SEMESTER - V

ELECTRONIC INSTRUMENTATION

UNIT - II OSCILLOSCOPES

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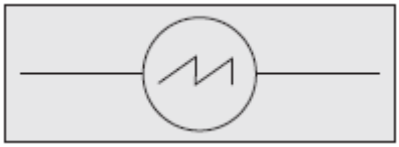
UNIT-2

OSCILLOSCOPES

An oscilloscope is a versatile tool used in science, medicine, engineering, and telecommunications. It displays the exact wave shape of electrical signals, showing amplitude, distortion, and timing.It helps measure pulse width, period, rise time, and the relative timing between signals.

the cathode ray oscilloscope (CRO) is generally referred to as anoscilloscope. It is a basic electronic test instrument that allows observations ofconstantly varying signal voltages usually as a two-dimensional graph of one or more electricalpotential differences.



.1. Explain the construction and working of CRT?

Ans: ***Construction***

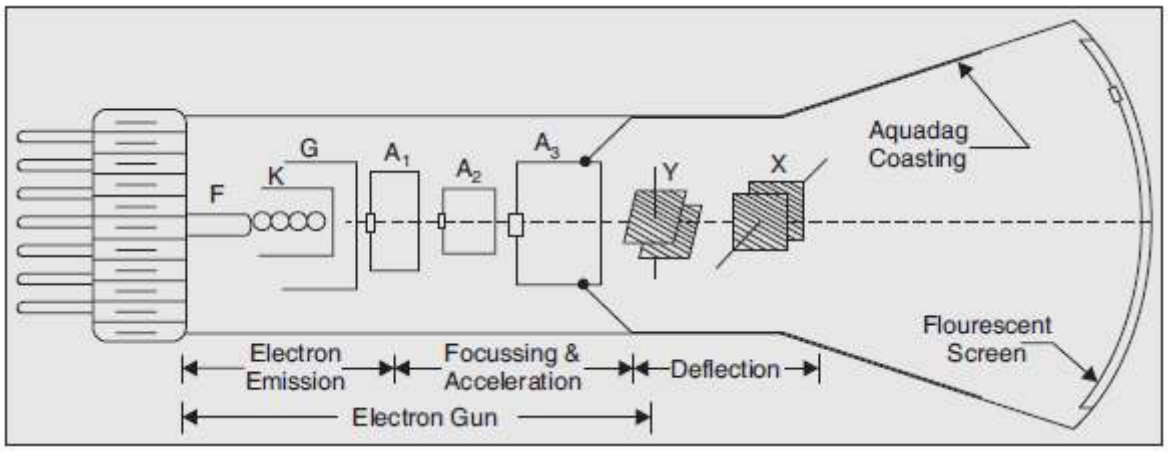
It has four major components are:

1. an electron gun for producing a stream of electrons,

2. focusing and accelerating anodes-for producing a narrow and sharply-focused beam of electrons,

3. horizontal and vertical deflecting plates-for controlling the path of the beam,

4. an evacuated glass envelope with a phosphorescent screen which produces bright spot



1. ***Electron Gun Assembly***

(a) Cathode K:

The indirectly-heated cathode emits electrons by thermionic emission.

These electrons form a focused beam and are accelerated toward the screen.

(b) Control Grid:

The control grid controls the number of electrons passing through by its negative bias. This adjusts the beam current and brightness, known as intensity control.

(c) Accelerating Anode:

Anodes A1 (pre-accelerating) and A3 accelerate the electron beam using positive voltage. They create an electric field that speeds up electrons emitted from the cathode.

(d). Focusing Anode:

The focusing anode A2 directs scattered electrons into a narrow beam hitting one spot. It uses negative potential, and its voltage is adjusted by the focus control knob.

2. Deflecting Plates

Two sets of plates control the electron beam—Y-plates for vertical and X-plates for horizontal deflection. Input signal is applied to Y-plates, moving the beam up and down; ramp (sawtooth) voltage is applied to X-plates for horizontal sweep. Without voltage, the beam stays centred. Applying voltage shifts the spot based on signal amplitude and creates visible traces due to persistence of vision. Y- and X-plates have cantering controls to adjust beam position.

