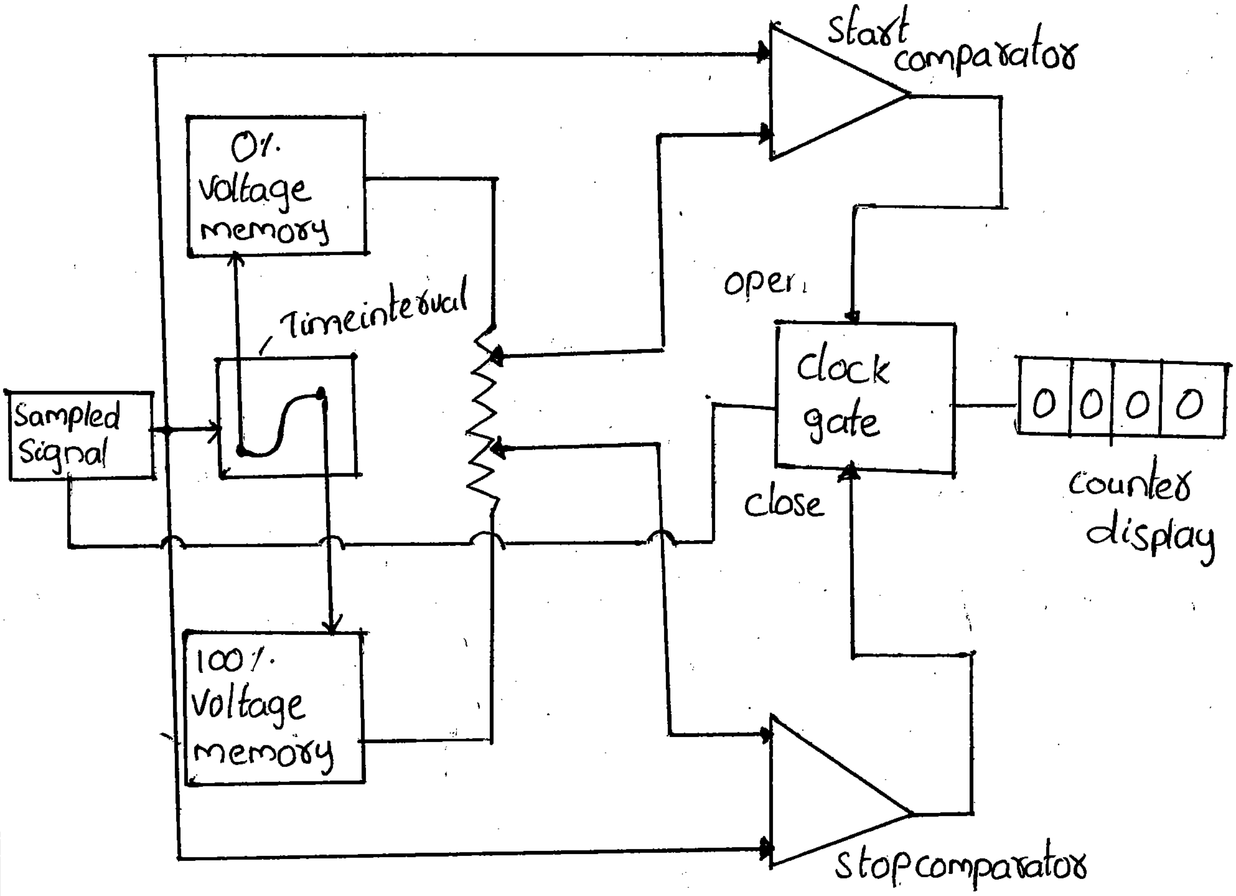
Digital Read out oscilloscope

The digital read out oscilloscope consists of CRT display & a counter display.



The input signal is first sampled using sampling circuit the sampled signal is given as one output to each start & stop comparators. when input is sampled, the sampling circuit advances the sampling position by a fixed amount. This process is called strobing. The selected sweep time per cm control & number of samples taken per cm decide the equivalent time between two samples.

The CRT trace is used to identify 0% & 100% zone positions. The positions can be shifted anywhere on display.

