# 15 Recording, Storage and Display Devices

## 15.1 INTRODUCTION

After collecting information about the state of some process, the next consideration is how to present it in a form where it can be readily used and analysed. This chapter, therefore, starts by covering the techniques available to either display measurement data for current use or record it for future use. Following this, standards of good practice for presenting data in either graphical or tabular form are covered, using either paper or a computer monitor screen as the display medium.

Nowadays, a wide variety of recorders are used in industry, laboratory and various fields Covering all these in a chapter is a formidable task. An attempt has therefore been made to classify the more common types of chart recorders. The definition of a chart recorder is *"a device for producing, as a permanent record in analog form, the change of a variable signal (x) against time (t) (whether this be continuous or intermittent)"*. In this section, only electrically actuated recorders will be considered, although in many applications, such as the recording of pressure, mechanically actuated devices are used. However, with the increasing requirement for display as well as recording at a remote central point, where the information is also required to be passed for data processing, there is a greater tendency nowadays to use electrical methods employing suitable transducers.

Many techniques now exist for recording measurement data in a form that permits subsequent analysis, particularly for looking at the historical behaviour of measured parameters in fault diagnosis procedures. The earliest recording instruments used were various forms of mechanical chart recorders. Whilst many of these remain in use, most modern forms of chart recorder exist in hybrid forms in which microprocessors are incorporated to improve performance. The sections below discuss these, along with other methods of recording signals including digital recorders, magnetic tape recorders, digital (storage) oscilloscopes and hard-copy devices such as dot-matrix, inkjet and laser printers, *X-Y* recorders, ultraviolet recorders and thermal array recorders.

### Classification of Recorders

There are many ways for classifying recorders; the popular one is according to the type of signal to be recorded, which is as follows:

1. Analog recorders
    a. Graphic recorder
        i. Strip chart recorder
            - Galvanometer type

- Null type
  - Potentiometric recorders
  - Bridge recorders
  - LVDT recorders

ii. Circular chart recorders

iii. *X-Y* Recorders

b. Magnetic tape recorders

c. Oscillographic recorders

d. Others [hybrid, paperless, ultraviolet and thermal dot matrix recorder]

2. Digital recorders

## 15.2 ANALOG RECORDERS

These kinds of recorders are used to record analog signals in the form of a chart paper for keeping the record permanently. Despite the present emphasis by the electronics industry on digital instrumentation, the use of analog recorders is still popular. As they present an instantaneous visual indication of the data being recorded, they it it in an analog way, which is often more meaningful than digital indication to people in the laboratory or on the production line. There are basically three types of analog recorders available: graphic, oscillographic and magnetic tape recorders.

### 15.2.1 Graphic Recorders

A graphic recorder is basically a measuring device which is able to produce in real time a hard copy of a set of time functions with the purpose of immediate and/or later visual inspection. The curves/lines are mostly drawn on a (long) strip of paper (from a roll), often called strip chart recorder. When the curves are drawn on a circular paper, it is called a *circular chart recorder*, and when two independent variables are to be recorded on a piece of paper with respect to each other, it is called an *X-Y* recorder.

#### *1. Strip Chart Recorder*

A strip chart recorder records physical variable with respect to the independent variable time on a long paper kept in the form of a roll. The independent variable time *(t)* then corresponds to the strip-length axis and the physical variables measured *(y)* are related to the chart width. Tracings are obtained by a writing process at sites on the chart short axis *(y)* corresponding to the physical variables magnitudes with the strip being moved at constant velocity to generate the time axis. Graphs cannot be interpreted if essential information is absent; scales and reference levels for each physical variable recorded and for time are all necessities. Additional information concerning the experimental conditions of the recording is also necessary and is preferably printed by the apparatus (data, investigated item, type of experiment, etc.). Figure 15.1 shows different components of a strip chart recorder. A typical industrial strip chart recorder is shown in Figure 15.2

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.

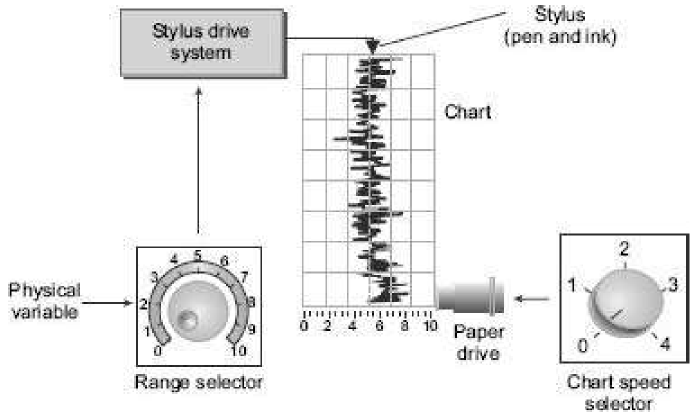


**Figure 15.1** *Strip chart recorder*


**Figure 15.2** *Industrial strip chart recorder [Manf: Omega Corporation]*

A strip chart consists of the following:

**(a) Chart/Paper** Long graph paper kept on two rollers, lower roller drags the paper vertically with the help of a motor.

**(b) Chart Speed Selector** Controls the speed of the roller at some specified speed selected by the operator and hence controls the time scale.

**(c) Range Selector** Amplifier or attenuator which is to be adjusted according to the amplitude level of physical variable. If the physical variable to be recorded is of very low amplitude then it needs to be amplified with proper gain. The gain value is adjusted by selecting proper range.

**(d) Stylus Driving System** Moves the stylus in proportion to the physical variable to be recorded, in most recorders, a synchronous motor is used for driving the paper.

**(e) Stylus** Create marking/impression on the moving graph paper [most recorders use a pointer attached to the stylus, which (pointer) moves over a calibrated scale thus showing instantaneous value of the quantity being measured].

The most commonly used mechanisms employed for making marks on the papers are

(i) **Pen and ink:** Marking with ink-filled stylus

(ii) **Thermal type:** Marking with heated stylus on temperature sensitive paper (e.g. fax paper)

(iii) **Impact type:** Marking with pressure sensitive paper (e.g. carbon paper)

(iv) **Electrostatic stylus:** Marking with charged stylus on plain paper

(v) **Optical type:** Marking with light ray on photosensitive paper

Strip chart recorders are commonly used in laboratory as well as process measurement applications. Modern strip chart recorders have the facility of

(i) **Simultaneous recording and display of multipoint data**

(ii) **Universal input:** The recorders accept wide range of dc voltage, all common thermocouple and RTD. Often these ranges can be programmed for each channel.

(iii) **Universal power voltage** of 100 V ac to 240 V ac, 50/60 Hz

(iv) **Alarm Display/Printings**

(v) **Chart illumination** convenient to confirm printed signal in the night or in dark places.

There are various kinds of strip chart recorders. According to their working principles, these are divided in mainly two categories. One works on the principle of the galvanometer and other is called null type.

**(a) Galvanometric Type** Galvanometric instruments usually use a d'Arsonval galvanometer as the basic movement. This galvanometer consists of a moving coil (shown in Figure 15.3) suspended either on pivots or a taut ligament. The coil is then able to rotate in the field produced by a permanent magnet. When a small current is applied to the coil, a field is created which reacts with that of the permanent magnet, and the coil rotates. A control spring in a pivoted instrument and the ligament with a taut suspension provide an opposing torque. Thus, depending on the current applied, equilibrium will be established. A pointer shows the deflection. In practice, this principle is applied in several ways. In direct-writing moving-coil instruments, an arm with a pen attached, which is fed from an ink reservoir, is directly connected to the moving coil. The pen then writes in sympathy with the coil movement on a chart, which may be either in strip form or circular from. Such instruments are capable of recording full-scale deflections from upwards of l00 mV dc and 500 mV ac. Corresponding currents are 500 mA dc and 1 mA ac. Direct-writing instruments can be fitted with a variety of chart-drive mechanisms ranging from an alternating-current synchronous motor, with or without spring wound reserve (which enables the recorder to continue to operate for a reasonable period), to a completely mechanically driven clock mechanism. This latter feature, of course, makes the instruments portable and for suitable for field use. There are many possible variations. Some manufacturers offer up to as many as six movements writing independently on one chart. With the use of shunts and current and voltage transformers, ranges may be extended for higher values. On some types, control facilities for high and low alarms are also fitted.

**(b) Potentiometric Type** With the development of ac amplifier techniques in the mid 1930s, the requirement for increased sensitivity in process control could be satisfied by the use of a closed-loop recorder. In addition, the mechanism, though more complicated, could be made much less susceptible to vibration. The self-balancing potentiometer type of instrument consists of a bridge circuit. Across one arm of the bridge is a reference voltage, and across the other arm is a feedback network (shown in Figure 15.4). Initially, the bridge is adjusted so that the servo amplifier and its motor are in balance and stationary. When a signal is fed to the amplifier, the output causes the servomotor to drive a balancing potentiometer, which in turn refers a feedback voltage to the amplifier input. When the two signals are equal and opposite, the system balances and the servomotor stops. If a pen unit is attached to the motor/ potentiometer mechanised drive, at the point of balance, the pen will show the proportional value of the input signal. As with galvanometric instruments, this principle may be applied in various ways.

