UNIT IV STORAGE AND DISPLAY DEVICES

A recorder is a measuring instrument which records time varying quantity, even after the quantity or variable to be measured has stopped. The electrical quantities such as voltage & current are measured directly. The non- electrical quantities are recorded using indirect methods. The non- electrical quantities are first converted to their equivalent voltages or currents, using various transducers.

Electronic recorders may be classified as:

1. Analog recorders
2. Digital recorders

Analog recorders dealing with analog systems can be classified as

1. Graphic recorders
2. Oscillographic recorders
3. Magnetic Tape recorders

Digital recorders dealing with digital output can be classified as

1. Incremental digital recorders
2. Synchronous digital recorders

4.2 Magnetic Disk And Tape

Magnetic Tape Recorder

- Ø The magnetic tape recorders are used for high frequency signal recording.
- Ø In these recorders, the data is recorded in a way that it can be reproduced in electrical form any time.
- Ø Also main advantage of these recorders is that the recorded data can be replayed for almost infinite times.
- Ø Because of good higher frequency response, these are used in Instrumentation systems extensively.

Basic Components of Tape Recorder

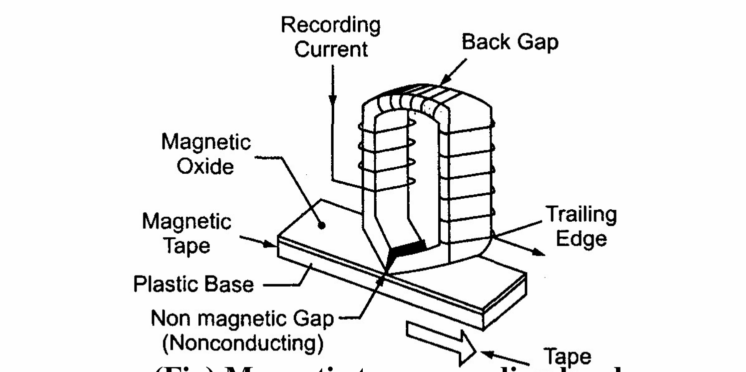
Following are the basic components of magnetic tape recorder

1. Recording Head
2. Magnetic Tape
3. Reproducing Head
4. Tape Transport Mechanism
5. Conditioning Devices

Recording Head

- Ø The construction of the magnetic recording head is very much similar to the construction of a Transformer having a toroidal core with coil.

- Ø There is a uniform fine air gap of 5µ m to 15µ m between the head and the magnetic tape.



(Fig) Magnetic tape recording head

- Ø When the current used for recording is passed through coil wound around magnetic core, it produces magnetic flux.
- Ø The magnetic tape is having iron oxide particles.
- Ø When the tape is passing the head, the flux produced due to recording current gets linked with iron oxide part ices on the magnetic tape and these particles get magnetized.
- Ø This magnetization particle remain as it is, e vent Hough the magnetic tape leaves the gap.
- Ø The actual recording takes place at the trailing edge of the air gap.
- Ø Any signal is recorded in the form of the patterns.
- Ø These magnetic patterns are dispersed anywhere along the length of magnetic tape in accordance with the variation in recording current with respect to time.

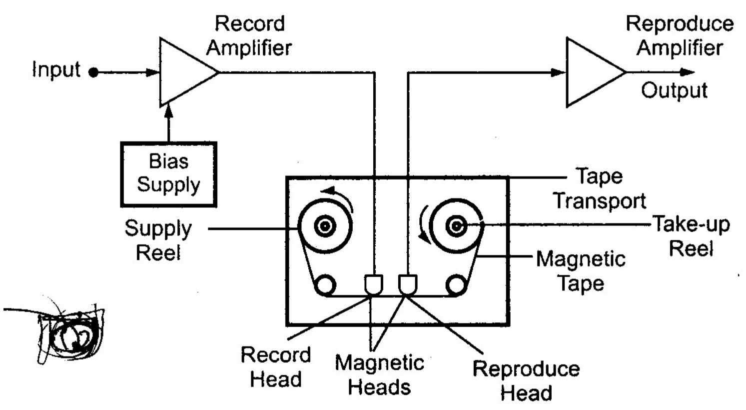
Magnetic Tape

- Ø The magnetic tape is made of thin sheet of tough and dimensionally stable plastic ribbon.
- Ø One side of this plastic ribbon is coated by powdered iron oxide particles ($Fe2O3$) thick.
- Ø The magnetic tape is wound around a reel.
- Ø This tape is transferred from one reel to another.
- Ø When the tape passes across air gap magnetic pattern is created in accordance with variation of recording current.
- Ø To reproduce this pattern, the same tape with some recorded pattern is passed across another magnetic head in which voltage is induced.
- Ø This voltage induced is in accordance with the magnetic pattern.

Reproducing Head

- Ø The use of the reproducing head is to get the recorded data played back.
- Ø The working of the reproducing head is exactly opposite to that of the recording head.
- Ø The reproducing head detects the magnetic pattern recorded on the tape.
- Ø The head converts the magnetic pattern back to the original electrical signal.
- Ø In appearance, both recording and reproducing heads are very much similar.

Tape Transport Mechanism



(Fig) Basic tape transport mechanism

- Ø The tape transport mechanism moves the magnetic tape along the recording head or reproducing head with a constant speed
- Ø The tape transport mechanism must perform following tasks.
  - It must handle the tape without straining and wearing it.
  - It must guide the tape across magnetic heads with great precision.
  - It must maintain proper tension of magnetic tape.
  - It must maintain uniform and sufficient gap between the tape and heads.
- Ø The magnetic tape is wound on reel.
- Ø There are two reels; one is called as supply & other is called as take-up reel.
- Ø Both the reels rotate in same direction.
- Ø The transportation of the tape is done by using supply reel and take-up reel.
- Ø The fast winding of the tape or the reversing of the tape is done by using special arrangements.
- Ø The rollers are used to drive and guide the tape.