The potential divider is used which taps the voltage between the 0% & 100% levels. The 0% levels is used to produce a pulse for opening of gate while 100% is used to produce a pulse for closing gate.

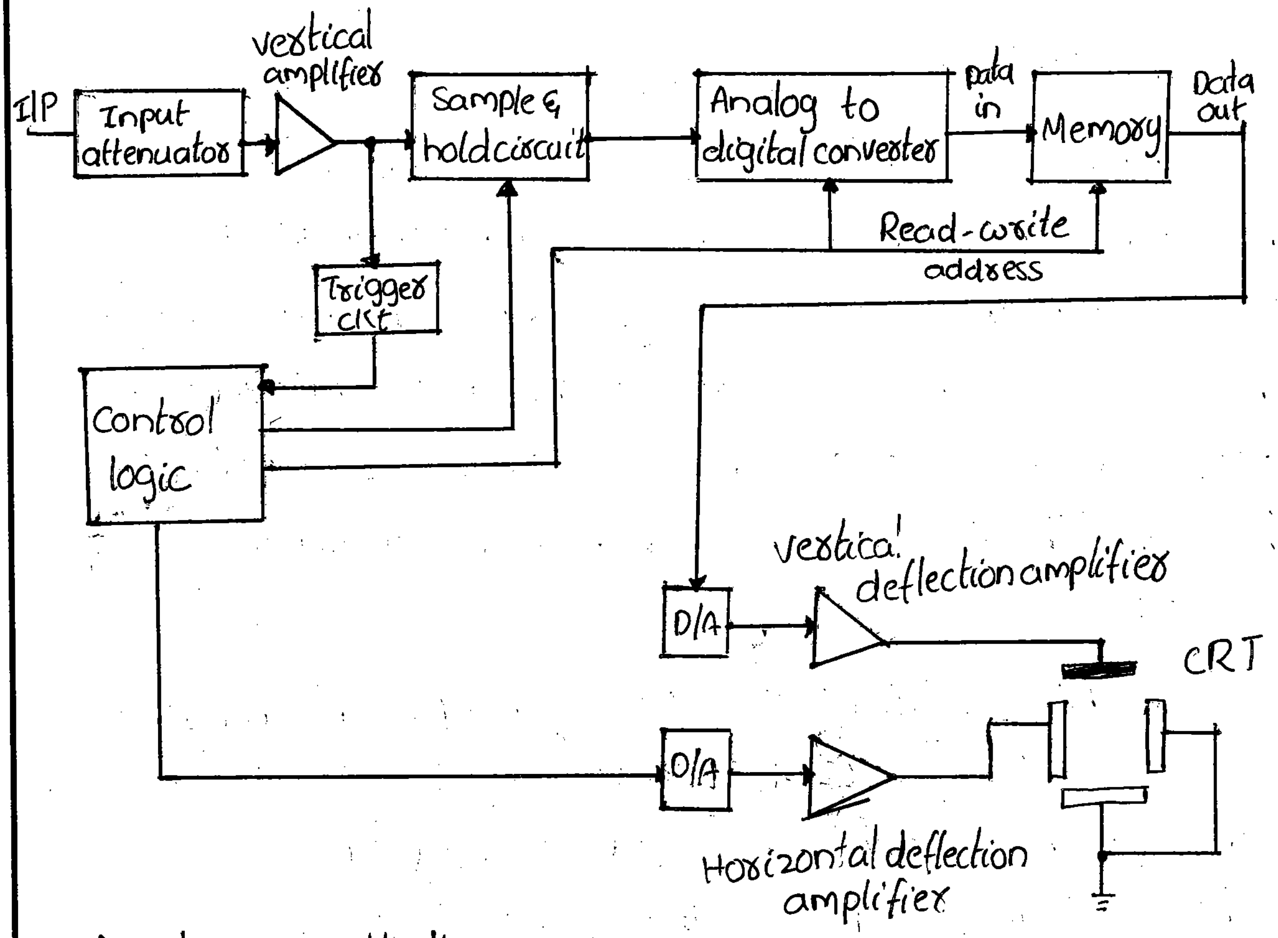
The coincidence of any of the input waveforms with the selected percentage point is sensed by the voltage comparator. when 0% level gives the start pulse, clock gate opens & counter starts counting the pulses. when 100% level gives stop pulse, clock gate closes & counter stop counting.

