Dual Trace Oscilloscope

Definition: In dual trace oscilloscope, a single electron beam generates 2 traces, that undergoes deflection by two independent sources. In order to produce two separate traces, basically, 2 methods are used, known as alternate and chopped mode.

These are also known as the two operating modes of the switch.

Now the question arises what is the need for such an oscilloscope?

So, we know to analyse or study multiple electronic circuits, the comparison between their voltages is really important. Hence to compare the different circuits, one can use multiple oscilloscopes.

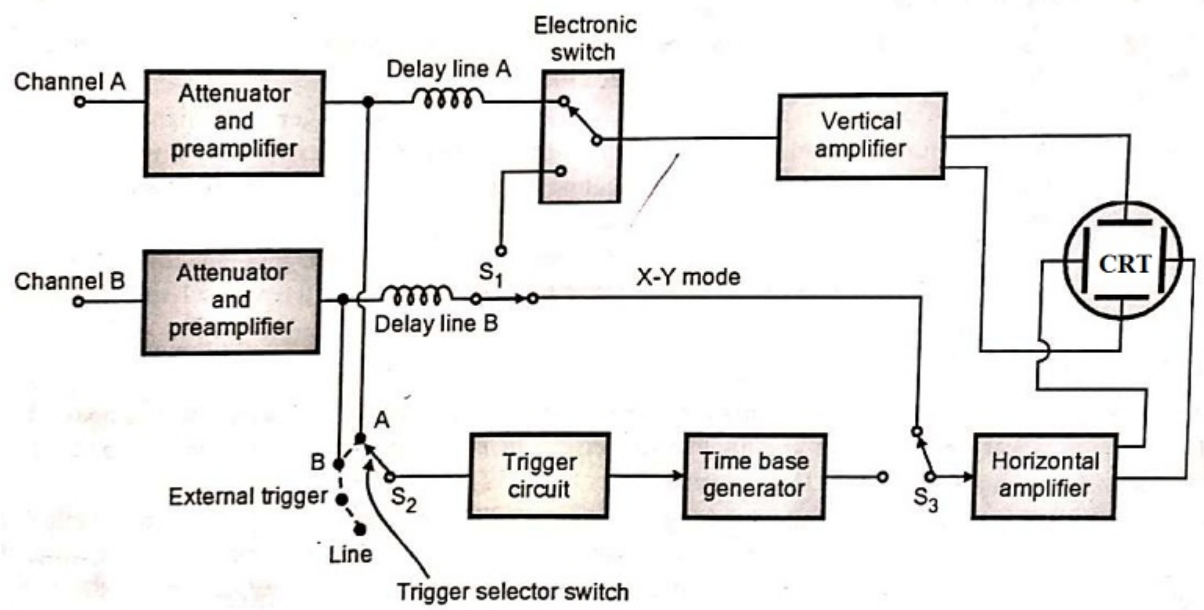
But simultaneously triggering the sweep of each oscilloscope is a quite difficult task.

Thus we have used dual trace oscilloscope provides two traces by making use of a single electron beam.

Block diagram and Working of Dual Trace Oscilloscope

In dual trace CRO, two separate vertical input signals can be displayed simultaneously. The CRO consists of a single beam CRT, single time base generator, and two identical vertical amplifiers with an electronic switch. The output of the vertical amplifiers is connected to the electronic switch via a mode control switch.

Dual trace CRO is used to generate only one electron beam but display two traces. Thus the same electron beam is used for generating both the traces to display two different input signals



simultaneously.

There are two separate vertical input channels, channel A and B. They use separate attenuator and preamplifier stage. Because of this arrangement, it is possible to control the amplitude of each input independently.

After amplification, both the channels are applied to an electron switch. This switch will connect one channel at a time to the vertical amplifier via a delay line.

The trigger selector switch S2 allows the circuit to be triggered by channel A or channel B or line frequency or signal from an external source.

The Horizontal amplifier gets input either from channel B or from time base generator through switch S1 and S3 depending on the mode of operation.
Only in X-Y mode of operation, the input of the horizontal amplifier is from channel B. Otherwise it gets input from time base generator.

