6.1. Concept and Classification of Recorders

Concept

- A recorder records electrical and non-electrical quantities as a function of time.
- Currents and voltages can be recorded directly while the non-electrical quantities are recorded indirectly by first converting them to equivalent currents or voltages with the help of sensors or transducers.

"The recorders can be classified as following.

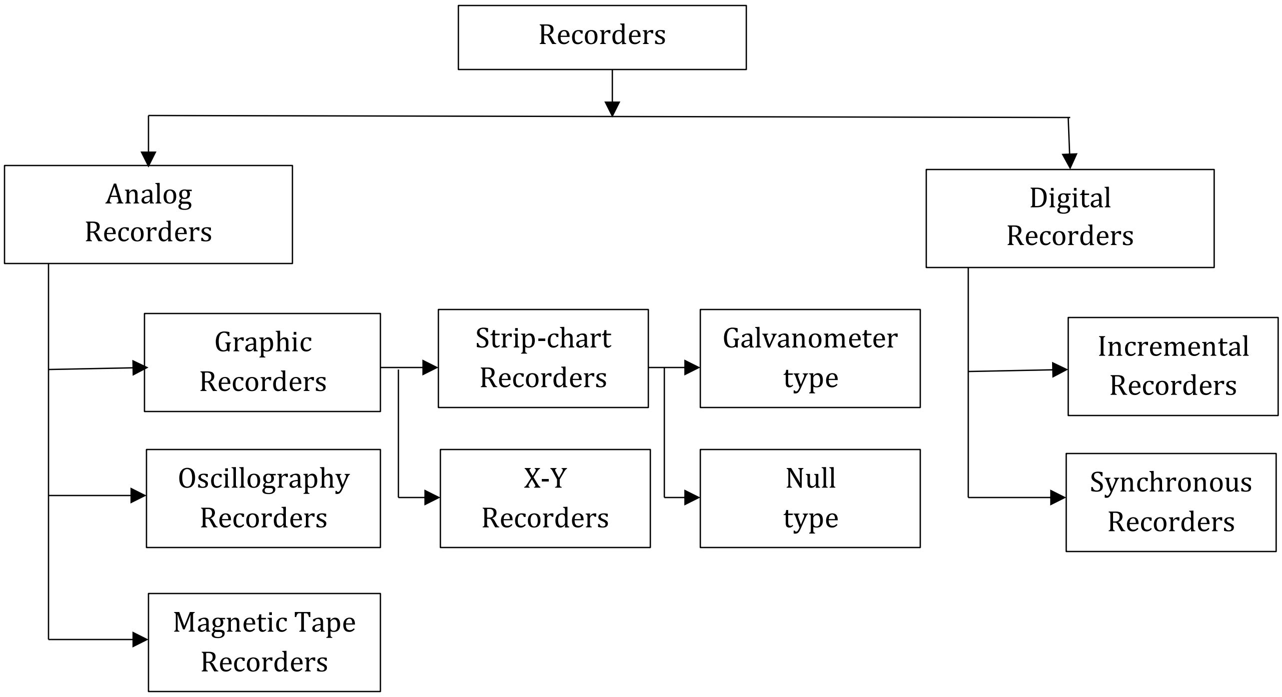

Figure 6. 1 Classification of recorders

Analog Recording

- An analog recording is one where a property or characteristic of a physical recording medium is made to vary in a manner analogous to the variations in air pressure of the original sound.
- Generally, the air pressure variations are first converted (by a transducer such as a microphone) into an electrical analog signal in which either the instantaneous voltage or current is analogous to the instantaneous air pressure.
- The variations of the electrical signal in turn are converted to variations in the recording medium by a recording machine such as a tape recorder or cutting lathe.
- Example – PMMC instrument (**P**ermanent **M**agnet **M**oving **C**oil)

Graphic Recorders

- Graphic recorders generally are devices which display and store a pen and ink record of the history of some physical event.
- Basic elements of a recorder include a chart for displaying and storing the recorded information, a stylus moving in a proper relationship to the paper and suitable means of interconnection to couple the stylus to the source of information.

- The graphic recorders can be classified in two categories:

  (i) *Strip chart recorders:* A strip chart recorder records one or more variables with respect to time. It is an X-t recorder.

  (ii) *X-Y recorders:* An X-Y recorder records one or more dependent variables with respect to an independent variable.

6.2. Basic Strip chart recorder

- Figure 2.2 shows basic constructional features of a strip chart recorder.