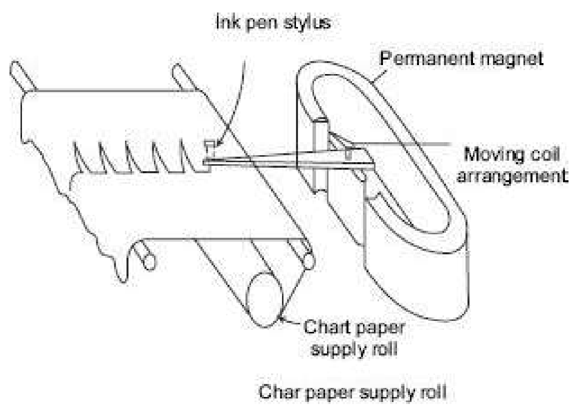


**Figure 15.3** *Galvanometer type recorder*

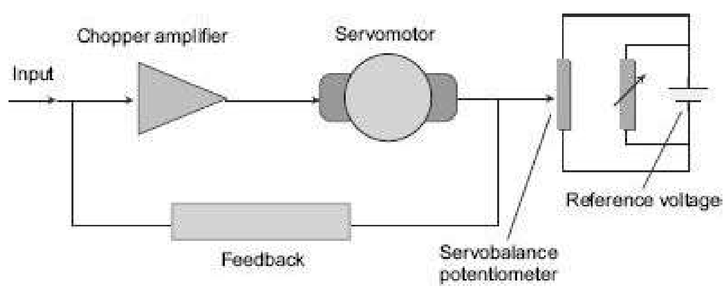


**Figure 15.4** *Potentiometric type recorder*

This kind of recorders having very high input impedance, infinity at balance conditions, and a high sensitivity.

The most common application of potentiometric recorder is for recording and control of process temperatures. Self-balancing potentiometers are unduly used in industry because of the following reasons:

(i)

Their action is automatic and thus eliminates the constant operation of an operator.

(ii) They draw a curve of the quantity of being measured with the help of a recording mechanism.

(iii) They can be mounted on the switchboard or panel and thus act as mounting devices for the quantity under measurement.

**(c) Single-Point and Multi-point Recorders** Instruments that record changes of only one measured variable are called single-point recorders.

A multi-point recorder may have as many as 24 inputs, with traces displaced in six colours.

## 2. Circular Chart Recorder

A circular chart recorder records data in a circular format. The paper is spun beneath one or more pens as shown in Figure 15.5. The pens are deflected in proportion to the varying signal resulting in a circular chart. Circular chart recorders are ideal for batch processes where a set process time is known. The charts are normally designed to rotate in standard time periods, such as 1 hour, 24 hours, 7 days, etc., although many recorders are flexible enough to accommodate non-standard time periods.

These recorders were developed mainly to take advantage of the availability and convenience of a spring-wound clock and synchronous motor movements to drive the chart in a circular direction. The circular chart used here has concentric circles ruled on it to form its scales as shown in Figure 15.5. In addition, there are printed arcs extending from the centre of the chart to the paper's edge. As the pen of the recorder is moved, it swings along these arcs; these arcs are called the 'time arcs'. The speed of the rotation of the chart is usually one revolution per 24 hours or per seven days or any other speed, which can be conveniently obtained by using a synchronous motor with suitable gear assembly. The radial position of the pen at any time indicates the instantaneous value of the quantity under measurement. A typical industrial circular recorder is shown in Figure 15.6.

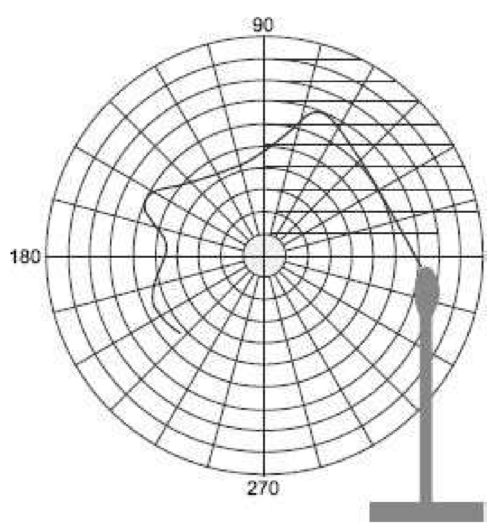


**Figure 15.5** *Circular chart recorder*

**Figure 15.6** *Industrial circular chart recorder [Manf: Omega]*

Chart diameter is limited to a maximum of 0.3 m. Speed of the chart is also limited, resolution along the scale length is usually non-uniform and the charts do not run for a long period. Magnitude of several variables can be recorded on a single chart which makes it easy and convenient to analyse the interrelationship of various measurements and also saves the panel mounting space.

The various drives for circular charts are classified as follows:

(a) Mechanical (spring clock drive)

(b) Pneumatic (air lock drive)

(c) Electric (synchronous regulated dc motor or motor wound spring)

(d) Dual powered drive (duplex), i.e. a synchronous motor and spring clock mechanical drive

(e) Externally controlled drives

Circular chart recorders are particularly suitable for direct actuation by a number of mechanical sensors such as bellows, bourdon tubes, etc.

### *3. X-Y Recorder*

With the development of the potentiometric principle, users were aware that a record was often required as the resultant of two varying signals, and thus the *X-Y* plotter was introduced (Figure 15.7). Today, *X-Y* plotters are as flexible as conventional potentiometric instruments, except that they have two completely independent servo-systems to operate the *X* and *Y* channels. The two most popular sizes are A4 and A3 (297 mm × 210 mm, 420 mm × 297 mm, respectively). Sensitivities similar to those obtainable with *Y-t* instruments are achieved, and, often, the more comprehensive instruments are also fitted with a time axis *t*, which provides single or repetitive time sweeps against the *Y* axis.

*XY* recorders accept two inputs and create a chart or graph of one input versus the other. They are commonly used to determine the relationship between the two inputs. For example, in a chemical process, an *XY* recorder might be used to monitor the effect temperature has on the pressure of the process. A typical industrial *XY* recorder is shown in Figure 15.7.

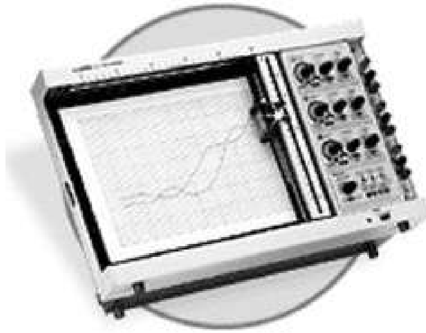

**Figure 15.7** *Industrial XY recorder [Manf: Omega]*

This system has a pen which can be positioned along the two axes with the writing paper remaining stationary. There are two amplifier units, one amplifier actuates the pen in the *Y*-direction as the input signal is applied, while the second amplifier actuates the pen in the *X*-direction. The movements of the pen in *X*-and *Y*-directions are automatically controlled by means of a motor, pulleys and a linear potentiometer. Obviously, trace of the marking pen will be due to the combined effects of two signals applied simultaneously. In these recorders, an emf is plotted as a function of another emf There are many variations of *X*-*Y* recorders. With the help of these recorders and appropriate transducers, a physical quantity may be plotted against another physical quantity. Figure 15.8 shows a block diagram of a typical analog *X*-*Y* recorder.

A signal enters in each of the two channels.

The signals are attenuated to the inherent full-scale range of the recorder (often 0.5 mA). The signal then passes to a balance circuit where it is compared with an internal reference voltage.

The error signal (i.e. the difference between the input signal voltage and the reference voltage) is fed to a “chopper” which converts dc signal to an ac 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 the axes simultaneously. Thus, we get a record of one variable with respect of another.