3. **Glass Envelope**

It is a funnel-shaped, highly evacuated tube with a phosphor-coated screen at the wide end. The inside is coated with Aquadag, a conducting layer at A3 potential, which maintains electrical balance. Aquadag accelerates the beam after deflection and collects low-energy secondary electrons from the screen.

4. **Graticules (Very Short Summary):**

Graticules are grid lines on the CRT screen used for measuring time and amplitude accurately. They reduce parallax error by being close to the phosphor and come in three types:

(a) **External:** On Plexiglas, may cause parallax error.

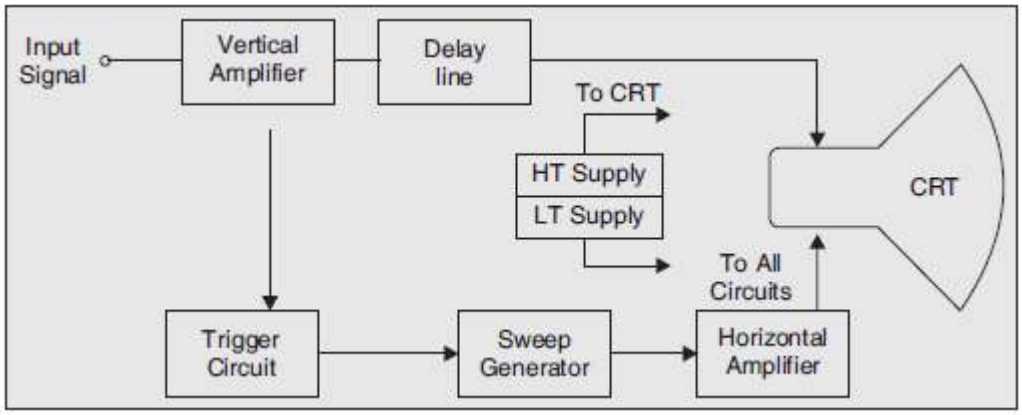
(b) **Internal:** Etched on inner glass, minimal error.

(c) **Projected:** Flexible, can show extra details like legends.

2.Explain the construction, working of cathode ray Oscilloscope?

Ans: Working: In the past, CROs used a vacuum tube with a cathode, anode, grid, X & Y plates, and a fluorescent screen. The heated cathode emits electrons, which are accelerated toward the anode, forming an electron beam. This beam hits the fluorescent screen, creating a bright visible spot. The grid controls beam intensity, while X & Y plates deflect it horizontally and vertically.A sweep generator connected to the X-plates moves the spot horizontally at a set frequency. The signal applied to the Y-plates, combined with the sweep, displays voltage variation with time.

The block diagram of a CRO is as shown below figure.



1. **Display.** In all the modern oscilloscopes it is usually LCD panel. In the old oscilloscopes the display was a cathode ray tube or CRT. The display whether LCD panel or CRT is laid out with both horizontal and vertical reference lines referred to as the graticule. In addition to the screen, most display sections are equipped with three basic controls, a focus knob, an intensity knob and a beam finder button.

2. Cathode Ray Tube (*CRT*). This is the cathode ray tube which emits electrons that strikes the phosphor screen internally to provide a visual display of signal. It displays the quantity being measured.

3. Vertical amplifier. It amplifies the signal waveform to be viewed.

4. Delay Line. It is used to delay the signal for some time in the vertical sections.

5. Horizontal amplifier. This is used to amplify the sawtooth voltage which is then applied

to the *X*-plates.

6. Sweep generator. Produces sawtooth voltage waveform used for horizontal deflection of the electron beam.

7. Trigger circuit. Produces trigger pulses to start horizontal sweep. It converts the incoming signal into trigger pulses so that the input signal and the sweep frequency can be synchronized.

8. High and low. Voltage power supply.

3. Write the Applications of CRO?

Ans:

1. Measures amplitude, frequency, time period, and phase difference of electrical signals.
2. Helps observe waveform shapes in AC and DC signals.
3. In ECG (Electrocardiography) and EEG (Electroencephalography) for monitoring heart and brain activity.
4. Tests and adjusts audio/video signals and equipment like amplifiers and TVs.
5. Analyzes modulated signals, checks for distortion and noise in radio and TV broadcasting.
6. Used to analyze return signals in radar and sonar systems.
7. Used in Industrial Automation

4.Explain how can you Measure voltage(DC and AC) by using CRO?

