UNIT V STORAGE AND DISPLAY INSTRUMENTS 12 hrs.

Cathode Ray Oscilloscopes - Storage Oscilloscope - Digital Storage Oscilloscope – Sampling CRO - Dual Trace Oscilloscopes – Electromechanical servo type XT & XY recorders - LED, LCD, Dot Matrix Display – Magnetic Tape and Disk Recorders/ Reproducers.

STORAGE AND DISPLAY INSTRUMENTS

Cathode Ray Oscilloscope

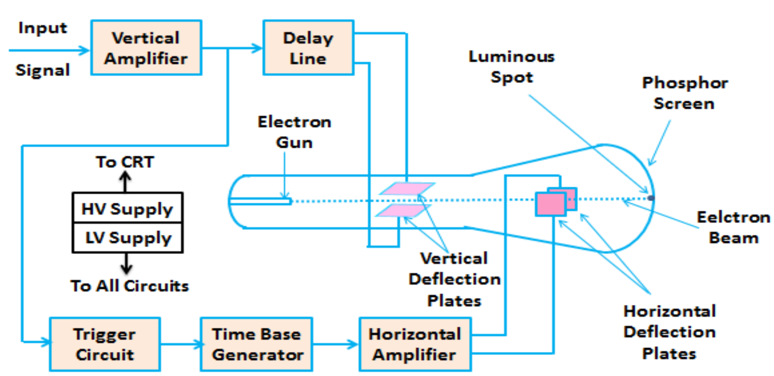
The cathode Ray Oscilloscope or mostly called as CRO is an electronic device used for giving the visual indication of a signal waveform. It is an extremely useful and the most versatile instrument in the electronic industry. CRO is widely used for trouble shooting radio and television receivers as well as for laboratory research and design.

Using a CRO, the wave shapes of alternating currents and voltages can be studied. It can also be used for measuring voltage, current, power, frequency and phase shift.

Different types of oscilloscopes are available for various purposes.

Block Diagram of CRO (Cathode Ray Oscilloscope)

The figure below shows the block diagram of a general purpose CRO.



Block Diagram of Cathode Ray Oscilloscope (CRO)

As we can see from the above figure above, a CRO employs a cathode ray tube (CRT), which acts as the heart of the oscilloscope.

In an oscilloscope, the CRT generates the electron beam which are accelerated to a high velocity and brought to focus on a fluorescent screen. This screen produces a visible spot where the electron beam strikes it. By deflecting the beam over the screen in response to the electrical signal, the electrons can be made to act as an electrical pencil of light which produces a spot of light wherever it strikes.

For accomplishing these tasks various electrical signals and voltages are needed, which are provided by the power supply circuit of the oscilloscope. Low voltage supply is required for the heater of the electron gun to generate the electron beam and high voltage is required for the cathode ray tube to accelerate the beam. Normal voltage supply is required for other control units of the oscilloscope.

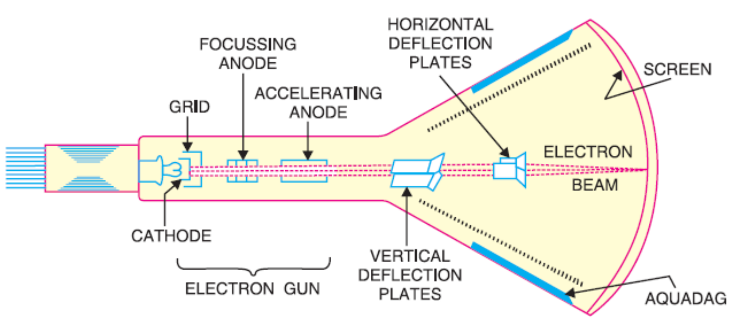
Horizontal and vertical deflection plates are fitted between the electron gun and the screen so that these can deflect the beam according to the input signal. To deflect the electron beam on the screen in horizontal direction i.e. X-axis with constant time dependent rate, a time base generator is provided in the oscilloscope. The signal to be viewed is supplied to the vertical deflection plate through the vertical amplifier, so that it can amplify the signal to a level that will provide usable deflection of the electron beam. As the electron beam is deflected in X-axis as well as Y-axis, a triggering circuit is provided for synchronizing these two types of deflections so that horizontal deflection starts at the same point of the input vertical signal each time it sweeps. Since CRT is the heart of the oscilloscope, we are going to discuss its various components in detail.

Cathode Ray Tube

The cathode ray tube or CRT is a vacuum tube of special geometrical shape which converts an electrical signal into a visual one.

A CRT makes available a large number of electrons which are accelerated to high velocity and are brought to focus on a fluorescent screen where it produces a spot when strikes it. The electron beam is deflected during its journey in response to the applied electrical signal. As a result, the electrical signal waveform is displayed visually.

The figure below shows various parts of a cathode ray tube (CRT).



(i) Glass Envelope

It is a conical highly evacuated glass housing which maintains vacuum inside it and supports various electrodes. The inner wall of CRT between the neck and screen are usually coated with a conducting material known as aquadag. This coating is electrically connected to the accelerating anode so that the electrons which accidentally strike the walls are returned to the anode. This prevents the walls from charging to a high negative potential.

(ii) Electron Gun Assembly

The electron gun assembly consists of an indirectly heated cathode, a control grid, a focussing anode and an accelerating anode and it is used to produce a focused beam of electrons. The control grid is held at negative potential w.r.t. cathode. However, the two anodes are held at high positive potential w.r.t. cathode. The cathode consists of a nickel cylinder coated with oxide coating and provides a large number of electrons. The control grid encloses the cathode and consists of a metal cylinder with a tiny circular opening to keep the electron beam small. By controlling the positive potential on it, the focusing anode focuses the electron beam into a sharp pin point. Due to the positive potential of about 10,000 V on the accelerating anode which is much larger than on the focusing diode, the electron beam is accelerated to a high velocity. In this way, the electron gun assembly forms a narrow, accelerated electron beam which produces a spot of light when it strikes the screen.

(iii) Deflection Plate Assembly

It consists of two sets of deflecting plates within the tube beyond the accelerating anode and is used for the deflection of the beam. One set is called as vertical deflection plates and the other set is called horizontal deflection plates. The vertical deflection plates are mounted horizontally in the tube. On application of proper potential to these plates, the electron beam can be made to move up and down vertically on the screen. The horizontal deflection plates are mounted vertically in the tube. On application of proper potential to these plates, the electron beam can be made to move right and left horizontally on the screen.

(iv) Screen

The screen is coated with some fluorescent materials such as zinc orthosilicate, zinc oxide etc and is the inside face of the tube. When high velocity electron beam strikes the screen, a spot of light appears at the point of impact. The colour of the spot depends upon the nature of fluorescent material.

Working of Cathode Ray Tube

As the cathode is heated, it produces a large number of electrons. These electrons pass through the control grid on their way to the screen. The control grid controls the amount of current flow as in standard vacuum tubes. If negative potential on the control grid is high, fewer electrons will pass through it. Hence the electron beam will produce a dim spot of light on striking the screen. Reverse will happen when the negative potential on the control grid is reduced. Therefore, the intensity of the light spot on the screen can be controlled by changing the negative potential on the control grid.

After leaving the control grid, the electron beam comes under the influence of focusing and accelerating anodes. Since, the two anodes are at high positive potential, therefore, they produce a field which acts as electrostatic lens to converge the electron beam at a point on the screen. After leaving the accelerating anode, the electron beam comes under the influence of vertical and horizontal deflection plates. When no voltage is applied to these deflection plates, the electron beam produces a spot of light at the centre as shown by point O in fig below on the screen.