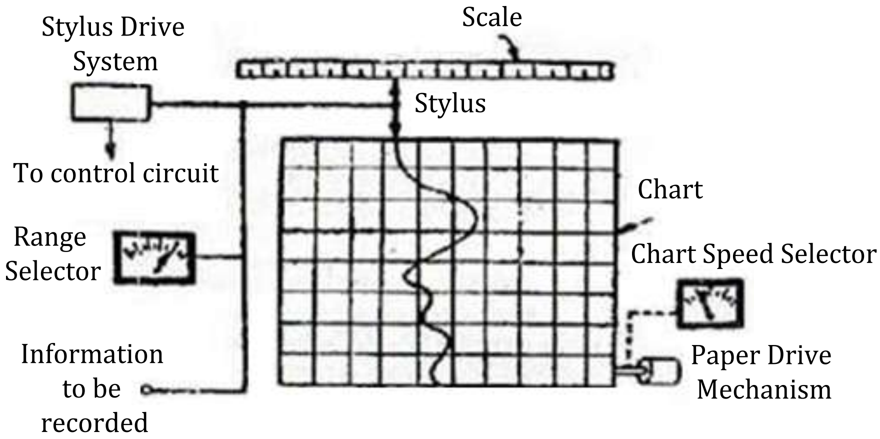

Figure 6. 2 Basic strip chart recorder

Construction

- A strip chart recorder consists of:

  (i) Paper drive systems: It should move the paper at a uniform speed. A spring wound mechanism may be used but in most of the recorders and a synchronous motor is used for driving the paper.

  (ii) Marking mechanism: The most commonly used marking mechanisms are as following:

    a. Marking with ink filled stylus
    b. Marking with heated stylus
    c. Chopper bar
    d. Electric stylus marking
    e. Electrostatic stylus
    f. Optical marking method

  (iii) Tracing systems: There are two types of tracing systems used for producing graphic representations.

    a. Curvilinear system
    b. Rectilinear system

Working

- A strip chart recorder has:

  (i) A long roll of graph paper moving vertically.

  (ii) A system for driving the paper at some selected speed. A speed selector switch is generally provided. Chart speed of 1-100 mm/s are usually used.

  (iii) A stylus for making marks on the moving graph paper. The stylus moves horizontally in proportional to the quantity being recorded.

(iv) A stylus driving system which moves the stylus in a nearly exact replica or analog of the quantity being recorded.
(v) A range selector switch is used so that input to the recorder drive system is within the acceptable level.
(vi) Most recorder use a pointer attached to the stylus. This pointer moves over a calibrated scale thus showing the instantaneous value of the quantity being recorded. An external control circuit for the stylus may be used.

6.3. Types of Strip Chart Recorders

- The different types of strip chart recorders are:

  1. Galvanometer type 2. Null type

  Galvanometer type strip chart recorder

  - This type of strip chart recorder operates on the deflection principle. The deflection is produced by a galvanometer which produces a torque on account of a current passing through its coil. This current is proportional to the quantity being measured.