Conditioning Devices

- Ø These devices consist of amplifiers and fitters to modify signal to be recorded.
- Ø The conditioning devices allow the signals to be recorded on the magnetic tape with proper format.
- Ø Amplifiers allow amplification of signal to be recorded and filters removes unwanted ripple quantities.

Principle of Tape Recorders

- Ø When a magnetic tape is passed through a recording head, the signal to be recorded appears as some magnetic pattern on the tape.
- Ø This magnetic pattern is in accordance with the variations of original recording current.
- Ø The recorded signal can be reproduced back by passing the same tape through a reproducing head where the voltage is induced corresponding to the magnetic pattern on the tape.

- Ø When the tape is passed through the reproducing head, the head detects the changes in the magnetic pattern i.e. magnetization.
- Ø The change in magnetization of particles produces change in the reluctance of the magnetic circuit of the reproducing head, inducing a voltage in its winding.
- Ø The induced voltage depends on the direction of magnetisation and its magnitude on the tape.
- Ø The emf, thus induced is proportional to the rate of change of magnitude of magnetisation i.e. e N (dI / dt)

  Where N = number of turns of the winding on reproducing head

  Æ = magnetic flux produced.

  Suppose the signal to be recorded is Vm sin Ủt. Thus, the current in the recording head and flux induced will be proportional to this voltage.
- Ø It is given by e= k 1. Vm sin wt, where k1 = constant.
- Ø Above pattern of flux is recorded on the tape. Now, when this tape is passed through the reproducing head, above pattern is regenerated by inducing voltage in the reproducing head winding.
- Ø It is given by e= k2 ỦVm cos wt
- Ø Thus the reproducing signal is equal to derivative of input signal & it is proportional to flux recorded & frequency of recorded signal.

Methods of Recording

The methods used for magnetic tape recording used for instrumentation purposes are as follows:

i) Direct Recording
ii) Frequency Modulation Recording
iii) Pulse Duration Modulation Recording

For instrumentation purposes mostly frequency modulation recording is used. The pulse duration modulation recording is generally used in the systems for special applications where large number of slowly changing variables has to be recorded simultaneously.

4.3 Digital Plotters And Printers

PRINTERS

- Ø Printers can be classified according to their printing methodology **Impact printers** and **Non-impact printers**.
- Ø Impact printers press formed character faces against an inked ribbon onto the paper.
- Ø A line printer and dot matrix printer are the examples of an impact printer.
- Ø Non impact printer and plotters use laser techniques, inkjet sprays, xerographic processes, electrostatic methods and e1ectrothermal methods to get images onto the paper.
- Ø A ink-jet printer and laser printer are the examples of non- impact printers.

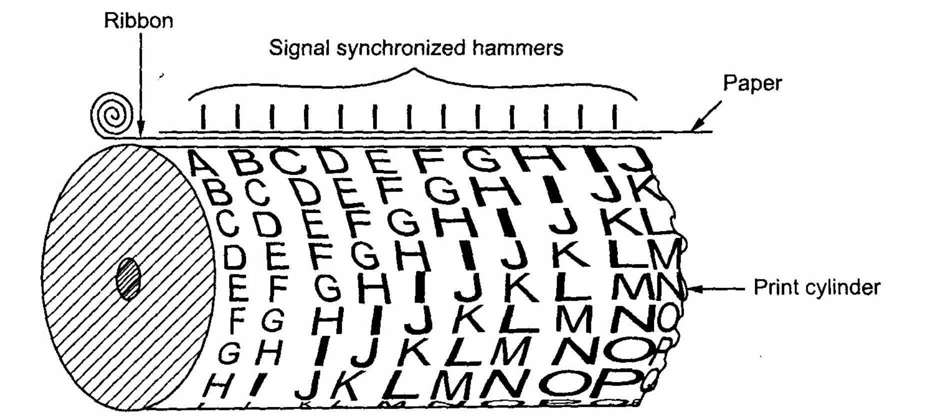
Line Printers

A line printer prints a complete line at a time. The printing speed of line printer varies from 150 lines to

2500 lines per minute with 96 to 100 characters on one line. The line printers are divided into two categories Drum printers and chain printer.

Drum Printers

Drum printer consists of a cylindrical drum. One complete set of characters is embossed on all the print positions on a line, as shown in the Fig. The character to be printed is adjusted by rotating drum.

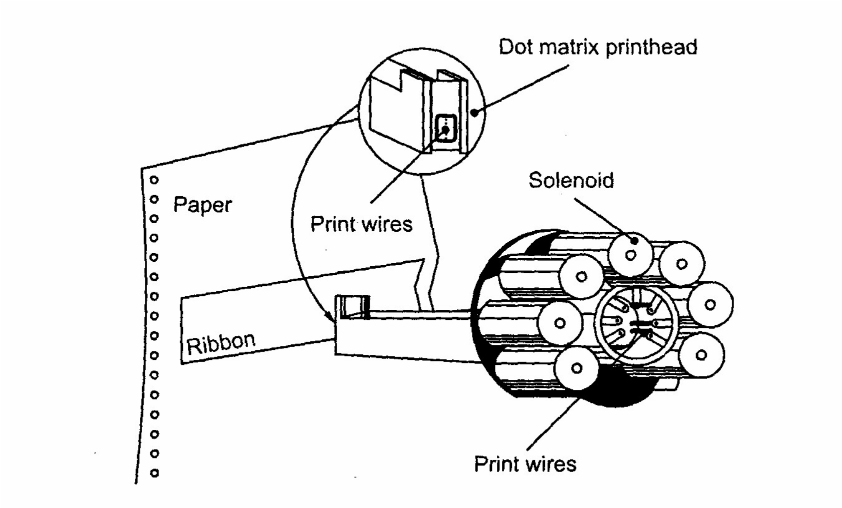


Chain Printers

In these printers chain with embossed character set is used, instead of drum. Here, the character to be printed is adjusted by rotating chain.

Dot Matrix Printers

Dot matrix printers are also called serial printers as they print one character at a time, with printing head moving across a line.