Ans: The Cathode Ray Oscilloscope (CRO) is fundamentally a voltage-measuring instrument. It can measure voltages of any frequency within its operational range, and from these voltage measurements, other quantities can be derived.

To measure the voltages.

1. The input voltage is applied on the vertical deflection plates

2. An appropriate sweep is applied to the horizontal plates.

3. The amplitude attenuator is than adjusted such that the signal is displayed comfortably on the screen.

4. The amplitude trace of the waveform is then observed on the screen.

5. The position of the attenuator knob gives the volts/cm position or volts/ division.

6. The peak to peak voltage of the input signal is measured by multiplying this position value with the number of centimeters the signal is occupying in the vertical direction. The peak to peak voltage of the signal is given by

$$V_{p-p} = \left(\frac{\text{volts}}{divisions}\right) (\text{number of divisions})$$

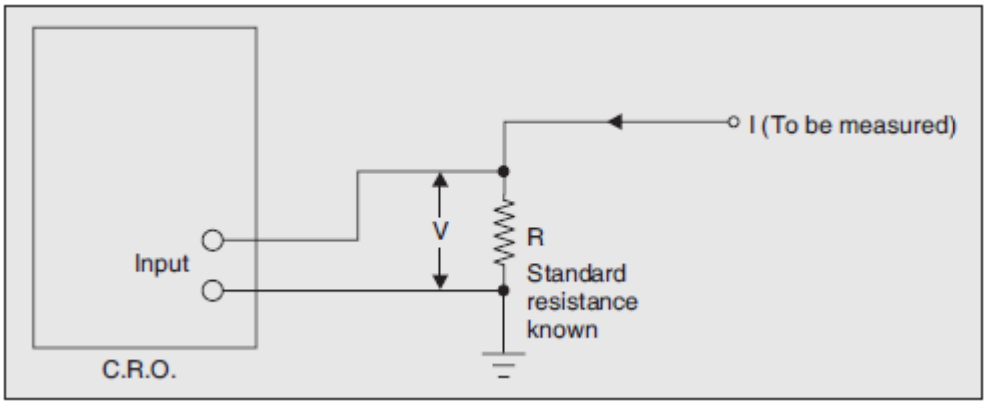
$$\text{Amplitude } V\text{max} = \left(\frac{V_{p-p}}{2}\right)$$

$$\text{R.M.S value, } V\text{r.m.s} = \left(\frac{V_{p-p}}{2\sqrt{2}}\right)$$

Measurement of Current:

Current cannot be measured directly with a CRO. To measure the current, a known resistance is taken and the potential drop across the resistance is determined with the help of measurement of potential at both ends of the resistor. The voltage across resistance is displayed on CRO and measured. The voltage divided by the considered resistance value gives the amount of current flowing in the device.

$$I = \frac{V_{measured} on\ CRO}{R}$$



5 . Explain how can you Measure frequency& time period by using CRO?

Ans: **Measurement of Time period**

The waveform is displayed on the screen such that one complete cycle is visible on the screen. Note the time/division on the front panel. Then the period of the waveform can be obtained as, $T = \frac{Time}{Divisions}$ number of divisions occupied by one cycle

