UNIT-IV

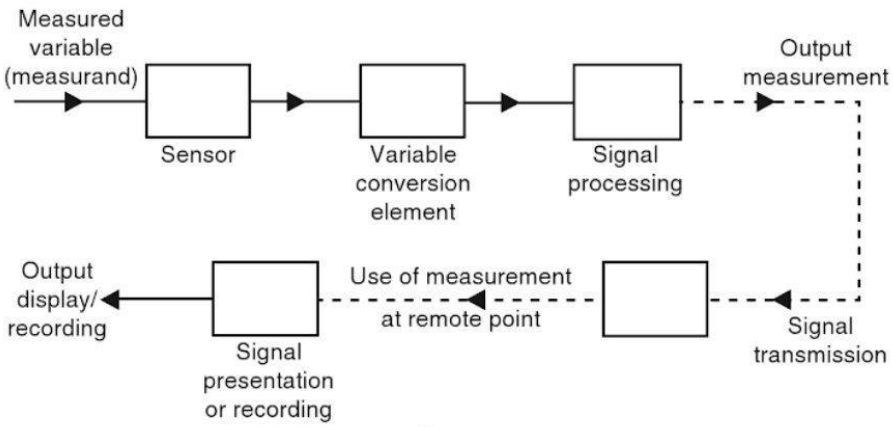
Electronic Instrumentation

Introduction: Electronic Instrumentation is about the design, realization and use of electronic systems for themeasurement of electrical and non-electrical quantities. The activity that is the basis of electronic instrumentation is measuring. The measurement of any quantity plays very important role in science, all branches of engineering, medicine and in almost all the human day to day activities.

Advantages of Electronic Measurement

- Most of the quantities can be converted by transducers into the electrical or electronic signals.
- An electrical or electronic signal can be amplified, filtered, multiplexed, sampled and measured.
- The measurement can easily be obtained in or converted into digital form for automatic analysis and recording.
- The measured signals can be transmitted over long distances with the help of cables or radio links, without any loss of information.
- Many measurements can be carried either simultaneously or in rapid succession.
- Electronic circuits can detect and amplify very weak signals and can measure the events of very short duration as well.
- Electronic measurement makes possible to build analog and digital signals. The digital signals are very much required in computers.
- Higher sensitivity, low power consumption and a higher degree of reliability are the important features of electronic instruments and measurements.

Functional elements of an instruments



Elements of a measuring system.

Basic Principle

Basic operation principle of a measurement instrument detecting an input signal and producing

an output signal. Instruments usually comprise a sensor, an amplifier, and a display.

CRT Features

Electrostatic CRTs are available in a number of types and sizes to suit individual requirements. The important features of these CR tubes are as follows.

1. Size

Size refers to the screen diameter. CRTs for oscilloscopes are available in sizes of 1, 2, 3, 5, and 7 inches. 3 inches is most common for portable instruments. For example a CRT having a number 5GP1. The first number 5 indicates that it is a 5 inch tube. Both round and rectangular CRTs are found in scopes today. The vertical viewing size is 8 cm and horizontal is 10 cm.

2. Phosphor

The screen is coated with a fluorescent material called phosphor. This material determines the color and persistence of the trace, both of which are indicated by the phosphor. The trace colors in electrostatic CRTs for oscilloscopes are blue, green and blue green. White is used in TVs, and blue-white, orange, and yellow are used for radar.

Persistence is expressed as short, medium and long. This refers to the length of time the trace remains on the screen after the signal has ended.

The phosphor of the oscilloscope is designated as follows.

- P1 - Green medium
- P2 - Blue green medium
- P5 - Blue very short
- P11 - Blue short

These designations are combined in the tube type number. Hence 5GP1 is a 5 inch tube with a medium persistence green trace. Medium persistence traces are mostly used for general purpose applications.

P11 phosphor is considered the best for photographing from the CRT screen.

3. Operating Voltages

The CRT requires a heater voltage of 6.3 volts ac or dc at 600 mA. Several dc voltages are listed below. The voltages vary with the type of tube used.

- Negative grid (control) voltage - 14 V to - 200 V.
- Positive anode no. 1 (focusing anode) - 100 V to - 1100 V
- Positive anode no. 2 (accelerating anode) 600 V to 6000 V
- Positive anode no. 3 (accelerating anode) 200 V to 20000 V in some cases

4. Deflection Voltages

Either ac or dc voltage will deflect the beam. The distance through which the spot moves on the screen is proportional to the dc, or peak ac amplitude. The deflection sensitivity of the tube is usually stated as the dc voltage (or peak ac voltage) required for each cm of deflection of the spot on the screen.