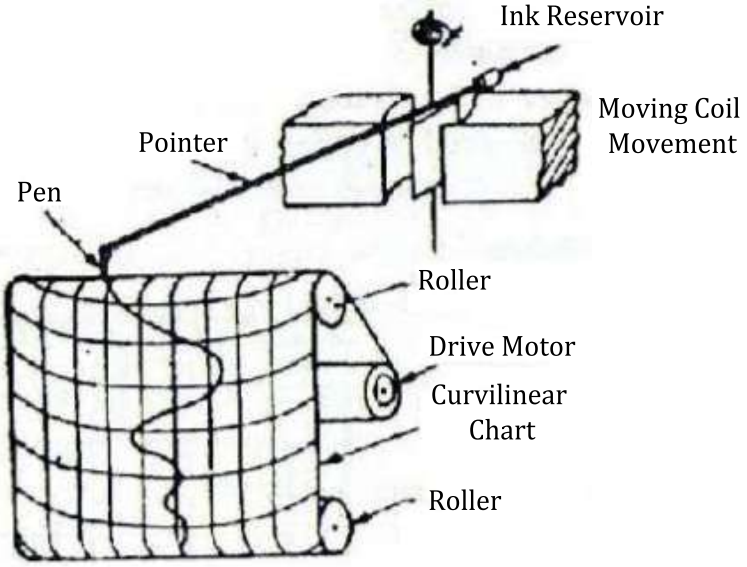

Figure 6. 3 Galvanometer type strip chart recorder

  - These recorders use a D'Arsonval galvanometer.
  - The pointer is equipped with a stylus. As the current flows through the coil, it deflects. When the pointer comes to rest on account of controlling torque exerted by springs, the stylus also comes to rest. Thus, the value of quantity is recorded.
  - This type of recorder is not useful for recording fast variations in either current or voltage or power. This records only the average values and hence it should be designed for these.
  - The type of chart used depends upon the form of movement. The recorder shown in figure 6.3 uses a chart having rectilinear system of tracing.
  - The recorders can work on ranges from a few mA to several mA or a few mV to several mV. It has narrow bandwidth of 0 to 10 Hz. It has a sensitivity of 0.4 mV/mm or from a chart of 100 mm width a full scale deflection of 40 mV is obtained. For measurement of smaller voltage linear amplifiers are used.

- In these recorders the bearings must be substantially larger than those used in indicator instruments, because of the large mass of coil and stylus.

Null type strip chart recorder

- Many recorders operate on the principle whereby a change in its input, produced by the signal from the sensor or transducer, upsets the balance of the measuring circuit of the recorder.
- As a result of this unbalance, an **error signal** is produced that operates some device which restores balance or brings the system to **Null conditions**.
- The amount of movement of this balance restoring device then, is an indication of the magnitude of the error signal, and the direction of the movement is an indication of the direction of the quantity being measured has deviated from normal.
- The signal from the transducer may take any of the several forms. It may be a voltage, a current or it may be a value of resistance, inductance or capacitance. The recorder, therefore, must be of a type able to accept the form of the input signal.
- There are a number of null type recorders. They are
  - Potentiometric recorders
  - Bridge recorders and
  - LVDT recorders

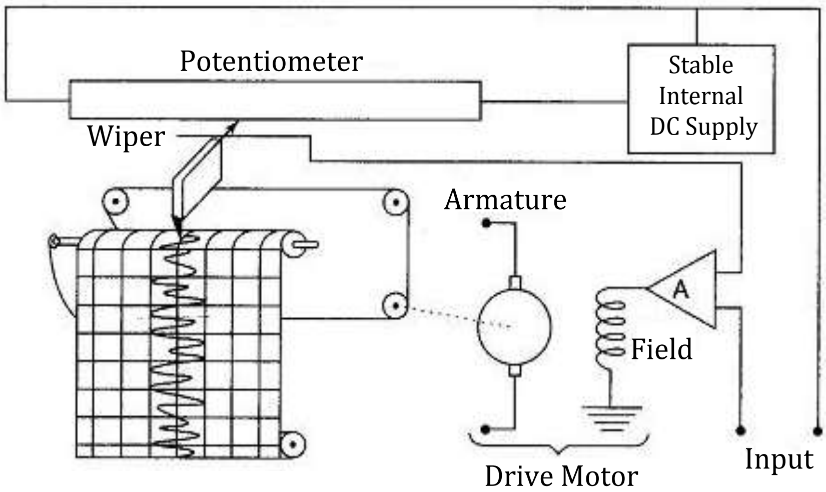

Figure 6. 4 Potentiometric type recorder

6.4. X-Y type recorders

- A strip chart recorder records the variations of a quantity w.r.t. time while a X-Y recorder is an instrument which gives a graphic record of the relationship between two variables.
- In X-Y recorders, an emf is plotted as a function of another emf. This is done by having one self-balancing potentiometer control the position of the rolls while another self-balancing potentiometer controls the position of the recording pen (stylus).
- In some X-Y recorders, one stylus moves in the X direction and second stylus moves in the Y direction at right angles to the X direction, while the paper remains stationary.
- With the help of X-Y recorders and appropriate transducers, a physical quantity may be plotted against another physical quantity.

- Hence, an X-Y recorder consists of a pair of servo-system, driving a recording pen and moving arm arrangement, with reference to a stationary paper chart. Attenuators are used to bring the input signals to the levels acceptable by the recorder.
- Figure 6.5 below shows a block diagram of a typical X-Y recorder.