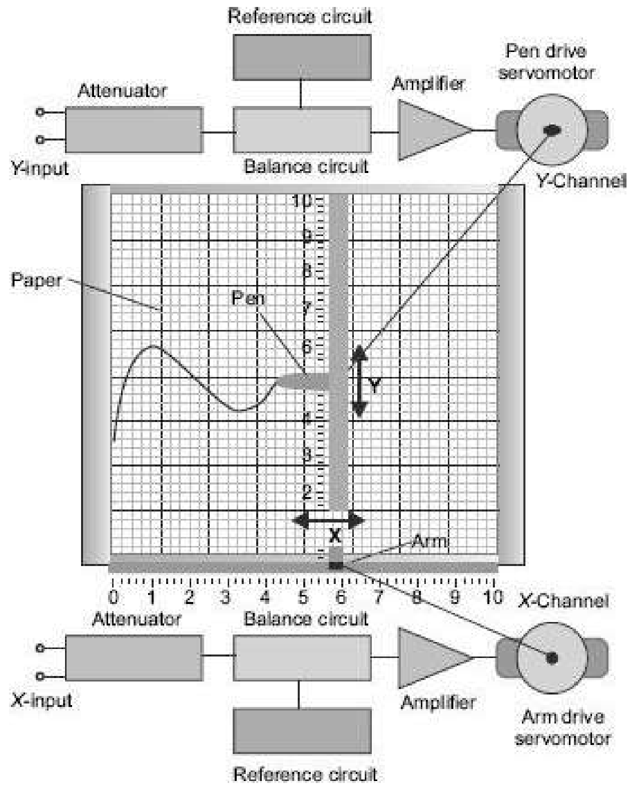


**Figure 15.8** *Different components of an XY recorder*

### Advantages

1. The instantaneous relationship between two physical quantities can be recorded.
2. The relationship between either electrical or non-electrical quantities can be recorded.
3. In modem types of recorders, zero offset adjustments are available.

**Applications** A few examples in which use of *X*-*Y* recorders are used are as under:

1. Plotting of stress-strain curves, hysteresis curves and vibrations amplitude against swept frequency
2. Pressure-volume diagrams for *LC* engines
3. Pressure-flow studies for lungs
4. Lift drag wind tunnel tests
5. Electrical characteristics of materials such as resistance versus temperature
6. Plotting the output from electronic calculators and computers
7. Speed-torque characteristics of motor
8. Regulation curves of power supplies
9. Plotting of characteristics of vacuum tubes, zener diodes, rectifiers and transistors, etc.

### *4. Hybrid Recorders*

Hybrid chart recorders represent the latest generation of chart recorder and basically consist of a potentiometric chart recorder with an added microprocessor. The microprocessor provides for selection of range and chart speed, and also allows specification of alarm modes and levels to detect when measured variables go outside acceptable limits. Additional information can also be printed on charts, such as names, times and dates of variables recorded. Microprocessor-based, hybrid versions of circular chart recorders also now exist. A typical industrial hybrid recorder is shown in Figure 15.9.

A hybrid recorder can function as a recorder or data logger. Like a standard recorder, the hybrid recorder can generate a chart of the inputs. However, it can also produce a digital stamp of the data similar to a data logger. They are commonly available in multichannel designs although one print head normally handles all channels. This makes the hybrid recorder a cost-effective solution for multichannel systems although the response time is not as fast as recorders which have a unique pen for each channel.

### 5. Paperless Recorders

Paperless recorders are one of the latest types of recorders to emerge on the market. Paperless recorders display the chart on the recorders' graphic display rather than print the chart on paper. The data can normally be recorded in internal memory or to a memory card for later transfer to a computer. The major benefit of paperless recorders is conservation of paper and easy transfer to a computer. A typical industrial paperless recorder is shown in Figure 15.10.

**Figure 15.9** *Industrial hybrid recorder [Manf: Omega]*

**Figure 15.10** *Industrial paperless recorder [Manf: Omega]*

### 6. Ultraviolet Recorders

The limited bandwidth problem of galvanometric recorders are due to system moment of inertia and spring constants can be reduced limited to the maximum bandwidth to about 100 Hz. Ultraviolet recorders work on very similar principles to standard galvanometric chart recorders, but achieve a very significant reduction in system inertia and spring constants by mounting a narrow mirror rather than a pen system on the moving coil. This mirror reflects a beam of ultraviolet light onto ultraviolet sensitive paper. It is usual to find several of these mirror-galvanometer systems mounted in parallel within one instrument to provide a multi-channel recording capability, as illustrated in Figure 15.11. This arrangement enables signals at frequencies up to 13 kHz to be recorded with a typical inaccuracy of ±2% full scale, while it is possible to obtain satisfactory permanent signal recordings by this method. Special precautions are necessary to protect the ultraviolet-sensitive paper from light before use and to spray a fixing lacquer on it after recording. Such instruments must also be handled with extreme care, because the mirror galvanometers and their delicate mounting systems are easily damaged by relatively small shocks. In addition, ultraviolet recorders are significantly more expensive than standard chart recorders.

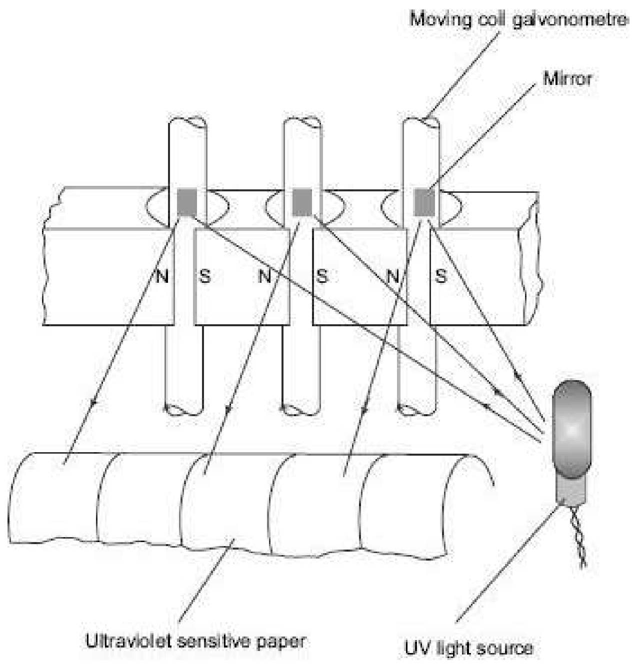


**Figure 15.11** *Internal recording components of UV recorder*

## *7. Thermal Dot Array Recorders*

Thermal dot array recorders have the advantage of not having any moving parts. The writing mechanism is an array of equidistant writing points which covers the total width of the paper. For writing, medium thermo-sensitive papers are generally used. In this array the writing system consists of miniature electrically heated coils. Maximum writing frequency is determined by thermal properties of the coils which are in close contact with the chart paper and the electric activating pulse. Heating of the thermo-sensitive paper results in a black dot with good long-term stability. The heating pulse is controlled in relation to the chart velocity in order to obtain sufficient blackness at high velocities. Tracing blackness or line thickness is seldom used for curve identification; and alphanumeric annotation is mostly applied. Different types of grid patterns can be selected by the user. Moreover, alphanumeric information can be printed for indicating experimental conditions. Ordinate axis resolution is determined by the dot array: primarily, 8 dots/mm; exceptionally, 12 dots/mm (as in standard laser printers). Most of the dot array instruments are intended for high-signal-frequency applications: per channel sampling frequencies of 100, 200, and even 500 kHz are used in real time. These sampling frequencies largely exceed the writing frequencies; during the writing cycle, data are stored in memory and for each channel within each writing interval, a dotted vertical line is printed between the minimal and the maximal value. For example, a sine wave with a frequency largely exceeding the writing frequency is represented as a black band with a width equal to the sine amplitude. In this way, the graphs indicate the presence of a phenomenon with a frequency content exceeding the writing frequency.

### 15.2.2 Magnetic Disk and Tape Type Recorder

At present, magnetic recording technology dominates the recording industry. It is used in the forms of hard disk, floppy disk, removable disk, and tape with either digital or analog mode. In its simplest form, it consists of a magnetic head and a magnetic medium, as shown in Figure15.12. The head is made of a piece of magnetic material in a ring shape (core), with a small gap facing the medium and a coil away from the medium. The head records (writes) and reproduces (reads) information, while the medium stores the information. The recording process is based on the phenomenon that an electric current $i$ generates a magnetic flux $f$ as described by Ampere's law. The flux $f$ leaks out of the head core at the gap, and magnetises the magnetic medium which moves from left to right with a velocity $V$ under the head gap. Depending on the direction of the electric current $i$, the medium is magnetised with magnetisation $M$ pointing either left or right. This pattern of magnetisation is retained in the memory of the medium even after the head moves away. Magnetic tapes are still popular in several areas such as

1. Medical research
2. Patient monitoring
3. Surveillance
4. Spying
5. Production control

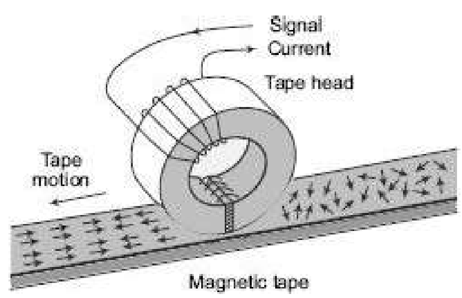


**Figure 15.12** *Magnetic tape recording*

#### *1. The Magnetic Tape*

Before actually going into the details of the magnetic tape recorder, it is better to know about the tape which is used for this purpose. Actually, the tape is made out of a special type of plastic material which is stable and can withstand continuous rubbing against the head. Normally, this material is either PVC or Mylar which are quite resistant to wear and stretching is necessary for the tape to remain useful for a long period of time. On top of this plastic base, there is a thin layer of magnetic material, usually iron oxide. The particles of this magnetic material are shaped in the form of tiny needles and occupy the top portion of the plastic base. The typical thickness of the tape is of the order of 25 micrometres.