Laser Printer

- Ø The line, dot matrix, and ink jet printers need a head movement on a ribbon to print characters.
- Ø This mechanical movement is relatively slow due to the high inertia of mechanical elements.
- Ø In laser printers these mechanical movements are avoided.

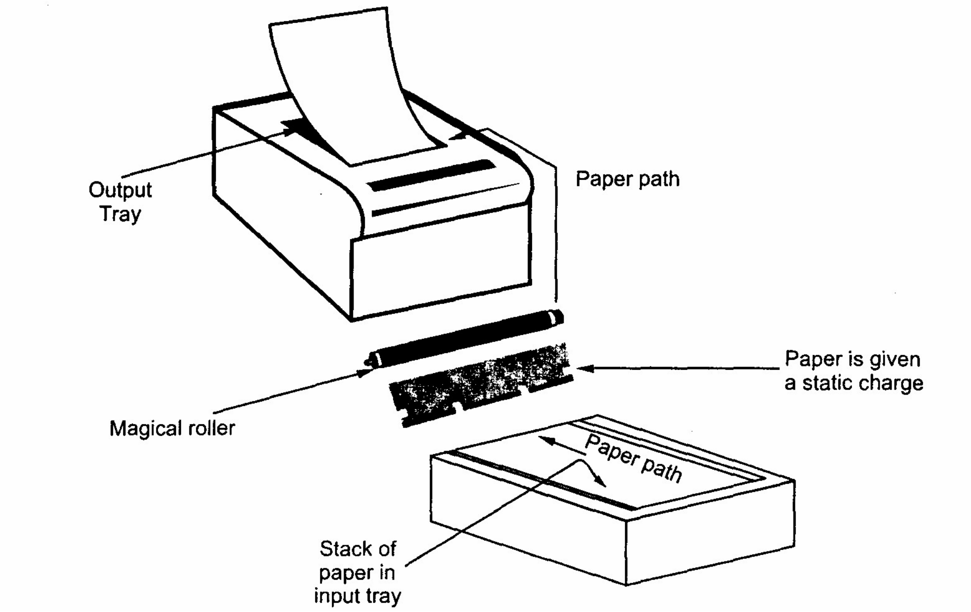
Ø In these printers, an electronically controlled laser beam traces out the desired character to be printed on a photoconductive drum.

Ø The exposed areas of the drum gets charged, which attracts an oppositely charged ink from the ink toner on to the exposed areas.

Ø This image is then transferred to the paper which comes in contact with the drum with pressure and heat.

Ø The charge on the drum decides the darkness of the print.

Ø When charge is more, more ink is attracted and we get a dark print.



Ø A colour laser printer works like a single colour laser printer, except that the process is repeated four times with four different ink colours: Cyan, magenta, yellow and black.

Ø Laser printers have high resolution from 600 dots per inch upto 1200 per inch.

Ø These printers print 4 to 16 page of text per minute.

Ø The high quality and speed of laser printers make them ideal for office environment.

Advantages of Laser printer

Ø The main advantages of laser printers are speed, precision and economy.

Ø A laser can move very quickly, so it can "write" with much greater speed than an inket.

Ø Because the laser beam has an unvarying diameter, it can draw more precisely, without spilling any excess ink.

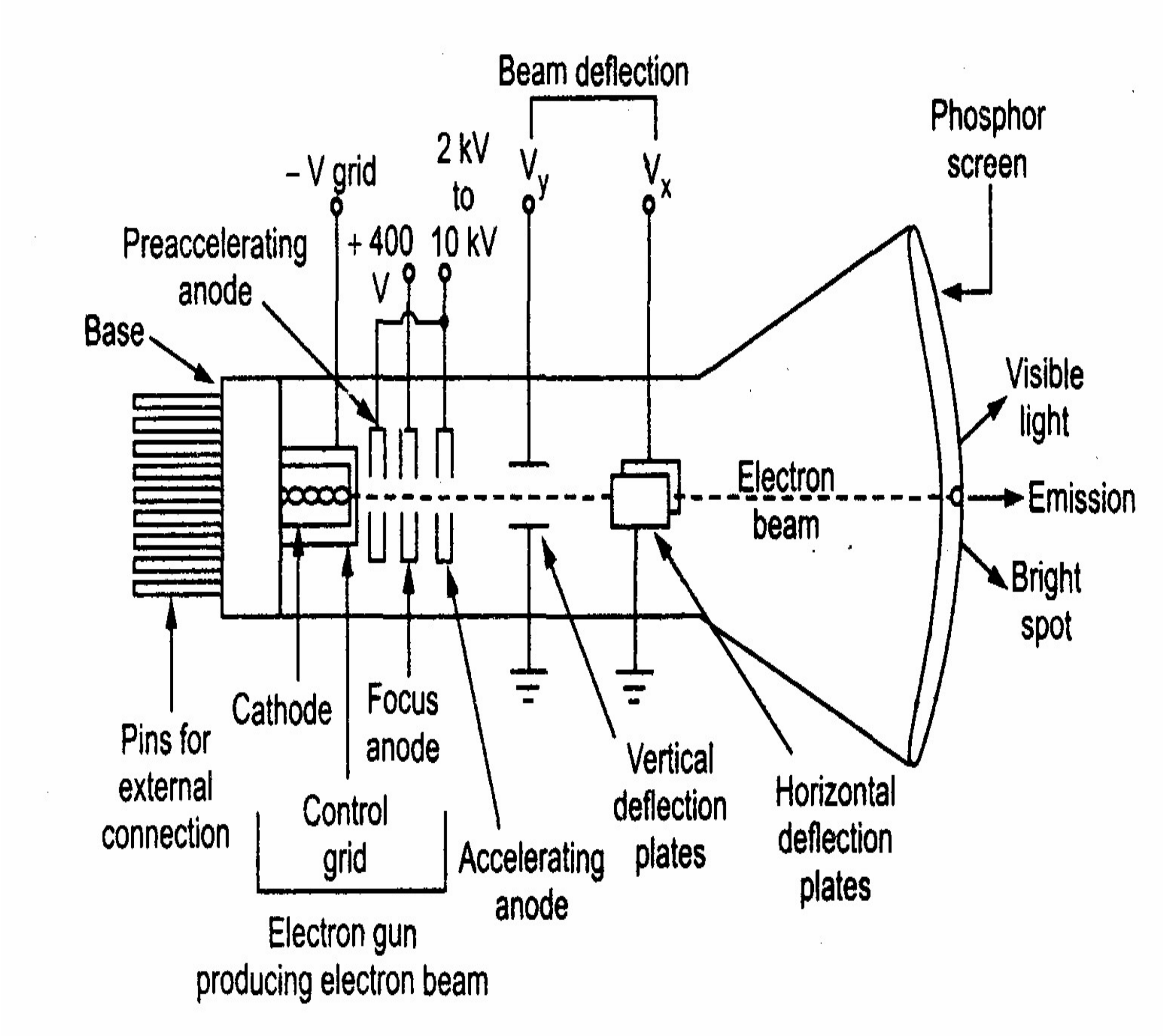
Ø Laser printers tend to be more expensive than ink-jet printers, but it doesn't cost as much to keep them running.

