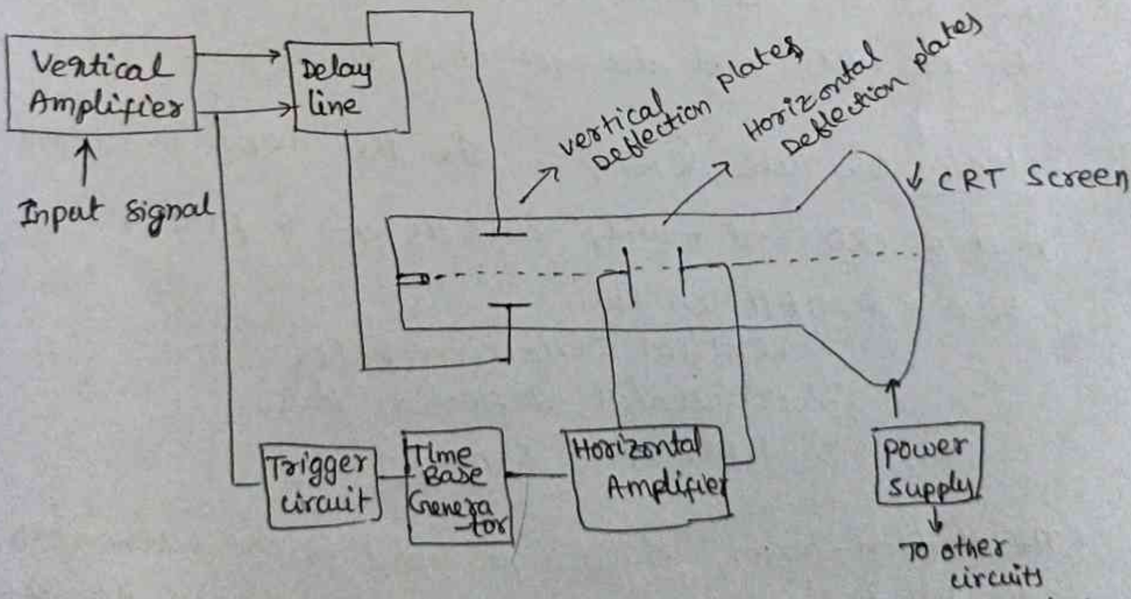
U-2 - Cathode Ray oscilloscope

Oscilloscope - is an electronic equipment which displays a voltage wave form. among the oscilloscopes cathode Ray oscilloscope (CRO) is the basic one which will displays time varying quantities or signals or wave forms.

study the block diagram of CRO -

It consists of set of blocks - those are
1. vertical amplifier
2. Delay line
3. trigger circuit
4. time base generator
5. horizontal amplifier
6. cathode Ray tube & power supply.



now understand the working of CRO with the help of its block diagram.

→ function of each block is as follows.

vertical Amplifier - It amplifies the input signal which is to be displayed on the CRT screen.

Delay line - It provides some amount of delay to the signal, which is obtained at the output of vertical amplifier. This delayed signal is then applied to the vertical deflection plates of the CRT.

Trigger circuit - It produces a triggering signal in order to synchronize both horizontal and vertical deflections of the electron beam.

Time Base generator - It produces a sawtooth signal, which is useful for horizontal deflection of electron beam.

Horizontal Amplifier - It amplifies the sawtooth signal and then connects it to the horizontal deflection plates of the CRT.

Power supply - It produces both high and low voltages for the CRT and also for other circuits.

Cathode Ray Tube (CRT) - It's the major important block of CRO and mainly consists of 4 parts.

Those are 1) Eletron Gun
2) vertical Deflection plates
3) Horizontal deflection plates
4) flurosscent Screen.