Frequency without Lissajous pattern, $f = \frac{1}{T}$

6. Explain differenttypes of oscilloscopes?

Ans: The oscilloscope classified as

1. Delayed Time Base Oscilloscope

2. Dual Beam Oscilloscope

3. Dual Trace Oscilloscope

4. Digital Storage Oscilloscope

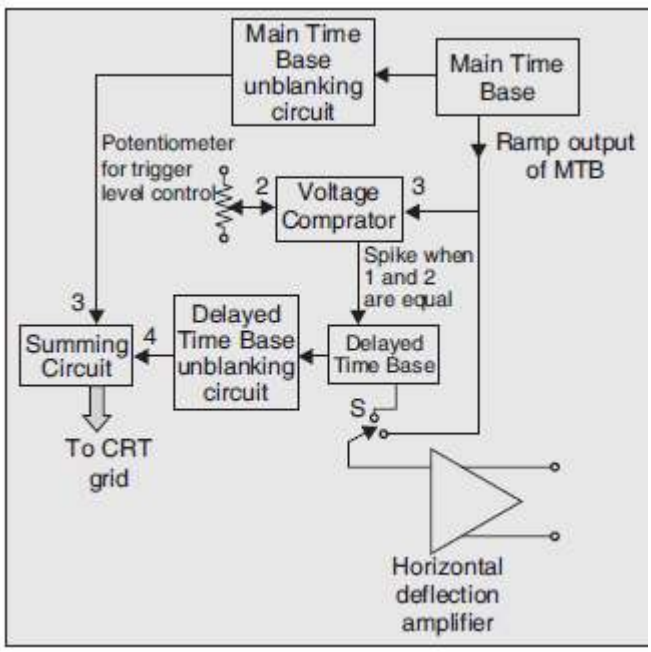
5. Sampling Oscilloscope

6. Digital Phosphor Oscilloscope

7. Digital Readout Oscilloscope

8. High Frequency Oscilloscope

1. **Delayed Time Base Oscilloscope:** In this oscilloscope, the input signal of the vertical plates is delayed by some finite time with delay circuit. The signal before the delay circuit is applied to the trigger time base circuit to the horizontal section. This allows the study of all leading or lagging edges of a pulse type waveform.



The delayed time base oscilloscope employs two time base generators: a normal time base and an additional one. This additional generator superimposes its output to brighten a specific section of the waveform, enabling detailed examination while the oscilloscope runs on its normal time base. This setup utilizes both main and delayed time base circuits for comprehensive waveform analysis.

The main time base circuit functions like other oscilloscopes, with its unblanking circuit activating the CRT's electron beam during sweep time. Its ramp output feeds a vertical comparator, along with an adjustable potentiometer input, and is directed to the horizontal deflection amplifier via a switch.

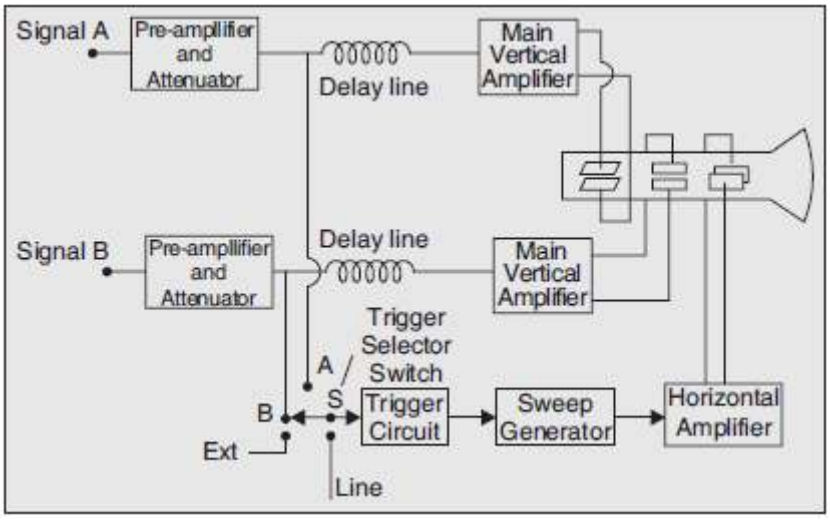
When the levels of ramp output of main time base and trigger level set by potentiometer are equal then the voltage comparator produce a negative or positive output spike at that instant. This spike triggers the delayed time base circuit.

The main time base and delayed time base unblanking circuit produces an unblanking pulse during the ramp time of delayed time base. The unblanking pulse from these is applied to the summing circuit and then applied to the CRT.

Uses:1. It is used to extend any part of the waveform on the entire screen of the oscilloscope and make it bright to analyse the desired portion of the waveform.