5. Viewing Screen

The viewing screen is the glass face plate, the inside wall of which is coated with phosphor. The viewing screen is a rectangular screen having graticules marked on it. The standard size used nowadays is 8 cm x 10 cm (8 cm on the vertical and 10 cm on horizontal). Each centimeter on the graticule corresponds to one division (div). The standard phosphor color used nowadays is blue.

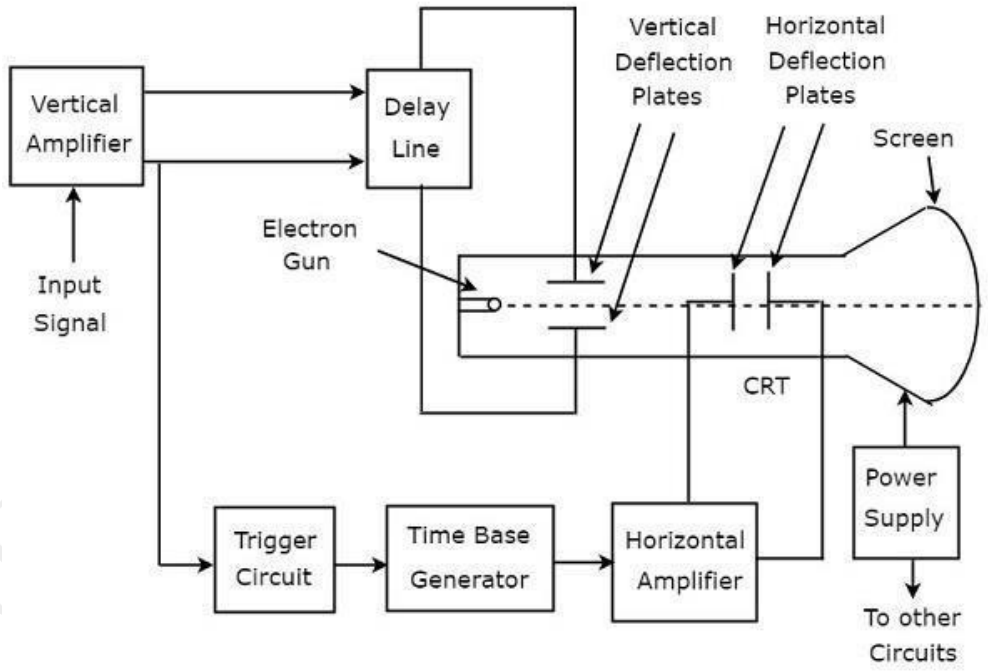
Cathode Ray Oscilloscope

The cathode ray oscilloscope is the instrument which generates the waveform of any electrical quantity. The waveform is generated in such a way that the amplitude of the signal is represented along Y-axis and the variation in the time is represented along X-axis.

CRO is the measuring device as well as it can generate waveforms in terms of amplitude andtime because it is very easy to measure the amplitude of the voltage signal to determine its intensity.

Block Diagram of Oscilloscope

The cathode-ray oscilloscope (CRO) is a common laboratory instrument that provides accurate time and amplitude measurements of voltage signals over a wide range of frequencies. Its reliability, stability, and ease of operation makes it suitable as a general purpose laboratory instrument.



- A general purpose oscilloscope consists of the following parts:
- Cathode ray tube
- Vertical amplifier
- Delay line
- Time base generator
- Horizontal amplifier
- Trigger circuit

- Power supply

Cathode Ray Tube - It is the heart of the oscilloscope. When the electrons emitted by the electron gun strikes the phosphor screen, a visual signal is displayed on the CRT.

Vertical Amplifier - The input signals are amplified by the vertical amplifier. Usually, the vertical amplifier is a wide band amplifier which passes the entire band of frequencies.

Delay Line - As the name suggests, this circuit is used to delay the signal for a period of time inthe vertical section of CRT. The input signal is not applied directly to the vertical plates becausethe part of the signal gets lost, when the delay time is not used. Therefore, the input signal isdelayed by a period of time.

Time Base (Sweep) Generator - Time base circuit uses a uni-junction transistor, which is usedto produce the sweep. The saw tooth voltage produced by the time base circuit is required to deflect the beam in the horizontal section. The spot is deflected by the saw tooth voltage at a constant time dependent rate.

Horizontal Amplifier - The saw tooth voltage produced by the time base circuit is amplified by the horizontal amplifier before it is applied to horizontal deflection plates.

Trigger Circuit - The signals which are used to activate the trigger circuit are converted to trigger pulses for the precision sweep operation whose amplitude is uniform. Hence input signal and the sweep frequency can be synchronized.

Power supply - The voltages required by CRT, horizontal amplifier, and vertical amplifier are provided by the power supply block. It is classified into two types -

(1) Negative high voltage supply

(2) Positive low voltage supply

The voltage of negative high voltage supply is from -1000V to -1500V. The range of positive voltage supply is from 300V to 400V.