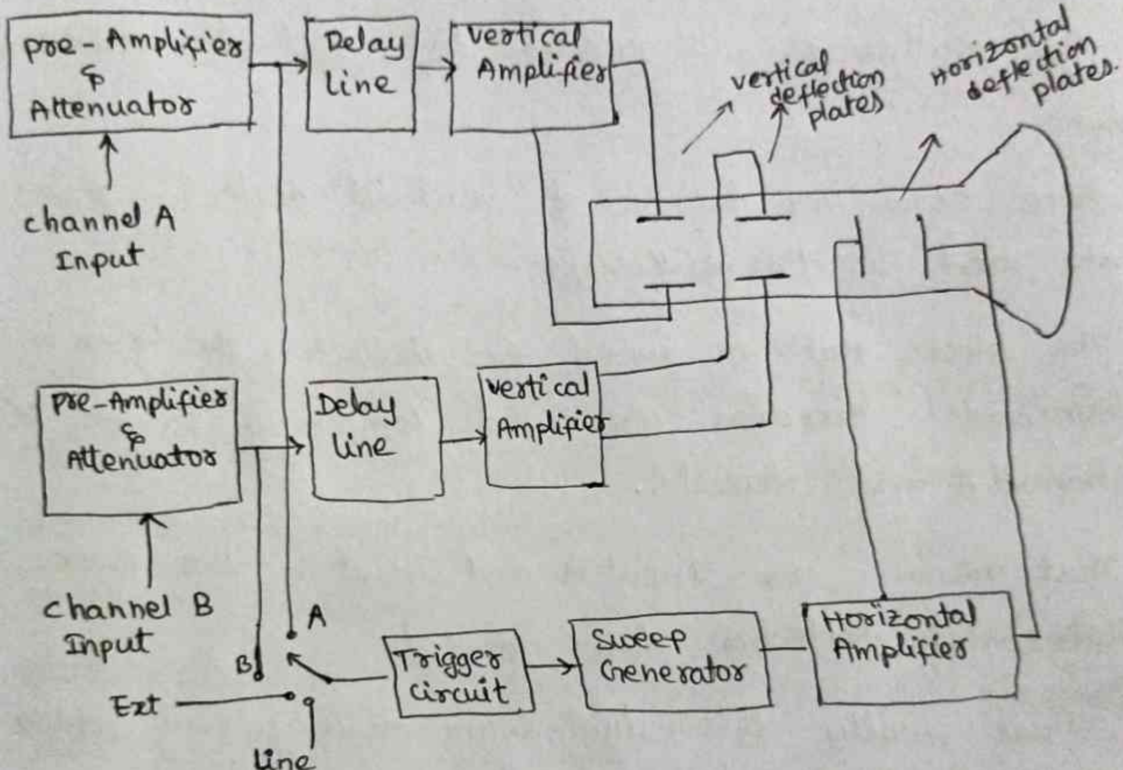
- The electron beam, which is produced by an electron gun gets deflected in both vertical and horizontal directions by the pair of horizontal & vertical deflection plates respectively. Finally the deflected beam will appear as a spot on the flurosscent screen.

- In this way, CRO will display the applied input signal on the CRT screen. We can analyze the waveforms

⇒ Dual Beam oscilloscope -

The oscilloscope which displays two voltage wave forms is called Dual Beam oscilloscope.

Its block diagram is as shown below.



- In dual beam oscilloscope, the CRT consists of two sets of vertical deflection plates and one set of horizontal deflection plates.

- The combination of the following blocks together is called a channel.
  * pre-Amplifier & Attenuator
  * Delay-line
  * vertical Amplifier
  * A set of vertical deflection plates.

Thus a dual beam oscilloscope is having two(2) channels Channel A and channel B.

and we can apply two signals namely signal A and B simultaneously to channel A, channel B respectively.

→ The trigger input is given to the trigger circuit for any of the signals namely, Input A, Input B, External signal (Ext) and Line Input.

→ This oscilloscope will produce two vertically deflected beams.

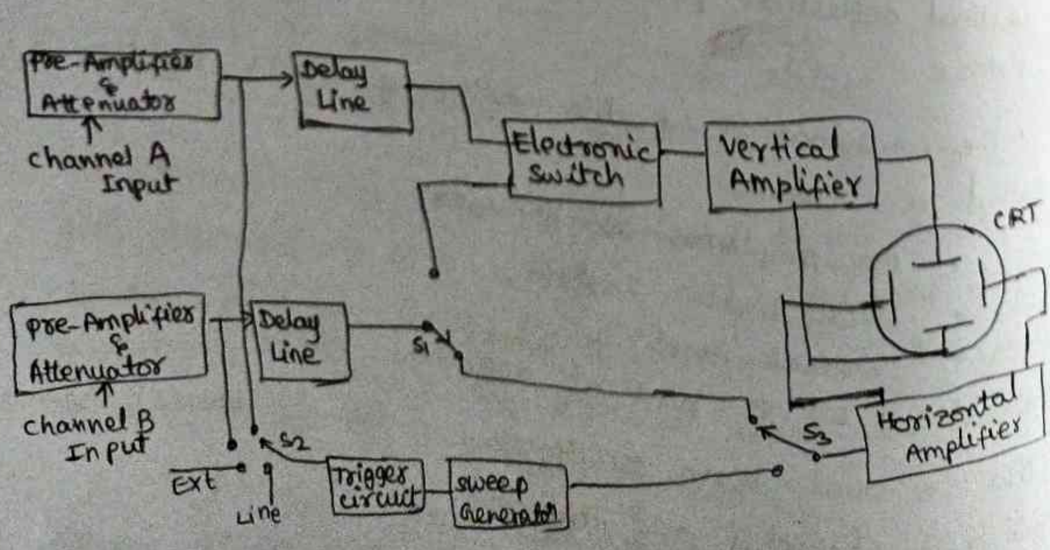
→ Since there are two sets of vertical deflection plates are used in this oscilloscope.

