure the peak value (amplitude) and frequency of AC voltages and currents. You will also get an opportunity to read the manual accompanying a CRO and use it to operate the CRO. You should ask for the manual from your counsellor.

9.2 AIM

The purpose of this experiment is to give you hands-on experience in using and maintaining a simple oscilloscope. You will also make measurements with the help of an oscilloscope.

After doing this experiment, you should be able to:

- identify and state the functions of various control knobs on the front panel of an oscilloscope;
- measure the peak value of AC voltage;
- measure the frequency of AC voltage; and
- take care of and maintain an oscilloscope.

The following apparatus is required for this experiment:

Apparatus
Oscilloscope, signal generator and tracing paper.

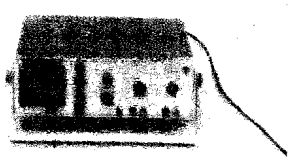

Fig.9.1: A simple cathode ray oscilloscope

9.3 MEASUREMENTS WITH AN OSCILLOSCOPE

Fig.9.1 shows the front panel of a simple CRO. Before you use an oscilloscope for measuring AC voltages and currents, you should be familiar with the

functions of various controls in a CRO. For this purpose, you should do the following activity.

Activity

a) List the control knobs on your CRO. Read the manual accompanying it or read Sec. 6.4 of Unit 6 and write down the functions of the various control knobs.

b) Using a metre scale, measure and note down the smallest separation that can be measured along the horizontal and vertical axes on the oscilloscope screen.

Discuss the outcome of this activity with your counsellor and if s/he is satisfied, you may proceed further.

The basic features of *AC* voltage are its amplitude, frequency and waveform. In this experiment, you will measure the (i) peak value (amplitude) and (ii) frequency of an applied *AC* voltage, and trace its waveform. *AC* voltage can be applied to the CRO using a **signal generator** or **oscillator**. A signal generator usually has the following control knobs on its front panel (Fig.9.2):

- **Output terminals**: The *AC* signal is drawn from these terminals.
- **Output amplitude selector**: By adjusting this knob, you can vary the amplitude of the voltage generated by it.
- **Frequency selector**: By adjusting this knob, you can vary the frequency of the output voltage.

There is also an ON-OFF switch to turn the signal generator on. You should familiarise yourself with these controls before proceeding further.

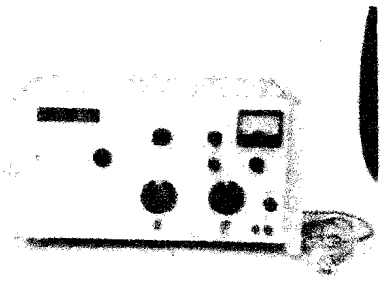

Fig.9.2: Signal generator

You will now set up the CRO for measuring the peak value and frequency of the *AC* voltage. **However, before you operate the oscilloscope you must carefully go through Sec. 6.4 of Unit 6 taking note of the precautions listed there.**

A. Setting up the CRO

1. Set the CRO in *AC* mode.
2. Set the time base control in off position.
3. Switch the oscilloscope on. Adjust the **focus** and **brightness** knobs to obtain a spot at the centre of the screen.

As you know, the bright spot at a fixed point on the screen for a long time may damage it. Therefore, after focussing the spot, keep the brightness control switched off until you are ready for measurement.

4. Set the gain control knob to say, 2V cm^{-1}. This means that 1 cm on the y-axis of the oscilloscope is equal to 2V. Now your oscilloscope is ready for receiving the AC input voltage.
5. Set the controls of the signal generator as follows:
   Amplitude : 4V
   Frequency: 100Hz
6. Connect the output of the signal generator to the input (y-terminals) of the oscilloscope as shown in Fig.9.3.

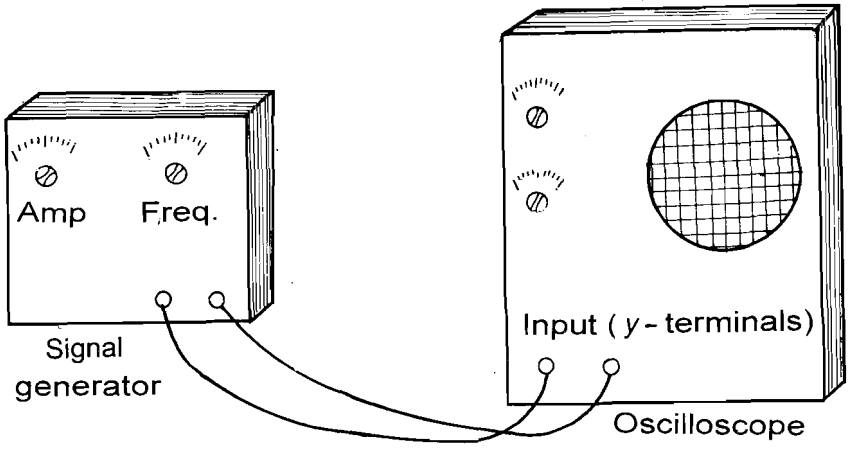

Fig.9.3: Circuit diagram for connecting an oscilloscope and a signal generator

7. Switch on the signal generator and the brightness control of the oscilloscope. You should observe a vertical line on the screen. If the line is too small or too big (so that it is extending beyond the screen,) adjust the gain control setting to bring it to a moderate height.
8. Turn the time base control on and set the trigger control to **automatic**. Adjust the x-shift, y-shift and time base controls to obtain a stable sinusoidal wave form on the screen as shown in Fig.9.4.
9. Trace the wave form of the signal on a tracing paper.

