EP10 Operation of a cathode ray oscilloscope (CRO)

OBJECTIVE

1. To understand the principle of a CRO.
2. To learn how to measure an A.C or a D.C voltage using a CRO.
3. To learn how to measure an unknown frequency using a CRO.

THEORY

The CRO is one of the most commonly used and most useful instruments in a physics laboratory. It is conventionally an analog system (some modern high performance CROs digitize the signals and process them digitally) and gives two dimensional displays of analogy signals. A CRO consists of three main parts: an electron gun, a fluorescent screen, and two pairs of deflection plates (X-plates and Y-plates). Other major additional feature includes trigger units.

When voltage signals V_x and V_y (or quantities converted to voltages) are applied to X- and Y-plates, horizontal defection x and vertical deflection y will be proportional to V_x and V_y. The voltages fed to the X-plate can be either an external voltage signal V_x or a time base voltage. In the former case, the CRO shows a graph of V_y versus V_x. In the later case, the CRO will show a graph of V_y versus time t. The time base generates a voltage which rises steadily to a certain value and then falls to its original value in a short time. The spot sweeps steadily from left to right when the voltage is rising, and then flies rapidly back when the voltage is falling and then starts out again. To make the time base frequency to synchronize with that of the input signal, a triggering pulse is applied to the time base generator from the Y- or input-signal through the trigger unit.

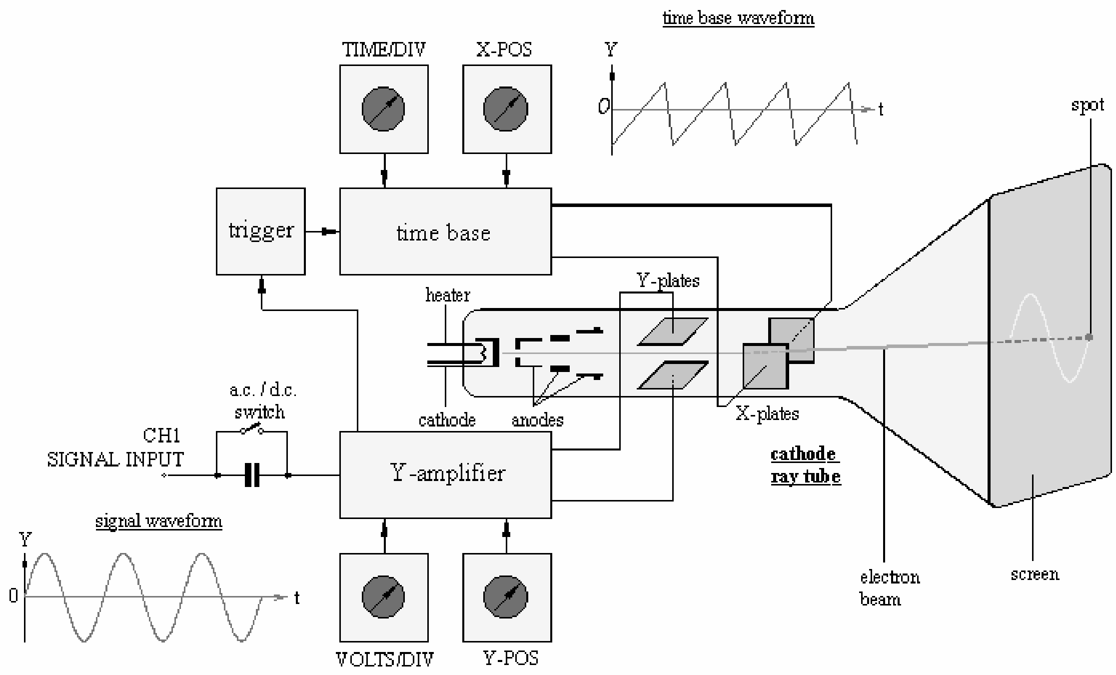


Fig1 the principle of CRO

PROCEDURE

(A) Adjust the device

(i) Initial setting up (for all models of CRO)

Before connecting the power cord to an AC line outlet, check that the AC line voltage selector plug on the rear panel of the instrument is correctly set for the AC line voltage. After ensuring the voltage setting, set the switches and controls of the instrument in the following positions:

POWER	II OFF position
INTENSITY	Mid-position
FOCUS	Mid-position
VERT MODE	CH1
↑ POSITION	Mid-position, push in
VOLTS/DIV	500 ***mV/DIV***
VARIABLE	CAL'D fully clockwise
AC-GND-DC	GND
LEVEL	Mid-position
SWEEP MODE	AUTO
TIME/DIV	0.5 ms***/DIV***
VARIABLE	CAL'D fully clockwise
↔ POSITION	Mid-position

(ii) Displaying an ac waveform: Use of the Signal Generator

After setting the switches and controls as indicated above, connect the power cord to the AC line outlet and then proceed as follows:

1. Turn-on the POWER switch and make sure that the power pilot LED is on. In about 20**s**, a trace will appear on the screen. If no trace appears after about 60**s**, repeat the switch and control settings as shown in the above.