→ The blocks that are useful for deflecting the beam in horizontal direction are used commonly for both the channel A and channel B.

→ That means for Input A and Input B the same horizontal deflection plates are used.

→ Thus finally this dual-beam oscilloscope will produce the two input signals simultaneously on the screen of CRT.

⇒ **Dual Trace oscilloscope** -



→ This dual trace oscilloscope, will produce two traces on the CRT screen.

It's block diagram is as shown in the above fig.

→ As shown in the figure, its CRT consists of a set of vertical deflection plates and a set of horizontal deflection plates.

But each channel consists of 4 blocks, they are.

* pre-Amplifier and attenuator
* delay-line
* vertical amplifier
* vertical deflection plates.

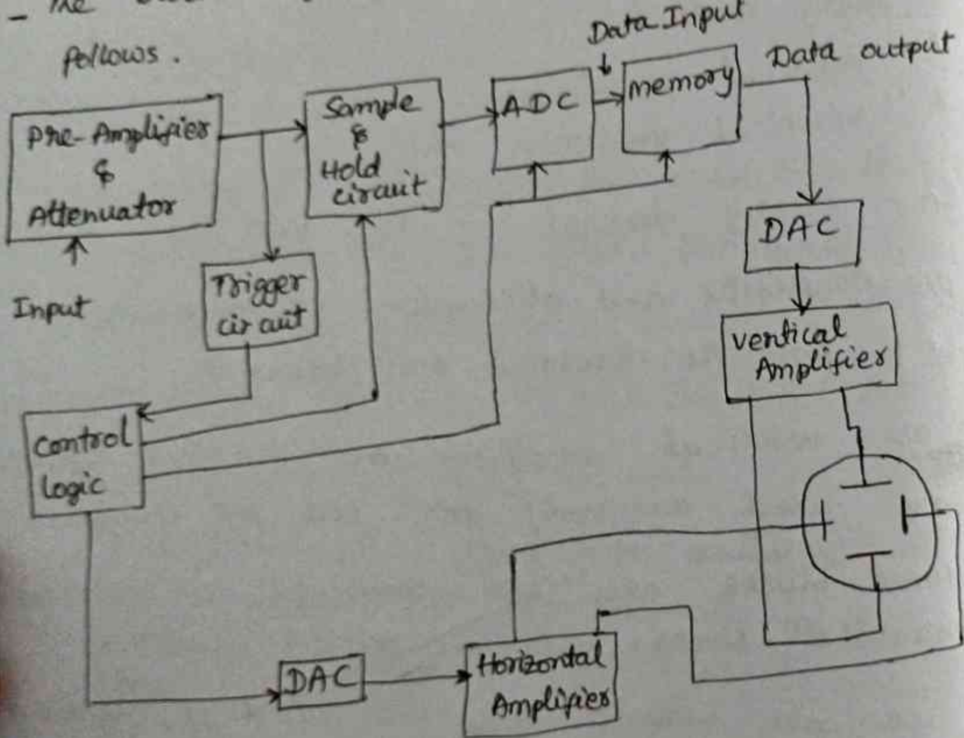
- But for every channel in the dual trace oscilloscope the pre-amplifier and attenuator are seperately available in both the channel A and channel B,
- where as vertical amplifier and vertical deflection plates are used commonly for both the channels.
- So these blocks are been connected to the channel A & channel B blocks with an electronic switch.
- Thus we can connect delay line output of either channel A or channel B to ~~the~~ vertical amplifier and vertical deflection plates blocks which were common to both of the channels.
- The trigger circuit can be triggered with the help of any of the 4-signals, namely - Input A, Input B, External Signal (Ext) and Line Input.
- This oscilloscope uses same electron beam for deflecting the input signals A & B in vertical direction by using an electronic switch and produces <u>two traces</u>.

