Physics Department
Kuwait University EXP. NINE
Course 127

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Cathode-ray Oscilloscope (CRO)

Objective

- To introduce the basic structure of a cathode-ray Oscilloscope.
- To get familiar with the use of different control switches of the device.
- To visualize an ac signal, measure the amplitude and the frequency.

Theory

Cathode-ray Oscilloscope

The device consists mainly of a vacuum tube which contains a cathode, anode, grid, X&Y-plates, and a fluorescent screen (see Figure below). When the cathode is heated (by

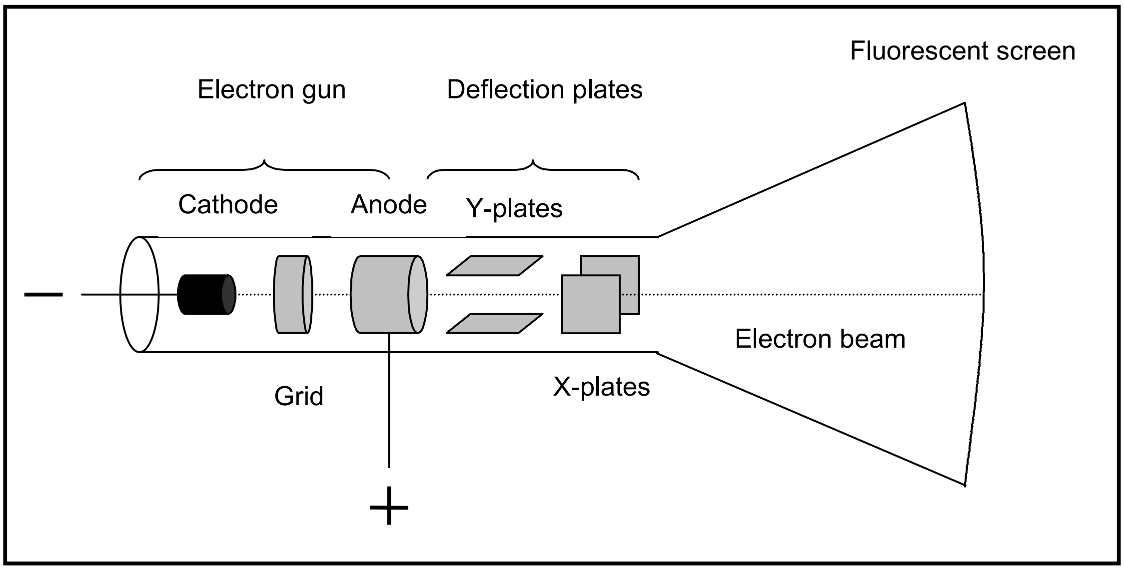

Figure 1: The basic structure of a *CRO*

applying a small potential difference across its terminals), it emits electrons. Having a 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 to the Y-plates. The combined sweep and Y-voltages produce a graph showing the variation of voltage with time, as shown in Fig. 2.

Front panel

The front panel of the *CRO* is shown in Fig. 2.