In X-Y mode of operation, the time base generator is disconnected from the horizontal amplifier and channel B acts as horizontal input. Channel A acts as a vertical input. It plots Y-input (Channel A) with respect to X-input (Channel B).

It allows two modes of operations:

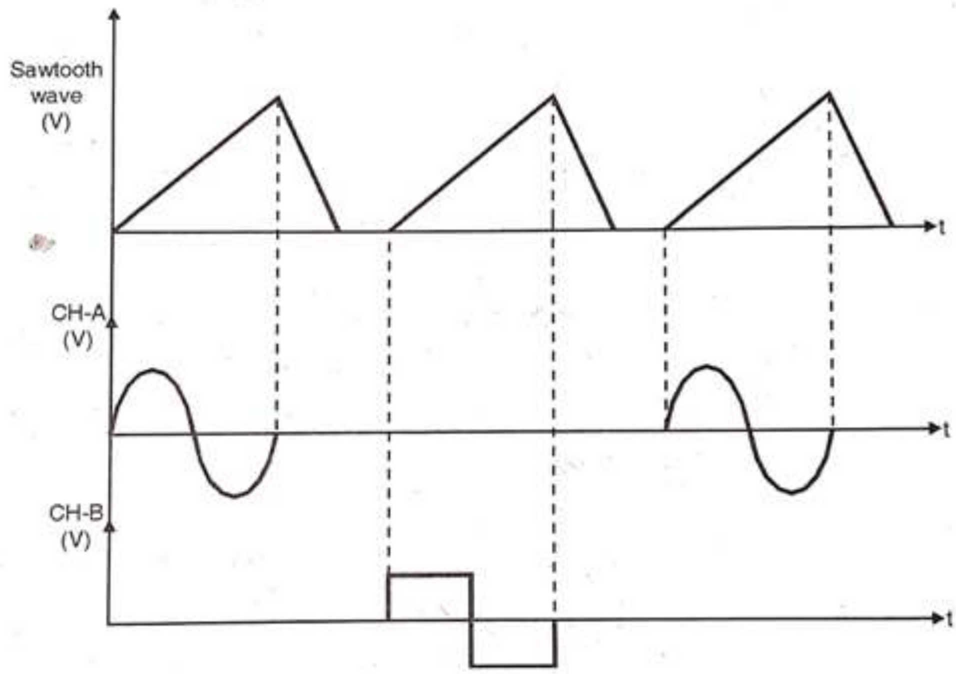
The alternate mode.
The chopped mode.

Alternate Mode (ALT Mode)

In the alternate mode, the electronic switch connects the two channels A and B alternately in the successive cycles of the time base generator. Thus two channels are alternately connected to the vertical amplifier.

The switching rate of the CRT is controlled by the sweep rate of the time base generator. Hence, the CRO alternately displays the two vertical signals. Each vertical amplifier has its own calibrated input alternators and position controls so that the amplitude of each signal can be separately adjusted.

The alternate mode is used for the high-frequency signal. Timebase is set at high speed so that