If the voltage is applied to the vertical deflection plates only, the electron beam and so as the spot of light will be deflected upwards i.e. point O1. Ans if the potential on the plates is reversed, the spot of light will be deflected downwards i.e. point O2. Similarly, the spot of light can be deflected horizontally by applying voltage across the horizontal deflection plates.

STORAGE OSCILLOSCOPE

It is sometimes necessary to be able to display a signal for a period of time. One situation where this may be required is for signals that have a very long period and the normal persistence of a display would mean that the trace would decay before the whole waveform was complete. A storage facility could also be required for single shot applications where the single trace would need to be displayed over a period of time to examine the trace. For these and many other situations, it is necessary to have a storage facility on the scope where it can display the trace for longer than would normally be possible.

Analogue storage scopes use a special cathode ray tube with a long persistence facility. A special tube with an arrangement to store charge in the area of the display where the electron beam had struck, thereby enabling the fluorescence to remain for much longer than attainable on normal displays. These cathode ray tubes had the facility to vary the persistence, although if very bright traces were held over long periods of time, they would have the possibility of permanently burning the trace onto the screen. Accordingly these storage displays needed to be used with care.

Two storage techniques are used in oscilloscope CRTs as,

-mesh storage

-phosphor storage.

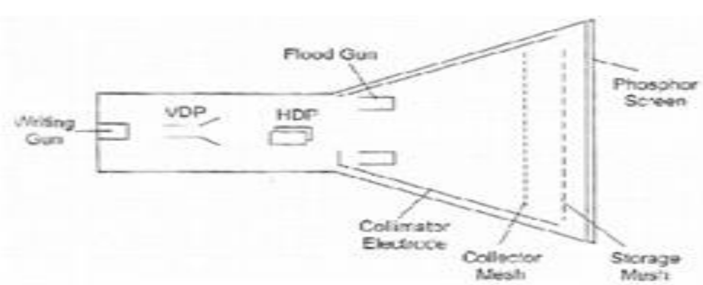
The Storage targets can be distinguished from standard phosphor targets by their ability to retain a waveform pattern for a long time, independent of phosphor persistence.

A mesh-storage CRT uses a dielectric material deposited on a storage mesa as the storage target. This mesh is placed between the deflection plates and the standard phosphor target in the CRT.

The writing beam, which is the focused electron beam of the standard CRT, charges the dielectric material positively e where hit. The storage target is then bombarded with low velocity electrons from a flood gun and the positively charged areas of the storage target allow these electrons to pass through to the standard phosphor target and thereby reproduced the stored image on the screen.

Thus the mesh storage has both a storage target and a phosphor display target. The phosphor storage CRT uses a thin layer of phosphor to serve both as the storage and the display element.

Mesh Storage It is used to display Very Low Frequencies (VLF) signals an: finds many applications in mechanical and biomedical fields. The convention-scope has a display with a phosphor persistence ranging from a few microseconds to a few seconds.



A mesh storage CRT, contains a dielectric material deposed on a storage mesh, a collector mesh, flood guns and a collimator, in addition BO all the elements of a standard CRT.

The storage target, a thin deposition of a dielectric material such as Magnesium Fluoride on the storage mesh, makes use of a property known as secondary emission. The writing gun etches a positively charged pattern on the storage mesh or target by knocking off secondary emission electrons.

Because of the excellent insulating property of the Magnesium fluoride coating, this positively charged pattern remains exactly in the position where it is deposited. In order to make a pattern visible, a special electron gun, called the flood gun, is switched on (even after many hours).

The electron paths ire adjusted by the collimator electrode, which constitutes a low voltage electrostatic lens system (to focus the electronbeam), Most of the electrons are stopped and collected by the collector mesh. Only electrons near the stored positive charge are pulled to the storage target with sufficient force to hit the phosphor screen.
The CRT will now display the signal and it will remain visible as long as the flood guns operate. To erase the pattern on the storage mesh, a negative voltage is applied to neutralize the stored positive charge.

Since the storage mesh makes use of secondary emission, between the first and second crossover more electrons are emitted than are absorbed by the material, and hence a net positive charge results. Below the first crossover a net negative charge results, since the impinging electrons do not have sufficient energy to force an equal number to be emitted.
In order to store a trace, assume that the storage surface is uniformly charge; and write gun (beam emission gun) will hit the storage target. Those areas of the storage surface hit by the deflecting beam lose electrons, which are collects by the collector mesh. Hence, the write beam deflection pattern is traced on the storage surface as a positive charge pattern.

Since the insulation of the dielectric material is high enough to prevent any loss of charge for a considerable length of time, the pattern is stored. To view, the stored trace, a flood gun is used when the write gun is turned off. The flood gun, biased very near the storage mesh potential, emits flood of electrons which move towards the collector mesh, since it is biased slightly more positive than the deflection region.

The collimator ,a conductive coating on the CRT envelope with an applied potential, helps to align the flood electrons so that they approach the storage target perpendicularly When the electrons penetrate beyond the collector mesh, they encounter either a positively charged region on the storage surface or a negatively charged region where no trace has been stored.

The positively charged areas allow the electrons to pass through to the post accelerator region and the display target phosphor. The negatively charged region repels the flood electrons back to the collector mesh. Thus the charge pattern on the storage surface appears reproduced on the CRT display phosphor just as though it were being traced with a deflected beam.

DIGITAL STORAGE OSCILLOSCOPE

Storage cathode ray tube has several limitations as follows,

1. There is a short duration of time, in which it can preserve a stored waveform, so the waveform may lose.

2. Trace of storage tube is not as fine as that of a normal CRT.

3. Writing rate of the storage tube is less than that of a conventional CRT which in turn limits the speed of the analog storage oscilloscope.

4. It is more expensive than a conventional CRT and requires additional power supplies.

5. Only one image can be stored. For comparing two traces they are to be superimposed on the same and displayed together.

Digital storage oscilloscope is used to limit these limitations. In DSO, the waveform to be stored is digitized, stored in a digital memory and retrieved for display on the storage oscilloscope. Stored waveform is continuously displayed by repeatedly scanning it. Therefore a conventional CRT can also be used for the display. The stored display can be displayed continuously as long as the power is applied to the memory which can be supplied from a small battery.

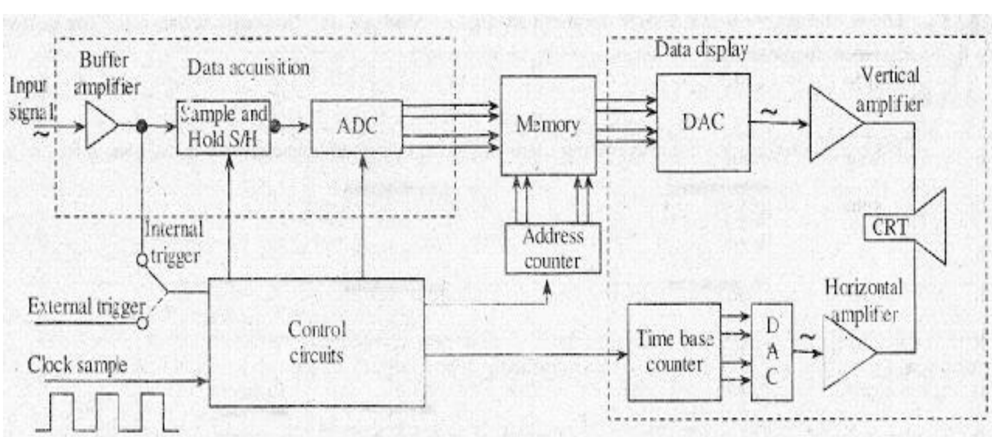


fig 3.1 Block diagram DSO

Digitized waveform can be analyzed by oscilloscope or by reading the contents of the memory into the computer. Display of the stored data is possible in both amplitude versus time and x-y modes. In DSO, fast memory readout is used for CRT display in addition to this a slow readout is also possible which is used for development of hard copy externally.