The number of pulses counted by a counter are proportional to actual sample taken. The digital readout is obtained using Nixie display tube.

Digital Storage oscilloscope

The digital storage oscilloscope eliminates the disadvantages of the analog storage oscilloscope. It replaces the unreliable storage method used in analog storage scopes with the digital storage with help of memory. The memory can store data as long as required without degradation. It also allows the complex processing of the signal by the high speed digital signal processing circuits.

In this digital storage oscilloscope, the waveform to be stored is digitised & then stored in a digital memory. The conventional cathode ray tube is used in this oscilloscope hence the cost is less. The power to be applied to memory is small & can be applied by small battery. Due to this the stored image can be displayed indefinitely as long as power is supplied to memory. once the waveform is digitised then it can be futher loaded into the computer & can be analysed in detail.



As done in all the oscilloscopes; the input signal is applied to the amplifier & attenuator section. The oscilloscope uses same type of amplifier & attenuator circuit as used in the conventional oscilloscopes. The attenuated signal is then applied to the vertical amplifier

The vertical input, after passing through the vertical amplifier is digitised by an analog to digital converter to create a data set that is stored in the memory. The data set is processed by the microprocessor & then sent to the display.

The main requirement of A/D converter in the digital Storage oscilloscope is its speed, while in digital voltmeters accuracy & resolution were the main requirements.

The digitising the analog input signal means taking samples at periodic intervals of the input signal. the rate of sampling should be atleast twice as fast as the highest frequency present in the input signal

once the input signal is sampled, the A/D converter digitises it. The signal is then captured in the memory. once it is stored in the memory, many manipulations are possible as memory can be readout without being erased.

Lissajous Figures:

One of the application of a CRO is to determine the phase, frequency, amplitude & other characteristics of a given waveform. The Lissajous pattern method is the quickest method of measuring the frequency. In this method ~~me~~, the known frequency signal is applied to horizontal plates & simultaneously unknown frequency signal is applied to the vertical plates.

Such patterns obtained by applying simultaneously two different sine wave to horizontal & vertical deflection plates are called Lissajous Figures.

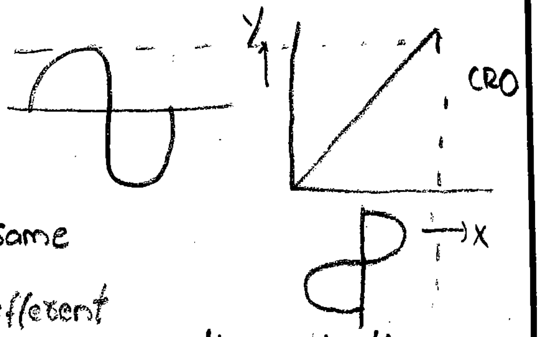
The shape of Lissajous figures depend on

1. Amplitudes of two waves
2. phase difference between two waves
3. Ratio of frequencies of two waves

Case 1: Amplitude

Let $Y = A \sin\omega t$ $\quad X = B \sin\omega t$

The frequency of the two sine wave inputs is the same (ω). ~~Howeve~~ However the peak amplitudes A & B are different. Then the resultant deflection of the electron beam on the CRO screen is



$$\frac{Y}{X} = \frac{A\sin\omega t}{B\sin\omega t} = \left(\frac{A}{B}\right) = m$$

$$Y = mx$$

* frequency same
* phase - 0°
* Amplitude - different

This equation of a straight line passing through the origin with slope 'm'. So the lissajous pattern is a straight line passing through the origin.