Ø Its toner power is cheap and lasts for longer time.

4.4 CRT Display

The device which allows, the amplitude of such signals, to be displayed primarily as a function of time, is called cathode ray oscilloscope. The cathode ray tube (CRT) is the heart of the C.R.O. The CRT generates the electron beam, accelerates the beam, deflects the beam and also has a screen where beam becomes visible as a spot. The main parts of the CRT are

i) Electron gun
ii) Deflection system
iii) Fluorescent screen
iv) Glass tube or envelope
v) Base



Electron gun

- Ø The electron gun section of the cathode ray tube provides a sharply focused, electron beam directed towards the fluorescent-coated screen.
- Ø This section starts from thermally heated cathode, emitting the electrons.
- Ø The control grid is given negative potential with respect to cathode.
- Ø This grid controls the number of electrons in t beam, going to the screen.
- Ø The momentum of the electrons (their number x their speed) determines the intensity, or brightness, of the light emitted from the fluorescent screen due to the electron bombardment.
- Ø The light emitted is usually of the green colour.

Deflection System

Ø When the electron beam is accelerated it passes through the deflection system, with which beam can be positioned anywhere on the screen.

Fluorescent Screen

- Ø The light produced by the screen does not disappear immediately when bombardment by electrons ceases, i.e., when the signal becomes zero.
- Ø The time period for which the trace remains on the screen after the signal becomes zero is known as "persistence or fluorescence".
- Ø The persistence may be as short as a few microsecond, or as long as tens of seconds or even minutes.
- Ø Medium persistence traces are mostly used for general purpose applications.
  - Ø Long persistence traces are used in the study of transients.
- Ø Long persistence helps in the study of transients since the trace is still seen on the screen after the transient has disappeared.

Glass Tube

- Ø All the components of a CRT are enclosed in an evacuated glass tube called envelope.
- Ø This allows the emitted electrons to move about freely from one end of the tube to the other end.

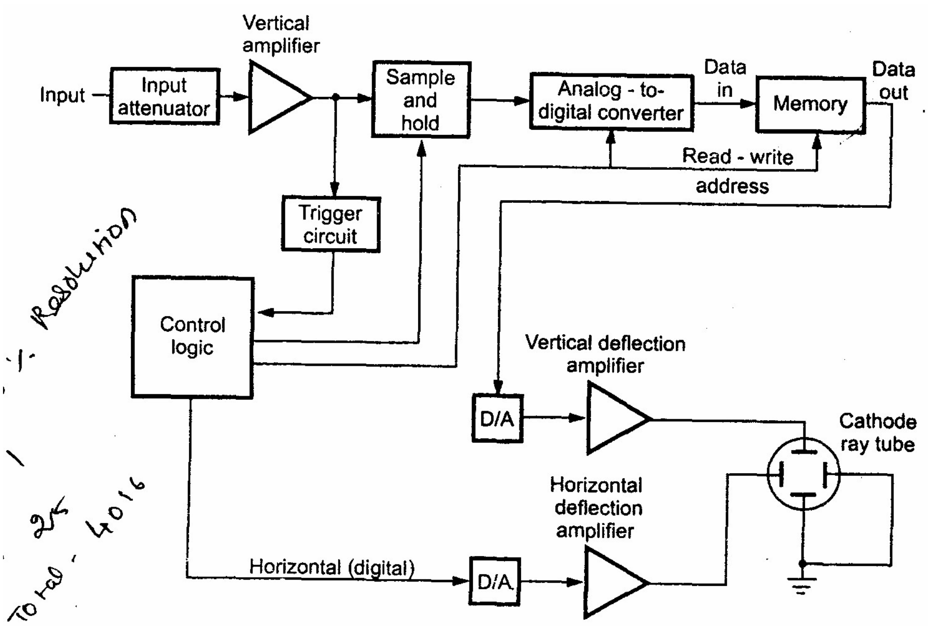
Base

Ø The base is provided to the CRT through which the connections are made to the various parts.

Digital Storage Oscilloscope

Block Diagram

The block diagram of digital storage oscilloscope is shown in the Fig.



- Ø The input signal is applied to the amplifier and attenuator section.
- Ø The oscilloscope uses same type of amplifier and attenuator circuitry as used in the conventional oscilloscopes.
- Ø The attenuated signal is then applied to the vertical amplifier.
- Ø To digitize the analog signal, analog to digital (A/D) converter is used.
- Ø The output of the vertical amplifier is applied to the A/D converter section.
- Ø The successive approximation type of A/D converter is most oftenly used in the digital storage oscilloscopes.
- Ø The sampling rate and memory size are selected depending upon the duration & the waveform to be recorded.
- Ø Once the input signal is sampled, the A/D converter digitizes it.
- Ø The signal is then captured in the memory.

Ø Once it is stored in the memory, many manipulations are possible as memory can be readout without being erased.