Figure shows the block diagram of DSO as consists of,

1. Data acquisition
2. Storage
3. Data display.

Data acquisition is earned out with the help of both analog to digital and digital to analog converters, which is used for digitizing, storing and displaying analog waveforms. Overall operation is controlled by control circuit which is usually consists of microprocessor.

Data acquisition portion of the system consist of a Sample-and-Hold (S/H) circuit and an analog to digital converter (ADC) which continuously samples and digitizes the input signal at a rate determined by the sample clock and transmit the digitized data to memory for storage. The control circuit determines whether the successive data points are stored in successive memory location or not, which is done by continuously updating the memories.

When the memory is full, the next data point from the ADC is stored in the first memory location writing over the old data. The data acquisition and the storage process is continues till the control circuit receive a trigger signal from either the input waveform or an external trigger source. When the triggering occurs, the system stops and enters into the display mode of operation in which all or some part of the memory data is repetitively displayed on the cathode ray tube.

In display operation, two DACs are used which gives horizontal and vertical deflection voltage for the CRT Data from the memory gives the vertical deflection of the electron beam, while the time base counter gives the horizontal deflection in the form of staircase sweep signal. The screen display consist of discrete dots representing the various data points but the number of dot is very large as 1000 or more that they tend to blend together and appear to be a smooth continuous waveform. The display operation ends when the operator presses a front-panel button and commands the digital storage oscilloscope to begin a new data acquisition cycle.

fig : -Screen of Digital Storage Oscilloscope

- DSO use the digital memory. It can store data as required with out degradation.
- DSO also uses for complex processing of the signal with high speed with the hepl of digital signal processing circuits.
- in this A/D converter use to create the data that is stored in microprocessors memory, and data sent to display on screen
- DSO convert analog in to digital form using to A/D convertor, it stores digital data in memory.
- then processes the signals and to be display on screen.
- the wave form is stored in digital ,advantage of using DSO ,that stored data can be used to visualize the signal at any time.

Advantages:-

1. Allows for automation.
2. In this, slow traces l**ike the temperature variation across a day can be recorded**
3. With colour Bigger and brighter display, to distinguish multiple traces
4. peak detection

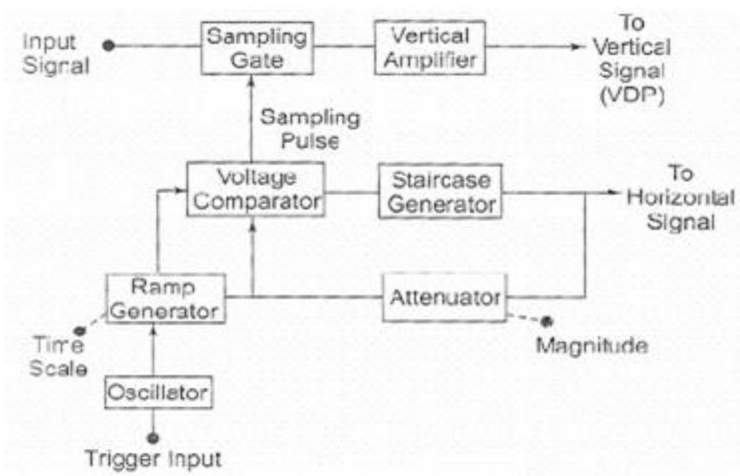
Disadvantage:-

Digital Oscilloscope is the limited refresh rate of the screen.

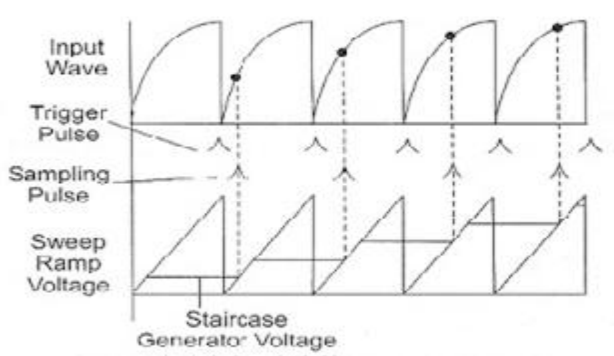
SAMPLING OSCILLOSCOPE

An ordinary oscilloscope has a B.W. of 10 MHz the HF performance can be improved by means of sampling the input waveform and reconstructing its shape from the sample, i.e. the signal to be observed is sampled and after a few cycles sampling point is advanced and another sample is taken. The shape of the wave form is reconstructed by joining the sample levels together. The sampling frequency may be as low as 1/10th of the input signal frequency (if the input signal frequency is 100 MHz, the bandwidth of the CRO vertical amplifier can be as low as 10 MHz).

As many as 1000 samples are used to reconstruct the original waveform.



The input is applied to the sampling gate. The input waveform is sampled whenever a sampling pulse opens the sampling gate. The sampling must be synchronized with the input signal frequency. The signal is delayed in the vertical amplifier, allowing the horizontal sweep to be initiated by the input signal. The waveforms are shown in fig



At the beginning of each sampling cycle, the trigger pulse activates an oscillator and a linear ramp voltage is generated. This ramp voltage is applied to a voltage comparator which compares the ramp voltage to a staircase generate-When the two voltages are equal in amplitude, the staircase advances one step and a sampling pulse is generated, which opens the sampling gate for a sample of input voltage.

The resolution of the final image depends upon the size of the steps of the staircase generator. The smaller size of the steps, larger the number of samples and higher the resolution of the image**.**

Dual Trace CRO

The block diagram of dual trace oscilloscope which consist of

1. Electronics gun (single)
2. Separate vertical input channels (Two)
3. Attenuators
4. pr-amplifiers
5. Electronic switch.

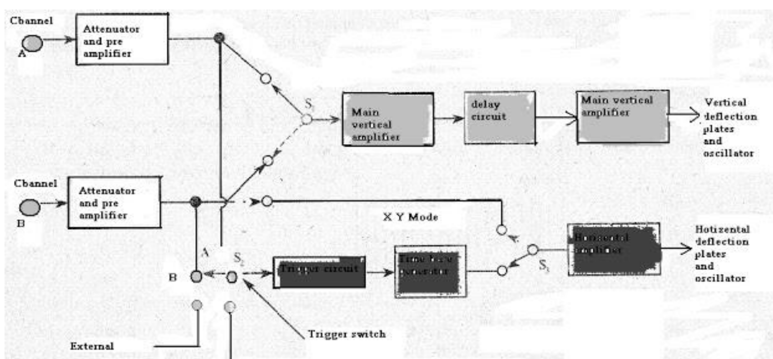


Fig: Block diagram of Dual Trace Oscilloscope

The two separate input signals can be applied to **single electron gun** with the help of **electronic switching** it Produces a dual trace display .Each separate vertical input channel are uses separate **attenuators and pr-amplifier** stages, so the amplitude of each signal can be independently controlled. Output of the pr-amplifiers is given to the electronic switch, which passes one signal at a time into the **main vertical amplifier** of the oscilloscope. The **time base-generator** is similar to that of single input oscilloscope. By using switch S2 the circuit can be **triggered** on either A or B channel, waveforms, or an external signal, or on line frequency. The **horizontal amplifier** can be fed from sweep generator or from channel B by switching S1. When switch S, is in channel B, its oscilloscope operates in the X-Y mode in which channel A acts as the vertical input signal and channel B as the horizontal input signal.