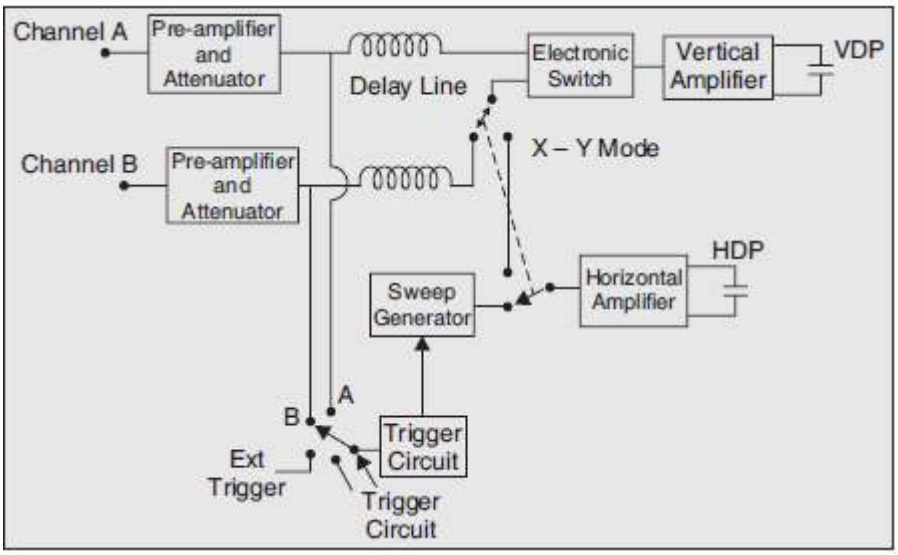
2. Dual Beam Oscilloscope:

A dual beam oscilloscope, distinct from dual trace, utilizes two independent electron beams generated by a special CRT, enabling simultaneous display of two signals. It features two separate vertical channels and amplifiers, but shares a single horizontal amplifier.



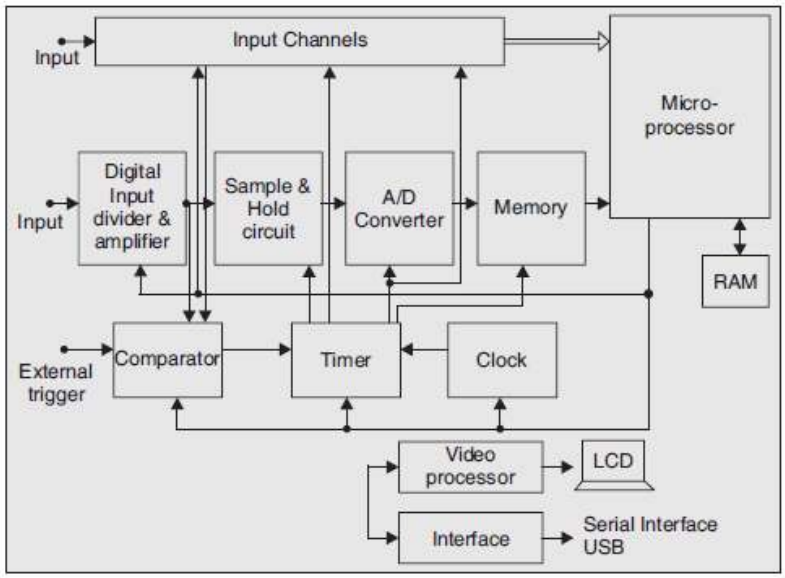
3. Dual Trace Oscilloscope

A dual trace oscilloscope uses one cathode ray gun and an electronic switch to alternate between two input signals through a single vertical amplifier. It enables the display of two waveforms using one electron beam by switching between alternate and chopped modes. This allows simultaneous comparison of two voltage waveforms, solving synchronization issues faced when using multiple oscilloscopes. Each channel has its own input attenuator and positioning control for independent signal adjustment. After pre-amplification, the signals are passed one at a time to the vertical amplifier through the electronic switch.



4. **Digital Storage Oscilloscope (DSO)**

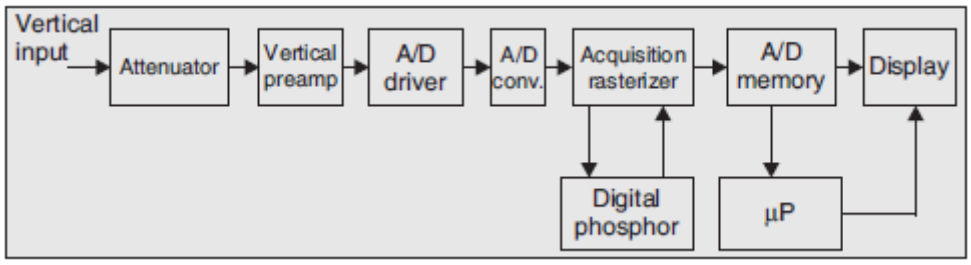
The digital storage oscilloscope just like a normal oscilloscope is a "test and measurement" equipment. It makes use of A/D and D/A converters internally to take advantage of processing of signals in digital form. The block diagram of a digital storage oscilloscope (DSO).