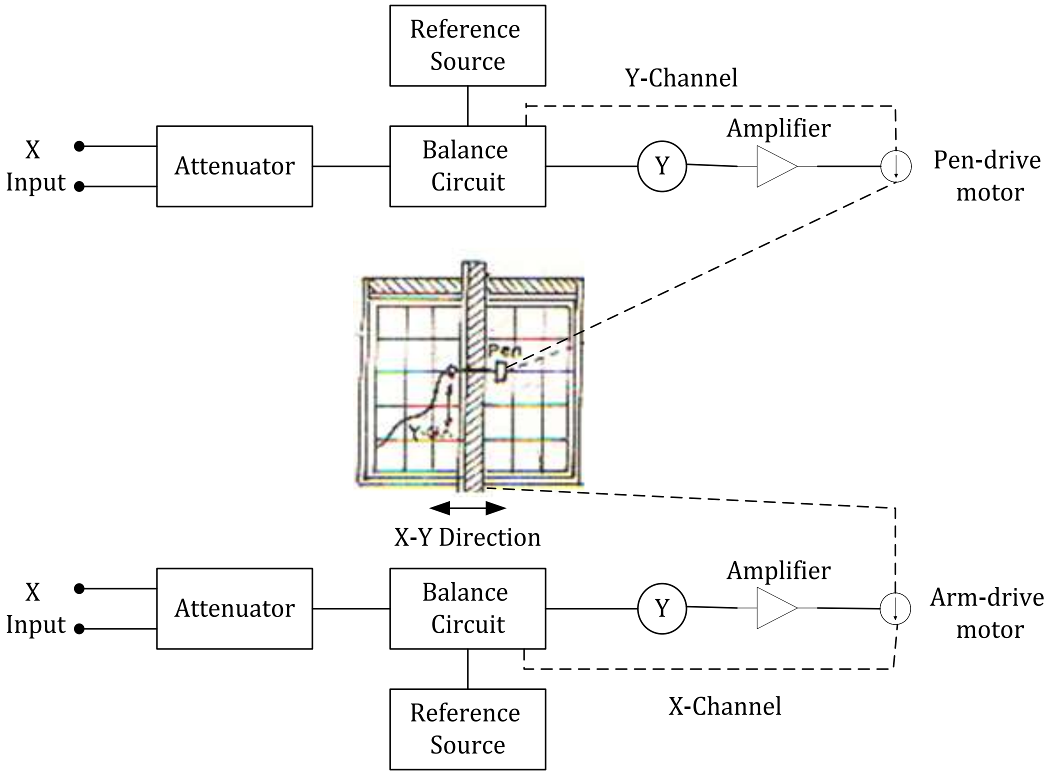

Figure 6. 5 Block diagram of a typical X-Y recorder

- A signal enters each block of the two channels. The signals are attenuated to the inherent full scale range of the recorder, the signal then passes to a balance circuit where it is compared with an internal reference voltage. The error signal and the reference voltage is fed to a chopper which converts d.c. signal to an a.c. signal. The signal is then amplified in order to actuate a servomotor which is used to balance the system and hold it in balance as the value of the quantity being recorded changes.
- The action described above takes place in both axes simultaneously. Thus we get a record of one variable w.r.t. another.
- The use of X-Y recorders in laboratories greatly simplifies and expedites many measurements and tests. A few examples are being given below:
    - ➢ Speed torque characteristics of motors
    - ➢ Lift drag wind tunnel tests
    - ➢ Plotting of characteristics of vacuum tubes, Zener diodes rectifier and transistors etc.
    - ➢ Regulation curves of power supplies
    - ➢ Plotting stress-strain curves, hysteresis curves and vibrations amplitude against swept frequency

- ➢ Electrical characteristics of materials such as resistance vs. temperature plotting the output from electronic calculators and computers.

6.5. Magnetic Tape Recorders

It is frequently desirable and in many cases necessary, to record data in such a way that they can be retrieved or reproduced in electrical form again. The most common and most useful way of achieving this is through the use of magnetic tape recording.

Principle

- When a magnetic tape is passed through a recording head, any signal recorded on the tape appears as magnetic pattern dispersed in space along the tape, similar to the original coil current variation with time.
- The same tape when passed through a reproduce or playback head reproduces variations in the reluctance of the winding thereby inducing a voltage in the winding dependent upon the direction of magnetization and its magnitude on the magnetic tape. The induced voltage is proportional to the rate of change of flux linkages. Therefore the emf induced in the winding of reproducing head is proportional to the rate of change of level of magnetization on the tape.