From the front panel several operating modes can be selected for display, like channel B only, channel A only, channels B and A as two traces, and signals A + B, A - B, B ~ A or - (A + B) as a single trace. Two types of common operating mode are there for the electronic switch, namely, 1. Alternate mode 2. Chop mode.

Recorders

It is often necessary to have a permanent record on the state of a phenomenon being investigated. In many of the industrial and research processes it is necessary to monitor continuously the condition, state, or value of the process variables such as flow, force, pressure, temparature, current, voltage, electrical power etc. A recorder thus records electrical and non-electrical quantities as a function of time. This record may be written or printed, and later, can be examined and analyzed to obtain a better understanding and control of the processes. 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 tranducers. The ever increasing emphasis on automation, continuously recording instruments are finding many applications in industry.

Recorders are classified as

1. Analog recorders
2. Digital recorders

Analog recorders are subdivided as

a) Graphic recorder, further subdivided as

1. Strip char recorder
2. X - Y recorder
3. Circular chart recorder

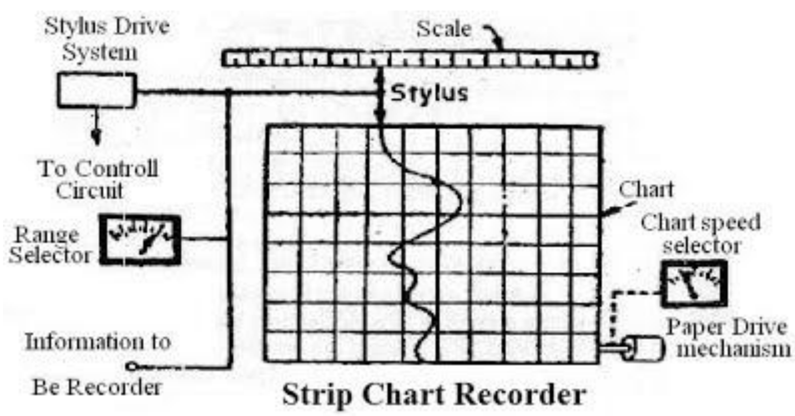
b) Magnetic tape recorders subdivided as

1. Direct recorder
2. FM recorder
3. Pulse duration modulatrion recorder

c) Oscillographic or ultraviolent recorder

Strip chart recorder

Strip chart recorders consist of a roll or strip of paper that is passed linearly beneath one or more pens. As the signal changes the pens deflect producing the resultant chart. Strip chart recorders are well suited for recording of continuous processes. Sections of the paper can be torn off and archived for future reference. Strip chart recorders are commonly used in laboratory as well as process measurement applications.



It records one or more variables with respect to time. It is a X-t recorder.

A strip chart recorder consists of:

1. A long roll of graph paper moving vertically.
2. A system for driving a paper at some selected speed.

A speed selector switch is generally provided. Chart speed of 1-100 m/s are usually used.

3. A stylus driving system which moves the stylus in a near exact replica or analog of the quantity being recorded.

A range selector switch is used so that input to the recorder drive system is with in the acceptable level.

A. Paper drive system

The paper system should move the paper at a uniform speed. A spring would may be used but in most of the recorder a synchronous motor is used for driving the paper.

B. Marking Mechanism

There are many types of mechanism used for making marks on the paper.

The most commonly used ones are:

1. Marking with ink filled stylus

The stylus is filled with ink by gravity or capillary actions. This requires that ihe pointer shall support an ink reservoir and a pen, or capillary connection between the pen and a pen reservoir. In general red ink is used but other colours are available and in instrumentation display a colour code can be adopted.

2. Marking with headed stylus

Some recorders use a heated stylus which writes on a special paper. This method overcomes the difficulties encountered in ink writing systems.

3. Chopper Bar

If a chart made from a pressure sensitive paper is used a simple recording process is possible. A V-shaped pointer is passed under a chopper bar which presses the pen into the paper once per second thus making a series on the special paper. In fact this system is not purely continuous and hence is suitable for recording some varying quantities.

4. Electric stylus marking

This method employs a paper with a special coating which a sensitive to current. When current is conducted from the stylus to the paper, a trace appears on the paper. It is clear that the electric stylus marking method has a wide range of marking speeds, has low stylus friction and a long stylus life. The disadvantage is that the cost of paper is very high.

C. Tracing system

There are two types of tracing system used for producing graphic representation.

1. Curvilinear system. In the curvilinear system, the stylus is mounted on a central pivot and moves through an are which allows a full width chart marking. If the stylus makes a full range recording, the line drawn across the chart will be curved and the time intervals will be along the curved segments.

2. Rectilinear system. It is notices that a line of constant time is perpendicular to the time axis and therefore this system produces a straight line across the width of the chart. Hence the stylus is actuated by a drive cord over pulleys to produce the forward and reverse motion as determined by the drive mechanism. The stylus may be actuated by a self-balancing potentiometer system, a photoelectric deflection system, a photoelectric potentiometer system, or a bridge balance system. This system is usually used with thermal or electric wiring. Source:

Advantages:

- These generally require the use of servo- mechanism to position the pointer or pen. Therefore more than adequate power is available, there being no real limitations on the weight of the pen, pressure between pen and paper or length of the pointer.
- Conversion of data is easier when rectangular coordinates are used.
- Many more separate variables can be recorded on a strip chart than on circular chart.
- The rate of movement of the chart can easily be changed to spread out the trace of the variable being observed.
- Relatively large amount of paper can be inserted at one time in the form of a roll.

Disadvantages:

- Observing behavior several hours or days back is not as easy as picking out one circular chart which covers the desired period of time.
- The mechanism is considerably more complicated than is required to drive a circular chart.

Applications:

- To measure voltage
- To measure current
- To measure frequency
- To measure temperature
  - To measure power factor etc.

X-Y recorder

A strip chart recorder records the variations of a quantity with respect to time while a X-Y recorder is an instrument which gives a graphic record of the relationship between two variables.

In strip recorders, usually self-balancing potentiometers are used. These self-balancing potentiometers plot the emf as a function of time. 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.

In some X-Y recorders, one self-balancing potentiometer circuit moves a recording pen in the X direction while another self-balancing potentiometer circuit moves the recording pen in the Y direction at right angles to the X direction, while the paper remains stationary.

There are many variations of X-Y recorders. The emf, used for operation of X-Y recorders, may not necessarily measure only voltages. The measured emf may be the output of a transducer that may measure displacement force, pressure, strain , light intensity or any other physical quantity. Thus 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-systems, driving a recording pen in two axes through a proper sliding 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.