* freq same * phase 90°
* amp same

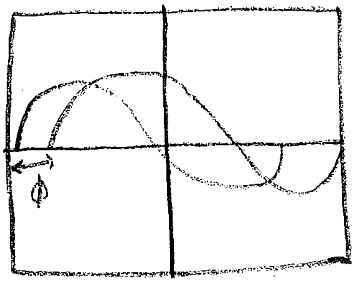
Circle: $Y = A\cos\omega t$ $x = A\sin\omega t$ ⟶

ellipse: $Y = A\sin\omega t$ $x = B\cos\omega t$

Measurement of phase:

1. using CRO: The phase difference of two different waveforms displayed on the CRT screen can be found from the time axis. Two sinusoidal signals of time period T are in the same phase at time t_1 & t_2 respectively & the phase difference between them is expressed as

$$\phi = \frac{2\pi}{T}(t_1 - t_2)$$



2. Using Lissajous Figures:

Lissajous figures are used to measure the phase difference between two sinusoidal voltages of the same amplitude & frequency. The signals are applied simultaneously to the horizontal & vertical deflection plates.

Let the values of the deflection voltages are given by

$$V_y = A\sin(\omega t+\phi) \rightarrow ① \qquad V_x = A\sin\omega t \rightarrow ②$$

Here A is the amplitude, ω is the angular frequency & φ is the phase angle.

Equ① can be expanded as $\sin(a+b) = \sin a\cos b + \cos a\sin b$

$$V_y = A\sin\omega t\cos\phi + A\cos\omega t\sin\phi \rightarrow ③$$

Eq② yields

$$V_x = A\sin\omega t$$

Squaring

$$V_x^2 = A^2\sin^2\omega t \Rightarrow V_x^2 = A^2(1-\cos^2\omega t)$$

$$A\cos\omega t = \sqrt{A^2-V_x^2}$$

Substituting sine & cosine term in Equ③

$$V_y = A\sin\omega t\cos\phi + \sqrt{A^2-V_x^2}\sin\phi$$

$$V_y = V_x\cos\phi + \sqrt{A^2-V_x^2}\sin\phi$$

$$V_y - V_x\cos\phi = \sqrt{A^2-V_x^2}\sin\phi$$

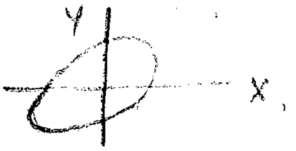
$$(V_y - V_x \cos\phi)^2 = (A^2 - V_x^2)\sin^2\phi$$

$$V_y^2 - 2V_x \cos\phi V_y + V_x^2\cos^2\phi = A^2\sin^2\phi - V_x^2\sin^2\phi$$

$$V_y^2 - 2V_x \cos\phi V_y + V_x^2\cos^2\phi + V_x^2\sin^2\phi = A^2\sin^2\phi$$

$$V_y^2 - 2V_x V_y \cos\phi + V_x^2(\cos^2\phi + \sin^2\phi) = A^2\sin^2\phi$$

$$\boxed{V_y^2 - 2V_x V_y \cos\phi + V_x^2 = A^2\sin^2\phi}$$

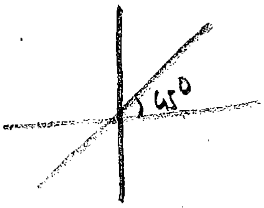


Case1: when $\phi = 0°$; $\cos 0° = 1$, $\sin 0° = 0$

$$V_y^2 - 2V_x V_y + V_x^2 = 0$$

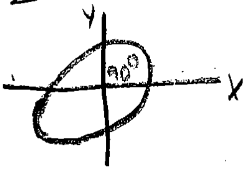
$$(V_x - V_y)^2 = 0$$

$V_x = V_y \rightarrow$ straight line



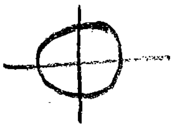
Case2: when $0 < \phi < 90°$ $\phi = 45°$; $\cos\phi = \frac{1}{\sqrt{2}}$ $\sin\phi \frac{1}{\sqrt{2}}$

$$V_x^2 + V_y^2 - \sqrt{2}V_x V_y = \frac{A^2}{2}$$



Case3: when $\phi = 90°$ $\cos\phi = 0$ $\sin\phi = 1$

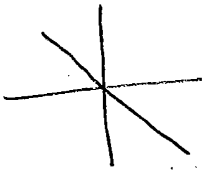
$$V_x^2 + V_y^2 = A^2$$



Case4: when $90 < \phi < 180$; $\phi = 135°$ $\cos\phi = \frac{-1}{\sqrt{2}}$; $\sin\phi = \frac{1}{\sqrt{2}}$