- The blocks that are useful for deflecting the electron in the horizontal direction i.e Horizontal amplifier & Horizontal Deflection plates are used commonly for both the channels A and B.

⇒ **Digital storage oscilloscope** -

- The oscilloscope, which stores the waveform digitally called a Digital storage oscilloscope.

- The block diagram of digital storage oscilloscope is as follows.



- As the digital storage oscilloscope stores the waveform in the form of binary (digital), it need some additional blocks when compared to an analog oscilloscope.

→ They are
* Sample and Hold circuit
* Analog to Digital Converter (ADC)
* memory
* Digital to Analog Converter (DAC)

* Sample and Hold circuit – converts the continous signals into discreet or dis continous signals

* ADC - the sampled voltages are converted to digital or binary form through encoders that is referred as Analog to Digital converter.

* Memory - this is the storage device which holds the binary data in their memory locations or memory cells.

* Digital to Analog Converter - The final output of the CRO on its CRT screen is analog waveforms, so we need Digital to Analog converter to change the Digital signals into Analog form.

- These blocks are used as additional blocks for a digital storage oscilloscope when compared to a basic analog oscilloscope.

- These blocks ~~are~~ lies in between pre-Amplifier and Attenuator block and Vertical Amplifier blocks.

→ control logic - this block controls the Sample & Hold Circuit block, ADC and memory blocks by providing control signals.

→ This control logic block and DAC are placed between the Trigger circuit and horizontal amplifier blocks.

→ Thus a digital storage oscilloscope stores the wave form data in the digital form in its memory unit.

→ This kind of feature is not available in the analog CRO's.

Measurement of Amplitude - using CRO

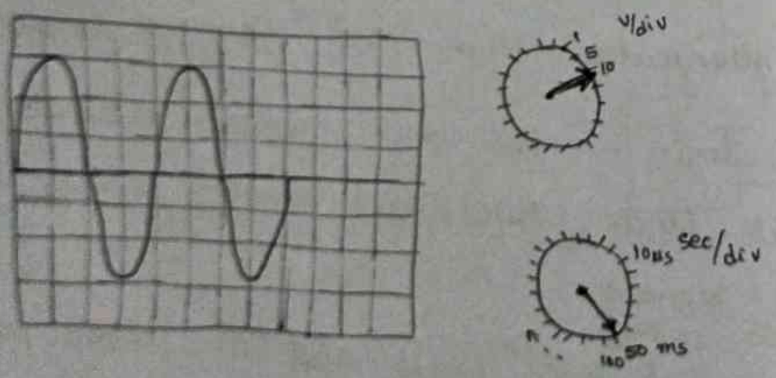
- CRO displays the voltage signal as a function of time on screen.
- The amplitude of that voltage signal is constant, but we can vary the no. of divisions that cover the voltage signal in vertical direction by varying volt/division knob on the CRO panel.
- Therefore, we will get the amplitude of the signal, which is present on the screen of CRO by using the below formula.

$$A = j \times n_v$$

here A = amplitude

j = the value that the pointer (rotary switch) volt/division indicates.

n_v = no. of divisions that cover the signal in vertical direction.



- Measurement of Time period -

The CRO displays a voltage waveform as a function of time period.

- The time period of the voltage signal is generally constant. But we can vary the number of divisions that cover one complete cycle of voltage signal in horizontal direction by varying time/division knob on the CRO panel.
- Therefore, we get the time period of the signal, which is present

on the screen of CRO by using following formula.

$$T = k \times n_h$$

where 'T' is the Time period

k is the value of time / division.

n_v is the number of divisions that cover on complete cycle of the periodic signal in horizontal direction.

Measurement of Frequency -

- the frequency, f of a periodic signal is the reciprocal of time period 'T'.
- mathematically, it can be represented as

$$\boxed{f = \frac{1}{T}}$$

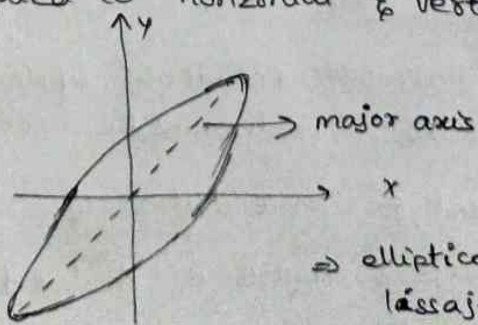
first find the Time period 'T' and then find its reciprocal.