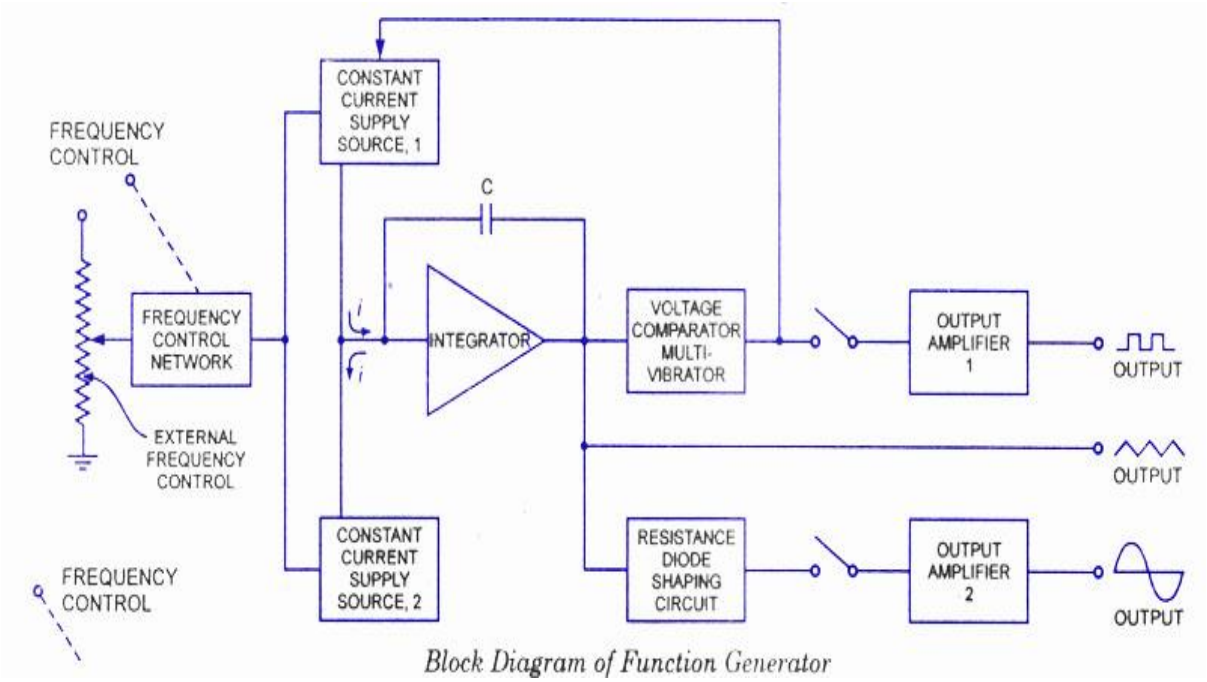
Working of Cathode Ray Oscilloscope

When the electron is injected through the electron gun, it passes through the control grid. The control grid controls the intensity of electron in the vacuum tube. If the control grid has high negative potential, then it allows only a few electrons to pass through it. Thus, the dim spot is produced on the lightning screen. If the negative potential on the control grid is low, then the bright spot is produced. Hence the intensity of light depends on the negative potential of the control grid.

After moving the control grid the electron beam passing through the focusing and accelerating anodes. The accelerating anodes are at a high positive potential and hence they converge the beam at a point on the screen.

After moving from the accelerating anode, the beam comes under the effect of the deflecting plates. When the deflecting plate is at zero potential, the beam produces a spot at the Centre. If the voltage is applied to the vertical deflecting plate, the electron beam focuses at the upward and when the voltage is applied horizontally the spot of light will be deflected horizontally.

Function generator: A function generator is a signal source that has the capability of producing different types of waveforms as its output signal.



Block Diagram of Function Generator

The block diagram of a function generator is given in the figure. In this instrument, the frequency is controlled by varying the magnitude of the current that drives the integrator. This instrument provides different types of waveforms (such as sinusoidal, triangular and square waves) as its output signal with a frequency range of 0.01 Hz to 100 kHz.

The frequency controlled voltage regulates two current supply sources. Current supply source 1 supplies a constant current to the integrator whose output voltage rises linearly with time. An increase or decrease in the current increases or reduces the slope of the output voltage and thus controls the frequency.

The voltage comparator multivibrator changes state at a predetermined maximum level, of the integrator output voltage. This change cuts-off the current supply from supply source 1 and switches to the supply source 2. The current supply source 2 supplies a reverse current to the integrator so that its output drops linearly with time. When the output attains a pre-determined level, the voltage comparator again changes state and switches on to the current supply source. The output of the integrator is a triangular wave whose frequency depends on the current supplied by the constant current supply sources. The comparator output provides a square wave of the same frequency as output. The resistance diode network changes the slope of the triangular wave as its amplitude changes and produces a sinusoidal wave with less than 1% distortion