5.Sampling Oscilloscope: A sampling oscilloscope measures very fast signals by taking small samples of the waveform at different time intervals. It does not display the entire signal in real-time but reconstructs it from repeated samples. A sample-and-hold circuit captures tiny parts of the signal for processing. It works best with repetitive signals and provides very high bandwidth and resolution. This method allows accurate viewing of signals that are too fast for traditional oscilloscopes.

6. **Digital Phosphor Oscilloscope (DPO):**

A digital phosphor oscilloscope uses parallel processing to capture and display signals with high accuracy, helping detect fast or rare events. It creates a digital phosphor database that updates continuously, storing signal data for each pixel on the screen. Each time a signal is captured, the data is mapped to this database, and pixels touched by the waveform gain intensity. The display then shows brighter areas where the signal appears more often, providing a clear view of signal behavior.



7. **Digital Read Out Oscilloscope:**

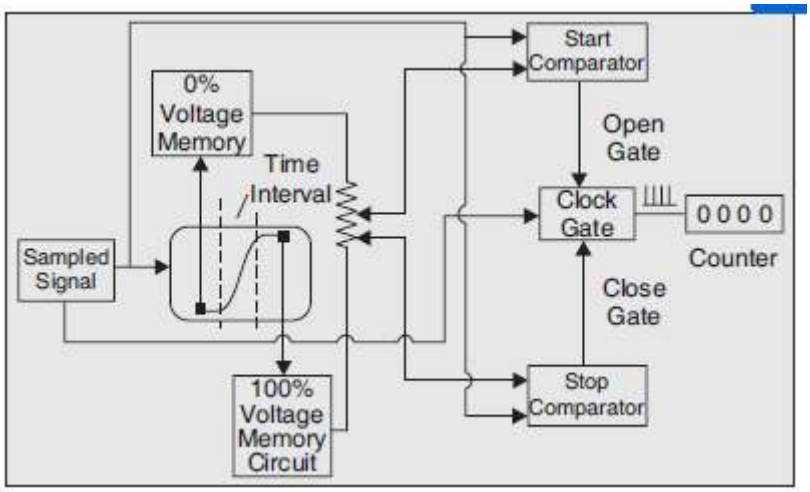
There are two modes of digital read out oscilloscope:

1. measuring voltage.

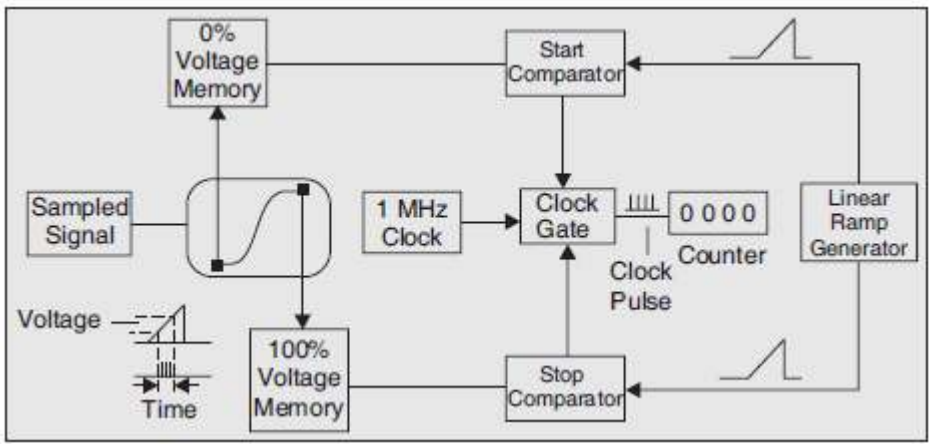
2. voltage to time conversion

1.Measuring Voltage: A digital readout oscilloscope uses two bright spots on the CRT to mark 0% and 100% voltage levels, which can be adjusted on the screen. Voltage divider taps set the timing points, and a comparator detects when the input waveform matches these levels.

The number of clock pulses during sampling is shown as a digital output using a Nixie display tube.



a. ***Voltage to Time Conversion:*** In a digital readout oscilloscope, a ramp generator starts and stops a gate at 0% and 100% reference voltages to measure voltage. The number of clock pulses during this time is counted and displayed on a Nixie tube as voltage in mV or volts.