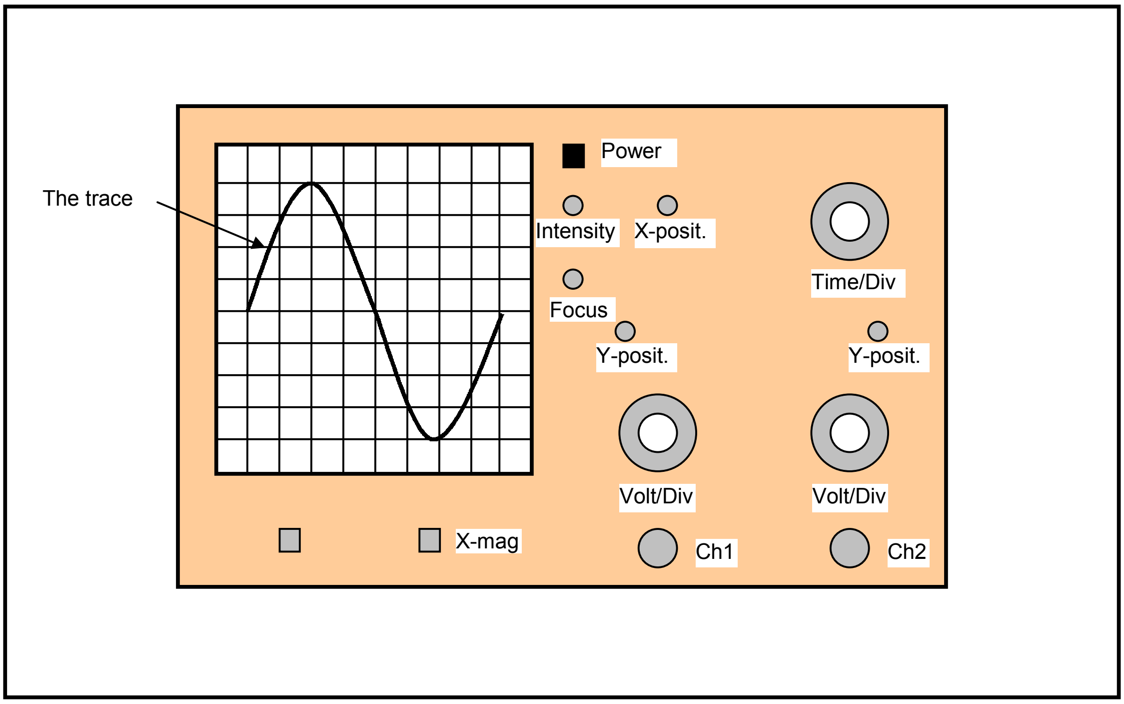

Figure 2: The front panel of the *CRO*

Alternating current (ac)

An ac signal can be of different forms: sinusoidal, square, or triangular. The sinusoidal is the most popular type, which is the natural output of the rotary electricity generators. An ac voltage source can be represented by

$$\varepsilon(t) = \varepsilon_m \sin(\omega t + \phi), \quad (1)$$

where ε_m is the maximum output voltage value, $\omega = 2\pi f$ (f is the frequency), and ϕ is the phase shift. The root-mean-square value, ε_{rms}, of the signal given by Eq.(1), can be written as

$$\varepsilon_{rms} = \sqrt{\frac{\int_0^T \varepsilon_m^2 \sin^2(\omega t + \phi)}{T}}, \quad (2)$$

which is reduced to

$$\varepsilon_{rms} = \frac{\varepsilon_m}{\sqrt{2}}, \quad (3)$$

Equipment

- Cathode-ray Oscilloscope.
- Electronic design experimenter (Heathkit).
- Multimeter.
- Wires.

Procedure

Part one

1. Turn on the Oscilloscope, wait a couple of seconds to warm up, then the trace will show up on the screen.
2. Adjust the intensity and the focus of the trace.
3. Use the X &Y-post. knobs to center the trace horizontally and vertically.
4. Connect a cable to Ch1 socket.
5. Turn on the Heathkit.
6. Connect the cable from Ch1 of the *CRO* to the SIN connector of the Heathkit, via a piece of wire.
7. A signal will appear on the screen.
8. Make sure that the inner red knobs of the Volt/Div and the Time/Div are locked clockwise.
9. Set the frequency of the generator to 200 Hz.

10. Adjust the Volt/Div and the Time/Div knobs so that you get a suitable size signal (from 1-2 wavelengths filling most of the screen vertically).
11. Count the number of vertical squares lying within the signal, then calculate the peak to peak value as:

$$V_{p-p} = \text{No. vertical Div.} \times \text{Volt/Div}$$

12. Calculate V_{rms} value, record in Table I:

$$V_{rms} = \frac{V_{p-p}}{2\sqrt{2}},$$

13. Measure V_{rms} using the multimeter (connect the probes of the multimeter to the SIN and the GND connectors).
14. Calculate the period T, record in Table I:

$$T = \text{No. horizontal Div.} \times \text{Time/Div}$$

15. Calculate the frequency, $f=1/T$, record in the table.
16. Repeat steps 10-14 for the frequency values as in the table.

Table I

Frequency (f) Hz	Period (T) sec	f (Hz)	V_{p-p} (V)	V_{rms} (V)
200				
X				
1000				
Y				
2000				

$V_{rms(multimeter)}=$

part two

1. Connect the cable from Ch1 to the upper connector of the line frequency of the Heathkit.
2. Adjust the Volt/Div and the Time/Div knobs so that you get a suitable size signal (from 1-2 wavelengths filling most of the screen vertically).
3. Calculate the peak to peak voltage value.
4. Calculate V_{rms} value.
5. Measure V_{rms} using the multimeter.

6. Measure the period T, then calculate the frequency.

$V_{p\text{-}p}$=

V_{rms}=

$V_{rms(multimeter)}$=

T=

f=

Questions

1. What is the purpose of the grid, and X&Y-plates?
2. For a certain ac input signal, if the Volt/Div knob is set to alower value, what effect does this have on the size of the signal on the screen?
3. The X-mag button magnifies the signal horizontally; is this button used for high or low frequency signal? Why?
4. What is the physical meaning of the root-mean-square value of an ac signal?