During recording, an electrical signal causes current to flow through the coil producing a magnetic field in the gap, as shown by the blue lines of force in Figure 15.12. As the electrical signal varies in amplitude and frequency, so does the magnetic field. The tape consists of a plastic film coated with a material that is magnetised by the field as it passes over the gap. As the magnetic field varies in strength, so does the magnetism stored on the tape. During playback, the tape passes over the same head (it is called the record/playback head). This time the magnetism stored on the tape induces a voltage in the head coil. This voltage is amplified and used for retrieval of the recorded signal.

(a) Principle behind Magnetic Recording—Hysteresis Loop  Those of you who have studied physics must surely remember that there are two magnet types, namely permanent magnet and temporary magnet. In a temporary magnet, the magnetism is induced as a result of some force which aligns the magnetic particles along a specifi c axis. This force could be due to rubbing of another magnetic material or an electromagnetic fi eld applied using a varying current.

Take a look at the typical magnetisation curve in Figure 15.13, which shows the graph of the magnetising force *H* against the flux density *B*. When a material is in purely non-magnetised state and a magnetising force is applied, the fl ux density rises along the dotted line *OAC*. But now if the current is brought to zero, the fl ux does not reduce to zero but a residual fl ux remains and the current has to be extended into the negative region (opposite direction) to bring B to zero again.

Hence, a loop is formed of the overall process as can be seen from the diagram and this is known as the *magnetisation curve* for the material or is also known as the *hysteresis loop*. Now this property may be undesirable in several situations but here you can intuitively imagine a great use for the same. Once the signal is applied to the magnetic tape via the recording head, the section of the tape gets magnetised in accordance with the signal which leaves a residual flux on the tape. This acts to store that signal on the tape which can be played back using the playback head.

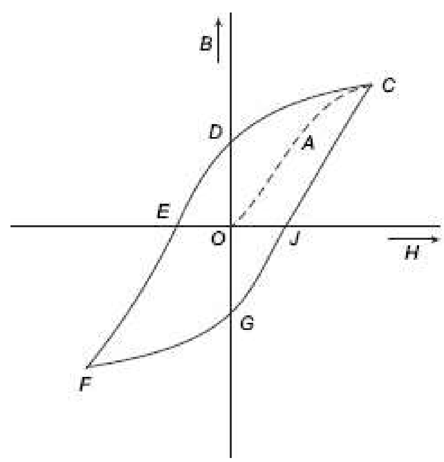


**Figure 15.13** *Hysteresis loop*

(b) The Basic Arrangement  The basic circuit of a magnetic recording and playback system is quite simple and can be understood by seeing Figure 15.14, which shows the entire arrangement. Of course, this is a highly simplified sketch without the inside nuts and bolts, yet it is useful to take a broad view of the system.

As you can see, the entire system consists of two portions—a mechanical arrangement to make the magnetic tape move across two points, and an electrical system which does the real job. The mechanical movement is achieved with the help of motor drive and a combination of rollers and belts. The electrical part is taken care of by appropriate circuits which do the work of recording, playback and amplification of sound. There are two heads which are used for recording and playback of the signals respectively.

(c) Recording and Playback The basic principle of operation is quite simple. As the tape rubs against the recording head, it applies a magnetic field which is proportional to the input signal. This signal orients the magnetic particles in a specific format which acts as indicators to the pattern of signal stored. When the playback head rubs against the tape, the signal is reproduced since now the particles induce similar magnetic patterns in the head. If you want to read more technical details about this process you can refer to the next article on this topic (coming soon and will be linked here).

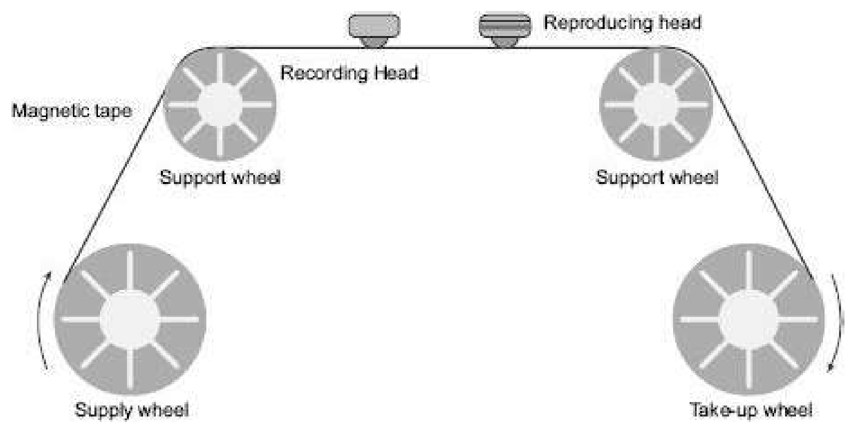


**Figure 15.14** *Magnetic tape recording mechanism*

There are several types of recording techniques which are used for recording on magnetic tapes and these can be

- Direct recording
- Frequency modulation recording
- Pulse duration modulation recording
- Digital recording

We will take a look at all these methods of recording on magnetic tapes

## *2. 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, magnetisation 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 in-built mechanism which averages the amplitude variation errors.

## *3. 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.

Figure 15.15 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.

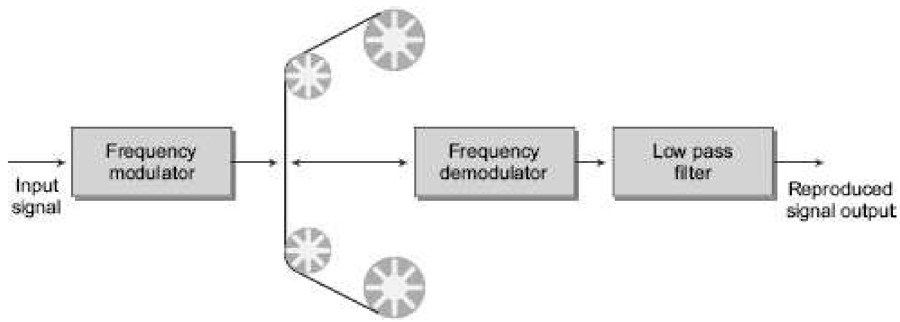


**Figure 15.15** *FM recording mechanism*

This system is more complicated in its construction and expensive to build 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.

### *4. 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

(a) Multi channel recording

(b) Great degree of accuracy

(c) Very low signal/noise ratio

### *5. Benefits of Magnetic Recording*

Now we will take a look at some of the advantages and drawbacks of the magnetic tape systems.

(a) The frequency range of the signals stored on the tape has a very wide range and spectrum, and an equally good dynamic range.

(b) here is very less distortion of signals stored on the tape. This is specifically useful for audio/ video purposes

(c) Tapes can be used to store multiple signals along the same length, thus increasing efficiency.

(d) Even though you might think that electronic memories are getting cheaper, the tape still is a winner in terms of cost per bit of storage. This is mainly due to large surface area of the tape and very high data density.

(e) Time base of the stored signal data can be varied as per requirement. This means that signals recorded at fast speed can be played back at slower speed and vice versa, which is useful in several applications

### 15.2.3 Oscillographic Recorders

Although, strictly speaking, oscillographs are direct-writing instruments, they also employ a moving coil, but the writing element uses much more power and is fed from an ac amplifier feeding a driver power amplifier. The writing element, usually referred to as a "pen motor", can consume more than 100 W. The angular deflection of the motor is often restricted to as little as 17° with the result that response times of up to 150 Hz can be obtained. Oscillographs are suitable for recording high transient signals such as occurring in strain-gauge measurements and in medical applications such as measuring heartbeat and brain-response (ECGs and EEGs). The recording is usually made on inkless paper using a heated stylus.

Used primarily for applications in the test and research fields, the capabilities of oscillographic recorders and the newer digital oscilloscopes have expanded greatly over the past several years. An oscillograph is a device for determining waveforms by plotting instantaneous values of a quantity such as voltage as a function of time. A decade ago, this implied either a recording galvanometer or a CRT recorder—analog instruments that afforded the needed bandwidths in excess of 20 kHz.

As in other recorder developments, however, digital is the buzzword today and Digital Storage Oscilloscopes (DSOs) or simply digital oscilloscopes have proliferated. These may be defined as oscilloscopes that digitise an input signal for storage in memory for later display or analysis. It is a logical and relatively simple step to use the stored data to provide a chart record, and many DSOs do just that, essentially acting as data loggers.

