# Cathode Ray Oscilloscope

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CRO is a digital instrument, which works on the principle of thermionic emission i.e. emission of electron from a heated surface. It is a linear device. With the use of CRO one can measure peak to peak, rms, peak or average value of voltage and current.

## ❑ Calibration of CRO

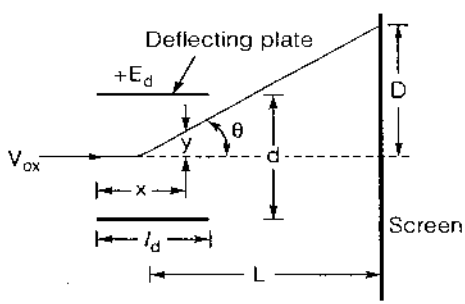
Calibration of CRO is done by applying a known quality of square signal having a frequency of 1 kHz and peak to peak magnitude of 1 mV.

## ❑ The rise time ($t_r$), of signal applied to CRO and bandwidth of CRO are related as

$$\boxed{t_r \times B.W. = 0.35}$$

If this condition fails then the signal is distorted at the output of CRO.

## ❑ Electrostatic Deflection




$$\boxed{y = \frac{1}{2}\frac{eE_y}{mv_{ox}^2}x^2}$$

where, $y$ = Displacement in y-direction; m

$e$ = Charge of an electron; Coulomb

$E_y$ = Electric field intensity in Y-direction; V/m

$m$ = Mass of electron; kg

$v_{ox}$ = Velocity of electron when entering the fields of deflecting plates; m/s

x = Displacement in x-direction ; m

### ❑ Deflection

$$D = \frac{L\, l_d\, E_d}{2d\, E_a}$$

where, L = Distance between screen and the centre of deflecting plates; m

$l_d$ = Length of deflecting plates; m

$E_d$ = Potential between deflecting plates; V

d = Distance between deflecting plates; m

$E_a$ = Voltage of pre-accelerating anode; V

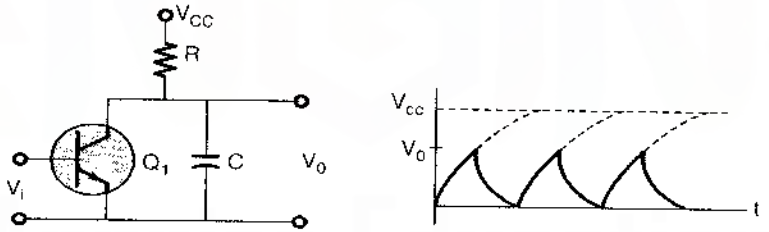
### ❑ Deflection sensitivity

$$S = \frac{D}{E_d} = \frac{L\, l_d}{2d\, E_a}\ m/V$$

### ❑ Deflection factor

$$G = \frac{1}{S} = \frac{2d\, E_a}{L\, l_d}\ V/m$$

## Sawtooth Generator




$$V_0 = V_{cc}\left[1 - \exp(-t/RC)\right]$$

where, $V_0$ = Instantaneous voltage across the capacitor at time t ; V

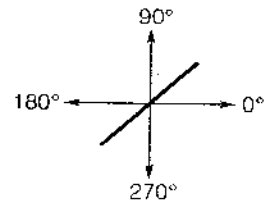
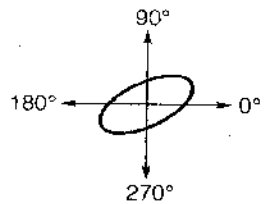
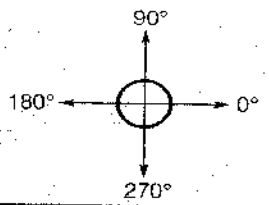
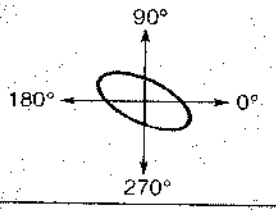
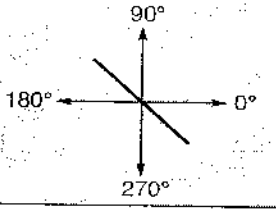
$V_{cc}$ = Supply voltage

## Lissajous patterns

If horizontal and vertical deflecting plate are applied with sinusoidal signal, the waveform pattern appearing on the screen is called Lissajous pattern.

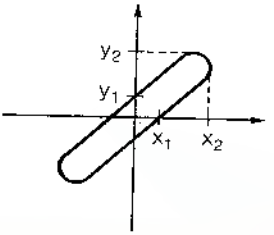
### Application

- Used for finding the phase angle difference between the signal applied to vertical and horizontal plate.
- Used for finding the frequency ratio between vertical and horizontal plates voltage.

| Phase angle ($\phi$) between $V_x$ and $V_y$ | Lissajous pattern |
|---|---|
| 0° or 360° |   |
| $0° < \phi < 90°$ (or) $270° < \phi < 360°$ |   |
| $\phi = 90°$ or 270° |   |
| $90° < \phi < 180°$ (or) $180° < \phi < 270°$ |   |
| $\phi = 180°$ |   |

## Finding the phase angle $\phi$ from given Lissajous pattern

### (a) When Lissajous pattern is in first and third quadrant

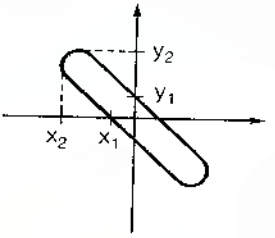



- First possibility

$$\phi = \sin^{-1}\left(\frac{x_1}{x_2}\right) = \sin^{-1}\left(\frac{y_1}{y_2}\right)$$

- Second possibility $= 360° - \phi$

### (b) When Lissajous pattern is in second and fourth quadrant




- First possibility

$$\phi = 180° - \sin^{-1}\left(\frac{x_1}{x_2}\right)$$

- Second possibility $= 360° - \phi$

## Measurement of Frequency Using Lissajous Pattern

$$\frac{f_y}{f_x} = \frac{\text{(number of intersections of the horizontal line with the curve)}}{\text{(number of intersections of the vertical line with the curve)}}$$

where, $f_y$ = Frequency of signal applied to Y plates

$f_x$ = Frequency of signal applied to X plates

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