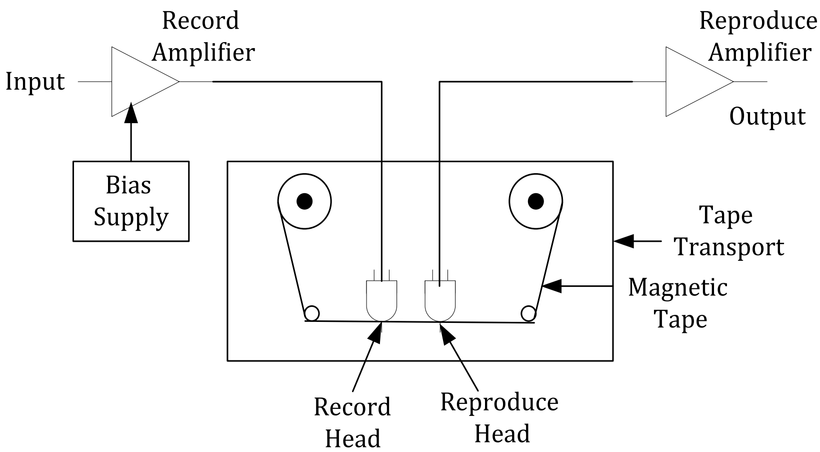

Figure 6. 6 Elementary Magnetic Tape Recorder

Methods of recording

- There are three methods of magnetic tape recording which are used for instrumentation purposes. They are:
  - ➢ Direct recording
  - ➢ Frequency Modulation (FM) recording
  - ➢ Pulse Modulation (PM) recording
- FM recorders are generally used for instrumentation purposes.
- The PDM recording is used in instrumentation systems for special applications where a large number of slowly changing variables have to be recorded simultaneously.

Advantages

- They have a wide frequency range from dc to several MHz.
- They have a wide dynamic range which exceeds 50 db. This permits the linear recording from full scale signal level to approximately 0.3% of full scale.

- They have low distortion.
- The magnitude of the electrical input signal is stored in magnetic memory and this signal can be reproduced whenever desired. The reproduced signal can be analyzed by automatic data reduction methods.
- The recorded signal is immediately available, with no time lost in processing. The recorded signal can be played back, or, reproduced as many times as desired without loss of signal.
- When the information has been processed, the tape can be erased and reused to record a new set of data.
- It permits multi-channel recording. A tape facilitates the continuous record of a number of signals, which may have a wide range of frequency, to be made simultaneously.
- The use of magnetic tape recorders provides a convenient method of changing the time base. Data may be recorded at very fast speeds and played back at speeds with low frequency recorders like graphic recorders.

6.6. Digital Tape Recorders

Principle

- An analog signal is converted to digital by an analog-to-digital converter, which measures the amplitude of an analog signal at regular intervals, which are specified by the sample rate, and then stores these sampled & quantized numerical value in computer hardware such as compact disc or hard disc.
- Digital recordings are very accurate, the accuracy determined only by the quality of D/A and A/D converters.
- For optical disc recording technologies such as CDs or DVDs, a laser is used to burn microscopic holes into the dye layer of the medium.
- A weaker laser is used to read these signals.
- This works because the metallic substrate of the disc is reflective, and the unburned dye prevents reflection while the holes in the dye permit it, allowing digital data to be represented.
- The digital data recorders are basic two type, namely, Incremental and synchronous.

6.7. Digital Storage Oscilloscope (DSO)

Construction

- DSOs use digital storage techniques while analog storage CROs use special CRTs called storage tubes.
- In this technique, the waveform to be stored is digitized, stored in a digital memory, and retrieved for display on the storage oscilloscope. The stored waveform is continually displayed by repeatedly scanning the stored waveform and therefore, a conventional CRT can be employed for the display and thus some of the cost of the additional circuitry for digitizing and storing the input waveform is offset.
- The stored display can be displayed indefinitely as long as the power is applied to the memory, which can be supplied with a small battery. The digitized waveform can be further analyzed by either the oscilloscope or by loading the contents of the memory into a computer.

- A generalised block diagram of digital storage oscilloscope is shown in fig. 6.7.