A recent survey lists some 30 different suppliers of DSOs, many of them PC-based. They cover a range of bandwidths—some around 40 to 50 MHz while others go as high as 350 MHz. These are sophisticated electronic instruments that have capabilities far beyond traditional analog CRT-based oscilloscopes, which have been around for many decades.

## 15.3 DIGITAL RECORDERS

Digital recorder record the data in the form of '1' and '0'. There are several types of digital recorders. The following section discusses data loggers and magnetic-type digital recorders.

### 15.3.1 Data Logger

Data loggers are is a stand-alone devices that can record information electronically from internal or external sensors or other equipment that provide digital or serial outputs.

#### *1. Key Features of Data Loggers*

(a) Stand-alone Operation Most data loggers are normally configured with a PC, some models can be configured from the front panel provided by the manufacturer. Once the data loggers are configured, they don't need the PC to operate.

(b) Support for Multiple Sensor Types Data loggers often have universal input type which can accept input from common sensors like thermocouple, RTD, humidity, voltage, etc.

(c) Local Data Storage All data loggers have local data storage or internal memory unit, so all the measured data is stored within the logger for later transfer to a PC.

(d) Automatic Data Collection Data loggers are designed to collect data at regular intervals, 24 hours a day and 365 days a year if necessary, and the collection mode is often configurable.

Data logging and recording are both analog terms in the field of measurement. Data logging is basically measuring and recording of any physical phenomena or electrical parameter over a period of time. The physical phenomena can be temperature, strain, displacement, flow, pressure, voltage, current, resistance, power, and many other parameters. Typical industrial data loggers are shown in Figure 15.16.

**Figure 15.16** *Typical data loggers [Manf: National Instrument and Omega Corp.]*

The data logger collects information about the state of any physical system from the sensors. Then the data logger converts this signal into a digital form with the help of an A/D converter. This digital signal is then stored in some electronic storage unit, which can be easily transferred to the computer for further the analysis, the schematic diagram of a data-logging application in industrial environment is shown in Figure 15.17.

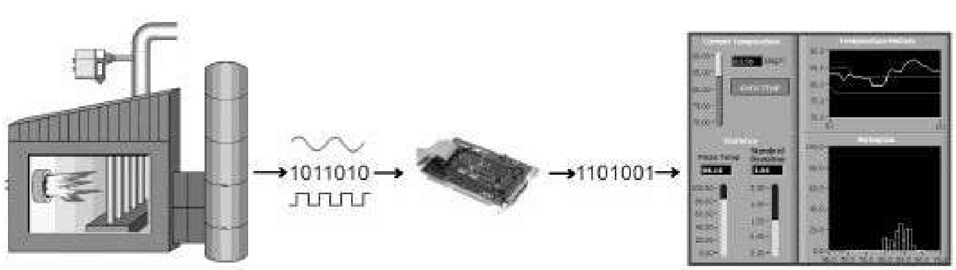


**Figure 15.17** *Industrial data logging and display*

A few basic components that every data logger must have are shown in Figure 15.17, which are:

1. Hardware components like sensors, signal conditioning, and analog-to-digital converter, etc.
2. Long-term data storage, typically onboard memory or a PC
3. Software for collecting data, analysing and viewing

### *2. Functions of Data Loggers*

Beyond the acquiring and storing data, a data logger often performs various kinds of other jobs like offline and online analysis, display, sharing data with other devices connected with the network, reporting events and providing alarm whenever some critical situation arises. A complete data-logging application typically requires most of the elements shown in Figure 15.18.

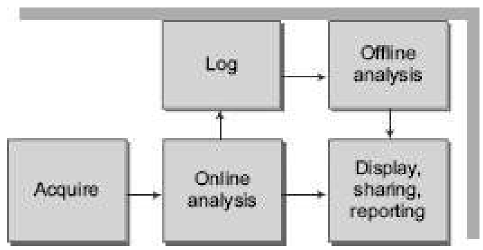


**Figure 15.18** *Different components of data loggers*

## 15.3.2 Digital Tape Recording

The very mention of the name *digital tape recording* brings the picture of hard drives, flash memories, etc. to our mind, but this also refers to another method of recording on the good old magnetic tape as well. Figure 15.19 shows the digital tape recording mechanism.

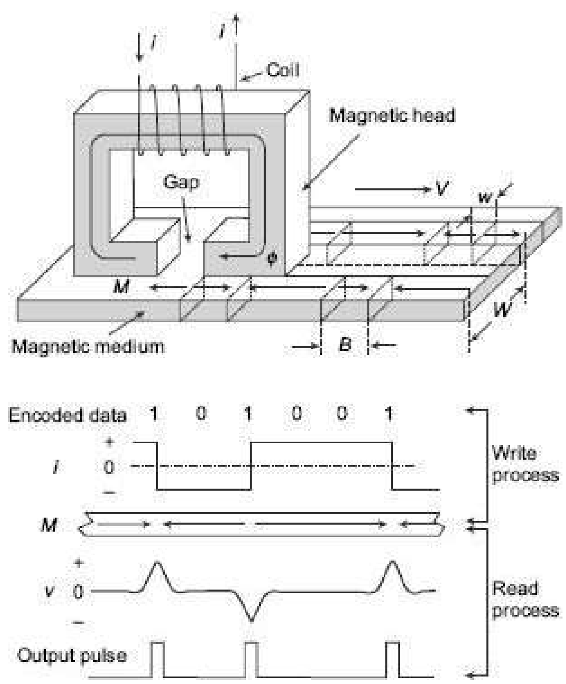


**Figure 15.19** *Digital tape recording mechanism*

The only difference is that the signals are recorded in the form of 0s and1s which are typical of the digital world. Obviously, it would require modulation of some form or the other, to convert analog to digital signals and hence there are several methods of magnetic tape recording which fall under the category of digital recording.

Some of these methods are

1. Return-to-bias method
2. Return-to-zero method
3. Non-Return-to-zero method

The detailed description of these methods would be a bit too complicated here so we will just go through the basics of one of these, let us say the Return-to-Bias (RB) method. Figure (15.19) schematically shows the digital recording/reproducing process. First, all user data are encoded into a binary format—a serial of 1s and 0s. Then a write current *i* is sent to the coil. This current changes its direction whenever a 1 is being written. Correspondingly, a change of magnetisation, termed a *transition*, is recorded in the medium for each 1 in the encoded data. During the reproducing process, the electric voltage induced in the head coil reaches a peak whenever there is a transition in the medium. A pulse detector generates a pulse for each transition. These pulses are decoded to yield the user data. The minimum distance between two transitions in the medium is the flux change length *B*, and the distance between two adjacent signal tracks is the track pitch *W*, which is wider than the signal track width *w*. The flux change length can be directly converted into bit length with the proper code information. The reciprocal of the bit length is called *linear density,* and the reciprocal of the track pitch is termed *track density*. The information storage area density in the medium is the product of the linear density and the track density. This area density roughly determines how much information a user can store in a unit surface area of storage medium, and is a figure of merit for a recording technique. Much effort has been expended to increase the areal density. For example, it has been increased 50 times during 90's.

## 15.4 DISPLAY SYSTEM

The display system acts as a final link between the measuring process and the user. If the display is not easy to see and easy to understand then that process is compromised. The user's sensory capabilities and cognitive characteristics, therefore, must both be addressed in display-system selection. Furthermore, display technologies and performance capabilities are easier to evaluate in the context of their intended application. The following section discusses various kind of commonly used display system.

### 15.4.1 Cathode Ray Tube (CRT)

The Cathode Ray Tube (CRT) was developed for television in the 40s. Now it has wide range of applications in oscilloscopes, radar and monitors, etc.

It consists of a glass envelope made from a neck and cone. All air has been extracted so that it contains a vacuum. At the narrow end are pins which make connection with an internal electron gun, as shown in Figure 15.20. Voltages are applied to this gun to produce a beam of electrons. This electron beam is projected towards the inside face of the screen.

Different basic component of CRTs are electron gun, electron accelerating anode, horizontal and vertical electric field coils, electron beam and a screen coated with phosphor. The electron gun generates a narrow beam of electrons. The anodes accelerate the electrons. Deflecting coils produce an extremely low-frequency electric field that allows for constant adjustment of the direction of the electron beam. There are two sets of deflecting coils: horizontal and vertical. (In the figure, only one set of coils is shown for simplicity). The intensity of the beam can be varied. The electron beam produces a tiny, bright visible spot when it strikes the phosphor-coated screen. The screen is covered with a fine layer of phosphorescent elements, called *phosphors*, which emit light by excitation when electrons strike them, creating a lit-up dot called a *pixel*.