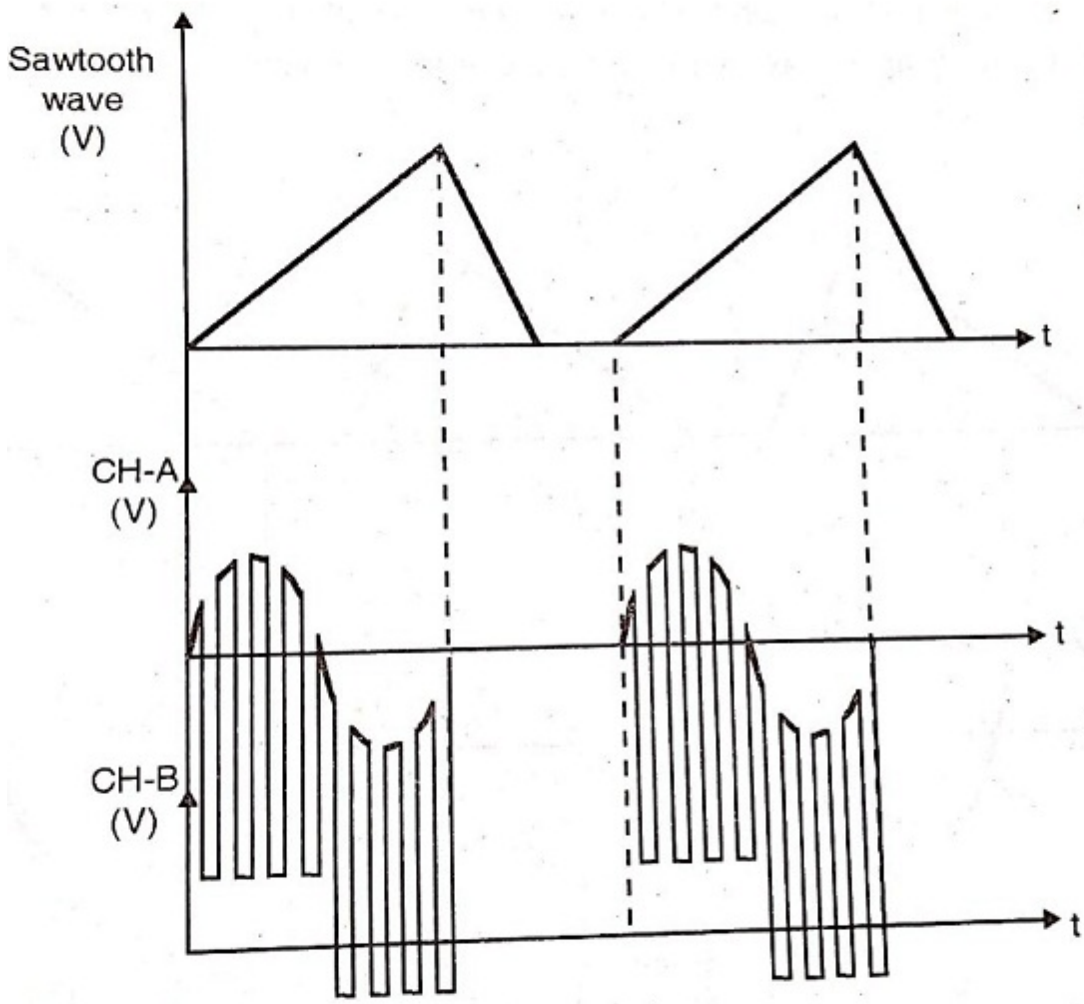
both the traces appear as continuous trace instead of alternate trace.

Chopped (Chop) Mode

In the chopped mode, the electronic switch will make several transitions from one channel to the other during one sweep.

A free-running oscillator is used to control the position of the electronic switch.

As the electronic switch is running at very high speed, each channel is displayed for a very short time.



The switching rate of the electronic switch or chopping rate is approximately 100 kHz or 0.01 msec.

This is of greater use for simultaneous observation of the low-frequency signals, whose frequency is much lower than the chopping frequency.

Oscilloscope Specifications and Performance

The oscilloscope specifications are necessary when choosing a particular oscilloscope for a particular application. It is necessary to look in detail at the specifications list to see whether the instrument meets its requirements. The oscilloscope specifications and performance are given below:

1. **Bandwidth**. The bandwidth specification tells you the frequency range the oscilloscope accurately measures. As signal frequency increases, the capability of the oscilloscope to accurately respond decreases. By convention, the bandwidth tells you the frequency at which the displayed signal

reduces to 70.7% of the applied sine wave signal. (This 70.7% point is referred to as the "–3 dB point," a term based on a logarithmic scale.)

2. **Rise Time.** Rise time is another way of describing the useful frequency range of an oscilloscope. Rise time may be a more appropriate performance consideration when you expect to measure pulses and steps. An oscilloscope cannot accurately display pulses with rise times faster than the specified rise time of the oscilloscope.

3. **Vertical Sensitivity**. The vertical sensitivity indicates how much the vertical amplifier can amplify a weak signal. Vertical sensitivity is usually given in millivolts (mV) per division. The smallest voltage a general purpose oscilloscope can detect is typically about 2 mV per vertical screen division.