Ø The digital storage oscilloscope has three modes:

1. Roll mode
2. Store mode
3. Hold or save mode.

Advantages

i) It is easier to operate and has more capability. ii) The storage time is infinite.

iii) The display flexibility is available. The number of traces that can be stored and recalled depends on the size of the memory.

iv) The cursor measurement is possible.

v) The characters can be displayed on screen along with the waveform which can indicate waveform information such as minimum, maximum, frequency, amplitude etc.

vi) The X-Y plots, B-H curve, P-V diagrams can be displayed.

vii) The pre trigger viewing feature allows to display the waveform before trigger pulse.

viii) Keeping the records is possible by transmitting the data to computer system where the further processing is possible

ix) Signal processing is possible which includes translating the raw data into finished information e.g. computing parameters of a captured signal like r.m.s. value, energy stored etc.

4.6 DATA LOGGER

Definition

Data logger is an electronic device that records data over time or in relation to location either with a built in instrument or sensor.

Components

Ø Pulse inputs

Counts circuit closing

Ø Control ports

Digital in and out

Most commonly used to turn things on and off

Can be programmed as a digital input

Ø Excitation outputs

Though they can be deployed while connected to a host PC over an Ethernet or serial port a data logger is more typically deployed as standalone devices. The term data logger (also sometimes referred to as a data recorder) is commonly used to describe a self-contained, standalone data acquisition system or device. These products are comprised of a number of analog and digital inputs that are monitored, and the results or conditions of these inputs is then stored on some type of local memory (e.g. SD Card, Hard Drive).

Examples

Examples of where these devices are used abound. A few of these examples are shown below:

- Ø monitoring temperature, pressure, strain and other physical phenomena in aircraft flight tests (even including logging info from Arinc 429 or other serial communications buses)

- Ø Monitoring temperature, pressure, strain and other physical phenomena in automotive and in-vehicle tests including monitoring traffic and data transmitted on the vehicles CAN bus.

- Ø Environmental monitoring for quality control in food processing, food storage, pharmaceutical manufacturing, and even monitoring the environment during various stages of contract assembly or semiconductor fabrication

- Ø Monitoring stress and strain in large mechanical structures such as bridges, steel framed buildings, towers, launch pads etc.

- Ø Monitoring environmental parameters in temperature and environmental chambers and test facilities.

- Ø A data logger is a self-contained unit that does not require a host to operate.

- Ø It can be installed in almost any location, and left to operate unattended.
- Ø This data can be immediately analyzed for trends, or stored for historical archive purposes.
- Ø Data loggers can also monitor for alarm conditions, while recording a minimum number of samples, for economy.
- Ø If the recording is of a steady-state nature, without rapid changes, the user may go through rolls of paper, without seeing a single change in the input.
- Ø A data logger can record at very long intervals, saving paper, and can note when an alarm condition is occurring. When this happens, the event will be recorded and any outputs will be activated, even if the event occurs in between sample times.
- Ø A record of all significant conditions and events is generated using a minimum of recording hardcopy
- Ø The differences between various data loggers are based on the way that data is recorded and stored.
- Ø The basic difference between the two data logger types is that one type allows the data to be stored in a memory, to be retrieved at a later time, while the other type automatically records the data on paper, for immediate viewing and analysis.
- Ø Many data loggers combine these two functions, usually unequally, with the emphasis on either the ability to transfer the data or to provide a printout of it

Advantages

Ø A data logger is an attractive alternative to either a recorder or data acquisition system in many applications. When compared to a recorder, data loggers have the ability to accept a greater number of input channels, with better resolution and accuracy.

Ø Also, data loggers usually have some form of on-board intelligence, which provides the user with diverse capabilities.

Ø For example, raw data can be analyzed to give flow rates, differential temperatures, and other interpreted data that otherwise would require manual analysis by the operator the operator has a permanent recording on paper,

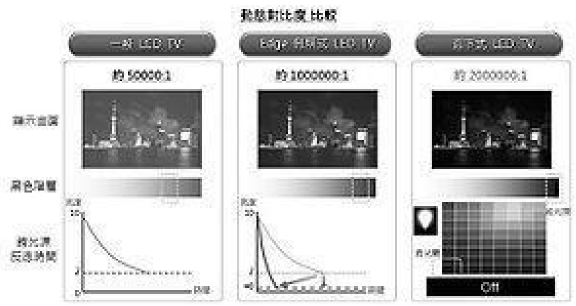
Ø No other external or peripheral equipment is required for operation, and

Ø Many data loggers of this type also have the ability to record data trends, in addition to simple digital data recording

Applications

Ø Temperature sensor
Ø Pressure sensor

4.7 LED-BACKLIT LCD TELEVISION



Comparison of LCD, edge lit LED and LED TV

LED-backlight LCD television (incorrectly called LED TV by (CCFLs) used in traditional LCD televisions. This has a dramatic impact resulting in a thinner panel and less power consumption, brighter display with better contrast levels. It also generates less heat than regular LCD TVs. The LEDs can come in three forms: dynamic RGB LEDs which are positioned behind the panel, white Edge-LEDs positioned around the rim of the screen which use a special diffusion panel to spread the light evenly behind the screen (the most common) and full-array which are arranged behind the screen but they are incapable of dimming or brightening individually

LED backlighting techniques

RGB dynamic LEDs

This method of backlighting allows dimming to occur in locally specific areas of darkness on the screen. This can show truer blacks, whites and PRs[*clarification needed*] at much higher dynamic contrast ratios, at the cost of less detail in small bright objects on a dark background, such as star fields

Edge-LEDs

This method of backlighting allows for LED-backlit TVs to become extremely thin. The light is diffused across the screen by a special panel which produces a uniform color range across the screen.

Full Array LEDs

Sharp, and now other brands, also have LED backlighting technology that aligns the LEDs on back of the TV like the RGB Dynamic LED backlight, but it lacks the local dimming of other sets.[6] The main benefit of its LED backlight is simply reduced energy consumption and may not improve quality over non-LED LCD TVs.[7]

Differences between LED-backlit and CCFL-backlit LCD displays

An LED backlight offers several general benefits over regular CCFL backlight TVs, typically higher brightness. Compared to regular CCFL backlighting, there may also be benefits to color gamut. However advancements in CCFL technology mean wide color gamuts and lower power consumption are also possible. The principal barrier to wide use of LED backlighting on LCD televisions is cost.