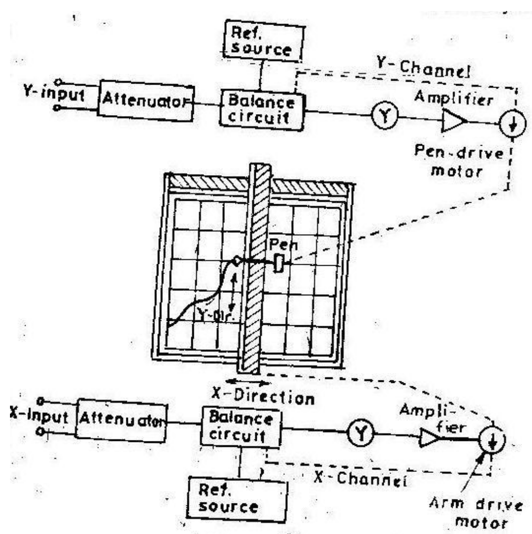


Fig. 28.53. X-Y Recorder.

This figure shows a block diagram of a typical X-Y recorder. A signal enters each 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 the difference between the input signal voltage 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 servometer which is used to balance the system and hold it in balance as the value of the quantity being recorder changes. The action described above takes place in both axed simultaneously. thus we get a record of one variable with respect to another.

The use of X-Y recorders in laboratories greatly simplifies and expedites many measurements and tests. A few examples are being given below

1. Speed torque characteristics of motors
2. lift Drag wind tunnel tests
3. Plotting of characteristics of vaccum tubes, zener diodes rectifiers and transistors etc
4. Regulation curves of power supplies
5. Plottering stress-strain curves, hysteresis curves and vibrations amplitude against swept frequency
6. Electrical characteristics of materials such as resistance versus and temperature plotting the output from
7. electronic calculators and computers

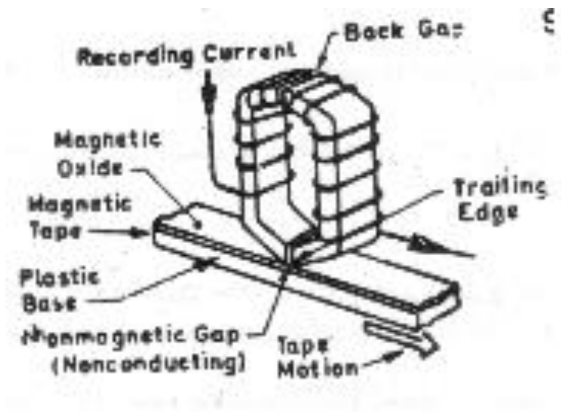
Magnetic Tape Recorders

A recorder is used to produce a permanent record of the signal that is measured. A record is used to analyse how one variable varies with respect to another and how the signal saries with time. The objective of a recording system is to record and preserve information pertaining to measurement at a particular time and also to get an idea of the performance of the unit and to provide the results of the steps taken by the operator. The basic components of a general recorder are an operating mechanism to position the pen or writer on the paper and a paper mechanism for paper movement and a printing mechanism.

A magnetic tape recorder is used to record data which can be retrieved and reproduced in electrical form again. This recorder can record signals of high frequency. It is frequently desirable and in many cases necessary, to record data in such a way that they can be received reproduced in electrical form again. The most common and the most useful way of achieving this are through the use of magnetic tape recorder.

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.



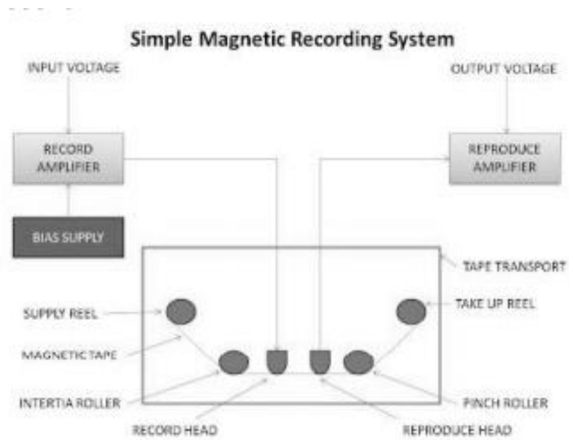
The same type when passes through a reproduce or playback head produces variations in the reluctance of the winding thereby inducing a voltage in the winding dependent upon the direction of magnetization and its magnitude on the magnetic tape. The induced voltage is proportional to rate of change of flux linkages, therefore the emf induced in the winding of reproducing head is proportional to rate of change of the level of magnetizing on the tape, e_{rep} aN df/dt, where N is the number of turns of the winding put on the reproduce head. Since the voltage in the reproduce head is proportional to df/dt, the reproduce head acts as a differentiator.

Description

The magnetic tape is made of a thin sheet of tough plastic material; one side of it is coated with a magnetic material (iron oxide). The plastic base is usually polyvinyl chloride (PVC) or polyethylene terephthalate. Recording head, reproducing head and tape transport mechanism are also present.

Basic components of Tape recorder:

1. Recording heat
2. Magnetic tape
3. Reproducing head
4. Tape transport mechanism
5. Conditioning Devices



Operation

1. The recording head consists of core, coil and a fine air gap of about 10 micrometer. The coil current creates a flux, which passes through the air gap to the magnetic tape and magnetizes the iron oxide particles as they pass the air gap. So the actual recording takes place at the trailing edge of the gap.
2. The reproducing head is similar to that of a recording head in appearance. The magnetic tape is passes over a reproducing head, thereby resulting in an output voltage proportional to the magnetic flux in the tape, across the coil of the reproducing head. Thus the magnetic pattern in the tape is detected and converted back into original electrical signal.
3. The tape transport mechanism moves the tape below the head at constant speed without any strain, distrortion or wear. The mechanism much be such as to guide the tape passed by the magnetic heads with great precision, maintain propoer tension and have sufficient tape to magnetic head contact.

Advantages

1. Wide frequency range from dc to several MHz..
2. Low distortion.
3. Immediate availability of the signal in its initial electrical form as no time is lost in processing.
4. The possibility of erase and reuse of the tape.
5. Possibility of playing back or reproducing of the recorded signal as many times as required without loss if signal.
6. They have a wide dynamic range which exceeds 50db. This permits the linear recording from full scale level to approximately 0.3% of full scale.

Applications

1. Data recording and analysis on missiles, aircraft and satelites.
2. Communications and spying.
3. Recording of stress, vibration and analysis of noise.

There are several types of recording methods which are used in magnetic tape recorders.

Direct Recording

If the signals are recorded in an analog manner in a way so that the amplitude and frequency of the signal is recorded linearly as a variation of the amplitude and magnetization and wavelength on the magnetic tape, such a system of recording is known as direct recording. Since low distortion is required on the playback signal, this is achieved by adding a high frequency AC bias signal to the signal being recorded.

This method of recording is most suited for audio signals rather than any other purpose. This is so because the human ear has an inbuilt mechanism which averages the amplitude variation errors.

FM Recording

We have learnt about frequency modulation in a previous article and know that frequency modulation is all about using a sine wave carrier signal and modulating or modifying it as per the signal to be loaded on that carrier signal. Similarly in case of FM recording in magnetic tapes, a frequency modulator is used to feed the input signal onto the carrier signal. This signal is then recorded onto the magnetic tape either with or without the ac-bias signal as described in the previous section of direct recording.