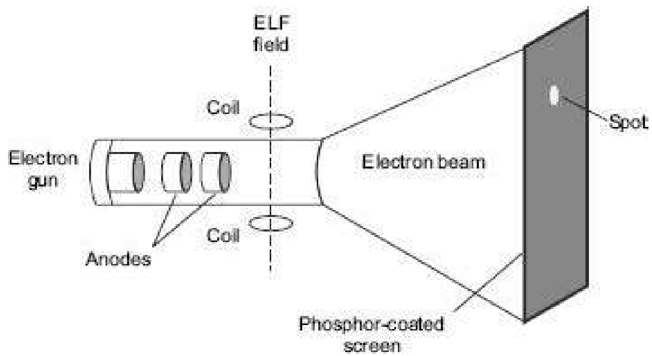


**Figure 15.20** *Internal components of a CRT*

To produce an image on the screen, complex signals are applied to the deflecting coils, and also to the apparatus that controls the intensity of the electron beam. This causes the spot to race across the screen from right to left, and from top to bottom, in a sequence of horizontal lines called the *raster*. As viewed from the front of the CRT, the spot moves in a pattern similar to the way your eyes move when you read a single-column page of text. But the scanning takes place at such a rapid rate that your eye sees a constant image over the entire screen.

The illustration shows only one electron gun. This is typical of a monochrome, or single-colour CRTs. However, virtually all CRTs today render colour images. These devices have three electron guns, one for the primary colour red, one for the primary colour green, and one for the primary colour blue. The CRT thus produces three overlapping images: one in red (R), one in green (G), and one in blue (B). This is the so-called *RGB colour model*.

In computer systems, there are several display modes, or sets of specifications according to which the CRT operates. The most common specification for CRT displays is known as SVGA (Super Video Graphics Array). Notebook computers typically use liquid crystal display. The technology for these displays is much different than that for CRTs.

### *Cold Cathode Display*

A cathode is any electrode that emits electrons as discussed in the section on CRT display. Generally, the cathode is heated so that electron emission occur at lower potential difference these cathode are called hot cathode and are widely used in vacuum tube CRT monitor oscilloscope, etc. By taking advantage of thermionic emission, electrons can overcome the work function of the cathode with lower electric field. But in the case of cold cathode, sufficient voltage is provided so that electrons can overcome the work function and come out from the cathode at ambient temperature. Because it is not deliberately heated, such a cathode is referred to as a cold cathode. Although several mechanisms may eventually cause the cathode to become quite hot once it is operating. Most cold cathode devices are filled with a gas which can be ionised. A few cold cathode devices contain a vacuum.

### 15.4.2 Light Emitting Diode (LED)

One of the cheapest and convenient ways to display information electronically is by using Light-Emitting Diodes ( LEDs). It is basically a *p-n* junction photodiode when excited at forward-bias condition emits light (basic theory of LEDs are discussed in chapter on “Fibre Optic Measurements”). It can be easily interfaced with a simple electronic circuit and is durable and reliable. These LEDs are often arranged in different formats to display information. Among these, the seven segments configuration and dot matrix display are very common and widely used. The seven-segment configuration of an LED arranged in the form of the digit 8 can be restrictive in that it does not adequately allow the display of some alphanumeric characters. By contrast, the versatility of a dot-matrix arrangement allows an LED unit to display more complicated shapes. The following sections discuss the about seven-segment and dot-matrix LED display.

#### *1. The Seven Segment Display*

One common requirement for many different digital devices is a visual display. Individual LEDs can of course display the binary states, i.e. ‘ON’ or OFF’. But when some numbers or characters are to be displayed then some arrangement of the LEDs are required. One possibility is a matrix of LEDs in a $7 \times 5$ array. However, if only numbers are to be displayed then this becomes a bit expensive. A much better way is to arrange the minimum possible number of LEDs in such a way that it can represent a number requiring only 7 LEDs. A common technique is to use a shaped piece of translucent plastic to operate as a specialised optical fibre, to distribute the light from the LED evenly over a fixed bar shape. The seven bars are laid out as a squared-off figure “8”. The result is known as a seven-segment LED.

Seven-segment displays having a wide range of applications. They used in clocks, watches, digital instruments, digital balances and many household appliances already have such displays.

There are basically two type of seven-segment displays—common cathode and common anode. *The common-anode type* is shown in Figure 15.21, where ‘a’, ‘b’, ‘c’, ‘d’, ‘e’, ‘f’ and ‘g’ represent individual LEDs which are arranged as shown in the figure. In order to display numbers often decimal point have to be displayed. For that, another LED has been added, which is represented by ‘dp’ (decimal point).

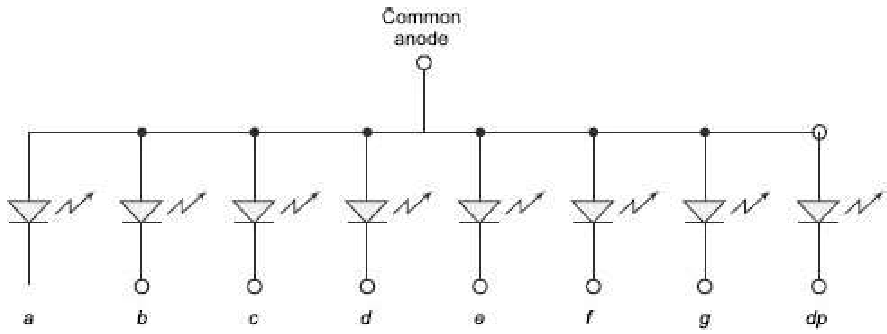


**Figure 15.21** *Common anode connection of seven segment display unit*

A typical seven-segment display unit is shown in Figure 15.22. Figure 15.23 shows the pin diagram of a common anode type seven-segment display. That means that the positive leg of each LED is connected to a common point which is the Pin 3 in this case. Each LED has a negative leg that is connected to one of the pins of the device. To make it work, you need to connect the pin 3 to 5 volts. Then to make each segment light up, connect the ground pin for that LED to ground. A resistor is required to limit the current. Rather than using a resistor from each LED to ground, you can just use one resistor from *V*cc to the pin 3 to limit the current.

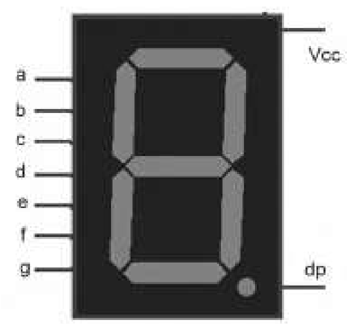


**Figure 15.22** *Typical seven segment display unit*

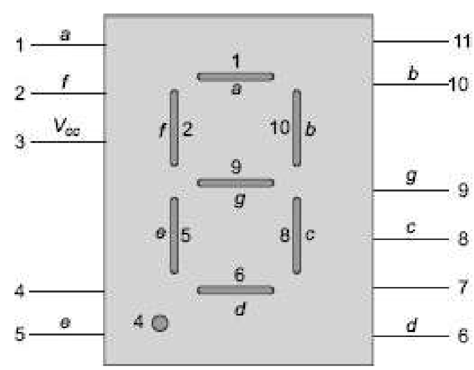


**Figure 15.23** *Pin diagram of seven segment display unit*

Table 15.1 shows how to form the numbers 0 to 9 and the letters A, B, C, d, E, and F. ‘0’ means that pin is connected to ground. ‘1’ means that pin is connected to $V_{cc}$.

**Table 15.1** *Forming numbers and letters.*

| | a (Pin 1) | b (Pin 10) | c (Pin 8) | d (Pin 6) | e (Pin 5) | f (Pin 2) | g (Pin 9) |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 4 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 5 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| A | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| b | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| C | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| d | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| E | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| F | 0 | 1 | 1 | 1 | 0 | 0 | 0 |

### *2. Dot Matrix Display*

LEDs are arranged in matrix form—common configurations are 5 × 7, 5 × 8 and 8 × 8, as shown in Figure 15.4. Based on the electrode connections, two kinds of LED matrices are possible, one is common anode. All the LEDs in a row having the anode are connected together. The other one is common cathode, having all LEDs in a row, the common cathode or cathodes are shorted. It is easier to understand the construction and interface capabilities of an LED matrix using an illustration. Figure 15.24 depicts a matrix construction of the common-anode type. A single matrix is formed by thirty-five LEDs arranged in five columns and seven rows (5 × 7). The anodes of the fi ve LEDs forming one row are connected together. Similarly, the cathodes of the seven LEDs of a column are connected together. In this arrangement of LEDs, the cathodes are switched to turn the LEDs of a row on or off.

The matrix (unit) illustrated in Figure 15.25 can be used to display a single alphanumeric character. Several such units can be placed next to each other to form a larger panel to display a string of characters.