The variations of LED backlighting do offer different benefits. The first commercial LED backlit LCD TV was the Sony Qualia 005 (introduced in 2004). This featured RGB LED arrays to offer a color gamut around twice that of a conventional CCFL LCD television (the combined light output from red, green and blue LEDs produces a more pure white light than is possible with a single white light LED). RGB LED technology continues to be used on selected Sony BRAVIA LCD models, with the addition of 'local dimming' which enables excellent on- screen contrast through selectively turning off the LEDs behind dark parts of a picture frame.

Edge LED lighting was also first introduced by Sony (September 2008) on the 40 inch BRAVIA KLV-40ZX1M (referred to as the ZX1 in Europe). The principal benefit of Edge-LED lighting for LCD televisions is the ability to build thinner housings (the BRAVIA KLV-40ZX1M is as thin as 9.9mm). Samsung has also introduced a range of Edge-LED lit LCD televisions with extremely thin housings.

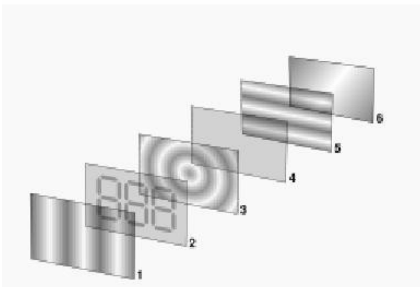
LED-backlit LCD TVs are considered a more sustainable choice, with a longer life and better energy efficiency than plasmas and conventional LCD TVs.[10] Unlike CCFL backlights, LEDs also use no mercury in their manufacture. However, other elements such as gallium and arsenic are used in the manufacture of the LED emitters themselves, meaning there is some debate over whether they are a significantly better long term solution to the problem of TV disposal.

Because LEDs are able to be switched on and off more quickly than CCFL displays and can offer a higher light output, it is theoretically possible to offer very high contrast ratios. They can produce deep blacks (LEDs off) and a high brightness (LEDs on), however care should be taken with measurements made from pure black and pure white outputs, as technologies like Edge-LED lighting do not allow these outputs to be reproduced simultaneously on-screen.

In September 2009 Nanoco Group announced that it has signed a joint development agreement with a major Japanese electronics company under which it will design and develop quantum dots for LED Backlights in LCD televisions.[11] Quantum dots are valued for displays, because they emit light in very specific gaussian distributions. This can result in a display that more accurately renders the colors than the human eye can perceive. Quantum dots also require very little power since they are not color filtered. In September 2010, LG Electronics revealed their new product which claimed as the world's slimmest full LED 3D TV at the IFA consumer electronics trade show in Berlin

4.8 LCD & Dot Matrix Display

LIQUID CRYSTAL DISPLAY



Reflective twisted nematic liquid crystal display.

1. Polarizing filter film with a vertical axis to polarize light as it enters.
2. Glass substrate with ITO electrodes. The shapes of these electrodes will determine the shapes that will appear when the LCD is turned ON. Vertical ridges etched on the surface are smooth.
3. Twisted nematic liquid crystal.

4. Glass substrate with common electrode film (ITO) with horizontal ridges to line up with the horizontal filter.
5. Polarizing filter film with a horizontal axis to block/pass light.
6. Reflective surface to send light back to viewer. (In a backlit LCD, this layer is replaced with a light source.)

A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly.
They are used in a wide range of applications including: computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have displaced cathode ray tube (CRT) displays in most applications. They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eyes. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in. LCDs are more energy efficient and offer safer disposal than CRTs.

Overview

LCD alarm clock

Each pixel of an LCD typically consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axes of transmission of which are (in most of the cases) perpendicular to each other. With no actual liquid crystal between the polarizing filters, light passing through the first filter would be blocked by the second (crossed) polarizer. In most of the cases the liquid crystal has double refraction.

The surface of the electrodes that are in contact with the liquid crystal material are treated so as to align the liquid crystal molecules in a particular direction. This treatment typically consists of a thin polymer layer that is unidirectionally rubbed using, for example, a cloth. The direction of the liquid crystal alignment is then defined by the direction of rubbing. Electrodes are made of a transparent conductor called Indium Tin Oxide (ITO).

Before applying an electric field, the orientation of the liquid crystal molecules is determined by the alignment at the surfaces of electrodes. In a twisted nematic device (still the most common liquid crystal device), the surface alignment directions at the two electrodes are perpendicular to each other, and so the molecules arrange themselves in a helical structure, or twist. This reduces the rotation of the polarization of the incident light, and the device appears grey. If the applied voltage is large enough, the liquid crystal molecules in the center of the layer are almost completely untwisted and the polarization of the incident light is not rotated as it passes through the liquid crystal layer. This light will then be mainly polarized perpendicular to the second filter, and thus be blocked and the pixel will appear black. By controlling the voltage applied across the liquid crystal layer in each pixel, light can be allowed to pass through in varying amounts thus constituting different levels of gray. This electric field also controls (reduces) the double refraction properties of the liquid crystal.

LCD with top polarizer removed from device and placed on top, such that the top and bottom polarizers are parallel.

The optical effect of a twisted nematic device in the voltage-on state is far less dependent on variations in the device thickness than that in the voltage-off state. Because of this, these devices are usually operated between crossed polarizers such that they appear bright with no voltage (the eye is much more sensitive to variations in the dark state than the bright state). These devices can also be operated between parallel polarizers, in which case the bright and dark states are reversed. The voltage-off dark state in this configuration appears blotchy, however, because of small variations of thickness across the device.

Both the liquid crystal material and the alignment layer material contain ionic compounds. If an electric field of one particular polarity is applied for a long period of time, this ionic material is attracted to the surfaces and degrades the device performance. This is avoided either by applying an alternating current or by reversing the polarity of the electric field as the device is addressed (the response of the liquid crystal layer is identical, regardless of the polarity of the applied field).