4. **Sweep Speed.** For analog oscilloscopes, this specification indicates how fast the trace can sweep across the screen, allowing you to see fine details. The fastest sweep speed of an oscilloscope is usually given in nanoseconds/div.

5. **Gain Accuracy**. The gain accuracy indicates how accurately the vertical system attenuates or amplifies a signal. This is usually listed as a percentage error.

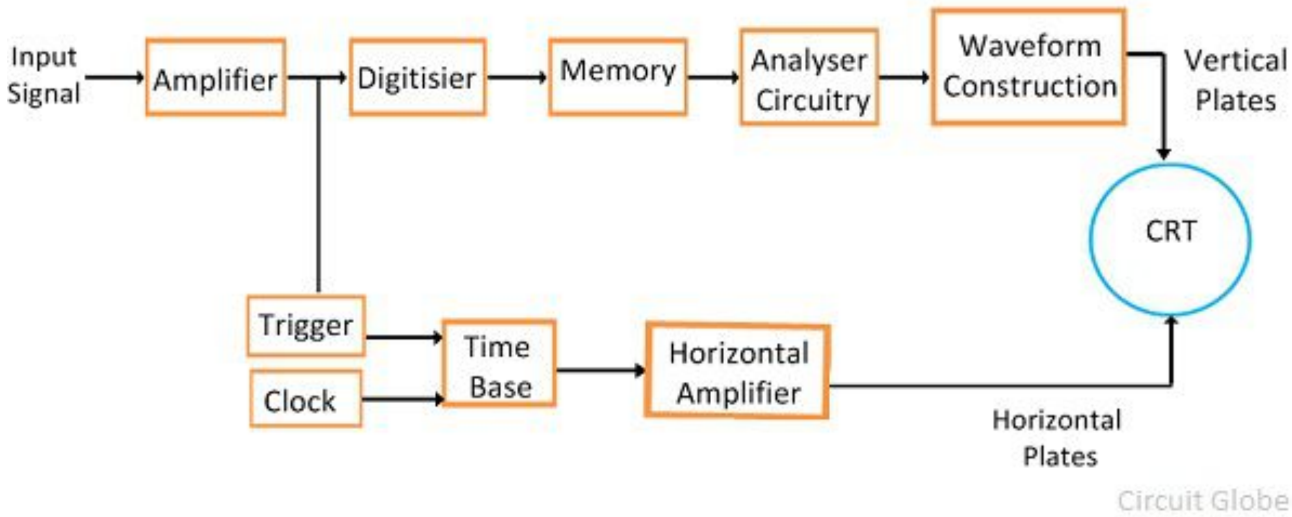
6. **Time Base or Horizontal Accuracy.** The time base or horizontal accuracy indicates how accurately the horizontal system displays the timing of a signal. This is usually listed as a percentage error.

7. **Sample Rate.** On digital oscilloscopes, the sampling rate indicates how many samples per second the ADC (and therefore the oscilloscope) can acquire. Maximum sample rates are usually given in megasamples per second (MS/s). The faster the oscilloscope can sample, the more accurately it can represent fine details in a fast signal. The minimum sample rate may also be important if you need to look at slowly changing signals over long periods of time. Typically, the sample rate changes with changes made to the sec/div control to maintain a constant number of waveform points in the waveform record.

8.**ADC Resolution (Or Vertical Resolution)**. The resolution, in bits, of the ADC (and therefore the digital oscilloscope) indicates how precisely it can turn input voltages into digital values. Calculation techniques can improve the effective resolution.

Working Principle of Digital Storage Oscilloscope

The digital oscilloscope digitises and stores the input signal. This can be done by the use of CRT (Cathode ray tube) and digital memory. The block diagram of the basic digital oscilloscope is shown in the figure below. The digitisation can be done by taking the sample input signals at periodic waveforms.



The maximum frequency of the signal which is measured by the digital oscilloscope depends on the two factors. Theses factors are the

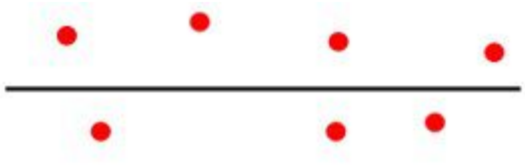
Sampling rate
Nature of converter.