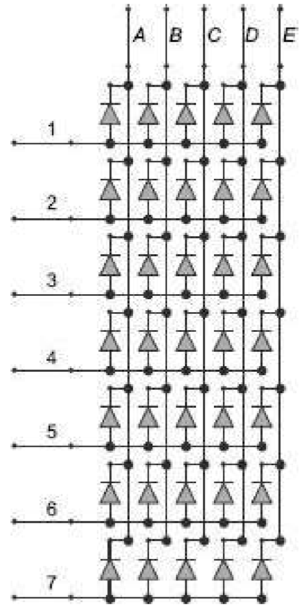


**Figure 15.24** *LED Matrix with common-anode arrangement*

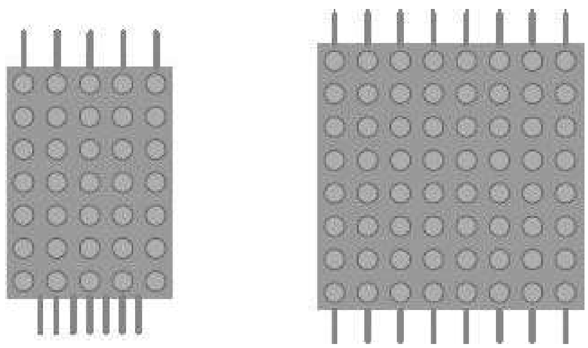

**Figure 15.25** *5×7 and 8×8 dot matrix display*

### *3. Display of Information using LED Matrix*

From Figure15.26 it is clear that switching/multiplexing of rows is required to display a character on the matrix unit. These are often done by using external hardware like latches. Each row of the LED is driven for a brief period before switching to the next row. As the human eye retains a visual impression of an object for a short duration after the object is removed. Retention time depends on the brightness of the image. Due to this visual phenomenon termed persistence of vision, the human eye considers that the LEDs are glowing continuously and can visualise the characters.

Rapid switching between rows produces the illusion that all the rows are ON at the same time. To function as intended, two additional requirements must be met:

1. The LEDs must be overdriven proportionately or they can appear dim. The dimness occurs because a row is ON for only a fraction of time.
2. The rows must be updated often enough (e.g. each row is scanned about 30–40 times per second), to avoid display flicker. For actual character display, it is necessary to map the shape of the character to the 5x7 LED matrix. Figure 15.26 illustrates the characters A and B.

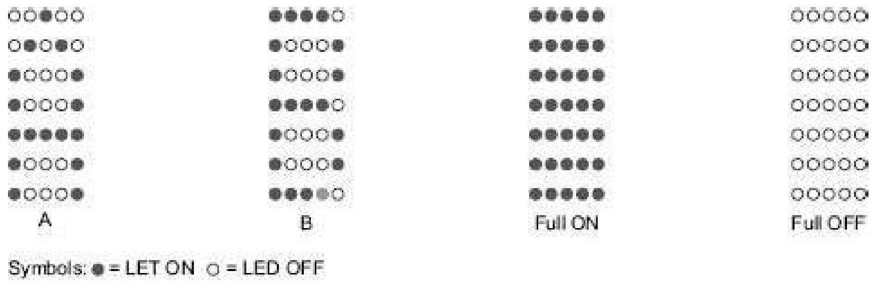


**Figure 15.26** *Illustration of the Characters A and B*

For any given character, a corresponding pattern of LED ON and LED OFF must be generated, for example, the character A, as displayed in the figure, is formed with the pattern shown in Table 15.2.

**Table 15.2** *Display Pattern for the Character A*

| | *C0* | *C1* | *C2* | *C3* | *C4* | *C0* | *C1* | *C2* | *C3* | *C4* | *Data* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R0 | OFF | OFF | ON | OFF | OFF | 1 | 1 | 0 | 0 | 1 | 0 × 1B |
| R1 | OFF | ON | OFF | ON | OFF | 1 | 0 | 1 | 0 | 1 | 0× 15 |
| R2 | ON | OFF | OFF | OFF | ON | 0 | 1 | 1 | 1 | 0 | 0 × 0E |
| R3 | ON | OFF | OFF | OFF | ON | 0 | 1 | 1 | 1 | 0 | 0 × 0E |
| R4 | ON | ON | ON | ON | ON | 0 | 0 | 0 | 0 | 0 | 0 × 00 |
| R5 | ON | OFF | OFF | OFF | ON | 0 | 1 | 1 | 1 | 0 | 0 × 0E |
| R6 | ON | OFF | OFF | OFF | ON | 0 | 1 | 1 | 1 | 0 | 0 × 0E |
| Note: 0 = LED ON; 1 = LED OFF . | | | | | | | | | | | |

Other characters/objects can be developed in a similar manner and stored in the memory to be used while displaying. By frequently switching the rows or columns with the proper selection of LED ON/ OFF patterns, the human eye perceives the display as continuous.

### 15.4.3 Liquid Crystal Display (LCD)

The Liquid Crystal Display ( LCD) has been one of the enabling technologies of the current electronic revolution. It is an essential part of every mobile phone, every laptop and every personal organiser. *Liquid crystal* is an organic compound that polarises any light that passes through it. A liquid crystal also responds to an applied electric field by changing the alignment of its molecules, and in so doing changing the direction of the light polarisation that it introduces. Liquid crystals can be trapped between two parallel sheets of glass, with a matching pattern of transparent electrode on each sheet. Figure 15.27 shows different layers of a typical LCD display. When a voltage is applied to the electrodes, the optical character of the crystal changes and the electrode pattern appears in the crystal. A huge range of LCDs has been developed, including those based on seven-segment digits or dot matrix formats, as well as a variety of graphical forms. Many general-purpose displays are available commercially.

The liquid crystal fluid is the active medium that is used to create an image. It consists of a very large number of elongated crystals suspended in a fluid. This reservoir is sandwiched between two thin sheets of glass. Each piece of glass has a transparent conductive pattern bonded to it. The crystals are aligned in a spiral pattern until an electric field is impressed on the conductors.

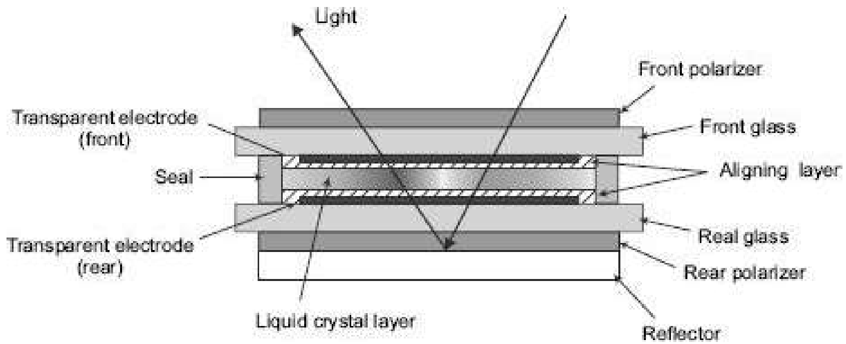


**Figure 15.27** *Different layers of a typical LCD display*

A sheet of polarising material is bonded to the outside surfaces of both the front and rear glass covers. As incident light of random polarisation enters the top polarizer, it is stopped except for that which is polarised in the proper direction. With no electric field applied, the light is twisted or its polarisation is changed by the spiral pattern of the crystals. The bottom polariser is aligned opposite of the top one but the “twisted” light is now aligned with the bottom polariser and passes through. The display is now transparent and appears light.

A simple black-or-white LCD display works by either allowing daylight to be reflected back out at the viewer or preventing it from doing so—in which case the viewer sees a black area. The liquid crystal is the part of the system that either prevents light from passing through it or not.

The crystal is placed between two polarising filters that are at right angles to each other and together block light. When there is no electric current applied to the crystal, it twists light by 90°, which allows the light to pass through the second polariser and be reflected back. But when the voltage is applied, the crystal molecules align themselves, and light cannot pass through the polariser: the segment turns black, this phenomena is shown in Figure 15.28.

Many other types of LCD displays are being developed for the laptop and CRT replacement market including full colour versions. These include double and Triple Twisted Nematic (DSTN and TSTN) displays and the Active-matrix Thin-film Twisted Nematic and Metal-Insulated-Metal Twisted Nematic (TFT-TN and MIM-TN) displays. Unfortunately, these advanced display are too expensive for most of the calculator market. TN LCDs almost completely dominate today’s calculator market due to their extremely low power requirements, thin size and low cost.