When a large number of pixels are needed in a display, it is not technically possible to drive each directly since then each pixel would require independent electrodes. Instead, the display is multiplexed. In a multiplexed display, electrodes on one side of the display are grouped and wired together (typically in columns), and each group gets its own voltage source. On the other side, the electrodes are also grouped (typically in rows), with each group getting a voltage sink. The groups are designed so each pixel has a unique, unshared combination of source and sink. The electronics, or the software driving the electronics then turns on sinks in sequence, and drives sources for the pixels of each sink.

ILLUMINATION

LCD panels produce no light of their own, they require an external lighting mechanism to be easily visible. On most displays, this consists of a cold cathode fluorescent lamp that is situated behind the LCD panel. Passive-matrix displays are usually not backlit, but active-matrix displays almost always are, with a few exceptions such as the display in the original Gameboy Advance. Recently, two types of LED backlit LCD displays have appeared in some televisions as an alternative to conventional backlit LCDs. In one scheme, the LEDs are used to backlight the entire LCD panel. In another scheme, a set of green red and blue LEDs is used to illuminate a small cluster of pixels, which can improve contrast and black level in some situations. For example, the LEDs in one section of the screen can be dimmed to produce a dark section of the image while the LEDs in another section are kept bright. Both schemes also allows for a slimmer panel than on conventional displays.

Passive-matrix and active-matrix addressed LCDs

A general purpose alphanumeric LCD, with two lines of 16 characters. LCDs with a small number of segments, such as those used in digital watches and pocket calculators, have individual electrical contacts for each segment. A external dedicated circuit supplies an electric charge to control each segment. This display structure is unwieldy for more than a few display elements.

Small monochrome displays such as those found in personal organizers, electronic weighing scales, older laptop screens, and the original Gameboy have a passive-matrix structure employing super-twisted nematic (STN) or double-layer STN (DSTN) technology (the latter of which addresses a colour-shifting problem with the former), and colour-STN (CSTN) in which colour is added by using an internal filter. Each row or column of the display has a single electrical circuit. The pixels are addressed one at a time by row and column addresses. This type of display is called passive-matrix addressed because the pixel must retain its state between refreshes without the benefit of a steady electrical charge. As the number of pixels (and, correspondingly, columns and rows) increases, this type of display becomes less feasible. Very slow response times and poor contrast are typical of passive-matrix addressed LCDs.
Monochrome passive-matrix LCDs were standard in most early laptops (although a few used plasma displays). The commercially unsuccessful Macintosh Portable (released in 1989) was one of the first to use an active-matrix display (though still monochrome), but passive-matrix was the norm until the mid-1990s, when colour active-matrix became standard on all laptops.

High-resolution colour displays such as modern LCD computer monitors and televisions use an active matrix structure. A matrix of thin-film transistors (TFTs) is added to the polarizing and colour filters. Each pixel has its own dedicated transistor, allowing each column line to access one pixel. When a row line is activated, all of the column lines are connected to a row of pixels and the correct voltage is driven onto all of the column lines. The row line is then deactivated and the next row line is activated. All of the row lines are activated in sequence during a refresh operation. Active-matrix addressed displays look "brighter" and "sharper" than passive-matrix addressed displays of the same size, and generally have quicker response times, producing much better images.

ACTIVE MATRIX TECHNOLOGIES

A Casio 1.8 in colour TFT liquid crystal display which equips the Sony Cyber-shot DSC-P93A

Twisted nematic (TN)

Twisted nematic displays contain liquid crystal elements which twist and untwist at varying degrees to allow light to pass through. When no voltage is applied to a TN liquid crystal cell, the light is polarized to pass through the cell. In proportion to the voltage applied, the LC cells twist up to 90 degrees changing the polarization and blocking the light's path. By properly adjusting the level of the voltage almost any grey level or transmission can be achieved.

In-plane switching (IPS)

In-plane switching is an LCD technology which aligns the liquid crystal cells in a horizontal direction. In this method, the electrical field is applied through each end of the crystal, but this requires two transistors for each pixel instead of the single transistor needed for a standard thin-film transistor (TFT) display. Before LG Enhanced IPS was introduced in 2009, the additional transistors resulted in blocking more transmission area, thus requiring a brighter backlight, which consumed more power, and made this type of display less desirable for notebook computers. This newer, lower power technology can be found in the AppleiMac, iPad, and iPhone 4, as well as the Hewlett-Packard Elite Book 8740w. Currently Panasonic is using an enhanced version eIPS for their large size LCD-TV products .Advanced fringe field switching (AFFS)
Known as fringe field switching (FFS) until 2003, advanced fringe field switching is a technology similar to IPS or S-IPS offering superior performance and colour gamut with high

luminosity. AFFS is developed by HYDIS TECHNOLOGIES CO.,LTD, Korea (formally Hyundai Electronics, LCD Task Force). AFFS-applied notebook applications minimize colour

In 2004, HYDIS TECHNOLOGIES CO.,LTD licenses AFFS patent to Japan's Hitachi Displays. Hitachi is using AFFS to manufacture high end panels in their product line. In 2006, HYDIS also licenses AFFS to Sanyo Epson Imaging Devices Corporation.
HYDIS introduced AFFS+ which improved outdoor readability in 2007.