2. Adjust the trace to an appropriate brightness and to the sharpest image with the INTENSITY control and FOCUS control.

3. Align the trace with the horizontal center line of graticule by adjusting the CH1 POSITION control

4. Connect the probe to the CH1 INPUT terminal.

5. Adjust the FOCUS control until the trace becomes sharp.
   Select the required SINE OUTPUT and Set the frequency to *100***Hz**. Then connect the signal generator output to the C.R.O. and switch the AC-GND-DC to AC.
6. For displaying the signal, adjust the VOLTS/DIV switch and TIME/DIV to appropriate positions so that the signal waveform is displayed with appropriate amplitude and an appropriate number of peaks (4 or 5).
7. Adjust the ↑ position and ↔ position controls to appropriate positions so that the displayed waveform is aligned with the graticule and the voltage $V_{p\text{-}p}$ and period T can be read as desired. Record the SWEEP TIME/DIV.

8. Set the frequency to *1K***Hz,** *10K***Hz,** *100K***Hz**, repeat procedure 6, 7and record the SWEEP TIME/DIV values in table 1.

The above is the basic operating procedure for single-channel operation with CH1. Single-channel operations with CH2 can also be made in a similar manner.

(B) Measuring voltage

(i) Measuring the virtual value of a A.C voltage

Set the frequency to *1K***Hz,** adjust the VOLTS/DIV switch and TIME/DIV to appropriate positions, Adjust the ↑ position in order to measure the Vp-p, then calculate its virtual value using the following equation:

$$U = \frac{\sqrt{2}}{4} \times V_{p-p} \qquad V_{p-p} = H \times VOLT / DIV \times Attenuation\ ratio\ of\ the\ probe$$

(ii) Measuring a D.C voltage

Connect a **D.C power supply** across the CH1 input-earth or CH2 input-earth terminal with either polarity. The AC-GND-DC is set to DC. This applies a dc potential to the Y-plates. Rotate the screw on the panel until the index points 1.5V. Measure the shift in cm and convert to volts according to your setting, 0.5**V/cm**. Repeat with reversed polarity.

You are now using the CRO as a simple voltmeter.

(C) Use of CRO to measure unknown frequencies

(i) single-channel operation of CRO

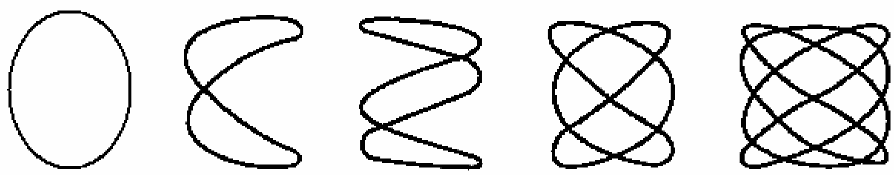
The Time/Div scale allows us to measure the period of any input signal and hence its frequency. One can measure the distance in cm for one full cycle, on half cycle or any whole number of cycles whichever is more convenient.

Let us assume that the nominal frequencies (i.e. the frequencies shown on the Sig. Gen. dial) are unreliable, but that the *Time/Div* of the CRO is reliable and accurate.

Set the Sig. Gen. dial to 50Hz and use the CRO to measure the "true" frequency.

(ii) Using Lissajous figures to measure unknown frequencies

Connect the CH1 input terminal of the CRO with the unknown sine-signal of the sig. Gen; and connect the CH2 input terminal of the CRO with SINE OUTPUT of the sig. gen. Adjust the knob of the frequency until **Lissajous figures** (Fig2)appear on the screen, and then we record the frequency.



$\frac{f_y}{f_x}=\frac{1}{1}$ $\frac{f_y}{f_x}=\frac{1}{2}$ $\frac{f_y}{f_x}=\frac{1}{3}$ $\frac{f_y}{f_x}=\frac{2}{3}$ $\frac{f_y}{f_x}=\frac{3}{4}$

Fig2 Lissajous figures

Since $\frac{f_x}{f_y} = \frac{N_y}{N_x}, N_x \ and \ N_y$ are respective the point of intersection numbers that the curve intersect with a horizontal line and a vertical line respectively. So, if f_x is known, f_y can obtained.

CAUTION

1 Note however that the *VOLTS/DIV* scale and *TIME/DIV* scale are valid only when the *VARIABLE* controls are fully clockwise.

2 When you measure the voltage of a dc supply, you cannot switch the *AC-GND-DC TO AC*. The reason is that switching to *AC* inserts a capacitor in series with the Y input terminal. The effect cancels out or "blocks" any dc component of the input.

DATA RECORDING AND PROCESSING

(A)

Table1 Write down the SWEEP TIME/DIV corresponding the following frequencies

	100Hz	1KHz	10KHz	100KHz
SWEEP TIME/DIV(ms)				

(B) (i) $V_{p-p} =$

$U_{A.C} =$

(ii) According to the setting used now, what is the number of divisions shifted?

$U_{D.C} =$

What is the shift if you change the setting to 1V/cm? And how about 0.2V/cm?

(C) Table 2

Nominal freq. (Hz)	Sweep time(s/div)	Wavelength (cm)	Period (s)	"True" freq. (Hz)	percentage error (%)
50					

Table3

N_X/N_Y	The known frequencies	The unknown frequencies
1:1		
1:2		
1:3		
2:3		

QUESTION

The *VARIABLE* controls of the *VOLTS/DIV* scale and *TIME/DIV* scale must be fully clockwise when you measure the voltage or frequency, why?