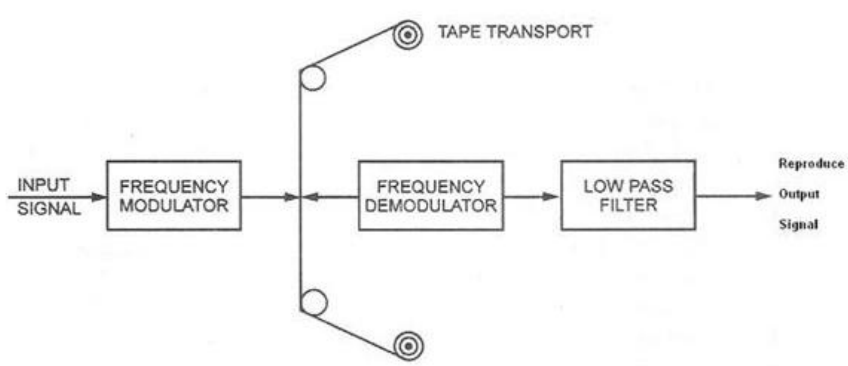


Fig shows a simplified view of such a recording system without showing the internal details. As you can see, when the signal is now reproduced using the playback head, it needs to be passed through a demodulator which separates the sine carrier wave from the recorded signal and then reproduced. This system is more complicated in its construction and expensive to built because of the various extra circuitries involved in it. Hence normally it is only used in situations where amplitude variation errors are not acceptable, such as instrumentation where the parameters of some delicate industrial process are recorded. Despite this advantage this system has a poor high frequency response and requires a higher tape speed which needs to be precisely controlled.

PDM Recording

In this type of magnetic tape recording system, the input signal is converted into a pulse signal. The duration of the pulse is in tune with the amplitude of the signal, hence the name pulse duration modulation since the duration of the pulse varies with the input signal.

Obviously since the continuous input signal is divided into discrete pulses, this type of recording system is even more complicated and expensive than the FDM system described previously. Yet it is used in situations which require special quality recording such as situations where a large number of variables are monitored and they change very slowly.

- The advantages of such a system are
- Multi channel recording
- Great degree of accuracy
- Very low signal/noise ratio

Magnetic Disks Recorder

Magnetic devices like floppy disks, hard disks and some tape units all use the same underlying technology to achieve this. The media (meaning the disk as opposed to the drive) is coated with magnetic particles a few millionths of an inch thick which the drive divides into microscopic areas called domains. Each domain acts like a tiny magnet, with north and south poles, and represents either zero or one depending on which way it is pointing.

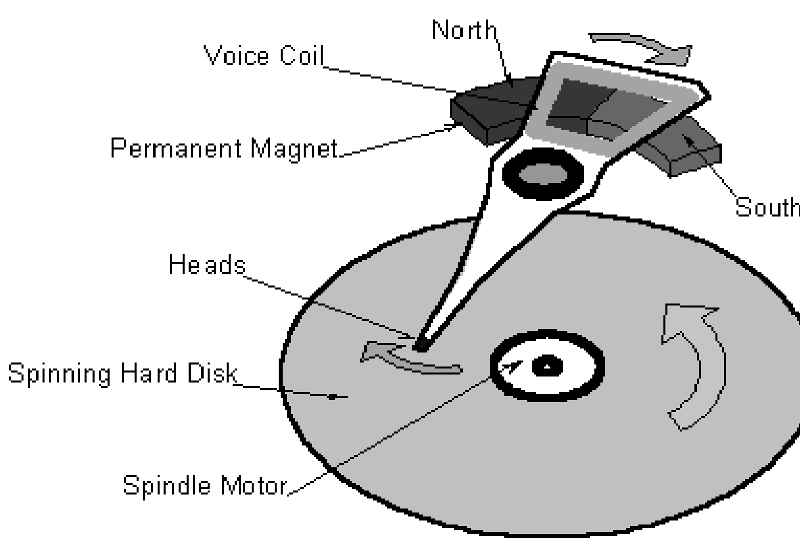
Information is read from, or written to, the media using a head which acts in a similar way to a record player stylus or the tape head in a cassette recorder. On a hard drive this head actually floats on a cushion of air created by the spinning of the disk. This contributes to the superior reliability of a hard drive compared to a floppy drive, where the head touches the surface of the disk. Both these drives are known as random access devices because of the way in which the information is organised into concentric circles on the surface of the disks. This allows the head to go to any part of the disk and retrieve or store information quickly.

Hard disks, in common with magnetic tape media, have the recording layer on top of a substrate. This architecture – referred to as air incident recording – works well in a sealed non-removable system like hard disks and allows the head to fly in very close proximity to the recording surface. A very thin coating, in the range of a few manometers, covers the recording surface to provide lubrication in the event of a momentary impact by the head.

Magnetic Disks

Recording data onto a disk has obvious advantages with respect to access times, as the head can readily be moved to the appropriate place on the disk whereas a tape would need to be rewound or advanced. There are two types of disk: floppy and hard. The principles of manufacturing and recording on floppy disks are very similar to that of particulate magnetic tape, i.e. the same particulate materials on a plastic substrates.

Hard disk drives are formed on a rigid substrate, usually aluminium, which is around 2mm thick. On to the substrate are deposited several layers: an underlayer to help adhesion (~10mm nickel phosphide); a layer of chromium (5-10nm) to control orientation and grain size of magnetic layer; the magnetic layer (50nm PtCo with various additions of Ta, P, Ni, Cr); a protective overcoat (e.g. 10-20nm zirconia) and finally lubricant to reduce friction and wear of the disk (e.g. a monolayer of long chain fluorocarbons). The magnetic layer forms a cellular structure of Co-rich magnetic cells in a non-magnetic matrix. These cells act just like particulate recording media but on a much finer scale.

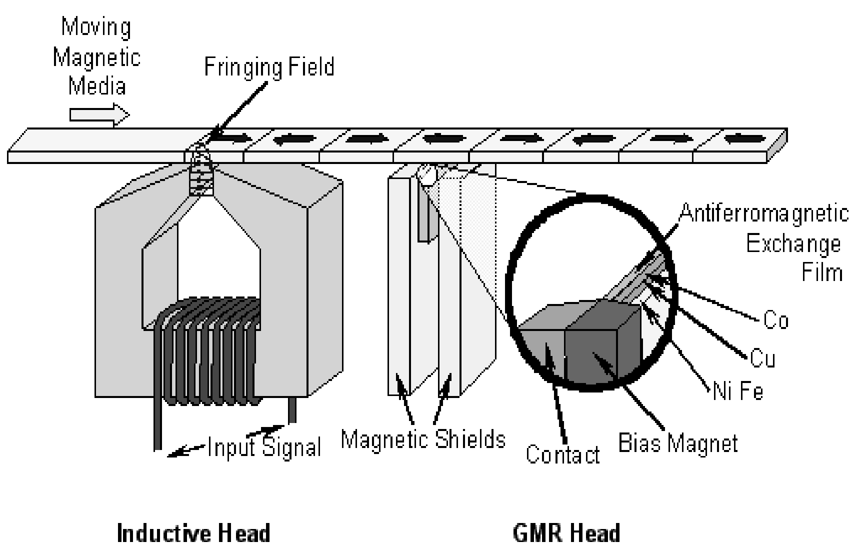


The construction of a hard disk drive is shown schematically in figure 3. The disk is attached to a spindle motor that will spin the disk; for greater storage capacity several disks can be built into a stack. Read and write heads are attached to a swinging arm (one for each side of the disks) that can be scanned across the disk using a voice coil.

Writing & Reading Data

Writing of data is performed using an inductive head, as illustrated in figure 4. Reading of data also uses an inductive head or, as in modern hard disk drives, a giant magnetoresistive (GMR) head.