Lissajous figures

→ It's the pattern which is displayed on the screen, when sinusoidal signals are applied to both Horizontal deflection plates and vertical Deflection plates respectively.

- These lissajous figures occurance will be based on the amplitudes frequencies and phase differences of the two applied sinusoidal input wave forms applied to horizontal & vertical deflection plates of the CRO.

example:



⇒ elliptical shape lissajous figure.
with its major axis has inclination with +ve X - axis.

Lissajous figures helps in the measurement of
① frequency of sinusoidal signal
② phase difference between two sinusoidal signals

measurement of Frequency -

- Lissajous figure will be displayed on the screen, when the sinusoidal signals are applied to both horizontal & vertical deflection plates of CRO.
- Hence, apply the sinusoidal signal, which has standard known frequency to the Horizontal deflection plates of CRO.
- Similarly, apply the sinusoidal signal whose frequency unknown to the vertical deflection plates of CRO.

Let f_H and f_V are sinusoidal signals applied - Horizontal & vertical deflection plates of CRO.

the relationship between f_H and f_V is

$$\boxed{\frac{f_H}{f_V} = \frac{n_H}{n_V}}$$

f_H = Horizontal deflection plates frequency "un known frequency"

f_V = known frequency → applied to vertical deflection plates.

n_H ⇒ no. of Horizontal tangencies

n_V ⇒ no. of vertical tangencies.

$$\therefore \boxed{f_H = \left(\frac{n_H}{n_V}\right) \cdot f_V}$$

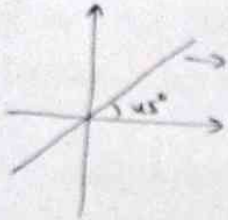
→ then the un-known frequency applied to the horizontal defection plates is determined.

⇒ measurement of phase difference -

- A Lissajous figure is displayed on the screen when sinusoidal signals are applied to both horizontal & vertical deflection plates of CRO.
- Hence, apply the sinusoidal signals, which have same amplitude and same frequency to both the horizontal & vertical

defection plates of CRO.

→ few lissajous figures based on their phase difference is as follows.

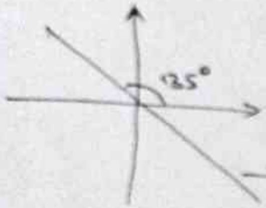
* 

→ straight line with 45° to +ve x-axis

⇒ the phase difference between two sinusoidal signals is 0°.

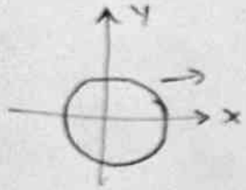
⇒ no phase difference

⇒ In-phase.

* 

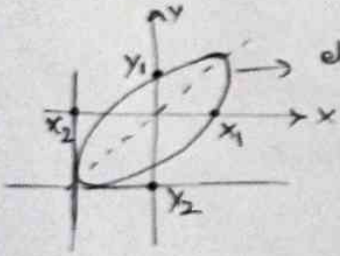
→ straight line with 135° to +ve x-axis

⇒ The phase difference is 180°.

* 

→ circular shape

⇒ The phase difference b/n them is 90° or 270°.

* 

→ elliptical shape.

⇒ the phase difference is given as 'ϕ'.

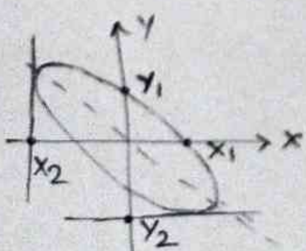
$$\phi = \sin^{-1}\left(\frac{x_1}{x_2}\right) \text{ or } \sin^{-1}\left(\frac{y_1}{y_2}\right)$$

where x_1 = the intersection point on x-axis.

x_2 = the point on x-axis where the tangent to the lissiajous figure meets x-axis.

y_1 = the intersection point on y-axis

y_2 = the point on y-axis where the tangent to the lissajous figure meets the y-axis.

* 

⇒ the phase difference is

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

$$180 - \sin^{-1}\left(\frac{y_1}{y_2}\right).$$