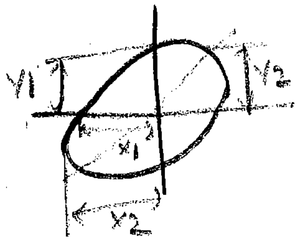
$$V_x^2 + V_y^2 + \sqrt{2}V_x V_y = \frac{A^2}{2}$$

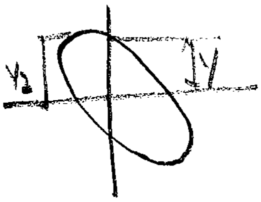
Case5: when $\phi = 180°$; $\cos\phi = -1$ $\sin\phi = 0$



For ellipse the phase angle can be obtained as

$$\phi = \sin^{-1}\frac{Y_1}{Y_2} = \sin^{-1}\frac{X_1}{X_2}$$



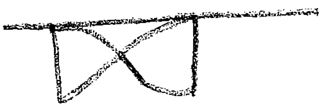


$$\phi = 180^\circ - \sin^{-1}\frac{Y_1}{Y_2}$$

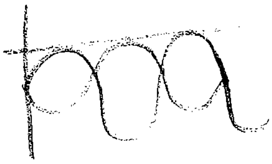
Measurement of Frequency

To measure the unknown frequency, the signal with unknown frequency is applied to vertical deflection plates called f_V. Then signal applied to horizontal deflection plates is obtained from a variable frequency oscillator of known frequency f_H.

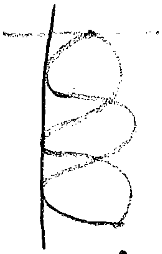
Integral patterns



$f_V = 2f_H$



$f_V = 3f_H$



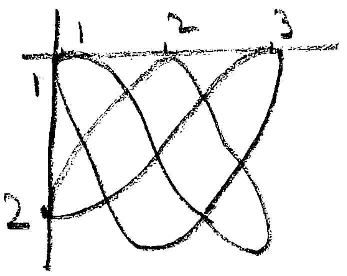
$f_V = \frac{1}{3}f_H$

The patterns depends on the ratio of two frequencies f_H & f_V

The ratio of two frequeinces can be obtained as

$$\frac{f_V}{f_H} = \frac{\text{Number of horizontal tangencies}}{\text{Number of vertical tangencies}}$$

As f_H is known, the unknown frequency can be calculated

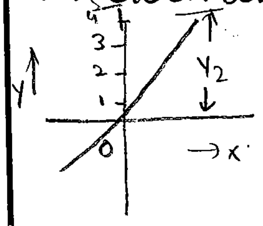


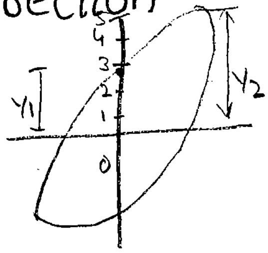
If the ratio of two frequeince is not integral then the pattern is obtained

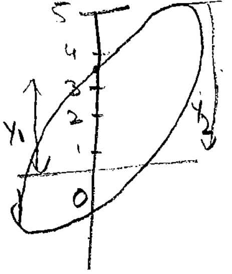
It can be seen that the horizontal tangencies are 3 while vertical tangencies are 2

Hence $\frac{f_V}{f_H} = \frac{3}{2} = 1.5 \quad \therefore f_V = 1.5 f_H$

prob: The sketches shown in fig display lissajous patterns for cases where voltages of same frequency out of different phase are connected to Y & X plates of oscilloscope. Find the phase difference in each case. The spot generating the patterns moves in a clockwise direction. calculate the angles if the spot generating the patterns moves in the anticlock wise direction







freq → prob - 6-56 - bakshi