Vertical alignment (VA)

Vertical alignment displays are a form of LCDs in which the liquid crystal material naturally exists in a vertical state removing the need for extra transistors (as in IPS). When no voltage is applied, the liquid crystal cell remains perpendicular to the substrate creating a black display. When voltage is applied, the liquid crystal cells shift to a horizontal position, parallel to the substrate, allowing light to pass through and create a white display. VA liquid crystal displays provide some of the same advantages as IPS panels, particularly an improved viewing angle and improved black level

Blue Phase mode

Blue phase LCDs do not require a liquid crystal top layer. Blue phase LCDs are relatively new to the market, and very expensive because of the low volume of production. They provide a higher refresh rate than normal LCDs, but normal LCDs are still cheaper to make and actually provide better colours and a sharper image

Military use of LCD monitors

LCD monitors have been adopted by the United States of America military instead of CRT displays because they are smaller, lighter and more efficient, although monochrome plasma displays are also used, notably for their M1 Abrams tanks. For use with night vision imaging systems a US military LCD monitor must be compliant with MIL-L-3009 (formerly MIL-L-85762A). These LCD monitors go through extensive certification so that they pass the standards for the military. These include MIL-STD-901D - High Shock (Sea Vessels), MIL- STD-167B - Vibration (Sea Vessels), MIL-STD-810F – Field Environmental Conditions (Ground Vehicles and Systems),MIL-STD-461E/F –EMI/RFI(Electromagnetic interference/Radio Frequency Interference), MIL-STD-740B – Airborne/Structure borne Noise, and TEMPEST - Telecommunications Electronics Material Protected from Emanating Spurious Transmissions

Quality control

Some LCD panels have defective transistors, causing permanently lit or unlit pixels which are commonly referred to as stuck pixels or dead pixels respectively. Unlike integrated circuits (ICs), LCD panels with a few defective transistors are usually still usable. It is claimed that it is economically prohibitive to discard a panel with just a few defective pixels because LCD panels are much larger than ICs, but this has never been proven. Manufacturers' policies for the acceptable number of defective pixels vary greatly. At one point, Samsung held a zero-tolerance policy for LCD monitors sold in Korea. Currently, though, Samsung adheres to the less restrictive ISO 13406-2 standard. Other companies have been known to tolerate as many as 11 dead pixels in their policies. Dead pixel policies are often hotly debated between manufacturers and customers. To regulate the acceptability of defects and to protect the end user, ISO released the ISO 13406-2 standard. However, not every LCD manufacturer conforms to the ISO standard and the ISO standard is quite often interpreted in different ways. LCD panels are more likely to have defects than most ICs due to their larger size. For example, a 300 mm SVGA LCD has 8 defects and a 150 mm wafer has only 3 defects. However, 134 of the 137 dies on the wafer will be acceptable, whereas rejection of the LCD panel would be a 0% yield. Due to competition between manufacturers quality control has been improved. An SVGA LCD panel with 4 defective pixels is usually considered defective and customers can request an exchange for a new one. Some manufacturers, notably in South Korea where some of the largest LCD panel manufacturers, such as LG, are located, now have "zero defective pixel guarantee", which is an extra screening process which can then determine "A" and "B" grade panels. Many manufacturers would replace a product even with one defective pixel. Even where such guarantees do not exist, the location of defective pixels is important. A display with only a few defective pixels may be unacceptable if the defective pixels are near each other. Manufacturers may also relax their replacement criteria when defective pixels are in the center of the viewing area. LCD panels also have defects known as *clouding* (or less commonly *mura*), which describes the uneven patches of changes in luminance. It is most visible in dark or black areas of displayed scenes

ZERO-POWER (BISTABLE) DISPLAYS

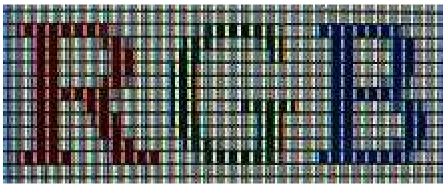
The zenithal bistable device (ZBD), developed by QinetiQ (formerly DERA), can retain an image without power. The crystals may exist in one of two stable orientations ("Black" and "White") and power is only required to change the image. ZBD Displays is a spin-off company from QinetiQ who manufacture both grayscale and colour ZBD devices. A French company, Nemoptic, has developed the BiNem zero-power, paper-like LCD technology which has been mass-produced in partnership with Seiko since 2007.

This technology is intended for use in applications such as Electronic Shelf Labels, E-books, E-documents, E-newspapers, E-dictionaries, Industrial sensors, Ultra-Mobile PCs, etc.

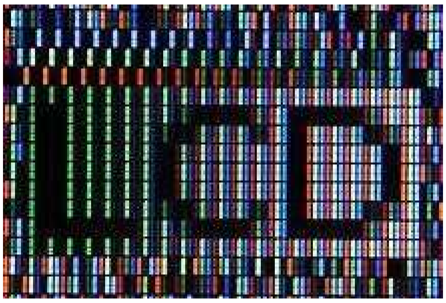
Kent Displays has also developed a "no power" display that uses Polymer Stabilized Cholesteric Liquid Crystals (ChLCD). A major drawback of ChLCD screens are their slow refresh rate, especially at low temperatures. Kent has recently demonstrated the use of a ChLCD to cover the entire surface of a mobile phone, allowing it to change colours, and keep that colour even when power is cut off. In 2004 researchers at the University of Oxford demonstrated two new types of zero-power bistable LCDs based on Zenithal bistable techniques. Several bistable technologies, like the 360° BTN and the bistable cholesteric, depend mainly on the bulk properties of the liquid crystal (LC) and use standard strong anchoring, with alignment films and LC mixtures similar to the traditional monostable materials. Other bistable technologies (i.e. Binem Technology) are based mainly on the surface properties and need specific weak anchoring materials. distortion while maintaining its superior wide viewing angle for a professional display. Colour shift and deviation caused by light leakage is corrected by optimizing the white gamut which also enhances white/grey reproduction.

Comparison of the OLPC XO-1 display (left) with a typical colour LCD. The images show

1×1 mm of each screen. A typical LCD addresses groups of 3 locations as pixels. The XO-1 display addresses each location as a separate pixel.



Example of how the colours are generated (R-red, G-green and B-blue)



In colour LCDs each individual pixel is divided into three cells, or subpixels, which are coloured red, green, and blue, respectively, by additional filters (pigment filters, dye filters and metal oxide filters). Each subpixel can be controlled independently to yield thousands or millions of possible colours for each pixel. CRT monitors employ a similar 'subpixel' structures *via* phosphors, although the electron beam employed in CRTs do not hit exact subpixels. The figure at the left shows the twisted nematic (TN) type of LCD.