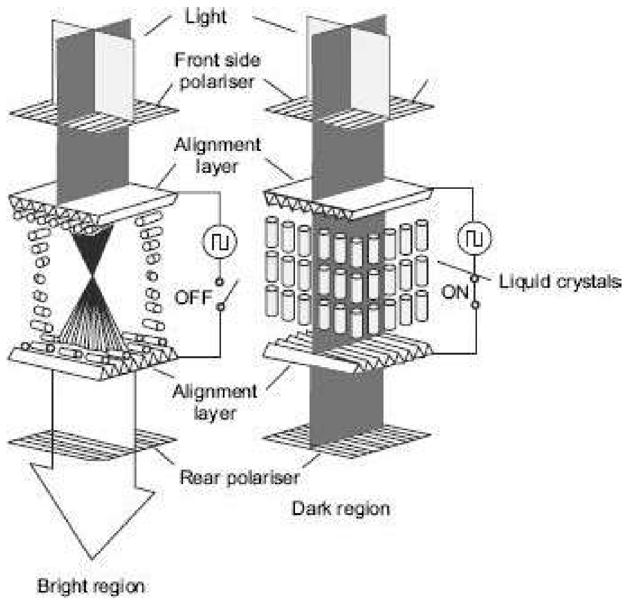


**Figure 15.28** *Working principle of LCD*

**Table 15.3** *Comparison of CRT and LCD*

| *Cathode Ray Tubes* | *Liquid Crystal Displays* |
|---|---|
| **Advantages**<br>• Fast response and high resolution possible<br>• Full colour (large modulation depth of E-beam)<br>• Saturated and natural colors<br>• Inexpensive, matured technology<br>• Wide angle, high contrast and brightness | **Advantages**<br>• Small in size<br>• Light weight (typ. 1/5 of CRT)<br>• Low power consumption (typ. 1/4 of CRT)<br>• Completely fl at screen—no geometrical errors<br>• Crisp pictures—digital and uniform colours<br>• No electromagnetic emission<br>• Fully digital, signal processing possible<br>• Large screens (>20 inch) on desktops |
| **Disadvantages**<br>• Large and heavy (typ. 70 × 70 cm, 15 kg)<br>• High power consumption (typ. 140W)<br>• Harmful dc and ac electric and magnetic fi elds<br>• Flickering at 50–80 Hz (no memory effect)<br>• Geometrical errors at edges | **Disadvantages**<br>• High price (presently 3 × CRT)<br>• Poor viewing angle (typ. +/– 50 degrees)<br>• Low contrast and luminance (typ. 1:100)<br>• Low luminance (typ. 200 cd/m2) |

## 15.4.4 Flat Panel Display

Flat-screen monitors, often termed Flat Panel Displays (FPDs), are becoming more and more popular, as they take up less space and are less heavy than traditional CRT monitors. Other greater advantages of FPDs are they consume less energy when compared to CRT monitors, and also have less electromagnetic radiation. There are basically two types of Flat Panel Display (FPD)—the popular one is Liquid Crystal Display (LCD) and the other one is Plasma Display Panel (PDP).

The theory of Liquid Crystal Displays was discussed in the LCD section. Here, Plasma

Display Panel (PDP) will be discussed in brief.

### *Plasma Display Panel (PDP)*

A Plasma Display Panel ( PDP) is a type of flat panel display now commonly used for large TV displays (typically above 32 ¢¢). It is often used in the home environment and is becoming increasingly popular in modern cultures.

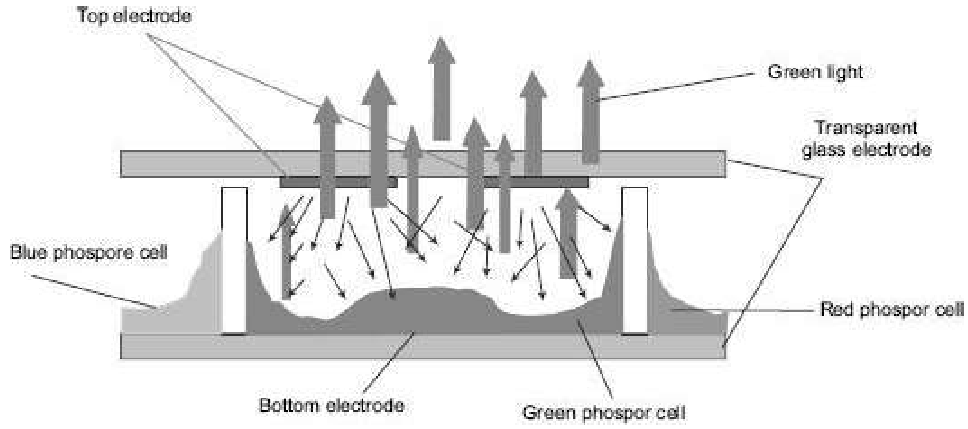


**Figure 15.29** *Working principle of plasma display*

A plasma display panel is based on emitting light by exciting gases. The gas used in plasma screens is a mixture of argon (90%) and xenon (10%). Gas is contained within cells, each one corresponding to a pixel that corresponds to a row electrode and column electrode, which excite the gas within the cell. A typical green colour cell is shown in Figure 15.29, where red and blue colour cells are located nearby. By modulating the voltage applied across the top and bottom electrodes and by changing the frequency of excitation, the inert gas can be excited. The gas excited this way produces ultraviolet radiation (which is invisible to the human eye). With blue, green, and red phosphors distributed among the cells, the ultraviolet radiation is converted into visible light, so that pixels (made up of 3 cells) can be displayed in up to 16 million colors (256 × 256 × 256).

Plasma technology can be used to create large-scale high-contrast screens, but plasma screens are still expensive. What’s more, power consumption is more than 30 times higher than for an LCD screen. A typical plasma TV of SAMSUNG Corp. is shown in Figure 15.30.

**Figure 15.30** *Plasma TV [Manf. SAMSUNG Corp.]*

## 15.4.5 Nixie Tube

Nixie tubes are nonplanar electronic devices that use the principles of glow discharge for displaying numerals or other information. These are actually gaseous glow tubes made of glass that contain two electrodes. The anode is in the form of a wire mesh and multiple cathodes that are shaped as numerals or other symbols that are to be displayed. When the cathode corresponding to the numeral to be displayed is activated, it gets surrounded by an orange gaseous glow discharge. The glass tube is generally filled with neon gas at low pressure, with a little mercury. The photograph of a Nixie tube is shown in Figure 15.31.

When a sufficient potential of around 170 volts is applied between the selected cathode and the anode plate, the gas surrounding the selected cathode gets ionised and emits an orange glow. A Nixie tube should not be confused with a vacuum tube since operation of the Nixie tube does not depend on thermionic emissions of electrons from a heated cathode. The operating temperature of Nixie tube rarely exceeds 40°C. Nixie tubes are thus also called cold-cathode tube.

The most commonly available Nixie tube has ten cathodes in the shapes of the numerals 0 to 9, and may be a decimal point. These cathodes displaying different numbers are arranged one behind another. Thus, when the characters glow one at a time, each character appears at a different depth.

**Figure 15.31** *Nixie tube (Courtesy, www.123rf.com)*

Nixie tubes were used in earlier days as display units in voltmeters, ammeters and other electrical and electronic measuring instruments.

# EXERCISE

## Objective-type Questions

1. A strip chart recorder is a/an
   (a) analog recorder
   (b) magnetic tape recorder
   (c) oscillographic recorder
   (d) none of the above
2. Printing mechanism of a FAX machine is of
   (a) thermal type
   (b) impact type
   (c) electrostatic type
   (d) optical type
3. Which is not the function of data loggers?
   (a) Display
   (b) Online analysis
   (c) Reporting
   (d) Control
4. The bandwidth of a magnetic tape recorder is
   (a) higher than electronic recorder
   (b) higher than strip chart recorder
   (c) lower than strip chart recorder
   (d) higher than ultraviolet recorder
5. Power consumption of an LED display is
   (a) higher than LCD display
   (b) lower than LCD display

(c) almost equal to LCD display

(d) Approximately two lines higher than same size LCD

6. In a CRT, the electron beam is deflected by

   (a) electric field

   (b) magnetic field

   (c) both magnetic and electric field

   (d) gravitational field

7. Servo mechanism is used in

   (a) potentiometric type recorder

   (b) galvanometric type recorder

   (c) magnetic tape type recorder

   (d) ultraviolet recorder

8. The response time of CRT display is

   (a) higher that LCD display

   (b) lower than LCD display

   (c) higher than plasma display

   (d) lower than plasma display

9. The gas used in plasma screens is a mixture of

   (a) nitrogen and oxygen

   (b) nitrogen and xenon

   (c) argon and nitrogen

   (d) argon and xenon

10. Time scale of a strip chart recorder is controlled by

    (a) controlling speed of the chart paper

    (b) controlling the stylus drive mechanism

    (c) controlling the range selector

    (d) controlling the stylus

**Answers**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. (a) | 2. (a) | 3. (d) | 4. (b) | 5. (b) | 6. (a) | 7. (a) |
| 8. (a) | 9. (d) | 10. (a) | | | | |

## Short-answer Questions

1. Classify different types of recorders.
2. What are the different components of a strip chart recorder? Briefly discuss those.
3. Compare a potentiometric with galvanometric recorder.
4. State the working principle of ultraviolet recorders.
5. What are the advantages of a magnetic tape recorder over the other recording system?
6. Draw a functional block diagram of a data logger. Also discuss about each element.
7. Compare cold cathode display with hot cathode display.
8. How Does a simple black-and-white LCD display work?
9. State the working principle of plasma display.
10. How are characters displayed in an LED dot matrix display unit?