The writing process involves passing a current (i.e. the signal to be recorded) through the coil of the head. This current generates a field in the air gap of the C-shaped core and a fringing field (in the plane of the tape or disk) that extends out of the gap to the tape or disk that is moving past it. The fringing field will change the magnetic state of the media and if the magnetic properties of the media are appropriate then the remanence of the tape in that region will be proportional to the amount of current applied to the coil. For digital signals only two remanent states are required for the material and hence the material requirements are not as stringent as for analogue recording, although smaller particle size is desired for high storage capacity and faster access time.



The reading process when carried out with an inductive head is very similar to the writing process. The magnetic fields extending out from the tape or disk induce a field in the C-shaped core of the read head, which in turn generates a voltage in the coil. This voltage can then be turned back into the original signal, be it audio, visual or digital data.

In modern hard disk drives the data is read back using a GMR head. The GMR element of this head experiences changes in electrical resistance under the influence of a magnetic field. They can sense very low magnetic fields and have a very high spatial resolution. The use of GMR heads is essential as the increased storage density and smaller magnetic domain size in the media means that the field strength, at a specific height above the surface of the media, has decreased. The GMR element shown in figure 4 is a spin valve type with 4 layers: an antiferromagnetic exchange film (e.g. iron/manganese); a layer of cobalt with its direction of magnetisation pinned by the antiferromagnetic exchange film (upwards in fig.4); a layer of copper which is a spacer and a layer of nickel/iron with its direction of magnetisation free to move under the influence of the magnetic field from the recording media. The biasing magnetic layer magnetises the NiFe in the plane of the film and perpendicular to the direction of magnetisation of the Co film. When the direction of magnetisation of the NiFe moves towards the direction of magnetisation of the Co then there is a drop in resistance; when it moves away then there is an increase in the resistance.

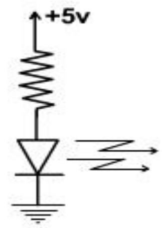
DISPLAY DEVICES

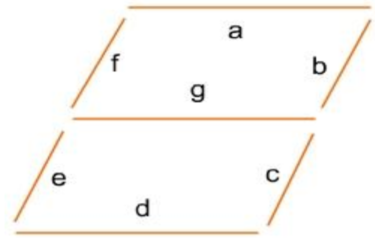
Display devices are the output devices for presentation of information in text or image form. An output device is a thing that provides a way to show information to the outside world. Some displays can show digits and alphanumeric characters only. Some displays can show images and all type of characters. Most commonly used displays are LEDs, LCD, GLCD, and 7-segment displays

Light Emitting Diode

In a forward biased diode free electrons cross the junction and enter into p-layer where they recombine with holes. Each recombination radiates energy as electron falls from higher energy level to a lower energy level. I n ordinary diodes this energy is in the form of heat. In light emitting diode, this energy is in the form of light.

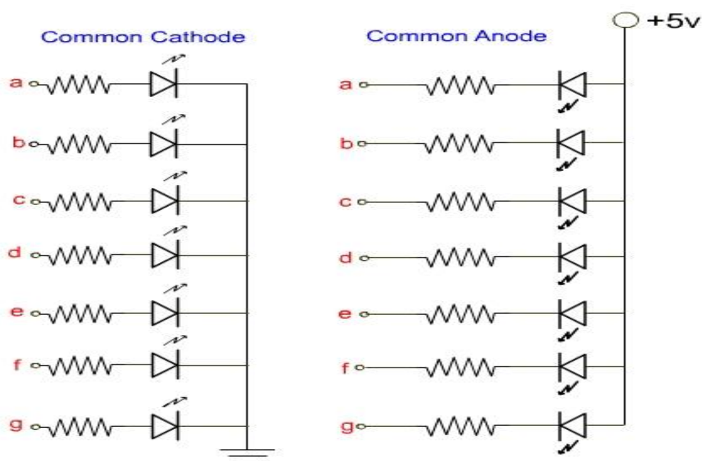
The symbol of LED is shown in fig Ordinary diodes are made of Ge or Si. This material blocks the passage of light. LEDs are made of different materials such as gallium, arsenic and phosphorus. LEDs can radiate red, green, yellow, blue, orange or infrared (invisible). The LED's forward voltage drop is more approximately 1.5V. Typical LED current is between 10 mA to 50 mA.





Seven Segment Display

Seven segment displays are used to display digits and few alphabets. It contains seven rectangular LEDs. Each LED is called a Segment. External resistors are used to limit the currents to safe Values. It can display any letters a, b, c, d, e, f, g as shown in fig.



The LEDs of seven-segment display are connected in either in common anode configuration or in common cathode configuration as shown in fig.

Liquid Crystal Display (LCD)

Liquid crystal display (LCD) has material which joins together the properties of both liquid and crystals. They have a temperature range within which the particles are essentially as mobile as they might be in a liquid, however are gathered together in an order form similar to a crystal.

The LCD is much more informative output device than a single LED. The LCD is a display that can easily show characters on its screen. They have a couple of lines to large displays. Some LCDs are specially designed for specific applications to display graphic images. 16×2 LCD (HD44780) module is commonly used. These modules are replacing 7-segments and other multi-segment LEDs.

It is actually a combination of two states of matter – the solid and the liquid. They have both the properties of solids and liquids and maintain their respective states with respect to another. Solids usually maintain their state unlike liquids who change their orientation and move everywhere in the particular liquid. Further studies have showed that liquid crystal materials show more of a liquid state than that of a solid. It must also be noted that liquid crystals are more heat sensitive than usual liquids. A little amount of heat can easily turn the liquid crystal into a liquid. This is the reason why they are also used to make thermometers.

Basics of LCD Displays

The liquid-crystal display has the distinct advantage of having a low power consumption than the LED. It is typically of the order of microwatts for the display in comparison to the some order of milliwatts for LEDs. Low power consumption requirement has made it compatible with MOS integrated logic circuit. Its other advantages are its low cost, and good contrast. The main drawbacks of **LCD**s are additional requirement of light source, a limited temperature range of operation (between 0 and 60° C), low reliability, short operating life, poor visibility in low ambient lighting, slow speed and the need for an ac drive.

Basic structure of an LCD

A liquid crystal cell consists of a thin layer (about 10 u m) of a liquid crystal sandwiched between two glass sheets with transparent electrodes deposited on their inside faces. With both glass sheets transparent, the cell is known as *transmittive type cell.* When one glass is transparent and the other has a reflective coating, the cell is called *reflective type.* The LCD does not produce any illumination of its own. It, in fact, depends entirely on illumination falling on it from an external source for its visual effect

Types of LCD

Two types of display available are dynamic scattering display and field effect display.