Sampling Rate – For safe analysis of input signal the sampling theory is used. The sampling theory states that the sampling rate of the signal must be twice as fast as the highest frequency of the input signal. The sampling rate means analogue to digital converter has a high fast conversion rate.

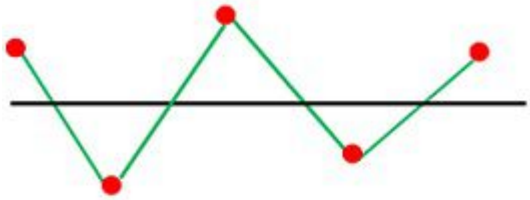
Converter – The converter uses the expensive flash whose resolution decreases with the increases of a sampling rate. Because of the sampling rate, the bandwidth and resolution of the oscilloscope are limited.

Waveform Reconstruction

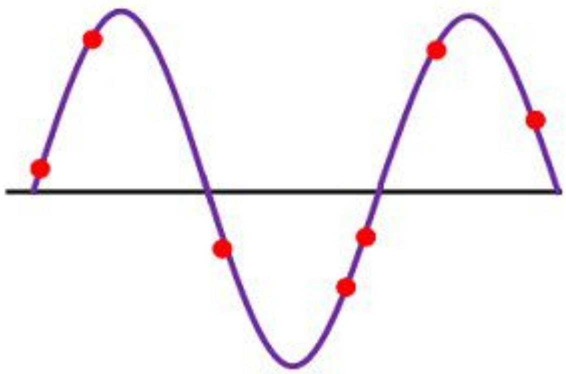
For visualising the final wave, the oscilloscopes use the technique of inter-polarization. The inter-polarization is the process of creating the new data points with the help of known variable data points. Linear interpolation and sinusoidal interpolation are the two processes of connecting the points together.



(a) Without Interpolation



(b) Linear Interpolation



(c) Sinusoidal Interpolation

For probes-refer to book.

Lissajous Figures

Lissajous Figures (or patterns) are named in honour of the French scientist who first obtained them geometrically and optically. They illustrate one of the earliest uses to which the CRO was put.

Lissajous patterns are formed when two sine waves are applied simultaneously to the vertical and horizontal deflecting plates of a CRO.
The shape of the Lissajous pattern depends on the frequency and phase relationship of the two sine waves.

Two sine waves of the same frequency and amplitude may produce a straight line, an ellipse or a circle depending on their phase difference.

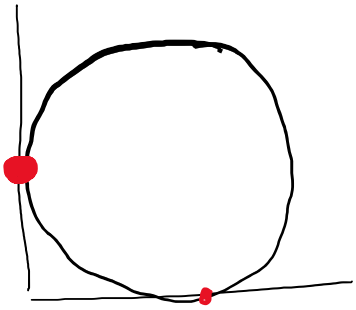
In general, the shape of Lissajous Figures depends on (i) Amplitude (ii) Phase difference (iii) Ratio of frequency of the two waves.

Frequency Determination with Lissajous Figures

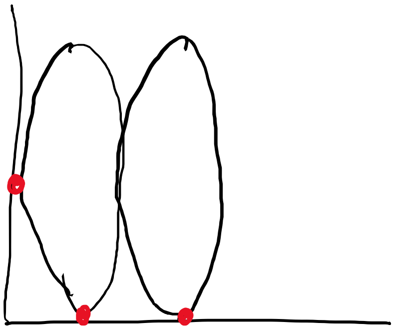
The unknown signal is applied across one set of deflecting plates and a known signal across the other. By studying the resultant Lissajous pattern, unknown frequency can be found.

Depending on the frequency ratio, the various patterns obtained are shown in Fig.. The ratio of the two frequencies is given by

$$\frac{f_V}{f_H} = \frac{\text{No. of points of vertical tangency}}{\text{No. of points of horizontal tangency}}$$



$\Rightarrow$ 1 : 1



$\Rightarrow$ 2 : 1

Practics Questions from Book.