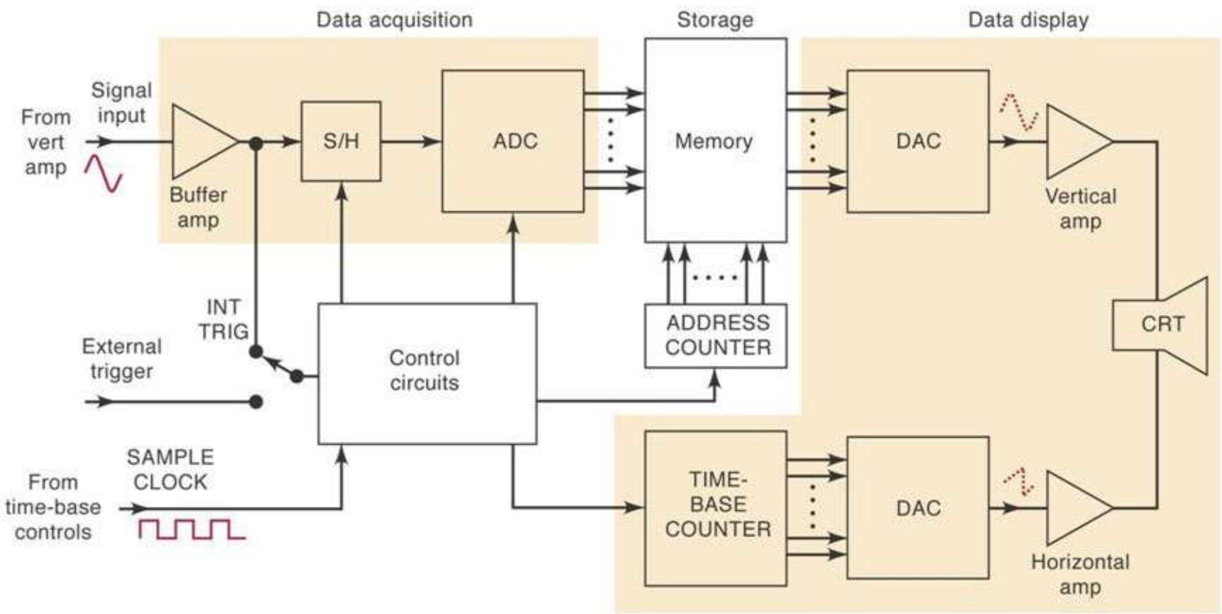

Figure 6. 7 Block diagram of Digital Storage Oscilloscope (DSO)

- Some of the DSOs use 12 bit converters, giving 0.025% resolution and 0.1% accuracy on voltage and time readings, which are better than the 2-5% of analog storage oscilloscopes.
- Split screen capabilities enable easy comparison of the two signals.
- The only drawback of DSO is limited bandwidth by the speed of their analog-to-digital converters. However, 20 MHz digitizing rates available on some oscilloscopes yield a bandwidth of 5 MHz, which is adequate for most of the applications.

Limitations

1. **Oscilloscope Loading and Probe Use:** To counteract the loading effect on an oscilloscope, voltage probes are used. Voltage probes are devices which increase the input impedance of an oscilloscope by inserting a high impedance in series with the oscilloscope inputs.
2. **Hum and Noise Pickup:** The oscilloscope is designed to be capable of amplifying and displaying small input signals. This capability also makes it susceptible to amplification of small unwanted signals and noise, especially when set to its most volts/division capability.
   The magnitude of hum picked up by an oscilloscope depends upon the impedance of the circuit under testing, the length of the oscilloscope leads, and the type of shielding used by these leads.
   Hum signals are largest when long, unshielded leads are connected to high-impedance circuits.
   The best way to reduce the level of such interference signals is to use short cables which have a shield that can be connected to ground. Differential inputs are also designed to help reduce noise pickup in low-level signals.

3. **Oscilloscope Errors:**
   - Reading error
   - Parallax error
   - Calibration error
   - Frequency-response error
   - Loading error

Oscilloscope Measurement Applications

1. Checking individual electrical components such as vacuum tubes, diodes, transistors, ICs, magnetic components, relays, and choppers.
2. Checking amplifiers and amplifier circuits.
3. Displaying transducer outputs.
4. Television, radio and communication equipment checking and repair.
5. Electrical diagnosis of automobile engines.
6. Special curve-tracer oscilloscopes are available for plotting the current-voltage characteristics of transistors, diodes, and other elements.
7. In Radar, CRO is used for providing the visual indication of target such as aeroplane, ship etc.
8. In Medical Sciences, the low speed time base CROs are used in electrocardiogram (ECG), electromyogram (EMG) and Electroencephalogram (EEG), which are employed for diagnosis of the condition of heart, brain and muscles, respectively of the patient body.