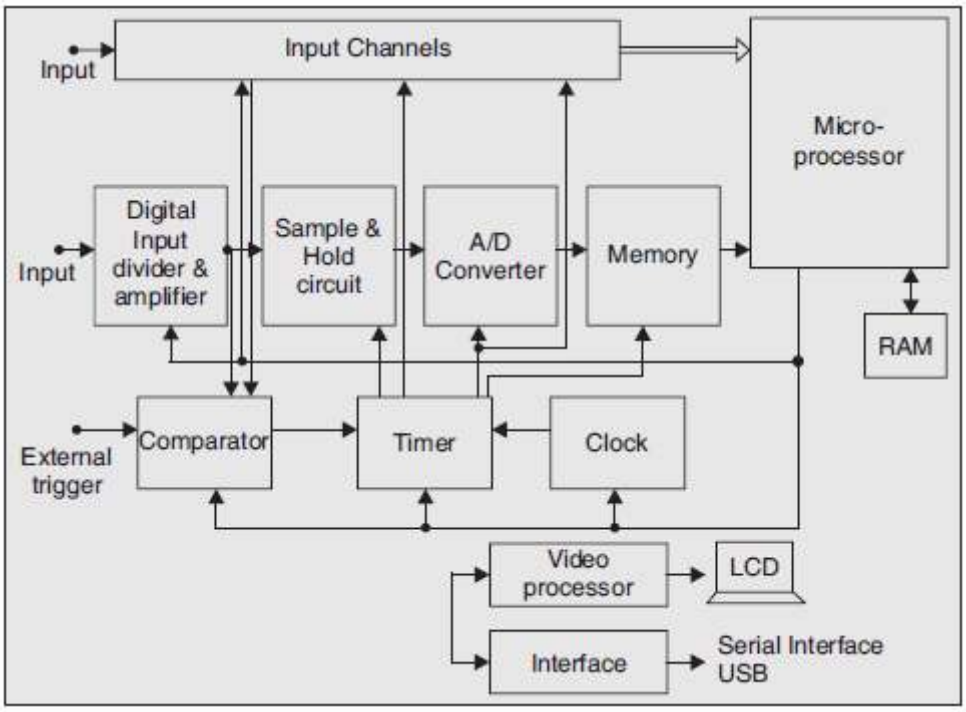


8. High Frequency Oscilloscope:

A high frequency oscilloscope is designed to measure and display very fast electrical signals accurately. It has a wide bandwidth and fast rise time to capture high-speed waveforms without distortion. These oscilloscopes are essential in applications like RF testing, radar systems, and high-speed digital circuits.

7. Explain digital storage of oscilloscope?

The digital storage oscilloscope just like a normal oscilloscope is a "test and measurement" equipment. It makes use of A/D and D/A converters internally to take advantage of processing of signals in digital form. The block diagram of a digital storage oscilloscope (DSO).



The DSO operation is controlled and operated by a comparator block in the microprocessor.The data acquisition system contains a sample-and-hold circuit and an A/D converter that takes the samples and digitizes the input signal at a rate determined by the clock. This digitized data will be stored in the memory. If the memory becomes full, the first stored data will be overwritten by the latest data. This data acquisition and storage process will happen till the external trigger receives at the comparator circuit. Once the trigger occurs, the data acquisition will be stopped and will not acquire any new data. At this point of time the saved data will be shown in the LCD.

Modes of Operation

The digital storage oscilloscope has the following mode of operation:

1. Roll Mode: This is used to observe the fast varying signal.

2. Store Mode: It is called refresh mode and is most commonly used.

3. Hold or Save Mode: This mode is also the commonly used mode.

Advantages

1.A DSO can store waveforms for a long time, unlike a normal CRO.

2.It lets you view waveforms even before the trigger happens.

3. You can move and scale the stored waveform on screen, which CROs can't do.

Disadvantages

1. DSOs are costly as compared to other oscilloscopes.

2. Slower compared to conventional oscilloscopes.

Applications

1. **Captures one-time events** like signal spikes that happen briefly.
2. **Allows detailed analysis** of any part of the recorded waveform.
3. **Can enlarge waveforms** to see small changes in amplitude or frequency.
4. **Performs math operations** like addition, subtraction, integration, etc.
5. **Works as a measuring tool** like a voltmeter, ammeter, or thermometer.

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