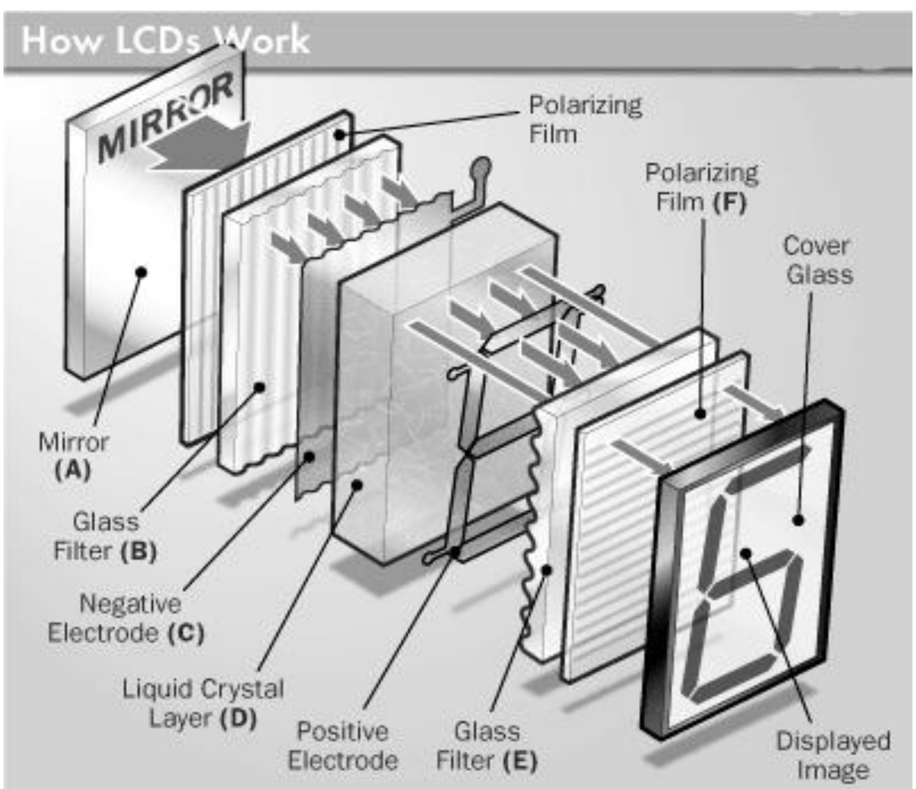
When *dynamic scattering display* is energized, the molecules of energized area of the display become turbulent and scatter light in all directions. Consequently, the activated areas take on a frosted glass appearance resulting in a silver display. Of course, the unenergized areas remain translucent.

Field effect LCD contains front and back polarizers at right angles to each other. Without electrical excitation, the light coming through the front polarizer is rotated 90° in the fluid.

Now, let us take a look at the different varieties of liquid crystals that are available for industrial purposes. The most usable liquid crystal among all the others is the nematic phase liquid crystals.

Liquid crystal molecules are further classified into thermotropic and lyotropic crystals. The former, changes proportionally with respect to changes in pressure and temperature. They are further divided into nematic and isotropic. Nematic liquid crystals have a fixed order of pattern while isotropic liquid crystals are distributed randomly. The lyotropic crystal depends on the type of solvent they are mixed with. They are therefore useful in making detergents and soaps.

To make an LCD, take two polarized glass pieces. The glass which does not have a polarized film on it must be rubbed with a special polymer which creates microscopic grooves in the surface. It must also be noted that the grooves are on the same direction as the polarizing film. Then, add a coating of nematic liquid crystals to one of the filters. The grooves will cause the first layer of molecules to align with the filter's orientation. At right angle to the first piece, you must then add a second piece of glass along with the polarizing film. Till the uppermost layer is at a 90-degree angle to the bottom, each successive layer of TN molecules will keep on twisting. The first filter will naturally be polarized as the light strikes it at the beginning. Thus the light passes through each layer and is guided on to the next with the help of molecules. When this happens, the molecules tend to change the plane of vibration of the light to match their own angle. When the light reaches the far side of the liquid crystal substance, it vibrates at the same angle as the final layer of molecules. The light is only allowed an entrance if the second polarized glass filter is same as the final layer. Take a look at the figure below.



Working of LCD

The main principle behind liquid crystal molecules is that when an electric current is applied to them, they tend to untwist. This causes a change in the light angle passing through them. This causes a change in the angle of the top polarizing filter with respect to it. So, little light is allowed to pass through that particular area of LCD. Thus that area becomes darker comparing to others.

For making an LCD screen, a reflective mirror has to be setup in the back. An electrode plane made of indium-tin oxide is kept on top and a glass with a polarizing film is also added on the bottom side. The entire area of the LCD has to be covered by a common electrode and above it should be the liquid crystal substance. Next comes another piece of glass with an electrode in the shape of the rectangle on the bottom and, on top, another polarizing film. It must be noted that both of them are kept at right angles. When there is no current, the light passes through the front of the LCD it will be reflected by the mirror and bounced back. As the electrode is connected to a temporary battery the current from it will cause the liquid crystals between the common-plane electrode and the electrode shaped like a rectangle to untwist. Thus the light is blocked from passing through. Thus that particular rectangular area appears blank.

Dot-matrix Display

Dot matrix LED display contains the group of LEDs as a two dimensional array. They can display different types of characters or a group of characters. Dot matrix display is manufactured in various dimensions. Arrangement of LEDs in the matrix pattern is made in either of the two ways: Row anode-column cathode or Row cathode-column anode. By using this dot matrix display we can reduce the number of pins required for controlling all the LEDs. By energizing different elements, a Dot-matrix Display can depict different characters that have greater resolution than a segmented Display.

A dot matrix is a two dimensional array of dots used to represent characters, symbols and messages. Dot matrix is used in displays. It is a display device used to display information on many devices like machines, clocks, railway departure indicators etc.

An LED dot matrix consists of an array of LED’s which are connected such that the anode of each LED are connected together in the same column and the cathode of each LED are connected together in the same row or vice versa. An LED dot matrix display can also come with multiple LEDs of varying colors behind each dot in the matrix like red, green, blue etc.

Here each dot represents circular lenses in front of LEDs. This is done to minimize the number of pins required to drive them. For example an 8X8 matrix of LEDs would need 64 I/O pins, one for each LED pixel. By connecting all the anodes of LEDs together in a column and all the cathodes together in row, the required number of input and output pins reduced to 16. Each LED will be addressed by its row and column number.

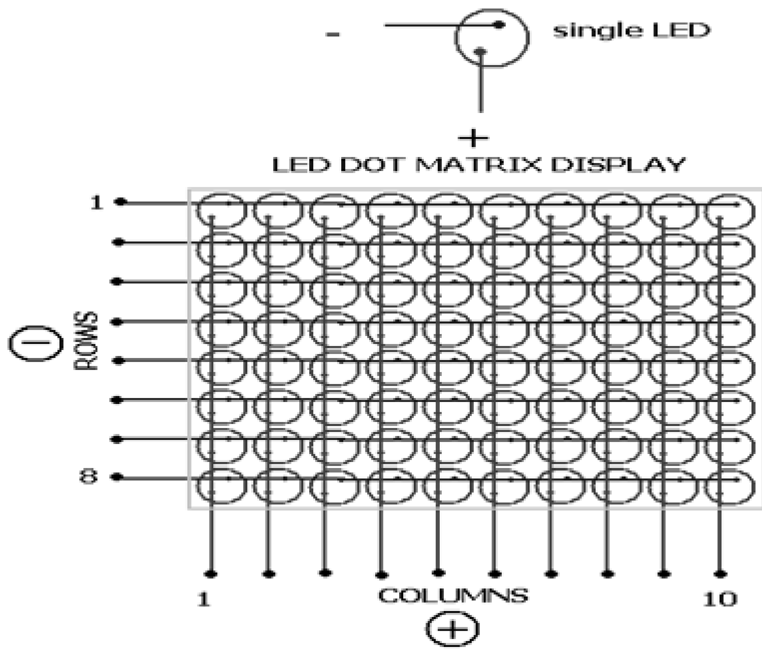


Diagram of 8X8 LED Matrix using 16 I/O pins