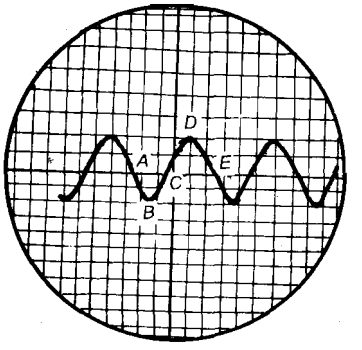

Fig.9.4: Wave form of the signal on the CRO screen

You can now determine the peak value and frequency of the AC signal as follows.

B. Measurement of peak value

1. Note down gain control setting:..... Vcm^{-1}
2. Count the number of divisions along the y-axis covered between points B and D of Fig.9.4. Note down the distance d, in cm, between these points:.....cm
3. The peak to peak value of the AC voltage,

$$V_p = d(\text{cm}) \times \text{gain control setting } (Vcm^{-1})$$

$$=.....V$$

The peak value of the AC voltage is obtained by dividing the peak to peak voltage by 2.

4. Peak value of AC voltage = ...V.

For the gain control setting at 2V cm^{-1}, the distance between B and D should be 4 cm corresponding to the given input signal. Therefore, the peak to peak voltage is 2 Vcm^{-1} × 4 cm = 8 V and the peak value is 4 V.

Note: To measure the distance BD accurately, make sure that either B or D touches a horizontal line. To achieve this, use the y-shift control knob.

ms cm^{-1} stands for milli seconds per centimetre. Time base control settings are usually in μs (10^{-6}s), ms (10^{-3}s) and s.

C. Measurement of frequency

1. Note down the time base control setting:.....ms cm^{-1}.
2. Use the x-shift to adjust the wave form so that either point A or E shown in Fig. 9.4 touches a vertical line.
3. Note down the distance between points A and E along the x-axis: .....cm
4. The time period T of the signal

   = AE (cm) × time base control setting (ms cm^{-1}).

   =.....ms = ... × 10^{-3} s
5. The frequency of the signal, $f = \frac{1}{T}$, where T is in seconds.

For example, if the time base control setting is at 2 ms cm^{-1}, and the distance AE = 5 cm,

the period of the signal, $T = 5\text{cm} \times 2\times10^{-3}\ \text{s cm}^{-1}$

$= 10^{-2}$ s

Therefore,

frequency of the signal $= \frac{1}{10^{-2}}\text{Hz} = 100\text{Hz}.$

Keeping the settings of the signal generator fixed, change the gain control and again obtain a stable wave form. Repeat the calculations above. You should get the same results.

Repeat the entire procedure for at least three different settings of amplitude and frequency of the signal generator and tabulate your results. Compare the values you obtain with the corresponding settings of the signal generator.

For each setting of the frequency of the signal generator, you will have to adjust the time base control knob of the oscilloscope to obtain a stable waveform.

List the precautions you have taken while using the CRO in this experiment.

APPENDIX

Experiments	Marks
1. Measurements in Physics	**(10)**
Handling of vernier callipers and screw gauge while taking observations for Observation Tables 1.1 and 1.2	3+3
Solving SAQ 1 and other exercises given in the text	2
Viva on care and maintenance aspects	2
2. Stationary Waves in Stretched Strings	**(10)**
Setting up of experimental arrangement, including handling of sonometer, tuning fork and physical balance	4
Completing Observation Tables 2.1 and 2.2	2
Graphing and Calculations	2
Viva on care and maintenance aspects	2
3. Measurement of Thermal Properties	**(10)**
Setting up of experimental arrangement for specific heat capacity of water and completing Observation Table 3.1	4
Setting up of telescope and optical lever arrangement and completing Observation Table 3.2	3
Graphing and Calculations	1
Viva on care and maintenance aspects	2
4. Investigations with Mirrors and Lenses	**(5)**
Activity in Sec. 4.3	1
Setting up of experimental arrangements and completing Observation Tables 4.1 and 4.2	3
Viva on care and maintenance aspects	1
5. Working with a Spectrometer	**(15)**
Adjusting the telescope, prism table, collimator and levelling the spectrometer	4
Handling of prism, sodium/mercury lamp and observing spectra	3
Completing Observation Tables 5.1 and 5.2	2+2
Graphing and calculations	2
Viva on care and maintenance aspects	2

6. Handling and Maintaining a Multimeter		**(15)**
	Activity in Sec. 6.3	2+1+1
	Measurement of resistance, *AC* and *DC* currents and voltages and testing the continuity of a wire	4
	Testing an electrolytic capacitor, *pn* junction diode and *pnp* and *npn* transistors	4
	Using the multimeter for identification of *p*- and *n*-ends of a *pn*-junction diode and emitter, base and collector terminals of *npn* and *pnp* transistors	1
	Viva on care and maintenance aspects	2
7. Fabrication of an Extension Board		**(10)**
	Identification of live, neutral and earth terminals of a socket and three core electrical wire	1
	Assembling the extension board including the quality of joints, placement of sockets and switches on the board	7
	Viva on care, maintenance and safety aspects	2
8. Simple Current and Voltage Measurements		**(10)**
	Activity in Sec. 8.3 and completing Observation Tables 8.1 and 8.2	1+1+1
	Setting up the experimental arrangements for handling ammeters and voltmeters and completing Observation Tables. 8.3, 8.4 and 8.5	4
	Plotting *IV* characteristics of resistor and a *pn*-junction diode; obtaining results and calculation of errors	1
	Viva on care, maintenance and safety aspects	2
9. Using an Oscilloscope		**(15)**
	Activity in Sec. 9.3	4+1
	Adjusting the signal generator for a sine wave output	2
	Setting an oscilloscope to display the sinusoidal signal	3
	Measurement of peak value and frequency of *AC* signal	3
	Viva on care, maintenance and safety aspects	2